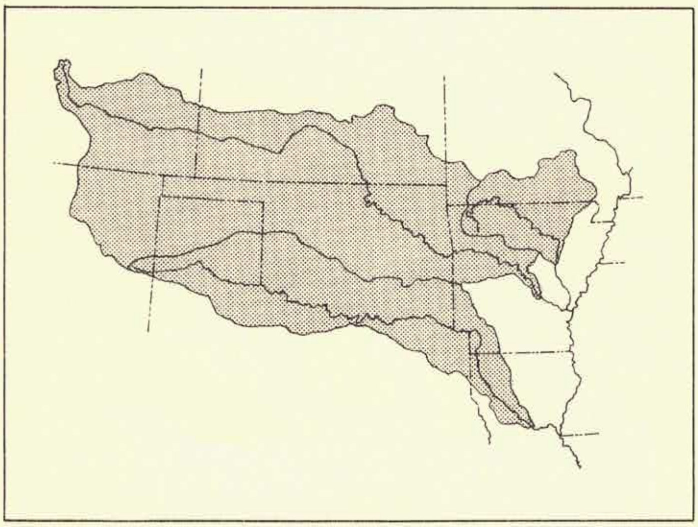
EFFECTS OF WATER DIVERSION

Panel Proceedings

October 13, 1982
Jefferson City, Missouri

Sponsored by
The Upper Mississippi River Basin Association
and
The Arkansas-White-Red Basins Inter-Agency Committee

Arkansas-White-Red Basins Inter-Agency Committee



The Arkansas-White-Red Basins Inter Agency Committee (AWRBIAC) was established in 1950 to respond to the Flood Control Act of 1950 providing for a comprehensive study of the Arkansas-White-Red river basins. The AWRBIAC was responsible for overall guidance in the study. In June of 1955 after completing the necessary investigations and adopting a proposed plan for the development of water and land resources of the Arkansas-White-Red Rivers Basins, the AWRBIAC considered itself discharged. However, a new charter, effective July 1, 1955, was issued by the Federal Inter-Agency River Basin Committee (FIARBC) which established a permanent AWRBIAC. Since 1955 only minor changes have been made in the charter.

The objectives of the present committee are:

- o to provide in the Arkansas-White-Red river basins, facilities and procedures for the coordination of the policies, programs, and activities of the federal agencies and states in water and related land resources investigations, planning, construction, operation and maintenance.
- o to provide means by which conflicts may be resolved.
- o to provide procedures for coordination of their interests with those of other federal, local governmental, and private agencies in the water and related land resources field.

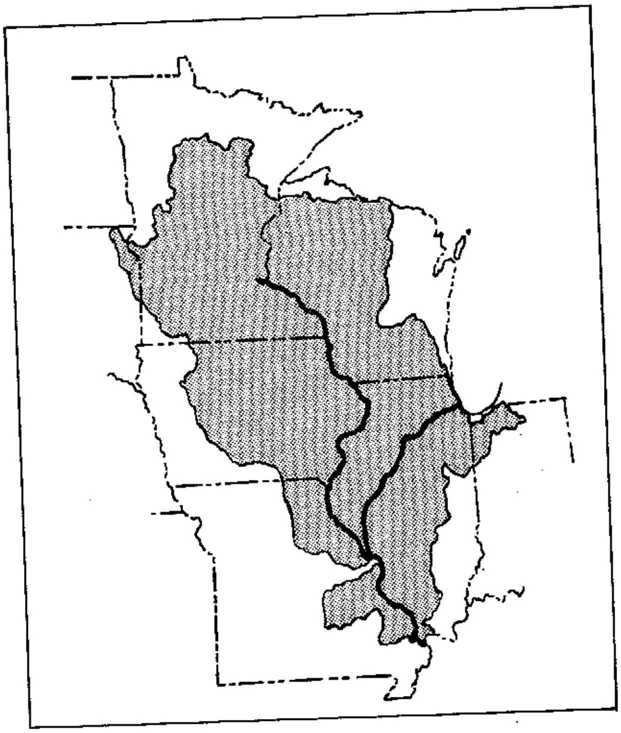
The AWRBIAC region includes the entire State of Oklahoma and portions of the states of Louisiana, Missouri, Arkansas, Texas, Colorado, Kansas, and New Mexico. AWRBIAC is composed of representatives of each of these eight states and eight federal agencies. The Governor of each state appoints a member to represent his state on the Committee. Federal members are designated by the head of the federal agency involved. The Chairman of the Committee is elected annually by the members of the Committee and provides necessary administrative support.

In addition to an Administrative Committee, there are three standing committees -- Environmental Resources, Exchange of Program Information, and Comprehensive Planning. The Environmental Resources Committee provides advice, recommendations, and support to AWRBIAC on environmental issues related to planning, development, and management of water resources within the region. The Exchange of Program Information Committee makes recommendations on methods of operation to improve the exchange of program information. The Committee also prepares and maintains a water resource activity report to reflect progress and status of planning, construction, operation, and other program activities relating to project development of state and federal construction agencies. The Comprehensive Planning Committee participates on behalf of AWRBIAC in regional planning and national assessment studies.

Members

State of Arkansas	U.S. Department of Agriculture
State of Colorado	U.S. Department of the Army
State of Kansas	U.S. Department of Commerce
State of Louisiana	U.S. Department of Energy
State of Missouri	U.S. Dept. of Housing and Urban Development
State of New Mexico	U.S. Department of Interior
State of Oklahoma	U.S. Department of Transportation
State of Texas	U.S. Environmental Protection Agency

Upper Mississippi River Basin Association



The Upper Mississippi River region has had a strong history of interstate coordination. The Water Resources Planning Act of 1965 (P.L. 89-80) authorized the formation of regional river basin planning commissions. In 1971 the Governors of Illinois, Iowa, Minnesota, Missouri, and Wisconsin petitioned the President to establish such a commission in the Upper Mississippi region. In March 1972 the Upper Mississippi River Basin Commission was established with a membership of five states and ten federal agencies. However, in December 1981 the Commission was terminated by Presidential Executive Order along with other basin commissions across the country.

During the summer of 1981, the demise of the Commission seemed imminent. Recognizing the importance of interstate water resource coordination, the five Governors signed a resolution recommending the continuation of an interstate organization. In December 1981 the states signed Articles of Association forming the Upper Mississippi River Basin Association and the Governors appointed representatives.

The Association assists its member states in understanding water resource issues of regional and national importance. Current issues, controversies, and decisions are monitored in an attempt to keep Association members informed on water resource matters that may impact state or regional programs and opportunities. In response to these issues and individual state concerns, the Association may develop collective state positions on issues of mutual concern. The Association in this way provides a vehicle for articulating state concerns through federal legislative and administrative channels.

The purpose of the Upper Mississippi River Basin Association is to maintain a cooperative forum to assist member states of the Upper Mississippi River Basin in the comprehensive coordinated management of their water resources. More specifically, the Association will strive to:

- Resolve regional conflicts among water and related land uses and among the region's institutional entities.
- Identify and solve water and related land resources problems.
- Serve as a regional body for the coordination of federal, state, interstate, and local plans for the management of water and related land resources.
- Unify state positions with respect to water and related land resources problems and issues.

The Association is composed of Governor-appointed representatives of the five states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. A chairperson is elected annually from among the membership. Meetings are held quarterly and additional meetings may be scheduled as necessary. The Association employs a small staff based in a Minneapolis, Minnesota office.

Members

State of Illinois
State of Iowa
State of Minnesota
State of Missouri
State of Wisconsin

Advisory Members

U.S. Department of Agriculture
U.S. Department of the Army
U.S. Department of Interior
U.S. Department of Transportation
U.S. Environmental Protection Agency

Preface

The availability of water is critical to the economic prosperity and environmental quality of this nation. However, water is not equally distributed throughout the country. While some areas enjoy ample or sometimes surplus supplies, other areas experience chronic shortages. The diversion or transfer of water offers one means of meeting water demands in arid regions.

Large scale interbasin transfers of water raise legal, political, and economic questions. In addition, changes in regional water balances can have irreversible effects that must be considered. Water diversions alter flow conditions downstream which may have both environmental, economic, and safety consequences.

The member States and Federal agencies of the Arkansas-White-Red Basins Interagency Committee (AWRBIAC) and the Upper Mississippi River Basin Association (UMRBA) are concerned about the positive and negative effects of water diversions both in the areas of water import and export. Within the past several decades there have been proposals to transport large volumes of water from "water rich" to "water poor" areas. The benefits and costs, in both dollars and resources, to the areas of import have been studied and are reasonably well understood. However, the impacts on the areas of export have not received the same attention.

To help better understand the effects of diversions, the State of Missouri hosted a panel discussion to disseminate current information and provide for possible ongoing discussions. The High Plains Council Report was discussed as one diversion option and the downstream effects on the Missouri and Mississippi Rivers were considered. Both of these rivers, as well as the Arkansas River, have common resource demands that make an exchange of information and ideas concerning effects useful.

High Plains Council Study

Dr. Herbert W. Grubb

Introduction

The High Plains Ogallala Aquifer Study was authorized by Congress in 1976 (P.L. 94-587). The authorizing legislation directed "...the Secretary of Commerce, acting through the Economic Development Administration, in cooperation with the Secretary of the Army, acting through the Chief of Engineers, and appropriate Federal, State and local agencies, and the private sector to study the depletion of the natural resources of those regions of the states of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, and Texas (Figure 1) presently utilizing the declining water resources of the Ogallala aquifer, and to develop plans to increase water supplies in the area and report thereon to Congress, together with any recommendations for further Congressional action."

Dr. Herbert W. Grubb

Dr. Grubb is currently the Director of Planning and Development for the Texas Department of Water Resources. This department is responsible for water use analyses, long-range projections of future water requirements, estimates of environmental impacts of water resource development, assessments of ground and surface water hydrology, and development of statewide water resources development alternatives.

He received his undergraduate degree from Berea College, his Masters in Agricultural Economics from Oklahoma State Univeristy, and his doctorate in Agricultural Economics from North Carolina State University. Prior to taking his current position in 1976, he directed the Economics Analysis Section of the Texas Governor's Office and was a member of the faculty of Texas Tech University.

Objectives

The High Plains Study objectives include computing and explaining the local, State, and national economic importance of this area and recommending a course of action to deal with the impending decline in the supply of natural resources of the area. Congress has recognized the potential national consequences of these problems and is now directing that actions be taken prior to depletion of the area's energy and water resources.

Organization

In order to accomplish the objectives of the study, the Governors and other representatives of the High Plains states organized the High Plains Study Council in November 1976 to guide and direct the study. Membership is composed of a representative of the Federal Government, the Governor of each state, or his designee, and three representatives from each state appointed by and serving at the pleasure of the Governor.

In February 1977, the objectives, work elements, and organization of the Study were specified by action of the Council. In late September 1978, a

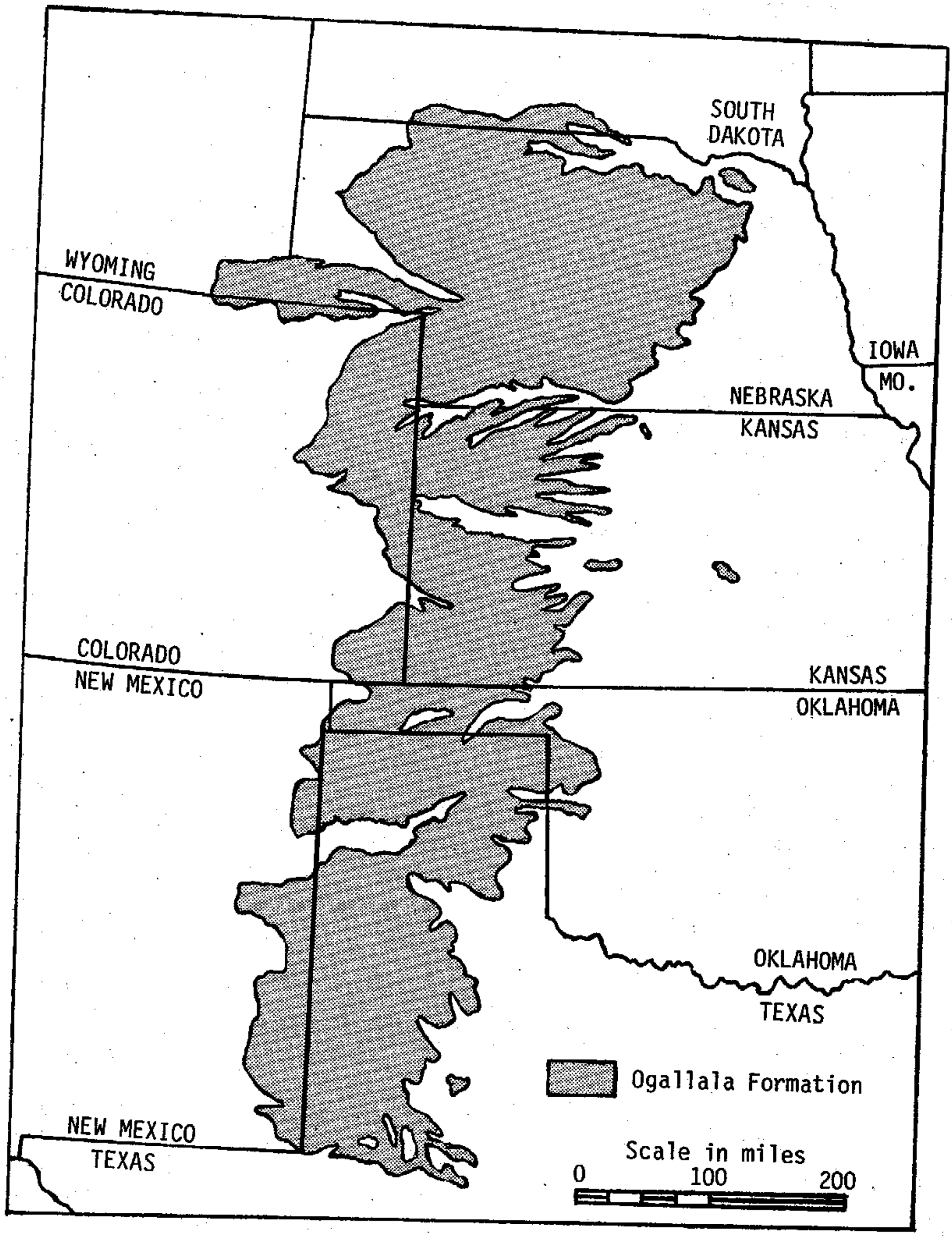


Figure 1. Ogallala Formation Location and the Principal Study Area

General Contractor -- Camp Dresser and McKee, Inc. in association with Arthur D. Little, Inc., Black and Veatch and others -- were engaged. The General Contractor managed the Study for the Federal Government and the Council and performed parts of the work. Each state performed fundamental parts of the work and the U.S. Army Corps of Engineers conducted the water import studies. Reports and several appendices have been written.

Summary of Study Results

The Ogallala region has one percent of the Nation's population and six percent of the Nation's land area. At the present time, the area is producing over 15 percent of the total value of wheat, corn, sorghum, and cotton and 38 percent of the total value of livestock produced in the Nation. The High Plains has approximately 14.3 million acres of irrigated land for which water is supplied from the underlying Ogallala formation with more than 170 thousand irrigation wells. The High Plains area also has about 18.3 million acres of dryland farming, a part of which is interspersed with the irrigated acreages. In addition to irrigated and dryland crop production, large scale cattle feedlot and meat packing industries have been developed due to the availability of feed grains and a climate that is ideal for cattle feeding.

Estimates were made of production, employment, and water use in the High Plains economy for a baseline and alternative water uses cases. In the Baseline Case, it is assumed that there will be no changes in laws which affect the use of ground water and that more efficient water-use technology will be adopted as it becomes available. Baseline case estimates, as well as estimates for all other cases considered, incorporate information about the effects of national and world markets upon prices for agricultural commodities and estimates of expected technological improvements in crops, irrigation methods, water conservation, and farm management. Data about water conservation technologies, crop yield trends, and expected improvements in plant breeding were obtained from agricultural scientists and leading farmers in the area. Crop prices and production costs were obtained from analyses of national and international markets for agricultural commodities.

Energy

Crude oil production and natural gas production are projected to decline by 80 percent in the period for 1980 to 2020. Electric power production is projected to increase almost 400 percent by 2020. The primary fuel is expected to be coal.

Employment and income from energy production in the six-state area are projected to almost double by the year 2000 but are expected to decline to one-half of the present by the year 2020.

Annual water use by energy industries is projected to increase about 77 percent from the present level of 130,500 acre-feet by 2000 and then decline about 13 percent to 201,400 acre feet by 2020. In the early years of the projection period, electric power production uses about half of the water used in energy production, but by 2020 this use increases to nearly 95 percent of water needed for energy industries in the area.

Agriculture

Production of the six major crops grown in the High Plains region -- wheat, corn, grain sorghum, soybeans, alfalfa, and cotton -- is projected to increase between 1977 and 2020. Wheat production is projected to increase by almost 45 percent, grain sorghums by more than 60 percent, corn and cotton by slightly more than 100 percent, and soybeans by more than 1,060 percent by 2020. The major High Plains crops constitute a significant part of the total national agricultural commodity supplies -- and thereby contribute significantly to nationwide prices of these commodities -- 13 percent of corn production, 16 percent of wheat, 25 percent of cotton, and 40 percent of grain sorghum. Corn production is projected to increase by almost 150 percent in the North due to projected growth in acreage and production in Nebraska but will decline in Kansas, Texas, and Colorado. Both grain and cotton are among the nation's major agricultural exports.

The total value of production from both irrigated and dryland crops for the study area increases from approximately $4.6 billion in 1977 to $11.5 billion (in real terms) in 2020. About 68 percent of total production value is from irrigated land. The increase in the value of production between 1977 and 2020 for the study area is the combined effect of slightly higher real crop prices, increase in yield per acre, and additional land brought into production. The assumption regarding increasing real prices for agricultural commodities (i.e., increasing faster than the rate of inflation) appears to be sensitive and questionable as it is contrary to historical trends in agricultural product prices. The amount of land under irrigation in the study area is projected to increase from 14.3 million acres in 1977 to 18.0 million acres in 2020. Most of this increase is projected to occur in Nebraska, where the aquifer is thickest, however, 5.6 million acres of irrigated land revert to dryland in the Region during the Study time period.

Estimated returns to land, water, and management increase from just over $1 billion in 1977 to almost $5 billion in 2020. The proportions of returns accounted for by irrigated production are 46 percent and 60 percent for 1977 and 2020 respectively.

For the Baseline Case in the six states, the total production of foodstuffs, feed grains, and fiber in the Ogallala region is projected to increase over the study period for the following reasons: (1) improvement in crop yields per unit of inputs, (2) new land developed into irrigated crop production (primarily conversion of rangeland into irrigated cropland in Nebraska), (3) a more efficient (yield per unit of input) use of irrigation water, and (4) long-term real increases in agricultural prices. Yields per acre of the major High Plains crops are expected to increase, but at a slower rate than historically since 1946 when dramatic productivity improvements began. All six states projected increased efficiency in water use. The amount of water use per acre is projected to decline 16 percent between 1977 and 2020 in Nebraska, 25 percent in Colorado, 25 percent in Kansas, 50 percent in Oklahoma, 60 to 65 percent in New Mexico, and 66 percent in Texas.

The agricultural prices used in the Study probably affect the projections more than any other factor. Domestic and export demand combine to affect crop prices. In the future, domestic demand for crops is projected to grow at a moderate rate due to slower population, economic, and real per capita income growth than in former years. In the long-run, export demand for crops is projected to show strong growth due to a growing world economy, continued agricultural shortages in several industrialized nations, and a U.S. policy encouraging agricultural exports. This projected growth in export demand would result in rising real prices for farm commodities as was projected in this study. The assumptions and estimates underlying this part of the analyses are critical to the results; export demand is drastically affected by shifts in trade policy which cannot be forecast in deterministic models such as those used in this study.

<u>Regional Economic Impacts</u>

Agricultural and energy production projected in the baseline analyses affects business, value added (regional product), employment, household income, per capita income, and government revenues of the regional economy. Value added is projected to increase over the study period from about $21 billion in 1977 to more than $49 billion in 2020 (all values are in 1977 prices.) The southern Ogallala subregion (New Mexico, Oklahoma, and Texas) is somewhat less dependent upon the primary agricultural sectors than is the northern subregion (Colorado, Kansas, and Nebraska) since the energy sectors are significantly larger in the south. Value added in energy sectors is projected to decline from about $12 billion in 1990 to about $4 billion in 2020. From a peak of 51 percent of the southern subregion's value added in 1990, energy production would account for an estimated 15 percent by 2020. Agriculturally related economic activities in the High Plains regional economy account for 20 to 30 percent of total regional value added. The projected growth in these sectors (led by production increases in the northern half of the region) tend to drive the overall growth of the economy. The accuracy of these projections is related to diversification of the local economies, as well as the agricultural and energy sectors.

Regional employment is projected to increase throughout the study period from a base of about 1.0 million jobs in 1977 to about 1.3 million by the year 2020. Growth in regional employment is strongest during the earlier (pre-2000) periods and levels off thereafter. This is related mainly to nonagricultural employment in the southern three states, especially employment within the energy sectors. Total household incomes are projected to increase by nearly 200 percent by 2020 under Baseline conditions, with a slightly smaller increase in the northern subregion (172 percent) and slightly larger increase in the south (211 percent).

Regional population is projected to increase from 2.2 million in 1977 to 2.9 million by 2020. The southern three states start with an estimated population base of 1.3 million in 1977, about 58 percent of total regional population, and grow to nearly 1.8 million by 2020, a 41 percent growth. Projected population growth trends in the South are expected to differ significantly from the North. Having almost a 40 percent projected increase in population by the year 2000 (an increase of 500,000 people), the South is projected to decline thereafter, losing about 24,000 in population between 2000 and 2020. The North, is projected to have very little population growth between 1985 and 2000. This period of limited population change is related to lack of diversification in the economy and further mechanization in the expanding agricultural sector. After 2000, growth in the North is projected to increase by approximately 37,000 for the period 2000 to 2020.

The Region had an estimated per capita income of about $5,800 in 1977, projected to increase to $12,660 by 2020.

State and local government revenues are estimated to rise more rapidly for the entire Region than population because of projected growth in real incomes and output. Constant growth in government revenue is projected for the northern portion of the Ogallala Region. However, a different trend is projected for the South. Taxes paid by the oil and gas industry are a significant portion of government revenue in the Ogallala portion of the three southern states. For the southern part of the Region, State and local government revenues are projected to increase by 73 percent from 1977 to 1990, then are expected to fall by 44 percent from 1990 to 2020 as the result of the projected decline in the quantities of oil and gas produced after 1990.

<u>Water Resource Estimates</u>

The estimated quantity of water in storage in the Ogallala aquifer within the study area in 1977 was 3.04 billion acre-feet, of which 3.1 percent was in Colorado, 8.1 percent was in Kansas, 77 percent was in Nebraska, 0.8 percent was in New Mexico, 2.0 percent was in Oklahoma, and 9.4 percent was in Texas. During the 1977-2020 projection period, for the Baseline Case, it is estimated that 23 percent of total water in storage in the study area in 1977 will have been used. However, in the three southern states, New Mexico, Oklahoma, and Texas, more than 50 percent of the quantity of water in storage in 1977 will have been used by 2020. Nearly two-thirds of the Texas supply is estimated to be used during the projection period. Although the water is hard and contains a low dissolved solid content, the Ogallala is generally uniform in quality. Large withdrawals for irrigation purposes, especially in areas of low transmissivity, may lower the head sufficiently to induce upward migration of water high in chloride content. In addition, the municipal and industrial requirements of the region are met primarily by ground water supplies. As the demand for additional supplies to meet these needs increases, entities will have to evaluate and assess alternative sources of supplies to meet anticipated demands.

Sustained pumping from the Ogallala Aquifer could result in the diminution of streamflow in some parts of the High Plains. If ground water usage were restrained to protect surface flows, the projections of this study could be altered in that there could be a somewhat reduced rate of irrigation development. This type of restraint was not considered when the High Plains projections were made.

Alternatives to the Baseline Case

The results of analyses of alternate cases using (1) increased voluntary conservation of Ogallala water, (2) mandatory conservation of Ogallala water, (3) local water supply augmentation, (4) intrastate surface water interbasin transfer, and (5) voluntary conservation of Ogallala water combined with imported water will be presented and compared with those of the Baseline Case. The conservation cases are presented in greater detail to show potential effects of reduced annual withdrawals of water from Ogallala aquifer upon production, employment, income, taxes, and the quantity of water remaining in storage at the end of the projection period.

The "conservation" cases included an analysis of voluntary conservation and mandatory conservation. For the voluntary conservation case, it was estimated that irrigation farm managers would be able to increase water use efficiency through increased investments in water saving equipment, improved soil moisture monitoring, improved irrigation scheduling, increased adoption of water efficiency improving technology, increased irrigation application efficiency, and perhaps the use of other water conservation techniques to reduce the quantity of irrigation water applied per acre without reducing crop yields. There is very little difference in output in this case in the year 2020 as compared to the Baseline Case.

These differences include:

1. Agricultural production:

   Very small increases (3.3 percent) in value of farm production in relation to that of the Baseline Case, with northern subregional increases greater than those in the southern part of the area;

   Returns to land, water, and management increase slightly (1.5 percent) because of reduced pumping costs;

   Relatively small change in water use in most states because farmers are expected to adopt most water saving technologies without added incentive programs.

2. Remaining ground water supplies and irrigated acreages:

   Irrigated acreage by 2020 is 0.94 million acres (5 percent) greater than irrigated acreage of the Baseline Case.

   The quantity of water remaining in storage was reduced slightly (0.1 percent) because improved water use efficiency would provide an economic incentive to keep about 100 thousand acres in irrigation that would have been returned to dryland production in the Baseline Case.

3. Regional economy:

A relatively small increase (0.9 percent) in regional value added in comparison to the Baseline Case;

Regional value added for the voluntary conservation case is increased by $364 million (0.8 percent) in 2000 and $449 million (0.9 percent) in 2020;

Regional employment would be increased 1.1 percent, or 14,000 employees, by 2020 over the Baseline Case employment projection.

In order to increase water conservation, reasonably priced capital for long-term investments in conservation equipment will have to be available to farmers. In addition, it will have to be profitable to remain in irrigation farming, a condition which is marginal in the early 1980's.

In the "mandatory water conservation" case, the major impetus to conservation is to limit the quantity of water that can be pumped annually, while applying the most efficient irrigation methods in the use of that quantity of water that is pumped. For the analyses of this case, the appropriate production, farm management and aquifer data developed for the other cases were used. However, it was assumed that the quantity of water that could be withdrawn for use in any one production season would be limited to a percent of the quantity estimated to be withdrawn in the voluntary conservation case. For this analysis it was assumed that the quantity of water available for use in 1985 would be limited to 90 percent of that which would have been used in the voluntary conservation case; the quantity in 1990 would be limited to 80 percent of that which would have been used in the voluntary conservation case; and the quantity in 2000 and beyond to 2020 would be limited to 70 percent of that quantity which would have been used during the periods 2000 and 2020 in the voluntary conservation case. The projected results of this limitation of annual water supply to the agricultural sectors in 2020 is presented as a comparison to the Baseline Case below.

1. Agricultural production:

   Generally decreased (7.9 percent reduced value) because of limitations on water use. Regional wheat production remains relatively stable compared to the Baseline Case, while corn, cotton, and soybean production is projected to decline;

   Total value of production is lower, but proportionately less than regional crop production because the reduction in agricultural production in the High Plains forces national crop prices to increase;

   Total returns to land water, and management for the Region are reduced (7.3 percent) relative to Baseline Case projections but not quite as much as decreases in total value of production.

2. Remaining ground water supplies and irrigated acreages:

   The quantity of water remaining in storage in 2020 is 123.7 million acre-feet (5.4 percent) more than in the Baseline Case;

   Relatively little change in irrigated acreage would be expected during the Study period. In the early years, irrigated lands are less than in the Baseline Case but by 2020, lands under irrigation would be only 0.1 percent less than in the Baseline Case.

3. Regional economy:

   Total projected value added for the Region in 2020 is 2.1 percent below Baseline Case projections -- 4.0 percent in the North and 0.9 percent in the South;

   Total projected declines over the Baseline Case in value added for the

Study period 1977-2020 for the Region is $1.05 billion.

Analyses of the potential for local water supply augmentation indicate some opportunity for development in Nebraska and Oklahoma through intrastate water transfers.

The Oklahoma Water Resources Board in cooperation with other state and federal agencies prepared the Oklahoma Comprehensive Water Plan in 1980, which contained two extensive intrastate water conveyance systems. The Northern Water Conveyance Systems would divert surplus flows at Lake Eufaula on the Canadian River and at Robert S. Kerr Reservoir on the Arkansas River, both in eastern Oklahoma, and convey the water for multiple uses in north central and northwestern Oklahoma. The Southern Water Conveyance System would divert surplus yields from existing and authorized reservoirs in southeastern Oklahoma for uses in central and southwestern sections of the state. Of interest in connection with Management Strategy Four is the Northern Water Conveyance System, in which water would be provided for irrigation in Subregions 1 and 11 of the Oklahoma High Plains Area.

The Northern Water Conveyance System, as updated, would deliver about 800,000 acre-feet per year to Oklahoma Subregion 1 and approximately 52,000 acre-feet per year to Subregion 11. Construction costs for the entire northern system would total $5.3 billion in 1978 dollars over a 30-year construction period. Beckham County in Subregion 11 will receive 5,000 acre-feet per year through the southern system.

Nebraska also investigated the possibility of intrastate diversions and transfers and found that it would be necessary to reexamine state policy before any plans could be implemented. In Colorado, the feasibility of diverting up to 200,000 acre-feet from the South Platte River to the Northern High Plains is being studied.

The other High Plains states concluded that very little, if any, surplus surface water is available within their borders that might be transferred to the High Plains area. Thus, this case could not be given further consideration.

The other case which was analyzed in the Study combines voluntary conservation and imported water.

Whereas in the previously described case, the source of water available for use is the Ogallala Aquifer, analyses in this case are based on the assumption that the aquifer would be supplemented with imported water in sufficient quantities to continue irrigation of acreage irrigated in 1977 that would otherwise have been lost because of ground water decline. The total lands irrigated in 2020 are estimated to be about 23 million acres of which 19 million acres would be irrigated from ground water supplies and the remainder (4 million acres) would be irrigated with imported water. It should be noted, however, that a significant part of those lands being irrigated from ground water in 2020 are expected to go out of production shortly after 2020 because of further declines in ground water supplies. The study methods and data are the same as those described previously in voluntary conservation, with the exception that the water supply available for use in each subarea is adequate to sustain irrigated acreage at the 1977 levels. The results are presented for the year 2020 in the form of comparisons with the projected results of the Baseline Case. The differences in income between this case and the Baseline Case are estimates of the returns to imported water and to conservation measures.

1. Agricultural production:

   Significant increase (14.8 percent) in value of crop production since water would be available for all acreages irrigated in 1977;

   Wheat, the principal dryland crop, would decline by 7.5 percent with the availability of imported water for producing higher-valued crops;

Projected returns to land, water, and management are 14.9 percent higher than for the Baseline Case but increased production results in lowered national prices of the commodities produced in the High Plains area.

2. Irrigated acreage and import volumes:

   3.3 million acres continued in irrigated production in 2000 with 5.5 million acres in 2020 (30.7 percent greater than in the Baseline Case projections);

   1.7 million acre-feet of imported water needed in 2000; 4.1 million acre-feet of imported water needed in 2020;

   Because ground water would be used throughout the study period where it is available, irrigated acreages would decrease in years after 2020 unless import volumes are increased from those stated above.

3. Regional economy:

   Imported water would result in increased agricultural production and a stronger regional economy -- 13.2 percent increase regionwide in annual gross value added by farm production in comparison to Baseline Case projections for 2020;

4. All economic sectors show increased annual value added.

   Annual employment is about 9 percent higher in the North and nearly 2 percent higher in the South than for the Baseline Case by 2020.

Water Importation

One of the objectives of the Study, as specifically authorized in P.L. 94-587, Sec. 193, was to develop plans to increase water supplies in the area. Thus in accordance with direction from the High Plains Study Council, the U.S. Army Corps of Engineers has made studies of four potential importation sources and routes to the High Plains area as follows (Figure 2):

A. Fort Randall, South Dakota, southwesterly across Nebraska to terminal storage near Bonny Reservoir in eastern Colorado;

B. St. Joseph, Missouri, southwesterly across Kansas to terminal storage near Dodge City, Kansas;1/

C. Clarendon, Arkansas, westward through Oklahoma to terminal storage in Texas on the Canadian River; and1/

D. Clarendon and Pine Bluff, Arkansas, southwestward across Arkansas to Northeast Texas, then westward across north Texas to terminal storage at Bull Lake in the Southern High Plains of Texas.

Transfer cost estimates, in 1977 dollars, range from a high of $569 per acre-foot for the smallest volume considered for Route C to $227 per acre-foot for the largest volume considered for Route B. The transfer cost estimates do not include costs of moving water from the terminal storage points and distributing it to farms. The cost of distribution of the imported water to the using farms would vary widely depending on the elevations and locations of the users relative to the terminal storage sites. The minimum distribution costs probably would be associated with Route A and the maximums with Routes B or D. The construction costs were estimated using a fifteen year construction period; accelerated construction could substantially reduce this cost. (Table 1).

1/ These route descriptions do not coincide with the originally selected routes for B and D since different terminal storage sites were used for capacity or efficiency reasons.

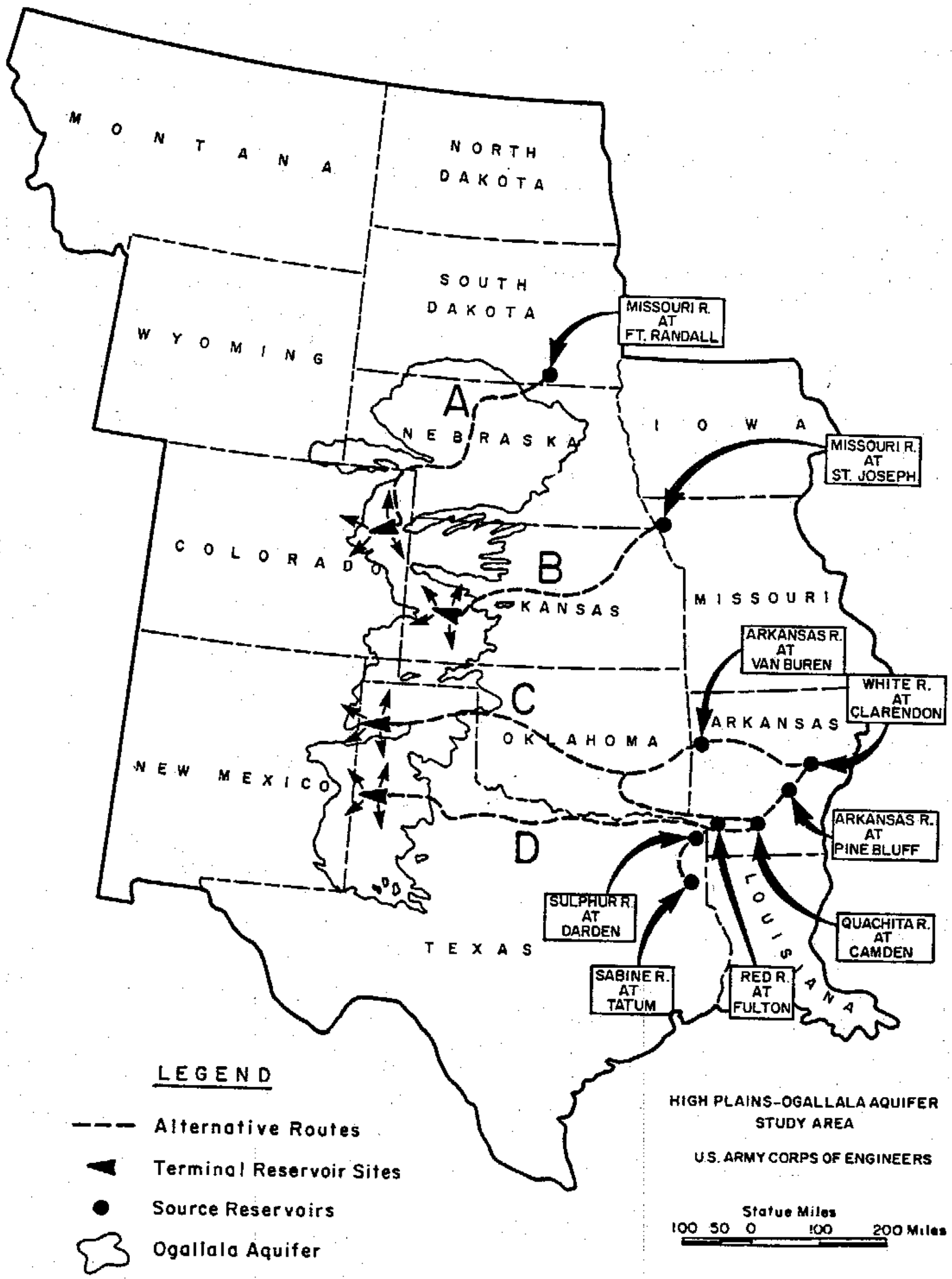


Figure 2. Interstate Water Transfer Route Alternatives Assessed by the Corps of Engineers

Source: Adapted from Figure 5, Review Draft, Water Transfer Elements of High Plains - Ogallala Aquifer Study, January 1982, U.S. Army Corps of Engineers

Table 1. Estimated Water Import Costs to the High Plains Ogallala Region; 1977 Dollars.

Route	Sizes of Water Transfer Facilities Studied a/	Total Length of Route	Elevation Difference Start to End	No. of Pumping Plants/Power Generating Plants	Total Energy Requirements of Pumping Stations	Total Costs Construction and interest during const. h/	Average Annual Cost (Amortization Interest, Pumping i/
	(million acre-ft. annually)	(miles)	(feet)		(MKWH/yr) f/ g/	($ billions)	($/acre-foot) j/
A	1.91	813 b/	2,400	18/0 e/	6,600	5.4	291
	3.40	813 b/	2,400	18/0 e/	14,300	8.9	291
B	1.62	376	1,745	29/3	7,700	3.6	255
	3.40	376	1,745	29/3	15,600	6.5	227
C	1.26	611	3,280	26/0	8,400	7.0	569
	7.51	1,135 c/	3,600 d/	46/0	49,700	27.8	430
D	1.55	568	2,610	21/0	7,500	5.3	370
	8.68	860	2,725	30/0	49,000	20.6	308

a/ The range of quantities of water delivered for each route was generally defined by the quantity of water needed to restore and maintain irrigated land that is projected to go out of irrigation between 1977 and 2020, and the estimated availability of water from a particular source or set of sources.
b/ Includes 193.1 miles of side canal.
c/ Does not include 209 miles of Arkansas River Navigation Channel.
d/ Maximum elevation difference (uses southern leg).
e/ Includes one pumping plant on side canal.
f/ Million Kilowatt Hours per year.
g/ The output of a 500 Megawatt coal-fired power plant averages about 3,100 million Kilowatt Hours per year.
h/ Assumes a 15 year construction period with interest rates at 7 3/8 percent per annum, amortized over 100 years.
i/ The energy cost used is the projected 1981 off-peak load rate in 1977 dollars. If increases in energy costs occur as projected, the unit cost of water will range from $320 to $880 (in 1977 dollars) per acre-foot in the year 2105.
j/ Distribution cost is not included; therefore, these unit costs should not be directly compared.

It is emphasized that the water import analyses of this study are very general in nature and are intended to give estimates of the potential costs of moving water from the generalized points of origin to the general destinations. In its instructions to the Corps, the High Plains Study Council set forth a statement of policy pertaining to the water importation parts of this study. The instructions provided that the present and prospective future needs in the potential basins of origin of surplus water would be considered as having prior rights, that only water surplus to these needs would be considered for exportation, and that transfers would be considered only on the basis of full and frank discussion with all directly involved states. The water import estimates were conducted in accordance with this principle. However, it is not possible at this time to determine whether or not there are surplus surface waters, and if so the potential quantities of such surplus waters at each originating area for each Route studied. Such estimates can only be made after fully assessing the water resources needs of the areas from which such surpluses might be obtained.

The Northern Subarea

The northern part of the High Plains study area including Nebraska, Colorado, and Kansas has a much larger supply of Ogallala water in storage. Thus, the analyses show significant economic development potential in the foreseeable future. However, most of the opportunity for growth of the irrigation sectors is in Nebraska. This three-state northern area had nearly 2.7 billion acre-feet of Ogallala aquifer water in 1977. For the Baseline Case analysis, six percent of the water reserves would be withdrawn and used between 1977 and 1990. An additional 12 percent to 13 percent of the water reserves of this area would be used between 1990 and 2020 for the Baseline and voluntary conservation cases respectively, leaving between 2.21 billion and 2.19 billion acre-feet of water in storage in the area in 2020. However, 25 percent of Colorado's reserves, 25 percent of Kansas's, and 16 percent of Nebraska's reserves are projected to have been used by 2020 in the Baseline Case.

The Southern Subarea

The three southern states of New Mexico, Oklahoma, and Texas have smaller quantities of water in storage than the northern area. From only 367.4 million acre-feet in storage in 1977, projected depletion is to 266.8 and 125.7 million acre-feet by 1990 and 2020 respectively, a loss of nearly two-thirds of the 1977 supply.

In comparison to the North, where increased conservation is projected to have very little effect upon the quantity of water used each year,[2] the conservation policies are projected to make a significant difference in the southern subarea -- about 11 percent more water would be left in storage in 2020 for the voluntary conservation case, and about 30 percent more would be left in storage for the mandatory conservation case than for the Baseline Case. In the mandatory conservation case, the fundamental decision would be to reduce the rate at which the water supplies would be used. Although the result would be to leave more water in storage at end of any planning period, this course of action would have a negative effect upon the regional economy of about over $2 billion in value added for the 1977-2020 study period.

Recommendations

Four basic methods are available for achieving the goals set forth in the High Plains study legislation: (1) improving irrigation efficiency, (2) restricting ground water use, (3) increasing the Region's water supply, and (4) expanding

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2/ Conservation has little effect on annual water use because improved water use efficiencies mean that irrigation remains feasible on more acreage.

opportunities for economic development in the Region. For the near term, it appears that a major commitment to water conservation should be made, since many desirable results of water conservation can be realized relatively quickly and at relatively low cost. Both public and private activities are needed.

The Council is currently considering recommendations pertaining to the Region's economy and natural resources. These recommendations will be presented for the following major areas of public and private programs and actions:

- Water Conservation Technology, Research, and Demonstration
- Public Information, Education, and Technical Assistance
- Energy
- Legal and Institutional
- Water supply
- Environmental
- General Economic Development

Municipal and Industrial Water Supply

William C. Ford

The Missouri River is an important source of water for Missourians. I was asked to discuss the Missouri River as both an industrial and a public water supply source. I plan to place more emphasis on public water supply because more information is available on it and because I'm more familiar with it.

William C. Ford

Mr. Ford has been involved in the water supply field for 16 years. He holds both a Bachelors and a Masters Degree in Civil Engineering from the University of Missouri-Rolla. He began his career with the Illinois Water Supply Program, served as a Captain with the U.S. Army working in environmental engineering activities, and he worked with a consulting engineering firm before joining the Missouri Public Drinking Water Program in 1973 as Chief Engineer. He has served as Director of the Public Drinking Water Program, Missouri Department of Natural Resources for the last year and a half.

He is a Registered Professional Engineer, a member of the National Society of Professional Engineers, the Missouri Water and Sewerage Conference, the American Water Works Association, and the Conference of State Sanitary Engineers.

Unfortunately, as far as I have been able to determine, there isn't much detailed information on industrial withdrawals from the Missouri River. The best source of information I have been able to discover is a compilation of ten years of recorded water withdrawal data put together by the Missouri Department of Natural Resources' Water Resources Group. This water withdrawal study covered the entire State and all water use purposes. Withdrawals were reported to the Department as required by a law covering every person, firm, corporation, or political subdivision in the State. The report of the study covered major water users which, in this case, were defined as those using 25,000 gallons per day average for any 30-day period. Over the 10-year period of the study, an average of 44 billion gallons per year was withdrawn from the Missouri River for industrial purposes.

One important result of this study was to demonstrate the tremendous amount of water dedicated to power production. Over the 10-year period, from 1969 to 1978, 91.8 percent of the water withdrawn was used by the power plants for power production, 4.9 percent was used for municipal water supply, and 1.1 percent went for industry.

It's important to remember that many industries will utilize an existing public water supply as a source of water when the water is of adequate quantity and quality. Of course, the figures we're talking about here are those that are self-supplied with water from the Missouri River.

There is an interesting story illustrating the importance of the

Missouri River to industry told by Walter Zollmann, who, for years, headed water treatment operations for the City of St. Louis. According to Walter, Anheuser-Busch, brewers of Budweiser and Michelob, utilizes St. Louis City water as an ingredient in its products, even though it has its own treatment plant. The City of St. Louis, in turn, utilizes the Missouri River as a source of supply (even though the Chain of Rocks Plant is located on the Mississippi, it treats Missouri River water which flows along the west bank at that point). Anheuser-Busch was opening a new east coast brewery and was having difficulty obtaining the right flavor for its products using the local eastern water. According to Walter, Anheuser-Busch resorted to shipping tank car loads of St. Louis City water, which is treated Missouri River water, to the east coast until its chemists could make the necessary adjustments to the local water supply. The Missouri River isn't Rocky Mountain spring water, but many beer drinkers would agree it does produce a premium product.

If we look at public water supplies, we have a little clearer picture of withdrawals from the Missouri River. Eight public water systems utilize the Missouri River directly as a source of water. Those systems are shown on Figure 1 by the solid squares, and starting with the farthest upstream, they are St. Joseph, Kansas City, Lexington, Glasgow, Boonville, Jefferson City, and St. Louis City and St. Louis County Water Company. Two other supplies, those indicated by the squares which are half darkened, are Higginsville and the City of St. Charles, both of which utilize the Missouri River as a back-up water source.

The 1980 Missouri Census population was 4,916,686. DNR data shows that 4,541,179 people in Missouri are served by public water supply. That's 92 percent of the State's population. The figure is, perhaps, surprisingly high to you. It has increased dramatically over the last 10 or 15 years as a result of construction of rural public water supply districts. The water supply districts have taken good quality drinking water into the rural areas of the State just as the rural electrification program brought light and power to the farms many years ago. This has been particularly important in northern and western Missouri, where you'll see in a moment, we have poor ground water.

If we look at the population served by these ten water supplies and if we take into account the secondary supplies which purchase water from these systems (these are water districts or small towns), we find that the total population served directly by the Missouri River is 2,250,770, and that's approximately 50 percent of the people served by public water supplies in the State. And if you look at it on a statewide basis, it comes out to about 45 percent of the State's population utilizing the Missouri River directly as a source of drinking water. These supplies use an average of 398.4 MGD, or 450,000 acre-feet/year.

If we want to expand our scope a little bit, we might look at Figure 2 which shows public water supplies which use wells drilled in the Missouri River alluvium, the alluvium being the gravel and sand deposits along the river. We could argue as to whether alluvial water should be included in a discussion of withdrawals from the Missouri River, but I think it's evident that the Missouri River, the alluvium, and the alluvial water all form an inter-related system.

Each circle shown on this map represents a water system utilizing water from the Missouri River alluvium. If we add the population served by these water supplies, including the secondaries that purchase from them, to those that utilize water directly from the Missouri River, we find that a total of 2,719,118 use the combined direct and alluvial Missouri River water. This represents 60 percent of the portion of the population in Missouri which is using a public water supply, and surprisingly, it represents approximately 55 percent of the total population of the State. These figures

Figure 1

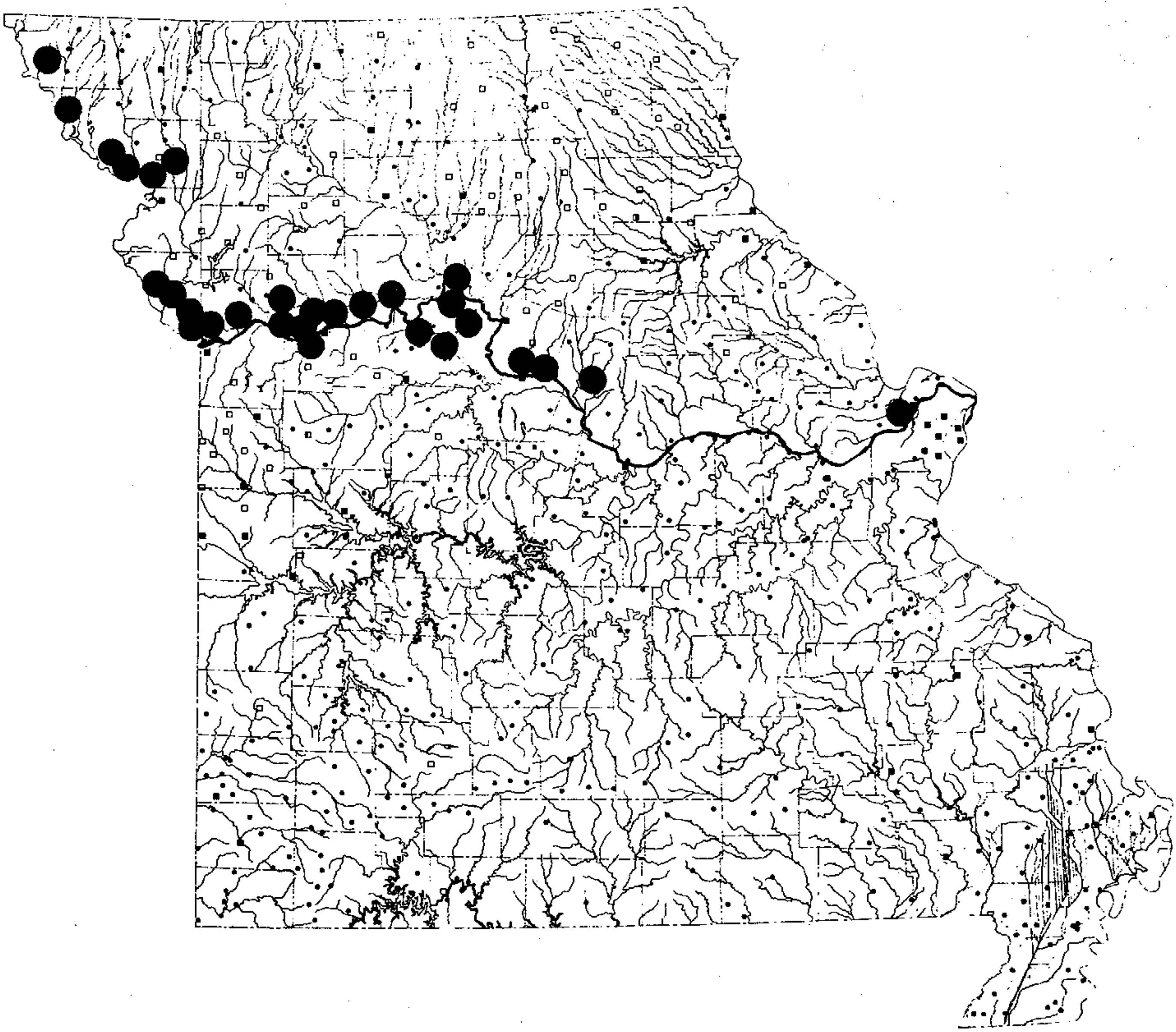

Figure 2

are high, of course, because several of the State's major population centers are served by these water supplies. Total withdrawal from the river and alluvium averages 444 MGD, or 502,370 acre-feet/ year.

You'll notice on the map of alluvial supplies that the supplies tend to cluster in a particular area. There is a reason for this. If we look at Figure 3 which shows ground water quality in Missouri in terms of total dissolved solids, you'll note that the ground water in the northern and western part of the State is saline. There's an area of particularly high dissovled solids and consequently poor quality ground water which corresponds to the heavy concentration of alluvial supplies plotted on the previous map.

Figure 4 will give you an idea of the areas of the State which are served by the Missouri River. This is a map of public water supply districts in Missouri. The areas which are shown solid are the areas of the State which utilize the Missouri River directly as a source of water. These water districts purchase water from one of the ten water supplies using the Missouri River directly. The cross-hatched areas are those water districts which purchase water from one of the alluvial Missouri River water supplies.

In summary, the Missouri River is an important resource to Missourians. Approximately 60 percent of those using water from a public water system in Missouri obtain their water in one way or another from the Missouri River. On a statewide basis, about 55 percent of the State's population are dependent on the Missouri River as a source of water either directly or from the water contained in the river alluvium.

A quote from a 1955 publication of St. Louis County Water Company says it very well -- "The Missouri is a good source of water, ample, unfailing, and with characteristics which make it -- after the elaborate processing required -- a fine water for all uses."

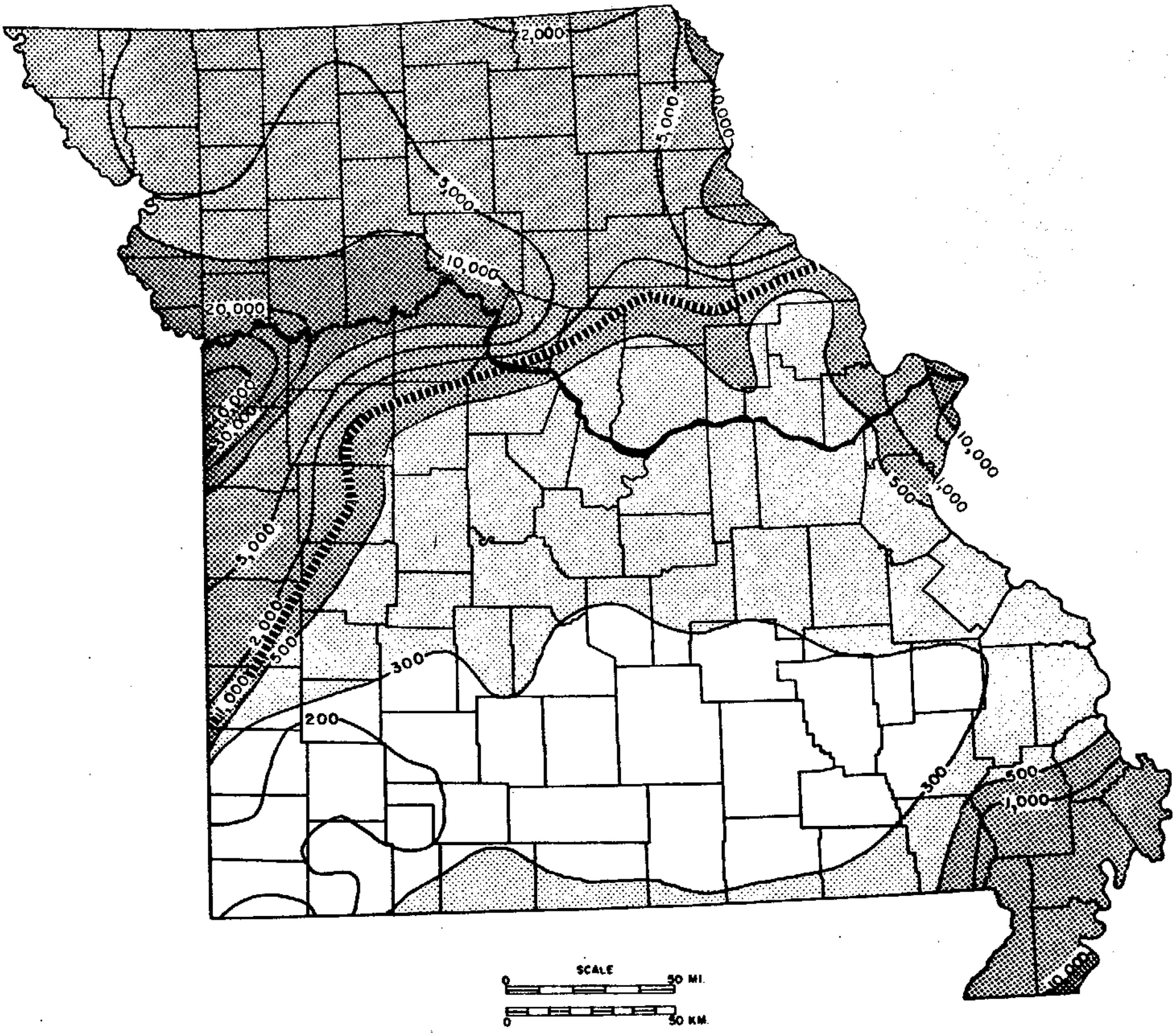
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Figure 3

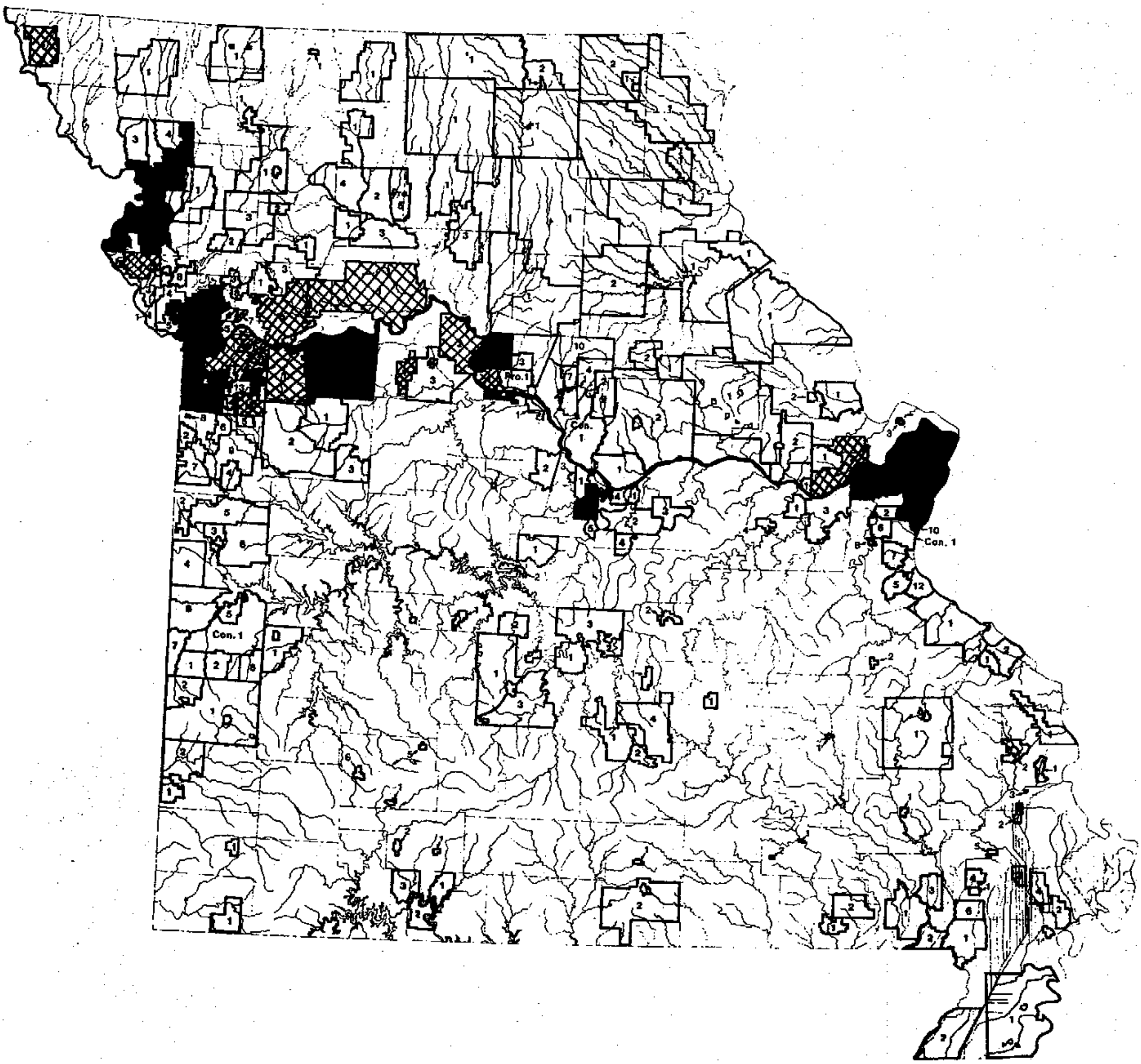


Figure 4

Fish and Wildlife

Norman P. Stucky

The Missouri Department of Conservation is the state agency charged with the control, restoration, and management of fish, wildlife, and forest resources in Missouri. The 553 miles of Missouri River that flows through our state is a significant natural resource. More than 60 percent of our citizens live in counties bordering the river. During the past few years, an increasing number of people have been looking to the Missouri River and the hunting, fishing, and recreation opportunities it offers. Key, of course, is the fact that it's "close to home." Another contributing factor worthy of mention is that during the past 15 years there has been a marked improvement in the water quality of the river. In a recent survey of the recreational value of our state's rivers and streams, the Missouri River ranked near the top with regard to future potential.

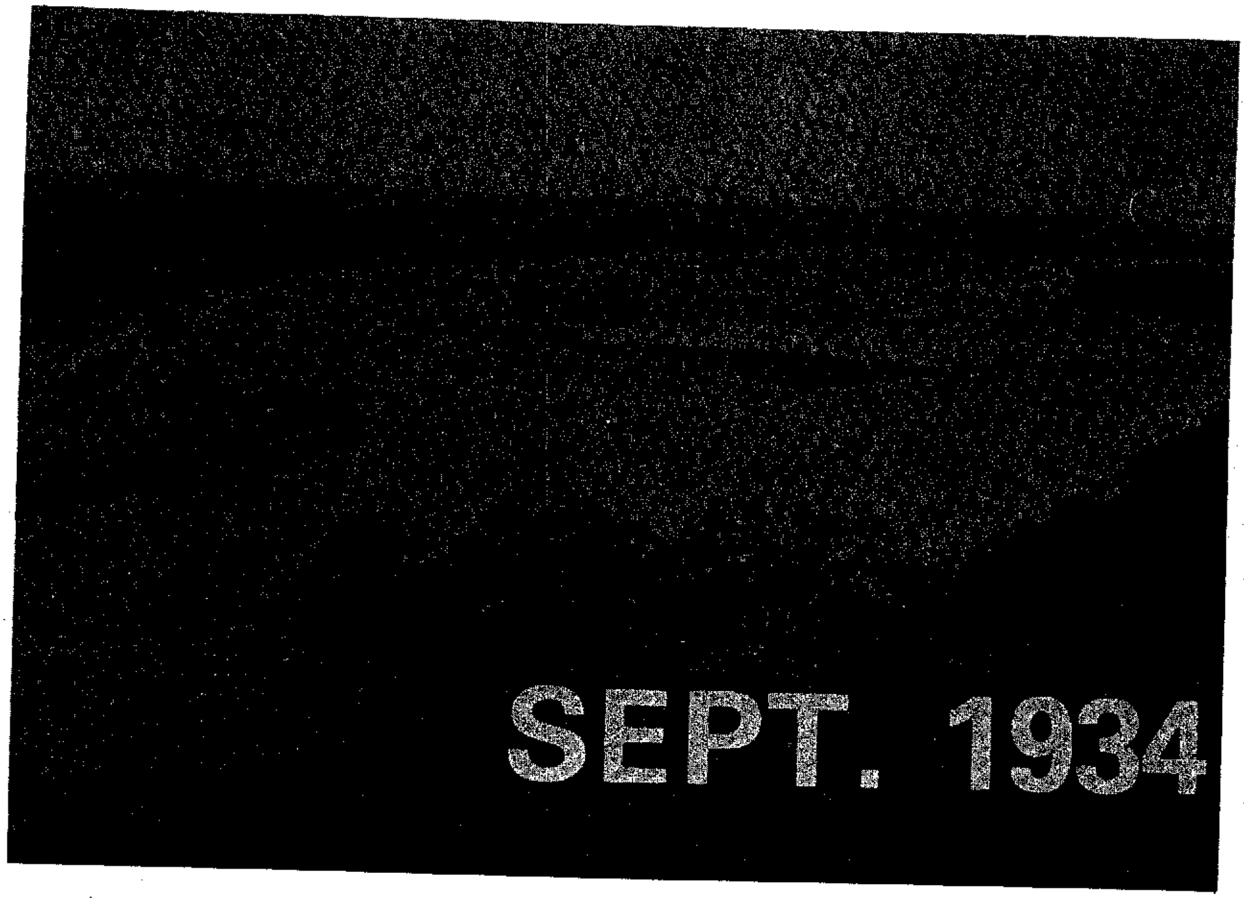
Norman P. Stucky

Mr. Stucky is an Environmental Coordinator for the Missouri Department of Conservation. He has been with the Department since 1978 and his primary area of responsibility is environmental coordination of activities on the Missouri and Mississippi Rivers. He has his Masters Degree in Fisheries from Kansas State University, 1969, and was a Research Biologist with the Nebraska Game and Parks Commission from 1969 to 1978. Much of that time was spent on investigations relating to the Missouri River -- Effects of thermal effluents from two nuclear power plants on the Missouri River Aquatic Ecosystem and also on the Life History work on sauger, walleye, and paddlefish in the Missouri River. Since 1976, he has been involved in the effort to mitigate fish and wildlife habitat losses resulting from the Missouri River Bank Stabilization and Navigation Project.

Aware of this potential, the Department of Conservation has utilized Department revenues to acquire nearly 25,000 acres which are contiguous with the river. This represents approximately 21 miles of river frontage and, I might add, is exclusive of the 1,745 acres in 197 small islands which the Department has claimed under a 1971 law known as the Island and Sandbar Bill.

In and of itself, our Department's investment in the Missouri River is cause to be deeply concerned about future diversions and potential adverse impacts to riverine fish and wildlife resources. Of greatest concern are the long-term cumulative impacts of relatively small diversions which nibble away at what may appear to be an abundant resource.

A good example of nibbling away, small changes over a long period of time, is the Missouri River Bank Stabilization and Navigation Project. As revealed in the Corps of Engineers' 1980 Missouri River Fish and Wildlife Mitigation Plan, Missouri lost more than 55,000 surface acres of water and more than 250,000 acres of wildlife habitat bordering the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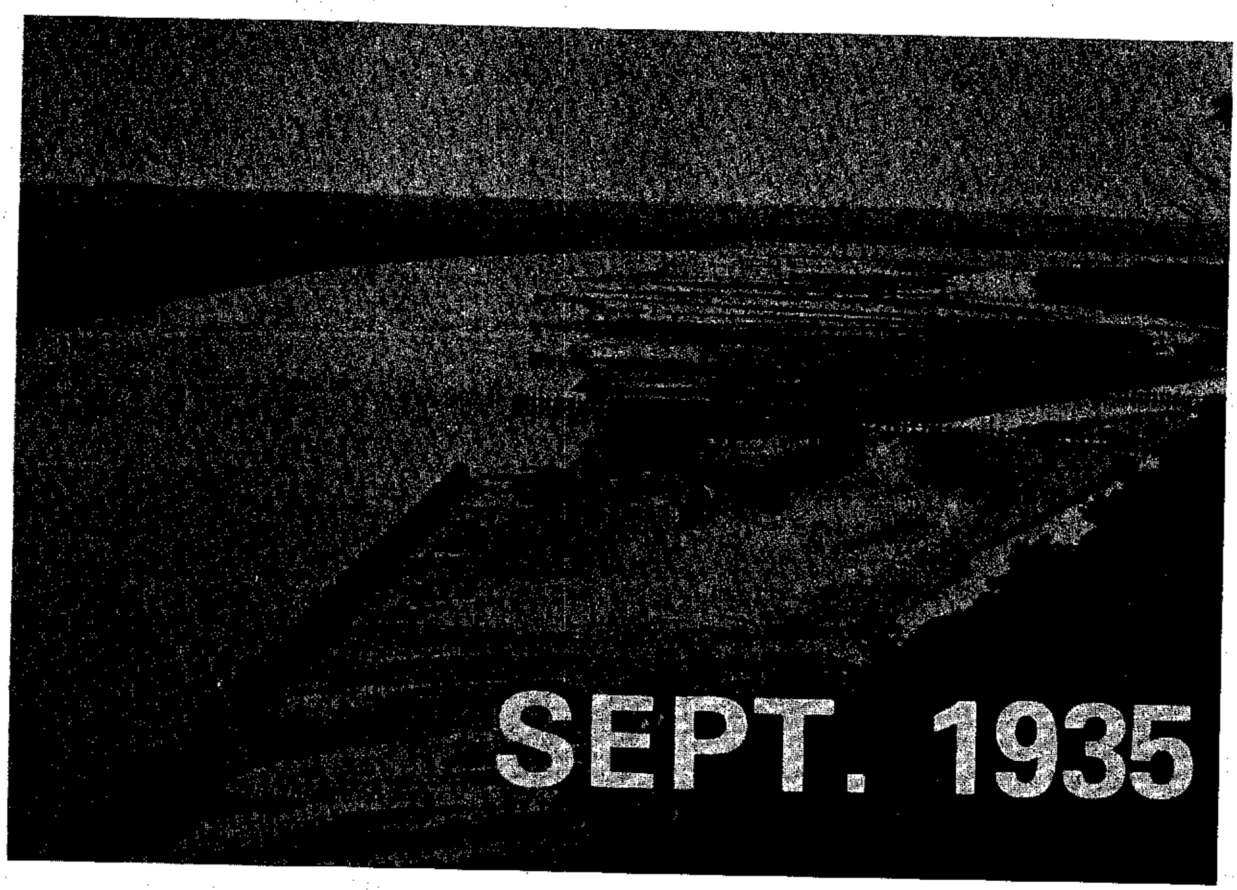
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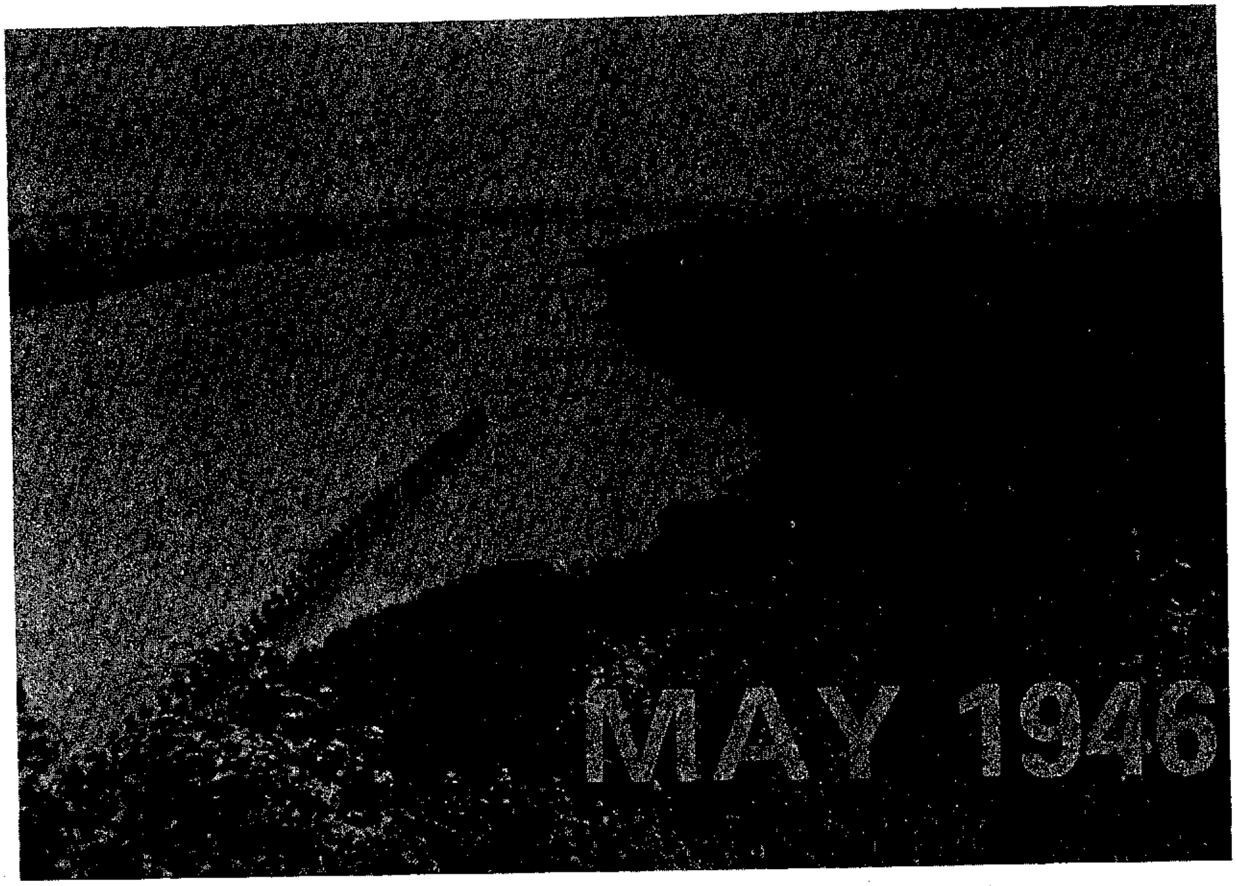
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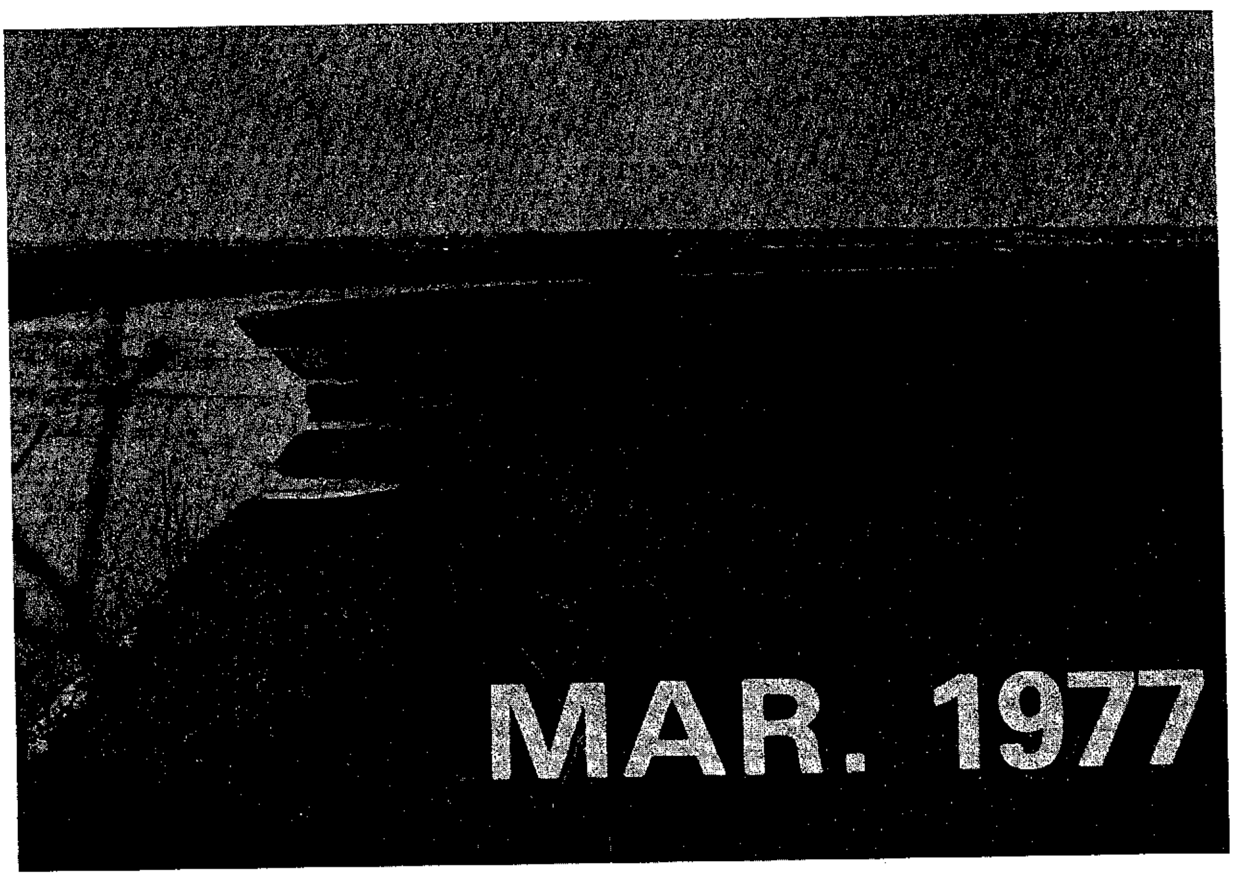
MAR. 1977

river as a result of this project. These losses, which occurred over a 70-year period beginning in 1912 when the project was authorized, represent a tremendous reduction in fish and wildlife resources and associated recreational opportunity. Interestingly, on a year-to-year basis, the changes were relatively minor and insignificant. The cumulative impact of 70 years, however, is highly significant. The following series of slides, taken along the Missouri River in Northwest Missouri, demonstrates this nibbling away process.

The cumulative impact of many small seemingly insignificant diversions forms the basis of our concerns.

Less water ultimately may mean less available wetland, aquatic habitat which can be inhabited by the critters. It also may mean the quality of remaining habitat will deteriorate as we don't foresee a major reduction in use of the Missouri River to assimilate wastes from our large cities and towns which border the river.

A quick look at Missouri water law as it relates to protection of our fish, wildlife, and associated recreational resources gives cause for alarm -- apart from a weak opening statement in the Missouri Clean Water Law, these resources have little assured protection.

So the Missouri River's fish and wildlife aquatic resources are, in a sense, hanging in balance.

Can we in Missouri, the lowermost state in this great river basin with the most to lose, get our water law act together to meet the challenges of the water hungry West? If we don't, the next few decades could see the grim reaper taking its toll of the aquatic resources in our 553 miles of the Missouri River.

Navigation Safety

Captain Richard C. Walton

The Missouri River Navigation Project is a navigation channel 9 feet deep and 300 feet wide. It is maintained through dredging and training dikes by the Army Corps of Engineers. The project depth at any given point is based upon an elevation above mean sea level. It is this elevation from which the Corps of Engineers determines if the channel is being maintained to a depth of 9 feet regardless of actual water depth. As a general rule, when the channel shoals, that's a Corps maintenance problem. When the water level drops, it's an industry problem. The general rule doesn't always apply on the Missouri River because the Corps of Engineers also controls the reservoir releases that provide additional water to raise the river level. The Corps does this very well within the constraints of present legislation. There are impacts to river navigation and other users when the river level cannot be maintained above certain minimum flow levels. These impacts need to be understood and fully considered in managing the resource.

Captain Richard C. Walton

Captain Walton entered the United States Coast Guard in 1958 after having obtained a B.S. in Business Management from Fairleigh Dickinson University. Coast Guard assignments have been varied, but were generally focused in the areas of aids to navigation and search and rescue. He has had command of both shore and floating units.

He is presently assigned to the Second Coast Guard District, St. Louis, Missouri, as the Ports and Waterways Liaison Officer. Those duties include representing the Department of Transportation and Coast Guard in the Ohio, Upper Mississippi, Missouri, and Arkansas-White-Red River Basins. He was also an active participant in the GREAT and Master Plan Studies dealing with river resource management problems.

First, I would like to tell you the story about the old sea captain who observed his first mate a little under the influence and logged that fact in the ship's log. The first mate was very upset by this as it surely would affect his chances for promotion. A few days later the first mate had occasion to make entries in the ship's log to which he added "the captain is sober today." I tell this story because things aren't always as they seem on the surface, but one thing is for sure, you can't operate a nine foot draft barge in 8 feet of water! Why not then load the barge to 8 feet or less? Economics is the main reason. Generally, the last foot of loaded draft is the profit. To reduce loading eliminates the profit or increases the rates and eliminates water transportation from the competitive transportation market. Secondly, fluctuations in river depth at St. Charles, Missouri are very difficult to plan for when a barge has entered the system 10 days before at New Orleans. Lightering the load along the way is also inefficient and certainly a needless added expense.

And what about those unplanned and very expensive groundings and collisions that may follow in the wake of changing river conditions? There is no question, and statistics bear this out, that when the water level decreases, the number of groundings and collisions increase. This increase in accidents results not only from reduced underkeel clearances, but also from the reduced channel width as well. In the GREAT II study, the Commercial Transportation Work Group developed some interesting facts relating to underkeel clearances. One had to do with a bottom suction effect that can cause the vessel to ground. For example, a tow with a ½ foot underkeel clearance will ground at a speed of approximately 3½ mph. With one foot underkeel it will ground at 5.2 mph. If the bottom is irregular, the tow will ground at slightly slower speeds due to an effect called "super squat." When a tow grounds on the bottom there is always danger of personal injury or loss of life, damage, delays, and expensive repairs. In many cases, however, the river bottom is sandy and minimal damage occurs at the point of impact. A far greater safety threat is the breakup of the tow caused by the shock of the grounding. In this case there may be barges free-floating down river that can collide with other tows, bridges, and marinas, etc. in a horrible chain reaction.

We also found that fuel efficiency is greatly reduced in shallow water by the bottom suction effect. For example, a tow 3 barges long and 2 wide drafting 8.5 feet in a 300 foot wide channel, while maintaining a constant speed of 6 mph, will double its fuel consumption when channel depth is reduced from 18 feet to 13.5 feet. Fuel consumption will double again if the depth is further reduced from 13.5 feet to 11 feet.

I would like to cite the impacts of an unusually low water period on the western rivers that occurred from 24 December 1980 to 25 February 1981. During this period there were 246 groundings involving 2,562 barges and 11 tow collisions. Thirty eight barges and 14 towboats sustained damage, including 6 barges and 1 towboat that sunk. While none of these incidents occurred on the Missouri River, the contribution of Missouri River water does affect water levels at St. Louis and below. I might add that minimizing the traffic delays, damages and losses that resulted during this low water period, is a real tribute to the cooperation that exists between the marine industry, Corps of Engineers, and the Coast Guard.

Another factor affecting safety is the reduction in a vessel's backing and maneuvering capability as underkeel clearances are reduced. Unfortunately, the Coast Guard has not addressed this factor to any great degree in its accident reporting system. I strongly suspect that very often the cause of an accident is cited as current, wind, pilot error, etc. when in fact the cause was insufficient water which affected the vessel's control. The Coast Guard and the Corps have a study in progress to quantify the effect of water depth on vessel control.

Another impact to the Coast Guard is that with each fluctuation of water level, we must adjust the navigation buoys to mark shoals and channel width. Increased water levels cause greater current velocities and the need for additional maneuvering room. At low water the channel becomes more constricted with many more shoals and tighter channel limits requiring additional navigation aids. The proper positioning of river buoys is very important for safe navigation at all water levels. Incidentally, for the low water period just discussed, the Coast Guard had to deploy 40 percent more buoys than normally used at that time of year.

While this talk is aimed at the possible consequences of low water caused by diversions I also want to mention the value of water level control on the western rivers. Too much water is just as bad, and maybe worse, than too little water. During the spring of 1982 the Coast Guard had to close portions of the

Missouri River to navigation because of potential wake damage to levees and other shore structures at high water and difficulties in safely controlling tows in the strong currents.

Still another concern is the prospect of oil and other chemical spills for which the Coast Guard responds. Tank barges are simply not designed to bounce along the river bottom. The potential for spills, with their economic and environmental consequences, is increased with increased groundings. Fortunately, the accident track record of the marine industry is excellent in comparison with other transportation modes.

In summary:

Water transportation must cease or become less efficient when water levels for navigation are decreased.

Moderate flows provide for adequate vessel control and safety under normal channel operating conditions.

Accident rates, and the potential for serious economic and environmental harm, is increased during periods of low flow.

As Pat Keyes, our regional DOT SECREP, recently stated "if it moves on the rivers we're interested, if it doesn't move we're concerned." The DOT is committed to a safe and efficient transportation system and that's the reason for my being here today. Be assured we in the Coast Guard will do our utmost to preserve and foster safe and efficient river navigation.

Recreation

Michael Hood

As Director of the Outdoor Recreation Assistance Program, one of my principal responsibilities has been statewide outdoor recreation planning. As such we have, for the past several years, worked to promote the Missouri River as a recreation resource. Early on we recognized that to many people the Missouri simply did not project an image of a recreational river -- to them, it was a river of swift currents, dangerous whirlpools, and polluted waters. On the other hand, we quickly found out that to the people who knew the river, who lived and worked along it, it was an extremely important recreational resource representing the recreational, cultural, and historical heritage of the State. A wide variety of recreational activities was taking place -- canoeing/boating, camping, picnicking, hunting, fishing, sightseeing, etc. As an exmaple, a 1980 study by DNR revealed 43 formally designated recreation sites on or adjacent to the Missouri between Kansas City and St. Louis. This included 27 sites providing direct access to the river.

Michael Hood

Mr. Hood is the Program Director for the Outdoor Recreation Assistance Program for the Missouri Department of Natural Resources. He has been with the Department for eight years and has previously worked in the administration of federal Land and Water Conservation Fund Grants and co-authored the 1980 State Comprehensive Outdoor Recreation Plan. Mr. Hood received his Masters of Science Degree in Recreation and Park Administration from the University of Missouri-Columbia in 1979.

The Outdoor Recreation Assistance Program is responsible for the administration of various federal grants relating to the development of public outdoor recreation facilities throughout Missouri as well as the coordination of statewide outdoor recreation planning.

We believe demand for the river as a recreational resource is growing and that this increased demand is a reflection of what we feel is a revolution in the appeal of the river as a natural resource. A 1974 study by the University of Missouri estimated recreation use of the river from Rulo, Nebraska to its mouth at St. Louis at 1,018,700 visitor days. In 1980, DNR surveyed 1,000 residents living on or near the river. In general, the respondents felt that available recreation facilities were less than adequate. The greatest needs were more access, camping, picnicking, trails, overlooks, and gasoline facilities. What I am saying is that while the river is presently a vital recreation resource, we believe its potential is just beginning to be tapped. It is estimated that 85-90 percent of Missouri's population lives within an hour's drive of the river.

Our new book, <u>Exploring Missouri River Country</u>, which is a complete guide to the recreational, cultural, and historical resources of the river, should be available before Christmas. We believe this document is going to have an estremely positive impact on the recreational use of the river.

We recognize that many people consider other uses more vital than recreation, however, I offered the above comments because we must recognize the value of the river as a recreation resource before we talk about the impact of diversions on its recreation use. In thinking about the impacts of diversions, we tried to approach it from a balanced perspective recognizing that there might be positive as well as negative impacts. In speculating about positive impacts we came up with two possibilities:

1. One of the most popular recreation areas of the river is its sandbars. A decreased flow might result in more sandbars for use by recreationists.

2. For some users, a decreased flow might cause the river to be perceived as a safer river for swimming, etc.

In general, however, our final conclusion was that major diversions would have a serious negative effect on the use of the river for recreation. Possible negative effects would include:

1. Decrease in hunting and fishing opportunities as a result of decreased fish and wildlife habitat.

2. A decreased flow would probably result in fewer sloughs, side-channels, and other backwater areas available for exploration by canoeists and other boaters.

3. A decreased flow might make many of our present access ramps unusable.

4. Less water would probably result in more conflicts between barges and recreational users of the river.

5. A decreased flow might seriously impact the visual aesthetics of the river.

6. A decreased flow might result in more boating hazards for small craft by lowering the clearance over sunken barges, submerged dikes, mudflats, etc.

7. The Missouri is one of the most important visual, historic, and cultural landmarks of North America. If the resource is diminished it is hard to determine the psychological impact on the recreationists' image of the Missouri as one of the Great Rivers of the country. We can't qualify or measure this impact but we are extremely concerned that diversions would lessen the appeal of the Missouri as one of the great natural landscapes of this continent.

Considering all of the above impacts previously mentioned, we must conclude that the overall effect of major diversions would be extremely negative for the recreation use of the Missouri within the State of Missouri.

Water Quality

John R. Howland

Similar to other concerns over water diversions, water quality effects vary according to the size of the water body from which water will be taken, and the volume of water to be diverted from a given water body. For the sake of simplicity, and since the subjects are immediately at hand, I will limit my talk to two examples,...a hypothetical diversion from a large river, the Missouri, and a hypothetical diversion from a small river, the Marmaton.

The Missouri Clean Water Law, through its Water Quality Standards, views the Missouri River as a permanent flowing stream, which is protected for the following beneficial uses,...irrigation, livestock and wildlife watering, protection of aquatic life, commercial fishing, boating, drinking water supply, and industrial use. DNR's water quality standards establish numeric criteria which must be met in order for this river to accommodate its beneficial uses.

Historically speaking, the aquatic life protection and drinking water supply use criteria are those which have been of greatest concern.

While it is difficult to accurately predict the ultimate water quality effects of a large withdrawal from the Missouri River, I will attempt to make a few projections based on historical information gathered by the water pollution control program.

In recent years, dissolved oxygen concentrations have frequently dropped below the 5 ppm standard. Historic data indicate this is due to rain affected flows, and is a result of nonpoint sources or major tributaries. Therefore, there is little reason to believe that a moderate decrease in flow due to a diversion would cause dissolved oxygen violations to a greater magnitude than the present.

Given a situation such as a 50 percent removal of Missouri River base flow, coupled with simultaneous runoff events in the Blue River, Little Blue, and selected northern tributaries, it is likely that the D.O. standard would be violated more frequently; however, it is doubtful that extreme negative impacts would surface.

John R. Howland

Mr. Howland received his Bachelors Degree from Kansas State University and his Masters of Science in Limnology from Colorado State University. In 1973 he began work as a biologist for the Missouri Clean Water Commission. In 1976 he moved to the planning section of the Division of Environmental Quality's Water Pollution Control Program. Since 1979 he has been chief of this section which is responsible for implementation of the State Water Quality Management Plan, groundwater management, lake classification and restoration, water quality standards, review of stream and effluent data, and underground injection control.

Another water quality concern would be the impact of heated cooling water discharges during winter months. Presently, some heated discharges on the Missouri significantly raise the temperature of up to 40 percent of the river's cross sectional area at certain locations. Decreased river flows during winter months could cause the cross sectional area of impact to become greater. The significance of this occurrence would be downplayed, however, since our aquatic life protection concerns are related to larval fish, which would be uncommon during the winter.

With regard to our drinking water supply standards, we might expect to see a change in concentration of certain constituents in the water column. This could mean an actual decrease in certain substances, such as sulfate, due to the fact that tributaries downstream from the proposed withdrawal point contain sulfate concentrations less than the mainstem river above Omaha.

By far, our biggest concern deals with the increased impact on the river by Kansas City. While I can downplay the increased concentrations of conventional pollutants such as BOD and suspended solids, the concern over low level toxic materials is the issue.

Recent studies have shown Kansas City, as any other large metropolitan area, to be a source of several of the constituents on EPA's priority pollutant list. Simple mathematics would indicate the instream concentrations of selected pollutants to approximately double if the receiving stream volume were to decrease by half.

Those of you who understand the problems with establishment of human health criteria for priority pollutants know that safe levels can be argued to death. At best, we might be able to agree on concentrations which would increase or reduce the incidence of cancer in test organisms by a factor of 10, based on EPA criteria documents. If removing half of the Missouri River flow were to double the concentrations of incoming pollutants (a factor of 2) we would still be left with a big question mark.

While it might seem useful either to prove or to disprove the alleged association between contaminated drinking water and cancer, I have seen no epidemiological studies with sufficient statistical sensitivity to meet this end. Unless epidemiological methodology is improved, it is doubtful whether it can be used to evaluate the potential carcinogenic risk of drinking reused water.

To date, the <u>limited</u> toxicity tests performed on reused water and epidemiological studies of exposed populations have not shown that consumption of reused water represents any greater or lesser risks than does consumption of water from other conventional sources.

Pessimists could say the situation will be twice as bad. People on the other end of the spectrum will say two times zero is still zero. Those of us in the middle are continually studying the problem, and hoping that sound research will provide data which will allow us to make educated decisions to protect human health and aquatic life.

Before I depart from the Missouri River, I would like to present one last scenario. Let us pretend that a dam is constructed above St. Joseph and all water is diverted out of the basin. The Missouri River at St. Joe is now a sandy dry streambed. Downstream tributaries such as the Platte, and treated sewage effluents (assuming Leavenworth, Atchison, and other municipalities located on the river can obtain water) now collectively make up the flow of the river, which would now have a 7 day Q 10 of about 40 cfs as it enters the Kansas City metropolitan area. As you can see, this flow is not sufficient to meet the water supply needs of Kansas City. There is not enough water to float a barge. Commercial fishing would be wiped out. Power plants would not have sufficient cooling water supply. The basic point is that navigation, drinking water supply, industrial use and commercial fishing would be impacted long before water quality was a concern.

While the impacts of withdrawal on water quality in the Missouri River can be downplayed, such is not the case for a river such as the Marmaton.

This river is currently classified as a "permanent" flow stream from the Kansas/ Missouri state line to the flood pool of Truman Reservoir. Present beneficial uses include: irrigation, livestock and wildlife watering, and aquatic life protection.

Our concerns over diversions or withdrawals from this river deal with flows, or lack thereof, and the assimilative capacity of the stream, or its ability to handle existing pollutant loads.

For the benefit of those who are unfamiliar with the situation at hand, there is a current proposal by the state of Kansas to increase the consumptive use of the Marmaton, an interstate stream that currently receives treated effluent from Fort Scott, Kansas and Nevada, Missouri. A decrease in base flows of the Marmaton would lead to a situation where a greater portion of the river flow would be treated effluent. A worst case situation would be a permanent flow stream composed entirely of treated effluent flowing into one of the arms of Truman Reservoir. If indeed, this were to be the case, dissolved oxygen problems could be expected up to 1.5 miles into Truman Reservoir.

I have attempted to identify some potential concerns of the water pollution control program. In summary, the impact of withdrawal from any river system is proportionate to the percent decrease in volume. Problems then appear when pollutants comprise a greater portion of the base river flow. It would take a sizeable withdrawal on the Missouri River to cause a water quality impact, however, a small withdrawal from a stream such as the Marmaton could have far reaching effects.

Effects of Diversions on . . .

Navigation Tonnages and Port Activities

Sam Masters

Low flow levels on the Missouri River have a significant impact upon navigation tonnage on both the Missouri and the middle Mississippi Rivers. Whether this low flow is caused by drought conditions in the Missouri Basin or by the diversion of Missouri basin water for out-of-basin uses the result is the same; a decrease in the navigation tonnages moved upon the river.

I would first like to make a few comments concerning the impact of low flows on navigation on the Missouri River and then conclude with some comments concerning these impacts as they affect the middle Mississippi River.

Sam Masters

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The Highway and Transportation Department serves as a voice, on the state level, to promote efficient and wise use of Missouri's waterways for economic and industrial transportation purposes. In so doing, he works with local public port authorities, regional planning groups, and other state and federal agencies to insure adequate conditions which are conducive to the growth of waterway transportation.

The navigable reach of the Missouri River extends from near Sioux City, Iowa, to its mouth near St. Louis, Missouri. Throughout this reach the Missouri is an "open" river; that is, a river without locks and dams. The flow on the river is regulated by the Corps of Engineers to insure among other items sufficient channel width and depth to permit the rivers use by commercial navigation. Unlike other rivers, the Missouri does not have a twelve-month navigation season. Normally, this season extends from April 1 to December 1 at St. Louis. It is important to note this condition because the magnitude of the Corps water releases from Gavins Point Dam (the downstream most reservoir on the Missouri River) varies with respect to the navigation season. During the navigation season (April 1 to December 1) 30,000 cfs (cubic feet per second) is noramlly released from Gavins Point. This flow is sufficient, with downstream inflows, to provide a 9 foot by 300 foot channel for navigation. During the "off" season, only 15,000 cfs is released; thus making the channel unfit for navigation use. Thus navigation tonnages on the Missouri River are generated during an eight-month time frame and not a twelve-month time frame as on other rivers.

Speaking of tonnage on the river, a comparison of figures from the past few years can be used to illustrate the possible impact of proposed water diversions from the Missouri. In 1979, 3,260,640 tons were transported on the Missouri. In 1981, 2,571,361 tons were transported on the Missouri. That is a decrease of 689,279 tons or 21 percent. It should be pointed out that the 1981 navigation season was shortened by three weeks due to drought conditions which existed in the Missouri Basin. This could be an indication of the effect low flows, resulting from diversions, would have on the amount of commercial tonnage moved upon the river.

The movement of tonnage on the Missouri River has a beneficial impact upon the economy of the Kansas City area. The tonnage handled in Kansas City moves over 33 public and private commercial docks. More than 250 jobs are directly related to the water transportation industry in Kansas City, generating in excess of $3.5 million in annual wages. Additionally, 1,050 jobs are indirectly related to this activity. A reduction of flow in the river reduces the tonnage moved on the river. Clearly, upstream diversions of Missouri River water which affect the river's flow would have significant adverse effects upon the number of these jobs and their resultant benefits.

Not only does the magnitude of flow on the Missouri River affect Kansas City, but it also has a very significant impact upon the middle Mississippi River in the St. Louis area. It has been estimated, that under normal low flow conditions, the Missouri River provides as much as 50 percent of the flow in the Mississippi River at St. Louis. This is important when it is considered that normal low flow on the Mississippi River is during the period when the Missouri River is "closed" to navigation (that is December 1 to April 1).

The St. Louis Corps of Engineers office has defined their "low water reference plane" in the St. Louis reach of the Mississippi River as 54,000 cfs. This is the flow which needs to be provided so the Corps can, without excessive dredging, maintain their Congressional directive: a 9 foot by 300 foot navigation channel. An example will point out the importance that flow from the Missouri River has upon this reference plane.

In the fall of 1976 (September through December) the average flow of the Mississippi River at St. Louis was 60,000 cfs. Of this flow, 40,000 cfs came from the Missouri River. This was the third lowest flow recorded on the Mississippi River at St. Louis since the 1930's. Should this situation occur at a future time when flows in the Misssouri River are reduced as a result of out-of-basin transfers the ability of the St. Louis Corps office to maintain the navigation channel on the Mississippi River as directed by Congress could be adversely impacted.

The cumulative effect of all presently proposed diversions of Missouri River water would be to reduce the present flow entering Missouri by 57 percent. The flow passing Hermann, Missouri would be reduced by 28 percent. Therefore, if this element is factored into the experience of the fall of 1976 the recorded flow at St. Louis would be 48,800 cfs. This flow is well below that required by the Corps to maintain the navigation channel without excessive dredging.

Reduced flow in the St. Louis area, as a result of proposed Missouri River water diversions, would have a significant impact upon the water transportation industry in the area. Two thousand jobs are directly related to water transportation in the St. Louis area. Another 43,000 jobs are related to this activity. Twenty-two million tons of freight, having a value in excess of $5 billion, are handled annually over the almost 100 docking facilities in the St. Louis port. The relationship this activity has upon the flow levels in the port can be illustrated by the experience of one dock during the 1976 low flow period.

During the severe low flows of 1976, $80,000 was expended in efforts to keep tonnage moving over the City of St. Louis Municipal Dock. Magnify this effect by the 100 docking facilities in the port and one can see the impact runs into the millions of dollars. Additionally, in less severe low flow periods (these have occurred annually since 1976) $15,000 to $30,000 has been expended annually to keep tonnage moving over this same dock. Similar expenses also occur at many other docks in the port.

In conclusion, proposed diversions of water from the Missouri River will have significant adverse impacts upon navigation use of the Missouri and Mississippi Rivers. Of most significance is the connection low flows on the middle Missisippi River near St. Louis will have on the Upper Mississippi River states in the movement of their products by water transportation.

Potential Downstream Impact of Water Diversion

Barry G. Rought

The purpose of this presentation is to stimulate the discussion of the potential impact, both positive and negative, of diversion of substantial quantities of water from the Missouri River to the High Plains overlying the Ogallala Aquifer. The diversions discussed deal with quantity of flows ranging from 2 million acre feet to 8 million acre feet. The discussion of ranges is important because it reflects a decision by the High Plains Council to avoid focusing on one volume of water. It was the opinion of the Liaison Committee of the HPSC that selection of one quantity would be interpreted as an evaluated surplus and decision as to how much water could be transferred. That would have been a misrepresentation of the situation. The decision was made to look at a number of streams (Missouri, Arkansas, Red-White) and determine the total yield and the safe yields that are available at a point in that stream.

Barry G. Rought

Mr. Rought is a native of Michigan, moving to Texas in April 1974. He obtained a B.S. in Civil Engineering in 1958 from Michigan Technological University and received his M.S. in Civil Engineering in 1968 at the University of Iowa. Mr. Rought joined the Corps of Engineers in 1958 and worked in the Detroit, Michigan; Rock Island, Illinois; and Buffalo, New York District Offices in construction, design, and planning.

He is presently the Chief of the Planning Division in the Southwestern Division Office. Mr. Rought supervises the work and operation of five Branches; serves as consultant and technical advisor to the Division Engineer, District Engineers, and staffs; participates in short and long range planning for five Districts; and represents the Southwestern Division with the Office of the Chief of Engineers, the Federal government, and states.

The water resource agencies of the states and the Fish and Wildlife Service were asked to help determine what the base flow (necessary minimum flow) should be for the particular stream under consideration. Taking the base flow away from the yield provides a potential source of water that could be available. The range of flows considered for each stream was held within that quantity. Again, this doesn't mean that the water is available; it means that there is a quantity of flow over an estimated base flow that could be available for use by somebody. It could be either in basin or out of basin. There are a number of depletion agreements, withdrawal arrangements, water rights, states rights, and compacts that must be considered before someone can say that water is available. To sort out just exactly what water is already called for, and will be called for, over the next 50 years is an extremely difficult problem. These socio-political questions were not addressed in detail in this study. What was addressed were the technological questions, the costs, the engineering feasibility of constructing the transfer, and the materials that would be needed in construction (such as concrete, pumps, electricity, and machinery). With the question of engineering feasibility, construction and operating costs, and environmental impacts answered, the next discussion concerning diversion, if Congress decides to study it further, should not go back and review these technical questions. Instead, the basic issue will have to be addressed. Are the various regions and states willing to negotiate with each other over availability of water and treat it as a commodity that can be marketed between states, between regions, between counties, and between cities? Obviously it can be treated as a commodity. It's done daily throughout the world. That is the issue that must eventually be addressed.

Downstream impacts are the key issues to be discussed by the panel. What are some of those impacts? It has been pointed out to me that impacts are an interesting but difficult item to discuss. Impacts are like the recession. That is, it's a recession if someone else is losing their job; it's a depression if I'm losing mine. It's the same way with impacts. It's probably a minor impact and can be mitigated if it is happening to somebody else, but it is unmitigable if it is happening to me.

It is possible to think of ways to mitigate the different problems that this panel has raised as long as it is on a water course somewhere else. Now when you get over and talk about my stream, in my backyard, I'm not so sure that those impacts can be mitigated; so impacts and mitigation are difficult and personal issues. There are both positive and negative impacts. If it is a positive impact, it's normally considered to be a benefit. If it is negative, it is normally classified as an impact. There can be short term or long term impacts. Generally, if it is an action that cannot be easily reversed, then it would be a long term impact. The focus of an impact can be primary or secondary. For instance, if a barge goes aground because the water is low, that's obviously a primary impact. If the farmer goes out of business because he couldn't ship his grain on that barge, that's a secondary impact. A tertiary impact would occur further down the line if the people who build barges can't afford to build them any more because shippers have decided to use a more reliable carrier. The point to be made is that impact analysis is not a simple process. If impacts have to be assessed in a region of concern, then it is necessary to look at the question of how mitigation can be accomplished and whether it should be accomplished. Mitigation is normally a sensitive issue that generates a great deal of discussion. One person's idea of mitigation is another person's view of totally destroying the opportunities. For instance, a farmer may have to give up a piece of land for a project so that it can be turned back into a terrestrial habitat for upland game. He probably will not consider that mitigation, rather, he may consider it a government removal of his rights to develop and husband the land that he purchased. The Fish and Wildlife Service on the other hand is helping us make that decision based on law and the premise that mitigation is a decision that must be made for the collective well being of the Nation. Although I will point out the obvious areas of impact if a water transfer plan were to be constructed, I will not attempt to quantify those impacts. If someone decides that the water transfer alternative should be considered further, then the question of the impacts on the water supplying area and on downstream areas, will have to be addressed in great detail. A great deal of work will have to go into that type of study.

We will now review a few of the impacts that would be involved with water transfer. Obviously, if you reduce the flows, then there could be problems involved with navigation, not just on the Missouri, but on the Mississippi River itself. From the Gulf of Mexico up the lower Mississippi River to Baton Rouge is a deep draft navigation channel. Studies show justification for deepening that channel from its present depth of 40 feet to 53 feet. Without the upstream flow imposed against the salt wedge that moves up the river, that wedge would be able to push further up the river due to the deep channel. Subsidence is a problem in the lower Mississippi delta, and fresh water flow is needed for diversion into those areas in order to avoid ground water withdrawal and thereby reduce the subsidence. Reduction of hydropower production is often mentioned in connection with interbasin transfer. Upstream diversion would result in some hydropower reduction. It would be relatively small, about 10 percent, with the maximum diversion considered in the High Plains Study. Navigation impacts with a maximum diversion would reduce the number of years that you could guarantee an eight-month navigation season.

Water quality impacts have been adequately addressed by the previous speakers. Impacts on water supply are difficult to quantify. Currently the municipal and industrial water users that withdraw water from the Missouri require a minimum flow of 15,000 cfs. When the flow drops below 15,000 cfs their intakes are no longer able to pull water. One way of addressing this problem is modifying the level of intake.

All impacts are not adverse, for instance, flooding could be reduced by the potential diversions. This is an issue that needs to be understood when discussing diversion impacts, and this is true whether it's a diversion of water to the high plains or any other diversion. A key to impact analysis is the quantity of flow during the periods when the diversion takes place. A distinction should be made between withdrawal rates and flow rates during withdrawal versus annual flow and annual withdrawal rate. The periods of withdrawal, planned methods of withdrawing flow, and flow rates during the period of withdrawal for diversion are more important than annual rates when considering impacts. For instance if the withdrawal takes the last two inches off the peak of a flood, that would be a benefit. If this is done over a three year period with a source storage system, then the positive impacts could be substantial.

Downstream irrigation can be impacted, of course, by upstream diversion. The present amount of irrigation downstream of potential diversion points appears to be small. There is apparently a large potential for irrigation, but it is not being adequately assessed because it is well into the future. With the consideration that others may be interested in this water, maybe now is the time to be assessing these downstream irrigation needs.

Fish and wildlife and recreation impacts mentioned by the earlier speakers were essentially correct. However, you can mitigate for those impacts in a number of different ways. It should be pointed out that recreation and fish and wildlife are not purely environmental items. In fact, in many cases these are economic outputs of the development. True environmental impact analysis requires an assessment of these functions on the ecosystem along with the other development items. The purpose of our investigations should be to find the best trade-off between competing water development needs.

Loss of lands due to construction is a potential but relatively minor impact. However, change in downstream land use due to altered flow conditions is an area of impact that will require serious consideration.

This has been a short overview on the diversion concept and a few of the potential downstream impacts, both positive and negative. There has been no attempt to make the discussion appear to be all inclusive nor to quantify the impacts mentioned. The key point to note is that there would be downstream impacts and they need to be included in any future study that is made on the potential diversion alternative.

Cumulative Impact of Diversions

Robert L. Dunkeson

Look at some statistics on the Missouri River: The average annual original flow of the Missouri River has been calculated to be approximately 65.3 million acre feet. That would have been prior to the time settlement began. From today's prospective, think of an acre foot as the full load for twenty rail tank cars. The Missouri was a mighty river.

In the late 1800's the first ditch companies in the West and miners began to use water consumptively so that by about 1900, nearly 3,000,000 acre feet of the Missouri River's flow was depleted annually. By 1949, it has been calculated that there was an additional 3,000,000 acre feet consumed annually; used by irrigation and other consumptive uses of many kinds: mining, industry, livestock, domestic uses, reservoir evaporation and watershed practices.

Robert L. Dunkeson

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He has been a Missouri State employee for thirty-four years, one-half with programs of the Department of Natural Resources, and one-half with the Department of Conservation.

By 1970, the amount consumed had increased. From the studies available, there were about 6.6 million acre feet consumed. The latest estimates of net streamflow depletion, adjusted to the 1977 level of consumptive use by water technicians in the basin states, is about 14.59 MAF. In other words, about 50.7 million acre feet average annual flow remains, undepleted, in the Missouri River today.

Now, let's look ahead. There have been a number of studies (six extensive ones) which looked at probable future consumptive losses of the river and future depletions. One of these studies particularly considered instream flow requirements.

Most basin states, including Missouri, do not have any mechanism for guaranteeing instream flow requirements, other than riparian case law. Colorado has given legal protection to instream flows; so has Montana. Wyoming and Kansas are working toward legal protection of instream flows. Certainly, we must plan ahead to guarantee some water to be left in the river. How much? The studies to date led by the Fish and Wildlife Service as part of the National Water Assessment, concluded between thirty and sixty percent of the average annual flow should be reserved for instream environmental purposes. That is the water that should be left in the stream.

If 60 percent of the average annual flow of subbasins within the Missouri River Basin was set aside for optimum instream flow protection, all subbasins are projected to be deficient, at least part of the time, by the year 2000!

There are twenty-four Indian Reservations in the Missouri River Basin. The quantification of Indian "reserved rights" is proceeding, but slowly. Most of the tribes have not agreed yet on the reservations. The U.S. Supreme Court Winters doctrine decision makes certain that there are Indian "rights," but most Indian tribes have not yet quantified their needs for the future. Some seriously question whether or not they should.

However, Dr. Warren Viessman's study for the Congressional Committee on Interior and Insular Affairs made an estimate which could be used for planning purposes. Assuming 2.5 acre feet per acre consumptive loss for irrigation and assuming 14 percent of reservation lands are irrigable, he concluded a total 4.3 million acre feet might be the Indian claim. Lacking any other planning estimate, I would use this as the figure for Indian Reserved Water Rights. The important point is that as reservation lands are developed, that amount will be unavailable for other downstream purposes.

At the time of the first energy crisis, the Corps of Engineers and the Bureau of Reclamation developed a "water marketing" program. Three million acre feet were labelled as "unneeded" until after the year 2000. Those two agencies signed up a number of industries which indicated they had planned uses of that water for "energy development." Not all of this would be consumptive use, but much of it would be. Not all the corporations have exercised their options. But they are enrolled for one million acre feet of water for "energy." The sign-up has been made. The water may not be available for other purposes. Water marketing of two million additional apparently is possible.

For a subtotal of future depletions, we have a planning estimate of 4.3 million acre feet to satisfy Indian water rights and 1 million acre feet of a possible 3 million, so far assigned to corporations for energy developments. Over 5 million acre feet of the annual flow of the upper basin would go for those two purposes.

For a total of future depletions to the year 2000, planners disagree. The high side says 13.5 MAF total; the low side says 10 MAF. For planning, we could use the average of the studies. This is 11.4 MAF. All projections agree that depletions for consumptive water uses will be substantial; all the projections expect development in the states upstream of Missouri to continue.

One reason in-basin depletions are expected to continue is the existing legal framework. The original Congressional authorization for basin-water development, authorized in the 1944 Flood Control Act as the Pick-Sloan Plan, had special language about these expected depletions; downstream navigation versus upstream consumptive water use. This is the O'Mahoney-Millikan amendment sponsored by the Senators from Colorado and Wyoming which declared:

> "The use for navigation...of waters arising in States lying wholly or partly west of the 98th Meridian shall only be such use as does not conflict with any beneficial consumptive use, present or future, in States lying wholly or partly west of the 98th Meridian, of such waters for domestic, municipal, stock water, irrigation, mining, or industrial purposes."

At the time, Congress was assured that this was not controversial; future Congressional action could change things. Nowdays we need to look at the possible result of this legal action. Water for navigation has last priority.

Recently, the Missouri River Basin States Asssociation put together a summary of all proposed out-of-basin diversions. They missed at least two, but in terms of the number of diversion proposals, the Association named seven. If the newer proposals such as the diversions to the High Plains are added to older proposals, like the Garrison diversion, the total would be about 8.6 MAF.

For the record, there are now only two small exports of water out of the basin (both associated with city municipal water supplies). On the other hand, water imports into the basin are more substantial, about 540,000 acre feet average annually.

Starting with the average annual natural flow of the river, 65.3 MAF: subtract the historic depletions, 14.59 MAF; save 60 percent of today's flow for instream needs, 30.4 MAF; subtract the expected in-basin depletions, 11.4 MAF; subtract the out-of-basin transfer proposals, 8.6 MAF: the remainder would be only 300,000 -- average acre feet annual flow.

Remember we are using average annual flows in those calculations. Half of the time the annual flow will be on the short side of our estimates. When flows are less than "normal," the six big mainstem dams would have storage intended to make up some of the deficit. There is disagreement about how extensive a drought ought to be included in the calculations of "normal flows." This basin has drought which lasts for more than one year.

Some say the drought record of the 30's should not be included in the planning because that drought was an atypical event. Others say the records of the high stream flow years in the 50's and part of the 70's ought not be included either. Those records are atypical too. That's a part of the debate about "excess" water in the River, and drought records of the 30's are not now used in the calculations of the latest study, the Missouri Basin States Hydrology Study.

The truth is that we have been on the verge of shortage restrictions on the release of stored water from the mainstem dams several times recently. Last year's navigation season was cut off early. Earlier there was a proposal for a winter release reduced to no more than 10,000 cubic feet per second from the most downstream dam. One long-range operating plan calls for winter release of no more than 6,000 cfs, and in times of most severe drought there would be no navigation season. These kinds of restrictions will occur when inflow does not refill the mainstem reservoirs.

If drought shortages are added to present and projected depletions and instream flow needs are taken into account, it is hard to identify any surplus water in the Missouri River Basin which is available to diversion.

To sum up what might be the situation in the year 2000 or shortly thereafter: the cumulative impact of water diversion from the basin would be an added burden on Missouri River uses. It is plain that diversions of water from the basin aggrevate the problems of depletions already planned for the water resource in the basin.

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