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Kenneth D. Frederick

Senior Fellow
Resources for the Future
Washington, D.C.

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I. Introduction

A. Summary

The scarcity and unreliability of natural water supplies were important factors in the early settlement and subsequent development of the West. Settlers attracted to the Great Plains by the lure of free, flat, tillable land exited in droves on several occasions when the rains failed to come. Early in the 20th century, technological advances in dam construction and in the production and transmission of hydroelectric power combined with a federal policy of encouraging settlement through irrigation set the stage for a prolonged period of development and rapidly growing use of western waters. This growth continued unabated for about seven decades until most of the region's rivers had been tamed and put to intensive use for irrigation, municipal, industrial, and hydropower purposes.

Several factors fueled this growth. Federal water projects received priority during the New Deal period as a means of providing jobs and during the two World Wars to increase power production. For several decades following World War II, water projects were prized as a means of diverting federal funds to the constituents of influential congressmen. By granting priority water rights to the earliest diverters, the doctrine of prior appropriation encouraged offstream use at the expense of instream flows. Technological advances in pumping and cheap energy encouraged a rapid use of western groundwater resources starting in the late 1930s.

The past two decades have brought a marked change in the trend toward increasing the control and offstream use of western streams. Rising water costs, environmental concerns, increasing values of instream water uses, rising pumping costs, and budgetary concerns have contributed to a sharp reduction in water development projects, a leveling off and in some cases a decline in ground and surface water withdrawals, and a host of environmental laws that present major hurdles to any new water projects.

B. General References

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II. Water and the Early Settlement of the West

A. The natural availability of water was an important factor in shaping the nation's exploration, settlement, and development during the 19th century.

1. Rivers provided the principal paths for exploring and trading.

2. Cities grew up around the best harbors and major rivers.

3. Mills and factories located alongside streams to harness the power of flowing water.

4. Agriculture located where rainfall was adequate or a stream could be easily diverted to irrigate neighboring lands.

5. But either too much or too little water was an obstacle to developing about one-third of the original forty-eight states. Floods were a problem in the Missouri, Mississippi, and Sacramento basins. Lack of reliable precipitation is a problem over much of the West.

B. Land and water rights encourage settlement

1. Swamp Land Acts of 1849 and 1850 encourage settlement of flood prone areas by granting federal lands to states in the lower Mississippi Basin under the condition that the funds from their sale be used for flood control and drainage.

2. Homestead Act of 1862 granted settlers free title to 160 acres after 5 years of residence and cultivation.

3. The Timber Culture Law of 1873 granted 160 acres of semiarid land to anyone who could keep trees healthy and growing on 40 acres for 10 years. The ownership requirements were subsequently reduced to 10 acres and 8 years. Underlying this legislation was a belief that the planting of trees would increase precipitation in the region.

4. The lure of free, flat, treeless lands; intensive promotion from the railroads and others who stood to profit from the settlers; a long period of above average rainfall; and a belief that "rain would follow the plow" led settlers to flock to the semiarid plains.

5. The Desert Land Law of 1877 provided 640 acres of arid lands at a cost of $1.25 per acre if irrigation were established within 3 years. The Carey Land Act of 1894 provided arid land to states or territories to promote reclamation. However, neither of these acts were very successful in establishing irrigation in the West.

6. Adoption of the appropriation doctrine by the western states provided more secure water rights to anyone withdrawing water for a beneficial use. The federal government recognized the validity of water rights created by local customs,

laws, and court decisions in the Mining Act of 1866, the Land Act of 1870, and the Desert Land Act of 1877; these laws declared all unappropirated water subject to appropriation and use of the public for irrigation, mining, and manufacturing.

III. The Situation about 1900

A. The welfare and even the survival of countless people living in arid, semiarid, and flood-prone areas depended on continued benign precipitation patterns.

B. The more easily irrigated lands were already developed, and further development would depend increasingly on storage to increase the dependable supply of water.

C. Many irrigators and irrigation projects were hopelessly in debt. Government support was considered necessary for the further expansion of irrigation.

D. The Jeffersonian ideal of creating a large number of self-sufficient, small farmers had been tarnished by over-settlement of marginal arid lands and the huge private land holdings that had been fraudulently acquired through the various federal land laws.

E. Los Angeles was the first city to feel threatened by the prospect of long-term water shortages. In 1904 the city was seeking additional supplies from Owens Valley.

F. Water technology had changed little from the achievements of the Romans two thousand years earlier and the Dutch several hundred years earlier. In 1900 wheelbarrows and mules were still the principal means of moving earth.

IV. Technology, Water Use, and Development

A. Drinking water

1. The water sources used for drinking also served as the principal medium for disposing of municipal and industrial wastes. Consequently, drinking water was a major source of debilitating and deadly disease in the 19th century.

2. By the late 19th century experiments had demonstrated that sand filtration could substantially reduce death rates from typhoid fever and other diseases.

3. Chlorination was shown in 1908 to be an inexpensive way to ensure bacteriological quality of water.

4. The first national drinking water standards were established in 1914. Soon thereafter, Americans began to take the quality of municipal drinking water supplies for granted.

B. Hydropower

1. Hydroelectric power was first used to light streets in 1882, and production grew rapidly in the 1890s.

2. Its use, however, was very limited until advances in transmission technology early in the 20th century made it possible to match the power production of large dams with the power use of cities and factories.

C. Water projects

1. Early in the 20th century mechanical power revolutionized earth moving and improvements in concrete production expanded the areas where dams could be constructed.

2. These advances contributed to rapid increases in national water use and dam construction.

a. Total water withdrawals increased from 40 billion gallons per day in 1900 to more than 90 bgd in 1920. Irrigation accounted for about 70 percent of the increase and more than 60 percent of all withdrawals by 1920.

b. From 1900 to 1920, 4,734 new dams with a total storage capacity of 42.7 million acre-feet were completed. In comparison, only 2,661 dams with a total storage capacity of less than 10 maf were constructed in the preceding 200 years.

D. Groundwater pumping

1. Until the mid 1930s, groundwater use was limited to areas of artesian pressure or low pumping depths.

2. 25 feet was the maximum pumping depth with the suction pumps in use in the early 1930s.

3. Economic factors limited the use of submersible pumps that had been developed about 1920 to the oil industry.

V. Private versus Public Development

A. The resource problems and abuses that emerged during the 19th century contributed to a growing disenchantment with the government policies and private actions that had guided the development and use of the nation's waters.

B. Alternative development views

1. The preservationists led by John Muir wanted to preserve the nation's most beautiful natural assets from any development.

2. The conservationists led by Gifford Pinchot believed it was wasteful to leave water resources unused that could be used to produce crops, power, or other such products. The

solutions to past abuses of the nation's natural resources lay in an activist federal government that would introduce benevolent, farsighted, scientific management. The views of the conservationists, which became ascendent when Theodore Roosevelt became president in 1901, are reflected in the Reclamation Act of 1902 and the 1913 decision to flood Hetch Hetchy Valley to provide water and power for San Francisco.

VI. The growing federal role in water resource development

A. The Reclamation Service (later renamed the Bureau of Reclamation) was established in 1902 to assist in developing the arid west through irrigation.

B. The 1908 report of the Inland Waterways Commission marked the beginning of a federal effort to systematically improve the nation's waterways to permit the efficient use of improved marine engines, propellers adapted to shallow-draft vessels, and towboats and barges.

C. The purview of the Corps of Engineers was broadened in 1913 to include power development and use in their reports on watersheds and to plan and construct flood control works in 1917.

D. The Federal Power Commission was established in 1920 as an inter-agency cabinet-level committee empowered to sell surplus power generated from federal dams, to license non-federal power developments on navigable waters and public lands, and to undertake surveys of water power developments. The Federal Power Act gave public interests precedence in the use of the power and reserved ultimate ownership rights for the federal government.

E. The Boulder Canyon Project Act of 1928 authorized a huge multipurpose water project on the Colorado River. Hoover Dam (initially named Boulder Dam) became an inspiration and model for countless other water projects.

1. The dam, which was the world's largest when it was completed in 1935, was an impressive engineering accomplishment that had required major technical innovations.

2. This project established a precedent for using hydroelectric power revenues to pay for the dams, reservoirs, and power plants of water projects. These "cash-register" dams played a major role after World War II in helping the Bureau of Reclamation justify many of its irrigation projects.

F. The New Deal

1. Water development gains support both as a way to generate employment and as a means of gaining greater control over a resource that became increasingly scarce and unreliable during the 1930s.

2. The National Industrial Recovery Act gave the president unprecedented powers to initiate public works including water projects. The Public Works Administration provided loans and grants to state and local governments and federal agencies for municipal water works, sewage plants, irrigation, flood control, and water power projects. California's Central Valley Project, the Bonneville and Grand Coulee dams on the Columbia River, and Fort Peck dam on the Missouri were among the many projects authorized under this act.

3. The 1936 Flood Control Act initiated a national flood control program and expanded the authority of the Corps of Engineers to develop river basin plans for navigation.

4. The drought eliminated hopes that "rain would follow the plow" and led to a mass exodus of destitute farmers from the Great Plains. Drought together with the development of improved pumping technologies led in the late 1930s to the start of major groundwater pumping for irrigation in the High Plains and other areas of the West.

5. The Soil Conservation Service was established in 1935 to deal with farming practices many believed contributed to the Dust Bowl and to downstream flooding. SCS's mission was soon broadened to include planning and construction of upstream agricultural water-storage facilities. Initially these reservoirs were supposed to be designed only for flood protection and agricultural purposes. In 1956 municipal and industrial water supplies, recreation, and fish and wildlife habitat became allowable functions of SCS reservoirs.

6. The favorable environment for water development during the New Deal period is reflected in the more than 5,000 dams constructed from 1933 to 1944. These dams more than doubled the storage capacity of the nation's reservoirs.

VII. <u>The Pork Barrel and Post World War II water development</u>

A. When the National Resources Planning Board was abolished by the Congress in 1943, the executive branch was left with no capability for overall water resource planning.

B. Congressional committees and the construction agencies gained control over the federal water development agenda.

C. With the federal government paying all the costs associated with flood control and navigation works and subsidizing the costs of other project benefits, local communities valued water projects as sources of federal funding regardless of the intrinsic merits of the project.

D. Although a project's benefits were supposed to exceed its costs, the construction agencies had no trouble manipulating the analysis to justify any project desired by the legislators in charge of their budgets.

E. River-basin accounting by the Bureau of Reclamation encouraged "cash-register" dams to finance uneconomic irrigation projects.

F. The Pacific Southwest Water Plan typifies the attitudes and views of the construction agencies in the early 1960s.

1. The agencies enjoyed large budgets and believed structural approaches were the way to providing for growing water demands.

2. The Plan submitted to the president in 1964 recommended 17 projects and programs including pumping Colorado River water over the mountains into central Arizona for Phoenix and Tucson, two big dams on the Trinity River in northern California, a tunnel to divert water from the Trinity to the Sacramento River, a wider California aqueduct to deliver more water to the central and southern parts of the state, and two large hydropower projects (cash-register dams) at Bridge and

Marble Canyons located at opposite ends of Grand Canyon National Park on the Colorado River. These two dams would not increase (and in some years might even reduce) the effective water supply in the basin. Nevertheless, the power revenues they would generate were needed to give the scheme even a vague pretense of providing enough revenue to repay the reimbursable costs.

G. Even if the Pacific Southwest Water Plan had been fully implemented (which it was not), some people foresaw a time when the arid Southwest would need even more water. The Bureau of Reclamation, until stopped by the Congress, undertook preliminary studies of an interbasin transfer from the Columbia River, and some privately developed plans even looked to Alaskan and Canadian rivers for a long-term solution.

H. Water use and development from 1945 to 1969 produced some major changes.

1. More than 35,000 dams were completed during these 25 years. This was more than twice as many dams constructed in all previous years.

2. The nation's storage capacity rose from 279 to 753 maf, an increase of 170 percent.

3. Offstream water use rose from about 170 to 370 bgd.

VIII. Changing patterns of irrigation

A. Irrigated land in the 17 western states increased from about 19 million acres in 1944 to 35 million acres in 1969.

B. This post World War II expansion differed considerably both as to location and character from that prevailing prior to 1945.

1. The Mountain states of Idaho, Montana, Wyoming, Nevada, Colorado, Utah, Colorado, Arizona, and New Mexico accounted for more than half of the nation's irrigated lands in the mid 1940s. Much of the irrigation in this region involved flooding riparian lands with gravity flows to grow relatively low-value crops such as pasture and hay.

2. In contrast, the expansion over the next 25 years depended largely on new pumping technologies and large-scale water development projects. Bureau of Reclamation projects resulted in an additional 4.4 million irrigated acres over this period, and most of the rest of the increase was based on groundwater. Seven of every eight additional acres irrigated in the West over this period were in the Plains and Pacific states where higher-value crops such as grains, fruits, and vegetables dominate.

C. Perfection of the vertical turbine pump in the late 1930s greatly increased the depths from which groundwater could be economically pumped. This technology together with the availability of low-cost energy encouraged the rapid development of groundwater irrigation. From 1950 to 1970 annual groundwater use for western irrigation rose from 18.2 to 46.2 maf and from 21 to 35 percent of all water withdrawals for western irrigators. Much of the increase came from the Ogallala aquifer underlying the High Plains of Texas, New Mexico, Oklahoma, Colorado, and Kansas.

IX. Economic factors leading to recent changes in water use

A. Rising costs and shrinking budgets curtailed new water development projects.

1. Water project construction peaked in the mid to late 1960s. On average, more than 2,000 dams and nearly 29 maf of new storage were completed annually from 1965 to 1969. In contrast, the annual rates dropped to 1,069 dams and less than 10 maf for the 1970 to 1982 period.

2. With the best sites already developed, the costs of increasing safe-yield within a basin rose sharply.

3. Policy changes reduced the federal funding for water development projects, increased the interest rates construction agencies must use to justify such projects, and more recently, increased the local cost shares for many projects. Thus, it became more difficult for federal agencies to justify and fund large water projects and local support for federal water projects waned.

B. Rising energy costs and declining groundwater tables curb the growth in pumping for irrigation.

1. Pumping exceeded aquifer recharge in 1975 by more than 22 maf, equivalent to 40 percent of the annual withdrawals for irrigation. In the Texas and Oklahoma High Plains alone, mining from the Ogallala aquifer was about 14 maf a year, equivalent to the average annual flow of the Colorado.

2. The energy price shocks following the OPEC embargo had a major impact on irrigation in the High Plains where pumping depths were often 200 feet or more. The resulting sharp increase in water costs produced a major transformation within a region

that had been characterized by relatively inefficient irrigation practices. Some farmers returned to dryland farming. Farmers continuing to irrigate relied much more on water-conserving crops, seed varieties, and irrigation practices.

X. Environmental challenges to water projects

A. Growing concerns over declining water quality and loss of instream flows diverted funding from new water supply projects toward measures to meet water quality objectives and lent support for federal and state environmental legislation to curb water development projects.

B. The Federal Water Pollution Contol Amendments of 1972 (commonly known as the Clean Water Act) established the goals of restoring all navigable waters to a "fishable and swimmable" condition by 1983 and to eliminate all discharges of pollutants into these waters by 1985. In pursuit of these unrealistically ambitious goals, federal funding of municipal wastewater treatment plants rose from less than $2 billion for all years prior to 1972 to $37 billion from 1972 to 1985. When the expenditures of state and local governments and industry are added to those of the federal government, the nation spent more than $100 billion to limit and treat industrial and municipal wastes in the 15 years following passage of the 1972 Clean Water Act.

C. The National Environmental Policy Act of 1969 requires all federal agencies to include an environmental impact statement as part of a project's analysis. This requirement has provided project critics a legal tool for challenging an agency's analysis

and for proposing alternative uses of the water resources affected by a project.

D. The Wild and Scenic Rivers Act of 1968 provides for designating selected rivers as wild and scenic, a status that precludes water projects that would excessively damage the natural amenities of these rivers. As of January 1989, 119 rivers and stretches of rivers had been officially designated as wild and scenic under this act.

E. The Endangered Species Act of 1973 prohibits federal agencies from undertaking actions that threaten the survival or critical habitat of a species officially designated as endangered. Water development agencies are required to await the results of biological studies before undertaking any actions that might result in irreversible damage to such a species. Where a threat is identified, the project must be altered or cancelled to remove the threat. This act has been used to kill or postpone proposed projects, and during the summer of 1988 the Corps of Engineers was required to alter the flow of the Missouri River below the levels needed to maintain navigation in order to protect the nesting grounds of the endangered least tern and the threatened piping plover.

F. The public trust doctrine, which holds that the state as trustee has an obligation to protect instream values, has been employed in state courts to protect instream flows. California's Supreme Court has ruled in the Mono Lake case that the state does have a public trust obligation to protect unique ecosystems.

Application of this doctrine poses a potential challenge to traditional water uses.

XI. Recent Changes in Western Water Use

A. Total freshwater withdrawals peaked in 1980 at about 202 maf (180 bgd), 76% of which was for irrigation. Between 1980 and 1985 withdrawals declined by 17 maf or more than 8 percent.

B. Irrigation withdrawals, which declined by nearly 9 percent, accounted for almost all of the decline in total withdrawals.

1. Groundwater pumping for irrigation declined from 58 to 42 maf between 1980 and 1985, a 28% reduction.

2. Surface water withdrawals for irrigation actually increased by nearly 3 maf or 3% over this period.

XII. Meeting Future Water Demands

A. Increasing affluence, leisure, and population tend to increase the demand for water and the services it provides.

1. The fastest growing demands for water in recent years appear to have been for the services provided by high-quality instream flows. This trend is likely to continue.

2. Development and adoption of more water-efficient technologies can temper or even reverse the growth in demand for agricultural, domestic, commercial, industrial, and other withdrawal uses.

3. However, technology is not likely to offer any suitable substitutes for such instream uses as fish and wildlife habitat, water-based recreation, and the amenities of natural waterways.

4. Although there are substitute power sources, hydroelectric power has advantages over many of these as a clean source of power.

B. Actual water use is limited by available supplies and how they are allocated among competing uses.

1. Large quantities of water are stored in groundwater reservoirs but the use of these supplies will be limited because of several factors.

a. Groundwater pumping from alluvial aquifers often results in a proportional reduction in streamflows.

b. Irrigation pumping has resulted in declining stocks and rising costs in some important agricultural areas. Rising costs have already resulted in a decline in significant reductions in groundwater use for irrigation.

c. Groundwater quality in many areas has been adversely affected by past land and water use practices.

2. The high values society seems to be attaching to instream uses and the high financial and environmental costs of adding to effective supplies for offstream use will place increasing emphasis on reallocating existing supplies to meet changes in the demand for offstream water uses.

C. Water will become scarcer as demand increases faster than supply. The West no longer has the luxury of being able to increase water supplies for some without adversely affecting other users. Demand-side management and institutions capable of reallocating water as supply and demand conditions change are now the principal challenges for planners and managers.