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AN ECONOMIC VIEW: Water Problems—National and Regional

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A commodity whose average retail price is approximately ten cents per ton would hardly seem to be one in which a vital interest would be shown by so many individuals. Yet water, whether viewed as a chemical, an input to a productive process, a source of recreational pleasure, or a basic resource, has in a long span of years continued to stimulate research, discussions, congressional hearings, and the issuance of policy statements by such groups as the League of Women Voters. This interest is more than an expression of idle curiosity. It stems from the basic importance of water in every phase of life and from the fact that water is regulated by law and largely supplied, allocated, and developed by governmental agencies whose programs are the concern of all.

It is the objective of the present paper to review our present and prospective water situation in terms of the amounts available and quantities used and to briefly discuss the implications for policy of the problems that may be expected to arise in the immediate future. The following section contains a discussion of the supply of fresh water and the beneficial applications of this supply in both the nation and the Missouri Basin. In the succeeding section there is a review of recent projections by the Select Committee on Natural Water Resources of national and basin water demands. Some of the implications of these projections for the Missouri Basin are considered in the final section.

WATER SUPPLY AND USE

Our annual supply of fresh water is derived from precipatation in the form of rain, hail, and snow. Though there is considerable variation from season to season and from year to year in the amount that falls, the long-run average for the United States is 30 inches a year. The largest portion of this average, however, is not available for management and use. About 21 of the average 30 inches re-enters the atmosphere

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through direct evaporation from surface soils and waters and through transpiration in the foliage of plants. This loss through evapotranspiration is substantial and represents a considerable dimunition of the original supply. There is, however, a favorable side to this reduction. The amount recycled to the atmosphere in transpiration supports the growth of forests, crops on nonirrigated farms, and other beneficial plants. The remaining 9 inches of average annual precipitation either drains from the soil surface to streams, rivers, and lakes, or seeps through the surface soils to underground reservoirs termed acquifers. In turn, the water collected underground usually flows from entering areas to others of natural discharge where it becomes a part of the surface supply. The drainage of water through surface channels, whether coming directly from the soil or from the discharge of acquifers, is defined as runoff and is the flow available, in varying degrees, for use. Unless the water that collects in acquifers is significantly different in amount than that which returns to surface channels, the average amount of runoff is equivalent to the 9 inches of annual precipitation (about 1145 billion gallons per day) that does not disappear through evapotranspiration.

The uses of water may be classified under two general headings, withdrawal and flow. When water is withdrawn from streams and acquifers it is employed by households, business establishments, farms, and governments. After withdrawal, most of the water is returned to stream, though often reduced in quality and value, and is available for the further employment by downstream users. The difference between withdrawals and returns is net consumption, the amount of water that leaves the ground phase of the hydrologic cycle through evaporation in use, chemical recombination, and incorporation in a product. Consumptive losses, like evapotranspiration losses, represent permanent depletions of the total supply. In Table I* are shown the gross withdrawals and consumptive losses in the contiguous states of the United States for 1954. These data indicate that of the total amount of water withdrawn from streams and acquifers approximately 37 percent was applied and not returned to flow. This consumptive loss is slightly less than 10 percent of average runoff. The data also show that the highest rate of consumption occurred in agriculture where 59 percent of the 176 billion gallons per

* TABLE I

Water Withdrawals and Net Consumption,
Continental United States, 1954
(Billions of gallons daily)

Purpose	Gross Withdrawals	Net Consumption	Ratio of Consumption to Withdrawals
Irrigation	176.1	103.9	.59
Municipal	16.7	2.1	.13
Manufacturing	31.9	2.8	.09
Mining	1.5	.3	.20
Steam Electric Power Cooling	74.1	.4	.01
Total	300.3	109.5	.37

Source: U. S. Senate, Select Committee on National Water Resources, Report of the Committee, 87th Congress, 1st Session, 1961, p. 6.

day (bgd) withdrawn was lost for further use.[1] The withdrawals and consumption by municipalities, manufacturing and mining establishments, and steam electric utilities were substantially smaller than those of irrigators.

In addition to the above applications of water after withdrawal from flow, there are uses of water dependent on the flow itself. Large quantities of flowing water are needed and used for power generation, the conservation of fish, navigation, and the dilution of wastes. It has been estimated that the flow of water employed in 1954 was 374 bgd for power generation, 281 bgd for navigation, and 78 bgd for sport fish habitat.[2] A comparable estimate does not exist for waste dilution.

The above figures would seem to indicate the absence of anything that may be described as a water problem. Unfortunately, this is not the case. Among others that could be appropriately discussed, there are current problems of inadequate supply relative to use and problems of quality.

1. The total for the United States conceals the fact that most of the irrigation loss occurred in the 17 western states. SELECT COMMITTEE ON NATIONAL WATER RESOURCES OF THE SENATE, WATER SUPPLY AND DEMAND, 86th CONGRESS, 2ND SESSION 44 (COMM. PRINT NO. 32, 1960).
2. S. REP. NO. 29, 78TH CONGRESS, 1ST SESSION 8 (1961).

An examination of the separate water regions of the United States reveals that some have a relative abundance of water while others are either approaching their limits or have reached them. The Pacific Northwest, as an example of a well endowed region, has an average daily runoff of 143 bgd. This compares with gross withdrawals in 1954 of 25 bgd and net consumption of 13 bgd.[3] The ratio of consumption to runoff indicates that less than 10 percent of runoff was actually consumed. At the other extreme is the South Pacific Basin which centers on Los Angeles. In 1954 consumption was more than double runoff, the deficiency being met by importations of water from other regions and depletions of supplies in ground reservoirs.[4] The Upper Missouri Basin holds an intermediate position with consumption at approximately the 50 percent level.[5] As will be noted in the following section, the consumption level in the Upper Missouri is expected to rise within the next 20 years and create difficulties that other basins are currently attempting to meet, difficulties of negotiation with other basins, of project development and finance, and of planning and implementation.

In addition to the difficulties arising because of relative shortages, there are others presented by the extent of pollution. The water that flows through streams and acquifers carries various substances with it which are contributed by both man and nature. These substances include sewage and other oxygen demanding wastes, infectious agents, mineral and chemical substances, synthetic organic chemicals such as detergents and insecticides, and radioactive wastes. These substances reduce the quality of the water and, if present in sufficient quantity, may eliminate fish life, create public health hazards, increase the puerification costs of water supply agencies, and destroy the usefulness of water to those who draw directly from streams and acquifers. Some appreciation of the magnitude of pollution may be drawn from a recent estimate by the Public Health Service that in 1954 the nation's water resources carried an oxygen demanding waste load that was equivalent to the raw sewage of 150 million people, a load considerably above acceptable limits.[6] However disturbing this estimate

3. SELECT COMMITTEE, *supra* note 1, pp. 39, 44, 49.
4. *Ibid.*
5. *Ibid.*
6. SELECT COMMITTEE ON NATIONAL WATER RESOURCES OF THE SENATE, POLLUTION ABATEMENT, 86TH CONGRESS, 2ND SESSION 4 (COMM. PRINT NO. 9, 1960).

may be, it should be noted that it understates the size of the problem since it does not indicate the extent of the pollution load from infectious agents, chemicals and minerals, and radioactive substances.

FUTURE NEEDS

Public officials have long recognized the problems created by pollution, floods, droughts, relative geographical shortages, and other water conditions. Testimony for this recognition is to be found in government sponsorship and support of numerous conferences and research projects, in the enactment of legislative proposals relating to water problems, and in the planning and financing of water facilities. One of the most recent public actions indicating the concern of officials was the formation under Senate Resolution 48 of the Select Committee on National Water Resources.[7] The committee was created for the purpose of making studies and recommendations on (1) the extent to which water resource activities are related to the national interest and (2) the nature and magnitude of water resource programs required to provide for all future needs. To gather information on which it could base its recommendations the committee conducted hearings throughout the country and asked various individuals, private organizations, and governmental agencies to submit reports on specified topics related to water. These reports were received and published by the committee. Numbering 32 in all, they constitute a valuable body of source material for anyone with a concern or interest in the subject of water. The last in the series contains estimates based in part on materials included in the earlier reports, on the demand for water in the year 1980 and 2000, the maximum sustainable flow of water that can be developed, the amount of storage needed to obtain the maximum flow, and the costs of development programs. These projections will be considered in this section because of the clear demonstration they provide of the necessity for action and the magnitude of programs required for development of water resources in both the nation and the Missouri Basin.

The estimated demands for water in 1980 and 2000 are based on several assumptions that deserve explicit recognition. One of the fundamental assumptions is that population will

7. S. RES. NO. 48, 86TH CONGRESS, 1ST SESSION (1959).

increase from 180 million in 1960 to 244 million in 1980 and to 329 million in 2000.[8] Some of the others are that the economy will continue to expand at a rate comparable to that of the recent past, with gross national product approximately doubling in the next 20 years and doubling again in the succeeding 20;[9] that irrigated acreage will go up to meet food production requirements, from acreage of 29.5 million in 1954 to 36.7 in 1980 and to 55.5 in the year 2000;[10] that acreage in swamps and wetlands will be enlarged in order to provide sufficient habitat for the support of a wildlife population that remains in balance with the number of hunters;[11] and that the expansions of population, production, irrigation, and wildlife habitat will in no way be limited by water availability.[12] While some of the assumptions may seem arbitrary or unrealistic, they are a necessary ingredient of the projections to be discussed. A mere listing of them serves as an indication of the care that must be exercised in the interpretation of results.

The total demand for water in 1980 is the sum of the expected consumption losses, on-site losses, and waterflows necessary to dilute waste materials.[13] As previously noted, a consumption loss is the amount of water withdrawn for use less the amount returned to flow. The expected losses in 1980 are those calculated to occurr when water is applied to beneficial use in municipalities, mines, farms, manufacturing establishments, and steam electric utilities. On-site losses are those that take place through evaporation and transpiration on swamps, wetlands, and small watersheds designed to abate soil erosion and conserve soil moisture. In the part of this paper where water use in 1954 was discussed no mention was made of such losses because an estimate of their size was not available. They were simply included in the 21 inches of average annual precipitation returned to the atmosphere through evapotranspiration. However, as additional land is converted to swamps and wetlands to provide habitat for wildlife and as additional erosion abatement and soil moisture conservation

8. SELECT COMMITTEE, WATER SUPPLY AND DEMAND, **supra** note 1, p. 35.
9. Gross national product measured in 1960 dollars. **Id.** p. 32
10. SELECT COMMITTEE ON NATIONAL WATER RESOURCES OF THE SENATE, LAND AND WATER POTENTIALS AND FUTURE REQUIREMENTS FOR WATER, 86TH CONGRESS, 1ST SESSION 70-72 (COMM. PRINT NO. 12, 1960).
11. SELECT COMMITTEE, WATER SUPPLY AND DEMAND, **supra** note 1, p. 18.
12. **Id.** p. 2.
13. **Id.** pp. 3, 16-21.

* TABLE II

Source, Use, and Storage of Water, Contiguous United States and Upper Missouri Basin, 1954, 1980, and 2000

Description	United States	Upper Missouri Basin
Use (billions of gallons daily)		
Consumption of Water in 1954	109.5	14.0
Flows Necessary to Maintain Quality of Water and Meet Projected Consumptive and On-site Losses[1]		
1980	552.7	33.6
2000	699.6	51.1
Source (billions of gallons daily)		
Average Runoff	1,145.0	29.0
Maximum Sustainable Flow[2]	1,080.8	26.9
Storage (millions of acre-feet)		
Capacity in 1954	278.0	74.8
Additional Storage Required to Achieve Necessary Flows for Maintainance of Quality and Satisfaction of Projected Losses[3]		
1980	315.6	30.0
2000	442.1	30.0

1. Consumptive losses occur in the use of water through incorporation in a product, chemical change, evaporation, and evapotranspiration. On-site losses occur through evaporation and evapotranspiration in swamps and wetlands for fish and wildlife and in land structures for the control of soil erosion and conservation of soil moisture.

2. Maximum sustainable flow that can be obtained from runoff after estimated evaporation losses from added reservoir capacity needed to develop maximum flow.

3. Additional water-storage facilities are estimated on the basis of a minimum cost program.

Source: Nathaniel Wollman, "Water Supply and Demand," Committee Print 32 in the Series **Water Resource Activities in the United States,** Select Committee on National Water Resources, U. S. Senate, 86th Congress, 2nd Session, 1960, pp. 8-9, 49.

programs are undertaken, the amount of runoff will be reduced from that of 1954. The expected size of this reduction is equivalent to projected on-site losses for 1980. The total demand, or requirement, for water in 1980 is the sum of the expected on-site and consumption losses *plus* the estimated amount of waterflow necessary to dilute the oxygen demanding waste effluent from municipalities and manufacturing enterprises to acceptable levels.

For the contiguous states of the United States the total water requirement is projected to be 522.7 bgd in 1980 and 699.6 bgd in the year 2000. (see Table II). These figures are well below either average runoff from precipitation or the maximum sustainable flow that could be achieved through full development of water storage facilities. While this is highly encouraging, it should be noted that present water storage facilities are not adequate to provide a daily flow that meets requirements by either 1980 or 2000. Additional storage facilities will have to be planned, financed, and placed in operation.

The projections for the entire country do not tell the whole story. Some of our water resource regions, particularly those in the arid west, are expected to have a relative shortage of water within the near future. One of these regions is the Upper Missouri Basin. It cover the upper drainage area of the Missouri River—the area north and west of Topeka, Kansas—as well as the American portion of the drainage area of the Red River of the North. By 1980 demand in the basin is projected to be 33.6 bgd (see Table II). Of this total, 15.0 bgd will be required in agriculture (primarily for irrigation), 13.1 bgd for additional swamps and wetlands, 4.4 bgd for the dilution of wastes to acceptable levels, and the remaining 1.1 bgd for other consumption and on-site losses.[14] By the year 2000 the water required to meet all demands is estimated to be 51.1 bgd. And of this amount, 20.5 bgd will be required in agriculture, 17.6 bgd for swamps and wetlands, 11.0 bgd for waste dilution, and the remaining 2.0 bgd for other consumption and on-site uses.[15] When these requirements are compared with the average runoff presently available of 29.0 bgd, it is apparent that the Missouri Basin is going to be water short. Unless the assumptions on which the prejections are based are wrong, or additional water can be imported from surplus regions and mined from ground reservoirs, full growth in the use of water for one or several purposes will not be realized.

CHALLENGE FOR THE FUTURE

The importance of an economic projection is that it points out what can surely be avoided, not what will inevitably happen. Economic growth in the Missouri Basin need not be limited because of a relative shortage of water. If constructive efforts are directed toward the full development of present runoff, the reduction of water-use requirements, and the

14. Id. p. 101
15. Ibid.

increase of fresh water supplies, it will be possible to sustain a high rate of growth.

The opportunities for constructive action are present. Additional water storage facilities are needed for collecting and controlling runoff. The additional facilities would reduce flood damage, provide expanded water supplies for municipalities or other users, and permit a larger and more closely regulated flow in streams for the dilution of wastes. It is not a matter of having insufficient technical knowledge to accomplish the job; it is only a matter of designing and financing the required projects, and designing and financing are tasks that can be accomplished.

Opportunities are also present for obtaining additional fresh water supplies and reducing water requirements. Large additional supplies can be secured by the application of techniques which reduce evaporation on lakes and reservoirs, which convert brackish water deposits into fresh water, and which reduce the amount of water lost annually through transpiration in worthless vegetation.[16] Known methods could also be applied in reducing the consumption of water in manufacturing and the waterflow requirements in waste dilution.[17] Some of these techniques are low enough in cost to be applied now with resulting benefits that exceed cost. Others have not as yet reached that stage. They deserve, however, continuing attention and appraisal.

While the above opportunities offer considerable scope for direct action by private and public organization, other possibilities for constructive efforts must be developed through research. One of the subjects on which more research could be fruitfully undertaken, a subject of interest to both economists and the legal profession, is that of the social process through which water is allocated, that is, the process that determines the amounts applied in specific uses, the locations of use, the efficiency with which the resource is applied, and the distribution of the water-supply cost burden. It would be of considerable value to know whether the process allocates water to those uses which give the greatest benefits, whether it provides strong incentives for efficiency in use and the elimination of water waste, and whether as conditions change it re-

16. GEORGE O. G. "Toward Greater Availability," in RESOURCES DEVELOPMENT: FRONTIERS FOR RESEARCH. pp. 39-48 (Pollak ed. 1960); S. REP. NO. 29, 87TH CONGRESS, 1st SESSION, pp. 51-58 (1961).
17. Ibid.

allocates water from lower benefit uses to those of higher benefit. With a more complete understanding of this process it will be possible to evaluate its performance and to offer recommendations as to how it should be changed for the advantage of the entire basin.

A fundamental part of the allocation process is water law. Among other things, it is the body of law which gives existence, powers, and objectives to the many governmental organizations that participate in the allocation process and whose operations largely determine how and how well the process works, which defines water rights and provides for their enforcement, and which determines on whom the ultimate cost burdens rest of supplying water and making additional supplies available. The following papers should contribute to a better understanding of the role that law plays in an important social process. And from a better understanding of how water is allocated it will be possible to alter the process and enlarge the benefits to be derived from a resource whose relative scarcity is growing.

"Let us develop the resources of our land, call forth its power, build up its institutions, promote all its great interests and see whether we also in our day and generation may not perform something worthy to be remembered."

Daniel Webster