ADDRESS OF THE PRESIDENT

WATER FOR PRACTICALLY EVERYBODY

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Water in some form seems to be a requirement of all living organisms, but *Homo sapiens*, to the best of my knowledge, is the only organism which insists that, instead of his going to the water, the water should go to him. This may or may not be an application of the higher intelligence which man stubbornly claims for himself, an attribute which is acknowledged by only a handful of domesticated plant and animal species and is resisted by several hundred thousand more, including most bacteria, mosquitoes, and Johnson grass. The purpose of this paper is to discuss some of the relations between water and people in the world, in our nation, and in our own state of Oklahoma.

Most of the supply of water available for human use exists in the great ocean basins and epicontinental seas which in our era cover approximately 71% of the surface of the globe. This primary fund of water, most of which is now in the southern hemisphere, seems to have remained about constant since the intial cooling of the earth's surface some two, three, or perhaps five billion years ago. Since the ocean water is present at an average depth of only two to three miles and a maximum known depth of less than seven miles, it is obviously only a thin film on the globe, a kind of frosting on the cake, serving to conceal some of the earth's irregularities and to provide a highly essential fillip for the earth's organic life, which evidently had its origin within it. At any one time, only a tiny fraction of the total water supply exists outside of the ocean basins, either as water vapor in the atmosphere, as ice in the glaciers, snowfields, or frozen rocks of high latitudes and high altitudes, or as fresh or brackish water in the streams, lakes, swamps, and saturated rocks of middle and lower latitudes.

If our amphibious ancestors had not chosen, perhaps unwisely, back in Devonian times, to start spending most of their time on the beach, we the people would not be faced with the well known water shortage which so plagues us but which still troubles not at all the salamanders, sea urchins, and sardines. Our physiological make-up has become such that we reiect, except for sailing, swimming, cooling, and a few other purposes, the vast reservoir of ocean water, now changed in taste somewhat by a 3½% content of sodium chloride and other soluble salts leached out of the surface rocks of the continents. Unfortunately, most of us animals and the great majority of our vegetable friends have long since learned to like our water fresh.

Less than a hundred generations ago scholars like Aristotle, Lucretius, and Pliny the Elder were puzzling intently over the source of the fresh water which poured from the sky, seeped out of the rocky hillsides, and ran down the stony river beds of Mediterranean Europe. Today most intelligent school children in their early teens can give a reasonably coherent explanation of the hydrologic cycle with its continuing round of evaporation, transpiration, condensation, precipitation, infiltration, and runoff. Hundreds of Ph. D.'s and many more unalphabetized scholars of our generation are puzzling over what to do about it. Should we try to increase rainfall, decrease fog, prevent frost, or let nature take its course? Should we try to make the water soak into the ground where it falls or catch it behind dams in the larger valleys? Should we spend public money to prevent floods, reduce stream pollution, develop internal waterways, provide recreational facilities, extend irrigation, and produce electric power? If so, how much, and where, and under what controls, and by which agencies? How shall we apportion the available water among private and public claimants, among states, and between nations? These are matters of policy which demand the attention of administrators coordinating the work of specialists in such fields as meteorology, geology, hydrology, engineering, biology, chemistry, sanitation, transportation, economics, and law.

As a geographer, I am proud to note that many members of my own profession have played an honorable and significant role in the practical affairs of water policy and water management. Geographers have served in some instances as technical experts on factual problems, and at other times as advisers or assistant administrators on matters of broad policy. Some examples of the first type which come to mind are Isaiah Bowman, Director of the American Geographical Society, serving as expert adviser in a U. S. Supreme Court case concerning the Red River boundary between Oklahoma and Texas; Lawrence Martin, Chief of the Division of Maps in the Library of Congress, acting as an expert witness in another Supreme Court case involving a boundary delimitation between the territorial waters of Wisconsin and Michigan; and Nels A. Bengtson, a former professor of mine at the University of Nebraska, making detailed climatological studies for use in the legal effort to find an equitable distribution of Platte River waters among the states of Colorado, Wyoming, and Nebraska.

Geographers in the role of consultants and administrators working with water problems have included Harlan H. Barrows of the University of Chicago, who served on the Water Resources Committee of the National Resources Board during the 1930's; G. Donald Hudson with the Tennessee Valley Authority, E. N. Torbert in the Columbia Basin, and John Abrahamson in the Missouri Basin; John C. Weaver, who is to be our guest speaker this evening, directing a U. S. Hydrographic Office research project on ice conditions in arctic and subarctic waters; Gilbert F. White, formerly president of Haverford College and now chairman of the Department of Geography at the University of Chicago, serving as Vice-Chairman of President Truman's Water Resources Policy Commission; Edward Ackerman, Wesley Calef, Walter Kollmorgen, Victor Roterus, Erwin J. Raisz, and Arthur H. Robinson, all of whom collaborated in the planning and presentation of the magnificent three-volume report of that Commission. A number of other geographers, whom I shall not take time to name, have served on the Arid Lands Commission of UNESCO and, according to Peverel Meigs(1), on not less than five of the twelve research committees of the Section on Hydrology in the American Geophysical Union. Dr. Paul A. Siple, director of research projects on the United States government expedition which has just left for the Antarctic, is a Ph. D. in geography from Clark University.

The water problem, of course, is a world-wide one with many interesting facets. A cursory examination of a world population map and a world rainfall map demonstrates the extent to which people have avoided settling in the dry lands. Not far from half of the land surface of the earth has a mean annual rainfall of less than 20 inches. Aside from the physiologically dry polar regions, where reduced evaporation keeps the low rainfall from being a serious deterrent to settlement, the shortage of water in the areas of less than 20 inches is unquestionably the principal obstacle to population growth. Low rainfall means limited economic opportunities. Farms and ranches must be large if the low and unreliable yields of cereal grains and grassland pastures are not to bring poverty and despair. Regardless of the urban amenities they may be willing to do without, cities and towns must have water.

The semiarid and arid lands of all the continents except Antarctica have "settlement islands" of moderately high to very high population density. Most of these islands of people are possible because of the local availability of water for irrigation, as in the valleys of Peru, the lower Nile Valley of Egypt, and the Imperial Valley of southern California, all of which have a mean annual rainfall of less than 5 inches. Other localized areas of high population density in regions of dry climates may be due to the presence of valuable mineral resources, such as the oil of Saudi Arabia and Kuwait, the coal of Karaganda in the Kazakh steppes of the Soviet Union, the iron ores of Magnitogorsk in the Urals and Iron Mountain in southwestern Utah, the copper of southern Arizona and of Cerro de Pasco and Chuquicamata in the high, dry Andes of western South America, the lead and zinc of the Broken Hill district and the gold of Kalgoorlie in Australia, the vanadium of Southwest Africa and the phosphates of the Tunisian Sahara, the salt of Lakes Elton and Baskunchak in the lower Volga River Basin, the potash of the Dead Sea, Searles Lake in California, and the Carlsbad district of New Mexico. In these dry mining areas fresh water is usally available only at a high cost, but the value of the minerals exploited justifies the expense of providing it. To use an extreme example, mining companies exploiting the nitrate-bearing *caliche* of northern Chile have found it profitable for more than a century to bring fresh water for hundreds of miles, for the supply at times of several tens of thousands of people in mining communities, where there simply is no local water.

Excess water—yes, even excess fresh water—is a serious problem in other parts of the world. The vast swamps in the drainage basins of the Ob and Amazon, the Parana and Paraguay, and on the lowlands of rain-soaked equatorial islands like Sumatra, Borneo, and New Guinea are areas which large capital outlays for drainage and fertilizers could make productive. While distance from markets, inherently infertile soils, debilitating climate, the lack of an energetic native labor supply, and a dozen other factors militate against any early use of the fresh water swamps just named, the Dutch in northwestern Europe are spending several hundred dollars per acre to dike, pump, and reclaim new land out of the brackish margins of the North Sea. Similarly, in the Belgian polderland behind the coastal dunes, and in the Fens of eastern England, an impressive effort is needed to keep the water table low enough to maintain the land in agricultural production. In our own country more than 87,000,000 acres of swampy bottomland has been brought into at least limited production by open ditches and tile drains during the past century, and a vast extent of reclaimable marshland still remains in Arkansas, Louisiana, Mississippi, and certain of the Atlantic coast states. Most of the potential hydro-electric power of the world, like that of Victoria Falls on the Zambesi, Iguassu Falls on the upper Parana, and in the great gorges of the Yangtze and Brahmaputra, is still undeveloped for lack of local markets.

The maintenance of a supply of fresh water on the continental land surfaces is dependent on natural precipitation, the occurrence of which is a consequence of the planetary wind circulation and the cooling of moist air beyond the point of condensation and droplet suspension. Such cooling occurs with greatest regularity where there is convergence of air over a permanent low pressure zone, as along the equator; where maritime air moves up slope on the windward side of mountains, as on many east coasts in the trade wind belts and on west coasts farther poleward; and in various latitudes where there is frontal contact between air masses with different temperature and moisture characteristics.

The amount of precipitation varies from more than 400 inches per year in such places as the south slope of the Khasi Hills in eastern India and the northeast slope of Mr. Waialeale in the Hawaiian Islands to no measurable precipitation at all for periods as long as twenty years at Iquique, Chile, and other places in the Atacama Desert of South America. While if all the moisture in all the atmosphere could be suddenly precipitated there would be an average rainfall of only about one inch over the surface of the earth, the processes of renewal make possible such phenomenal precipitation in local areas as 41 inches in a single 24-hour period at Cherrapunji, India, and 46 inches in a similar period at Baguio in the Philippines.(2) At least a dozen different localities in Oklahoma have recorded more than 10 inches of rainfall in a 24-hour period, and an unofficial measurement of 18 inches was recorded in a 12-hour period near Custer City, about fifteen miles northeast of Clinton, Oklahoma, during the afternoon and night of May 16, 1951.(3) Cheyenne, Oklahoma, in Roger Mills County, received more rain on April 4, 1934, than it did during the entire year of 1933.(4) In general, the variability of precipitation varies inversely with the amount "normally" expected.

The proportion of the precipitation on land which returns to the ocean in surface streams varies from none at all in some parts of the world—Professor de Martonne (5) of the University of Paris has calculated that 44% of the land surface has only interior drainage—to half or more of it in certain humid regions with relatively impervious surface rocks. Adolph F. Meyer(6) has estimated the total rainfall on the land areas at about 35,000 cubic miles of water per year, of which perhaps 7,000 cubic miles, or 20%, returns as surface flow in rivers. The largest of the world's rivers, the Amazon, exclusive of the water of the Xingu, which joins it at the upper end of the estuary, has an average flow of 110,000 cubic meters per second(7), or about twice the total surface runoff from the United States.

Data is still inadequate for studying, with any degree of accuracy, the cyclical variability of either rainfall or runoff over the world as a whole. For the 50-year period 1897 to 1947, according to Mead(8), the amount of rain falling on the entire United States seems to have varied in any given year no more than 15% from the "normal" or 50-year mean. During the same period, over the state of Texas, the extreme departures from the 50-year mean included one year with only 52.5% of the mean total for the state and another year with 147%. Fortunately, droughts and floods seem to be somewhat local in their occurrence, and more complete data may some day make it possible to estimate the likelihood of either at any given place and to make provision for insurance against the resultant catastrophes.

While systematic weather observation, using instruments, was begun in the United States by a few individuals before the middle of the 18th century, not until 1825 was there a government weather service collecting temperature and precipitation data at scattered Army posts. About 1847 the Smithsonian Institution began coordinating the activities of individual observers, and within a few years there was a thin network of climatological stations covering the entire country. The collection of weather information became a regular function of the Army Signal Corps in 1870. All of the existing records were collected by the U. S. Weather Bureau upon its organization in 1891, and the number of observing stations in the country, most of them manned by unpaid cooperative observers, has increased to more than 8,000.

Reasonably accurate records of river flow in the United States are of even shorter duration than our climatic records. For a few rivers, notably the Ohio and the Mississippi, some authentic hydrological information has been available for a century or more, although most of the early measurements were confined to simple indications of variation in water depth. The art of measuring velocity and volume of flow in natural streams was not developed until 70 to 80 years ago, and only a few reliable records of river flow in the United States are in existence for years preceding 1900. The U. S. Geological Survey, created by Congress in 1879, was requested in 1888 to conduct investigations in the arid regions of the country with a view to "the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and the prevention of floods and overflows."(9) The first regular stream gauging station of the Geological Survey was established on the Rio Grande River at Embudo, New Mexico, in January, 1889. By the middle of the 20th century the number of gauging stations on the nation's rivers was more than 6,000, and the number of titles in the Geological Survey's series of *Water-Supply Papers* was approximately 1300.

Precipitation and runoff measurements in the United States indicate for the nation a mean annual precipitation of just under 30 inches, of which 28%, or about 8½ inches, according to an estimate of Harold E. Thomas(10), flows to the ocean in surface streams. The remaining 72%, or about 21½ inches of water, is returned to the atmosphere by evapotranspiration, that is, by evaporation from free water surfaces, moist ground, and the surface of leaves. Areas receiving less than 20 inches of precipitation per year generally have less than one inch of annual runoff, and permanent streams would scarcely be possible in the dry lands between the 98th meridian and the line of the Sierra Nevada-Cascade Mountains were it not for somewhat increased precipitation on certain of the higher mountains and plateaus.

Every year an unknown but substantial amount of water sinks into surface cracks and seeps through porous mantle rock and bedrock to become what is known as ground water. The top of the saturated zone may be close to or even at the surface, causing springs along the bottoms or sides of valleys. While much of the ground water is moving slowly seaward, particularly in the deep alluvium of the larger river valleys, some of it is trapped more or less permanently due to the down-faulting or subsidence of the porous structures enclosing it. In some instances the saturated zone is capped by an impervious layer of shale or clay, making impossible further replenishment. Artesian conditions result when a dipping aquifer, or water-bearing layer, is capped for a considerable distance by an impervious rock, as for instance the Dakota sandstone by the tight Pierre shale across much of the length of South Dakota.

European scientists developed by experiment and observation during the 19th century most of the basic principles of ground water hydrology. Particularly notable was the work of Eugene Belgrand and Gabriel Daubrée in France, Adolph Thiem and A. Herzberg in Germany, Edouard Suess and Phillip Forcheimer in Austria, William Whittaker and Horace B. Woodward in England, W. Badon Ghyben in the Netherlands, and a number of other scholars in Belgium, Sweden, Italy, and Russia. Toward the end of the 19th century American geologists like T. C. Chamberlin, John Wesley Powell, Robert T. Hill, Israel C. Russell, Nelson H. Darton, Frank Leverett, and William H. Norton were preparing excellent reconnaissance studies of ground water reserves and artesian conditions in specific areas of the United States. Their work has been continued by Walter C. Mendenhall, Arthur C. Veatch, and many other research men, for the most part associated with the federal and state geological surveys.(11) Much detailed work remains to be done, and the federal penury in allotting money for ground water investigations, comparable only to the situation of the topographic mapping program, is most regrettable.

Much excellent work on ground water problems has been accomplished by members of the International Union of Geodesy and Geophysics, organized in Brussels in 1919. The International Union formed a Section of Scientific Hydrology, later called the International Association of Scientific Hydrology, which has held a number of international conferences. Since 1930 the American Geophysical Union, a member of the International Union, has had its own Section of Hydrology, with a number of committees working on such topics as snow, glaciers, evaporation, runoff, the dynamics of streams, underground water, and the physics of soil moisture. In its bi-monthly *Transactions*, the American Geophysical Union has published several hundred valuable research papers concerned with scientific hydrology, and the same society has compiled an impressive *Bibliography of Hydrology* published in several parts during the past twenty years.

Applied hydrology—what to do about it—has been the concern of such federal agencies as the U. S. Army Corps of Engineers, the Bureau of Reclamation, the Forest Service, the Soil Conservation Service, the Tennessee Valley Authority, and various inter-agency committees like the Arkansas-White-Red River Basins Inter-Agency Committee which submitted a major report on water development prospects in this part of the country only a few weeks ago. General research groups such as the Water Resources Committee of the National Resources Planning Board, which functioned over a four year period (1939-1943) during the Roosevelt administration; the President's Water Resources Policy Commission and President's Materials Policy Commission appointed during the Truman administration, study groups employed by the Interior and Insular Affairs Committee of the House of Representatives, and task forces of the Commission on Organization of the Executive Branch of the Government, under the direction of former President Hoover, have made many valuable and challenging suggestions on water management.

As a nation, the United States seems to be in no danger of a serious water shortage for at least several decades, but the rapidly rising per capita consumption necessitates further research on the fund of water available and its rate of recharge, more attention to the prevention of waste and pollution, additional provisions for storage and re-use, and closer study of the matter of legal priorities and allocations. Of the 8½ inches of annual precipitation which now finds its way back to the ocean through surface streams, less than one inch, or about 160,000,000 acre-feet, Thomas and others have estimated, is put to any productive use along the way.(12) Local shortages exist, to be sure, especially in the arid and semi-arid west, where over large areas the potential evapotranspiration exceeds precipitation. In the humid east, tremendous demands for industrial water may require its reuse many times. In the Mahoning Valley of eastern Ohio, the river water is reused by the steel mills of Youngstown as many as ten times, and the river has been known to reach a temperature of 140°F., even in the month of December.

On the basis of studies made by the U. S. Public Health Service and the American Water Works Association at the close of World War II, the average per capita use in the United States varied at that time from about 60 gallons per day in communities of less than 500 people to 140 gallons per day in cities of more than 10,000(13). For reasons not entirely clear, per capita consumption just before the last war was nearly four times as high in New York, Philadelphia, Baltimore, Chicago, and Detroit as it was in such large European cities as London, Edinburgh, Paris, Berlin, and Vienna.

The President's Materials Policy Commission(14) reported that in 1950 the daily use of water by major use-categories in the nation was as follows:

	Billions of Gallons	Percentage of Total
Municipal and rural domestic use	17	9
Direct industrial use	80	43
Irrigation use	88	48
	185	100

Municipal and rural domestic use has risen phenomenally during the 20th century with the installation of indoor plumbing facilities, air conditioners, automatic washing machines, dishwashers, and garbage grinders, and with widespread suburban lawn sprinkling and automobile washing. The Commission anticipated that by 1975 the domestic use of water would increase from 17 to 25 billion gallons, but that by 1975 domestic use would constitute only 7% of the total water used. Irrigation water used was expected to increase from 88 to 110 billion gallons per day, but the percentage of total consumption devoted to irrigation would decline from 48% to 31%. Direct industrial use, it was estimated, would increase from 80 to 215 billion gallons per day, and by 1975 would account for 62% of all water used.

The economic return from water made available for non-domestic uses needs to be kept under continuous review. In relation to value added by manufacture, the industries concerned with iron and steel manufacturing, pulp and paper production, and oil refining are by far the heaviest users of water in the industrial group. Some students of the American water supply problem would give a much higher priority to industry than to irrigation farming at a time in history when the disposal of crop surpluses is a major issue in national politics. Irrigaton easily represents the greatest consumptive use of water at the present time, since most irrigation water is used only once, while with adequate sewage treatment and pollution control more than 90% of the water used by cities for domestic and industrial purposes can be returned to the streams for use farther down the valley. The social value of a surface water supply for recreational purposes like fishing, boating, swimming, and skating is difficult to determine, but it obviously must bear some relation to the cost of providing the facilities.

Ground water, which supplies about 85% of all the water used in Germany, plays a lesser but increasing role in the United States. A recent compilation of data on ground water resources suggests that the United States has in storage beneath the surface an amount of water comparable to 10 years' annual precipitation or 35 years' runoff. This underground water represents far more than the total capacity of all our artificial and natural reservoirs, including the Great Lakes(15). Ground water withdrawals in the United States now total 17 to 20% of all water used for domestic, industrial, and irrigation purposes. Irrigation, of course, is the heaviest user of ground water in our country, accounting for 60% of the total withdrawn. The four states of California, Arizona, Texas, and New Mexico account for more than two-thirds of all the ground water used in irrigation, and all of these states have areas where the rate of withdrawal is considerably in excess of the rate of replacement. Unfortunately, ground water surveys are still far from adequate, and the work of completing such surveys will require several more decades at the present rate of progress.

I should like to conclude with a few comments on the water situation in Oklahoma, to which I have given closer attention in an earlier paper.(16) From a mean annual rainfall varying from 17 inches in the western panhandle to more than 50 inches in the Ouachita ridges near the Arkansas border, the state has a surface runoff of approximately 37,000,000 acre feet, of which only a small fraction is put to any productive use. Some of the runoff, like that of the Elm Fork of the Red River, the Salt Fork of the Arkansas River, and the Cimarron River from Harper County eastward, is unfit for use because of a naturally high salt content. Other streams, such as the North Canadian River below Oklahoma City, Little River, Salt Creek, Wewoka Creek, and several small streams in Osage, Kay, and Creek counties have been polluted by the improper discharge of salt water from oil wells.(17)

Most cities in the eastern third of the state have ample supplies of water either below the surface or in nearby impoundments. With permissive legislation, further productive use could be made of the water in such large reservoirs as the Lake O' the Cherokees (Grand Lake), Tenkiller Ferry Reservoir, Fort Gibson Reservoir, Hulah Reservoir, and Wister Reservoir. Cities in the central and western part of the state, including Oklahoma City, Enid, and Norman, have experienced rather serious water shortages and are looking for means of enlarging their supplies. Reservoirs in western Oklahoma, such as Lake Altus, Canton Reservoir, and Fort Supply Reservoir are generally low and sometimes nearly empty.

The large reservoirs built in our state by the federal government during the past twenty years, and the 100,000 or so farm ponds built during the same period, have changed the geographic aspect of Oklahoma in striking fashion. Many more changes are on the drawing boards of the Corps of Engineers, the Bureau of Reclamation, and the Soil Conservation Service, and new dams will be built as soon as funds become available. The list of authorized federal projects includes the Keystone Reservoir on the Arkansas River above Tulsa and the Eufala Reservoir on the lower Canadian River, each of which would cost, according to a 1955 Corps of Engineers estimate, $153,000,000(18). Rather interestingly, the official cost estimate of the two projects combined increased by $39,000,000 between 1953 and 1955. Federal appropriations will have to be somewhat more liberal than the $500,000 or so made available by the last session of Congress for a start on the Eufala project, or the Engineers will fall ever farther behind in their efforts to complete them.

The only large authorized project in the western half of the state is the Optima dam and reservoir on the upper North Canadian River in Texas County. In view of the large flood storage capacity generally available in the Fort Supply and Canton reservoirs, it seems doubtful that an additional shallow lake on the North Canadian farther upstream than Canton Lake, in an area where the mean annual runoff is scarcely half an inch and the mean annual reservoir evaporation is nearly six feet, would justify a proposed expenditure of nearly $23,000,000.

With minor exceptions, water for domestic use in Oklahoma is already abundantly available, either from ground water sources or surface lakes and streams. Nearly three-fourths of the communities in Oklahoma with a public water system, according to a 1951 joint study of the U. S. Geological Survey and the Oklahoma Planning and Resources Board(19), still depend entirely on subsurface water for their municipal supply. Most of the larger urban communities, especially the ones with substantial industrial water requirements, already depend mainly on surface streams and impoundments and are looking farther afield for additional supplies. Oklahoma City, for instance, is considering a number of possibilities—a low dam and weir on the South Canadian River near Union City to skim the surface from occasional floods on that stream for diversion over the low divide into Lake Overholser, the construction of a reservoir on the Little River east of Norman, a project now delayed by the discovery of oil under the reservoir site, the building of a reservoir on the Kiamichi River near Antlers with an aqueduct and pumping system for pulling the water uphill to the capital city, and a pump line of comparable length to draw water from Tenkiller Ferry Reservoir, providing the necessary water rights can be secured.(20)

A small fraction of the state's electricity requirement is being met by hydroelectric plants below the dams on Lake Texoma, the Fort Gibson and Tenkiller Ferry reservoirs, and the Lake O' the Cherokees, and there is a strong likelihood that work will be started soon on the Markham Ferry project on the Neosho River below the Lake O' the Cherokees if the Grand River Dam Authority is able to make satisfactory arrangements for the sale of current. As has been the case with most of the other large water projects in the state, the federal government would assume all of that portion of the total cost allotted to flood control.

The federal Soil Conservation Service, Bureau of Reclamation, and Corps of Engineers; the Arkansas-White-Red River Basins Inter-Agency Committee, Oklahoma A. & M. College, and various local groups in the state have studied the possibility of extending irrigation agriculture in Oklahoma. Slightly more than 2,000,000 acres in the state are considered to be physically suitable for irrigation, with roughly half of this acreage on the high plains between the rivers and the other half on river flood plains and terraces. Unfortunately, even by using water with the maximum tolerance in soluble salts, the potential supply of water from both surface and subsurface sources appears adequate for less than one-fifth of the otherwise suitable acreage.(17) Even the large reservoir of Lake Altus, completed by the Bureau of Reclamation in 1947 and designed to irrigate about 50,000 acres, had very little water available for irrigation during the dry season of 1953. Irrigated acreage in the state is estimated by Murphy(21) to have increased from 166,000 acres in 1954 to more than 220,000 acres in 1955.

The new Oklahoma Ground Water Law passed by the state legislature in 1949(22) provides for state control over rights to the use of ground water "other than ground water flowing in underground streams with ascertainable beds and banks"—whatever that means. I presume it means control of all ground water not in the alluvium of our present river valleys. While anyone may use ground water for domestic purposes and the watering of livestock, the use of ground water for other purposes is possible only after securing a permit or license from the Water Resources Division of the state Planning and Resources Board, which is authorized on request after a given ground water basin is adjudicated and the rates of safe yield and annual recharge are determined. During the first five years after the passage of the Oklahoma Ground Water Law approximately 3,000 new applications were filed requesting water rights for water to be used in irrigation or industry.

After long negotiations with Texas and New Mexico over rights to the surface flow of the Canadian River, an interstate compact was signed and given federal approval in 1952. Interstate compacts are urgently needed to allocate equitably the water in the channels of the Arkansas and Red Rivers. From time to time there are rumors that Dallas and other Texas cities are trying to get permission to pump water from Lake Texoma. If Oklahoma fishermen, resort owners, and users of Denison Dam electricity want to save their fair share of Lake Texoma water, it is high time someone found out how much of the water in that lake belongs to us. It is also high time that we have a state water authority empowered to create and finance regional water supply districts, if not precisely like that proposed by Senator Miskovsky in the last session of the state legislature and killed by pressure from irrigation interests, at least something like it.

Water is a popular subject in Oklahoma, and some of those who know the most about it—certainly the speaker does not put himself in that category—are the least vocal about it. Experts in fields like life insurance, business statistics, banking, industrial development, and politics are speaking and writing with great enthusiasm and some knowledge on problems of Oklahoma water. Those who know the most about Oklahoma water, and I would include in that category not only the amply vocal engineers of the U. S. Corps of Engineers, the Bureau of Reclamation, and the Soil Conservation Service, who have a private stake in seeing that large sums of public money are spent on water development in Oklahoma or somewhere, but also the patient scientists in the U. S. Weather Bureau, the Surface Water and Ground Water Branches of the U. S. Geological Survey and the state geological surveys, as well as scientists working in various other fields—yes, even including geography—at our colleges and universities.

If people who know how to go about finding out the essential facts concerning our water supply, where it comes from and where it goes to, what it is good for and what it is not good for, how far it can be stretched and what it costs to stretch it, if these people are only consulted by those in a position to spend private or public money for new water developments, we may be able to avoid unwise expenditures on dry irrigation ditches and industrial plants where industrial water is uneconomically expensive. Local, state, and national development are not retarded, in the long run, by taking time to find out as many as possible of the essential facts. Oklahoma still has a considerable amount of water available for domestic use and for the expansion of both industry and irrigation. If we do not insist on planning water use in ways and places that are neither necessary nor economical, and if we will cooperate with Nature in the utilization of one of her most bountiful gifts—H_2O—there is a reasonable prospect that we may be able to have enough water for practically everybody.

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