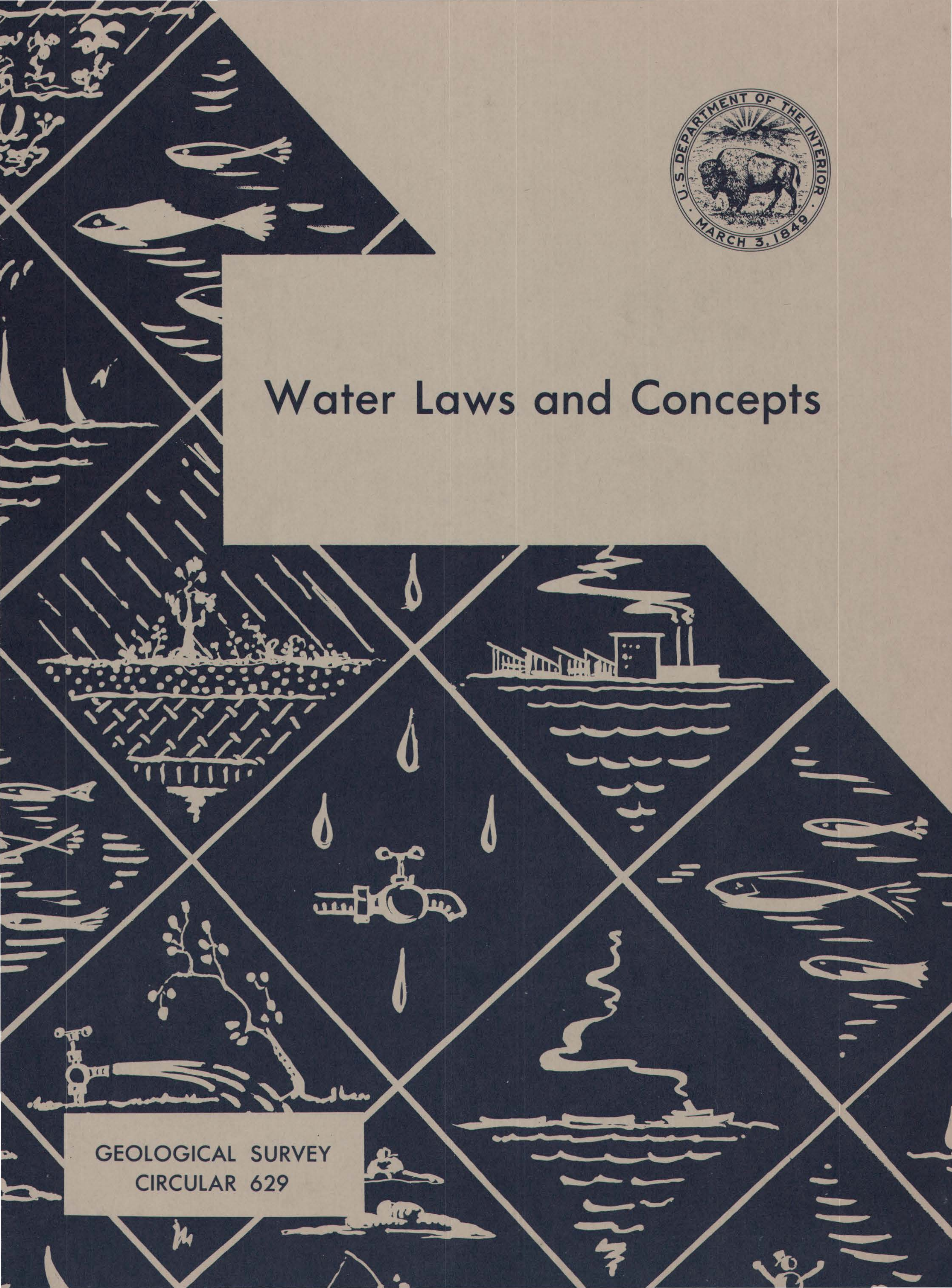

Water Laws and Concepts

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By Harold E. Thomas

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ABSTRACT

Throughout human history various laws and customs have developed concerning the individual rights and rights in common to the waters of the earth. Many existing laws and concepts are clearly influenced by the environment in which they originated and reflect the relative abundance or scarcity of water. Many concepts reflect the people's original interests in the water and once established have been passed from generation to generation with little modification. Some laws and concepts have been carried by people in their migrations and colonial expansions to vastly different environments, with rather curious consequences. In many places water laws that had been well adapted to the natural environment have become less tenable because of man's activities in modifying that environment, or becuase of increasing use of water: Increasing consumptive use shifts the water economy toward lesser abundance or increasing deficiency; increasing nonconsumptive use results in pollution of the water resources, so that they become less suitable for other users. The water-rights systems in the United States vary from State to State: some are reasonably fitted to their environment, some have outlived their place in history, some are wasteful of water, some show favoritism to certain special interests or segments of the population. Water-use rights are universally recognized as real property, with constitutional protection against deprivation without due process of law.

[1]Orginally published in the Transactions of the American Geophysical Union, 1969, v. 50, no. 2, p. 40–50.

INTRODUCTION

A publication on water management of the National Academy of Sciences (1966, p. 38) contains the following statement:

> In the public allocation process it is unlikely that society will welcome widespread and strict allocation of water. Water is regarded as a birthright of Americans—a common holding in which there are common stakes. Other commodities are not so regarded; water is singled out for special consideration.

This statement is an expression of human rights without qualification as to property or economic status. It also implies that people have rights to water suitable and adequate to their needs wherever they may be.

As a nation we have enough water for everyone's needs. There is no nationwide shortage and no imminent danger of one (National Academy of Sciences, 1966, p. 1). Local and regional shortages of usable water do exist—some imposed by the natural distribution of precipitation and others by pollution of fresh-water supplies—but science and technology are enlarging the range of possible alternatives in water management to alleviate this situation. With our existing technology, water of a specific quantity and quality can be delivered anywhere on the continent, provided that someone is able and willing to pay the costs, which technologies are attempting to reduce.

Until recently the rights in common to water, applicable to each member of the mass of population, have received far less attention than the individual rights to use water, recognized as property rights. However, most Americans, and practically all urbanites, obtain water as one of the "utilities," available upon demand, and for them water thus has become a common holding in which there are common stakes. Advancing technology, increasing affluence, and economies of scale are increasing our capabilities of surmounting whatever limitations may be imposed by natural environments, and it is likely that an increasing proportion of the total population will in future obtain water as a utility available upon demand, wherever they may be. The public rights in common to water are not specifically mentioned in the U.S. Constitution, and their protection has been developed over the years by increasingly broad interpretation.

It may well be that the concept of a "birthright" to water has grown with increasing urbanization. Several cities, when faced by a demand for water beyond the capabilities of the local supplies, have had the financial and political "muscle" to import supplies from sources tens and even hundreds of miles away. Today there are millions of urbanites whose water rights can best be described as common stakes in a common holding, since, whether they know the direct costs of water supply and disposal or not, they pay social costs in the form of local, municipal, county, State, or Federal taxes.

Advancing technology, increasing affluence, and economies of scale will make possible the development of farflung storage and distribution systems to move water from sources of supply to areas of demand, even including interregional transfers. Thus it is likely that an increasing proportion of the total population will receive water as one of the utilities, upon demand, once limitations imposed by the natural resources are surmounted. The concept of water as a utility, to be made available to man in whatever environment he may be, constitutes recognition of the right of every individual to water as a flow resource, a usufructuary right to a rate of flow set by his demands.

This concept is by no means universally established in law. Under those legal concepts developed when man attempted to adapt to his environment rather than to change it, a water right is a usufructuary right and is also real property, implying a stability greater than is possessed by water as a flow resource and more comparable to the stability of the land. If the inevitable natural fluctuations in the resource cause damage, this is accepted as one of the hardships this planet is periodically tossing at its inhabitants; but if any man is partly responsible, he may be subject to injunctions and damage suits. Thus many water rights are vested "in perpetuity," and the conditions under which the rights were established should not be changed by man: when once found to be navigable, a waterway remains so; natural shorelines and levels of lakes should not be changed by man; in some areas a well owner is considered to have a right to the water level or artesian pressure that existed at the time his well was drilled; along some streams every riparian owner has a right to the natural flow undiminished in quantity and unimpaired in quality by anyone else.

Many of our existing water laws and concepts are clearly influenced by the environment in which they originated; the characteristics of hydrologic environments are summarized below. Also, many concepts have been passed from generation to generation with little modification: these concepts are described subsequently as influences of heredity.

INFLUENCE OF ENVIRONMENT

Mankind has been able to occupy almost all the great variety of environments afforded by the land masses of the earth without modification of his basic biological requirements for "fresh" water by selective use of the waters available in each environment. The origin of practically all the fresh water on earth is traceable to a natural distillation process powered by solar energy and consisting of the three stages of evaporation, transport, and precipitation. The term "hydrologic cycle" denotes this circulation from oceans through the atmosphere to the lands, and then, possibly with numerous delays, back to the oceans.

THE HYDROLOGIC CYCLE

More than 97 percent of all the water on earth is in the oceans (Nace, 1964). Solar heat is sufficient to cause evaporation of water at an average rate of 1 meter a year over the surface of the globe (Budyko and Kondratiev, 1964, p. 552), although the rate is far less at the poles and greater in the tropics. Thus the oceans represent a vast water reservoir, of which only a very small proportion is involved in the hydrologic cycle: a molecule of ocean water has a statistical chance of getting up into the atmosphere once in 3,500 years and even less chance of being carried over land to be precipitated. (This statistic is based on the estimate that the average depth of the oceans is 3,500 meters and therefore 3,500 times the average annual rate of evaporation.) The lands gain more water by precipitation than they lose by evaporation: over the conterminous United States the long-term average annual precipitation is about 750 millimeters (30 inches); the average outflow to oceans by runoff in streams is about 200 millimeters (8½ inches); and the difference of 550 millimeters (21½ inches) is the estimated average annual evaporation within the Nation's boundaries plus the unknown subsurface flow to oceans, presumed to be small (Piper, 1965).

Precipitation includes all forms of water particles that fall from the atmosphere and reach the ground. Precipitation from a storm is either absorbed in the soil (infiltration) or, in cases of heavy rain or snow, accumulates on the surface or runs off overland. This **overland runoff**, if any, may continue only until the water finds a place where it can infiltrate into the ground, or it may enter a channel, drain, river, or lake. The **stormflow** collects in the various channels of the drainage system, where it may create flood stages and inundate lands capable of absorbing part of the water; this stormflow may continue for days or weeks and may eventually be debouched by the trunk river into an ocean.

After the storm, the surface materials dry off. Some of the water in the soil also evaporates, and some is used in the life processes of vegetation, including transpiration, which returns water as vapor to the atmosphere. Thus **soil moisture** constitutes temporary storage of flow resources in the hydrologic cycle, which resources benefit man by sustaining plants for food, forage and forest, but which are likely eventually to return to the atmosphere by **evapotranspiration.**

If water infiltrates into soil in excess of the soil's capacity for retention, it moves downward by **percolation** through the soil and underlying unsaturated materials; when it reaches a zone where all pores are full, it becomes **ground water.** A ground-water reservoir is made up of rock strata or rock materials sufficiently permeable to yield water to wells and springs; such strata are also called aquifers, or waterbearers. In them the flow is largely lateral, in the direction of decreasing head, and moves at slow rates because of the friction of the porous medium. Some ground water may travel only a few meters before it reappears at a sloping land surface as a seep or a spring. Some may be at shallow depth below the land surface, so that it can be reached by the roots of **phreatophytes** (plants whose roots tap ground water) and thus return to the atmosphere by transpiration. By contrast some ground water may travel long distances underground and some may never reappear at the land surface, discharging instead directly into an ocean. Between these extremes, most ground water moves slowly underground at sufficient depth to be invulnerable to evapotranspiration, until it is forced to the surface by a barrier of impermeable material, or until it discharges into a body of surface water. The ground water discharged into streams is a substantial component of the total stream runoff; it constitutes the sustaining or **base flow** of most perennial streams and is conspicuous during periods when there is no precipitation and no storm runoff.

The water that is rejected or ejected by the subterranean storage facilities of the lithosphere becomes **surface runoff.** Permeable materials in the path of this runoff may permit infiltration of some or all of the water. This is true of runoff in all drainageways of all sizes, from minor gullies to large rivers; wherever physical conditions are favorable, water is absorbed into the bed and banks. Thus, some surface water becomes subterranean water: in many places, such as in the Western United States, streams contribute significant recharge to ground water.

The surface runoff to the oceans is composed of waters that may have had a great variety of vicissitudes on the lands. Some of these waters may be direct runoff from rainfall only a few hours or days earlier or from snowfall several months earlier. Some may have been surface water at all times but have been retained for months or years by storage in swamps, lakes, or reservoirs. Some may have been subterranean water for a very short period before reappearing in a stream. Some may have been in ground-water reservoirs for many years and then reappeared as springs or as more diffused base flow in streams. In the water discharged to the oceans, the bulk of the dissolved material has been picked up during the subterranean phases of the hydrologic cycle, and the floating and suspended solids are transported in the turbulent flow of surface water.

In sum, the water that falls as precipitation upon the lands may become subterranean water by infiltration and then move downward by percolation and laterally by laminar flow as ground water; or it may move over the land surface, chiefly by turbulent flow; or it may alternate between surface and subsurface water during its earthly cycle. In this movement there are numerous delays that result in accumulation or storage of water. Wherever the water is within reach of the atmosphere, or within reach of plant roots, it may return to the atmosphere by evapotranspiration and thus fail to reach the ocean. The "work" performed by water during this cycle has been described in an earlier paper (Thomas, 1965).

In addition to the replenishable resources, there are fresh-water accumulations underground from bygone years or centuries of precipitation, which in the aggregate have a far larger volume than could be replenished by the annual precipitation and infiltration (Nace, 1964). These stock resources of ground water are estimated to aggregate about 0.6 percent of the total water on earth.

HUMID REGIONS AND ARID REGIONS

The pattern of average annual precipitation, based on records available from thousands of localities for more than 30 years and from several towns for more than a century, reflects the composite effect of the many factors responsible for precipitation. In the United States, the range is from less than 50 millimeters (2 inches) in Death Valley, Calif., to more than 11.7 meters (460 inches) on Mount Waialeale in Kauai, Hawaii. But, as pointed out by Thornthwaite (1948), we cannot tell whether a climate is moist or dry by knowing the precipitation alone. Tucson, Ariz., with average annual rainfall of 275 millimeters (11 inches) has a drier climate than Barrow, Alaska, where the average annual precipitation is only 110 millimeters (4½ inches). We must know whether precipitation is greater than the amount that can be pulled back to the atmosphere by solar energy, thus creating a surplus, or less than the amount that the solar energy could evaporate if the water were available. Desert vegetation is sparse and uses little water because water is deficient. When water supply rises, as in a desert irrigation project, evapotranspiration rises to a maximum that depends only on the climate: This is called **potential evapotranspiration,** as distinct from actual evapotranspiration. According to Thornthwaite's maps, the climate of the 31 Eastern States is moist or humid, although there are summer deficiencies in the Southern States; the six Plains States are generally in the subhumid-semiarid category, where average precipitation and potential evapotranspiration are nearly the same; the 11 conterminous States farther west are characteristically semiarid or arid, except for the humid mountain ranges, and most of the ranges have a summer water deficiency. Generally the potential evapotranspiration is greatest in the tropics and least in polar regions. Because of its minimum solar radiation and minimum evaporation, Antarctica is a region of water surplus as ice, even though the average annual precipitation is only 150 millimeters (6 inches) (Bentley, 1964, p. 383), less than in many parts of the arid Southwest. This surplus is returned to the ocean as icebergs (Shumskiy and others, 1964, p. 431) at an annual rate equivalent to three times the volume of water in Lake Erie. The stock resources of water in Antarctica is 1.6 percent of all the water on earth, and about two-thirds of the world's fresh water.

Humid regions, where average precipitation exceeds potential evapotranspiration, are regions of water abundance sufficient for vegetation and for a perennial surplus that appears as runoff in streams; also, closed depressions fill with water to form lakes that overflow. In arid regions, by contrast, the moisture requirement of vegetation is not satisfied in full, closed depressions may be occupied by temporary or saline lakes that do not overflow, and water is generally not available for overland flow to streams. These are areas of perennial water deficiency.

The averages upon which we base our classifications of climate hide very wide variations in daily, seasonal, and annual precipitation. National extremes, as shown by records of the U.S. Weather Bureau, range from 980 millimeters (38.7 inches) of rain in 24 hours at Yankeetown, Fla., to no measurable rain for 767 days at Bagdad, Calif. In a given year the annual rainfall in a desert community may range from 0.1 to 4 or 5 times the longtime average; in humid regions the range is less in percentage of the mean but greater in amounts of precipitation. Chiefly because of the variations in precipitation, the areas of water surplus and water deficiency enlarge or diminish reciprocally from one season to another and from a wet year to a dry year. Extreme variations from the average precipitation in any region, humid or arid, may create exceptional surpluses, evidenced in floods, during individual storms or individual years, and also exceptional deficiencies, evidenced in droughts, during periods that may be measured in months or years.

EFFECTS OF MAN UPON NATURAL FLOW SYSTEMS

Man's uses of water may be consumptive or nonconsumptive. In consumptive uses such as boiling, perspiring, or growing plants by irrigation, the water becomes vapor in the atmosphere, as it does in natural evapotranspiration processes. In nonconsumptive uses such as washing, processing, or cooling, the water carries off waste and unwanted products: these become pollutants when the water reenters a natural flow system. Man's achievements have been to intercept water while it is still fresh and before it can return to the atmosphere or ocean, to use it, and then to let it go again to atmosphere or ocean. Man's uses of water either reduce the quantity or impair the quality of the fresh-water resources, and many uses do both.

In addition to these effects of his uses of water, man's activities produce a variety of side effects upon the natural flow systems. The modification of these flow systems has been intentional and is essential if people are to have suitable water and be protected from natural excesses or deficiencies. It is true that some effects have not been foreseen: for example, the dust bowls that followed cultivation of semiarid grasslands during natural drought, the downward cutting of the river channel by the clear water discharged below Hoover dam, and recently the alewives that reached Lake Michigan by using a navigation channel to bypass Niagara Falls; but the causes were clear after the event. Increasing knowledge of the flow systems makes it increasingly possible to predict all the effects, including long-delayed effects, of human activities upon the systems. Even then, untoward effects and even disasters will not be eliminated because some are so rare that protection against them is uneconomic, but at least they will be *calculated* risks.

When a dam on a river creates a reservoir, it is likely that questions have already been resolved as to how much space to reserve for flood protection downstream and how much water to store for future diversions downstream and for recreational use. The sediments are no longer carried out to sea; they accumulate instead in the reservoir or along the channel upstream. Clear water released down the channel from the dam is no longer in equilibrium with the channel bed and may erode it. Some of the water diverted from the reservoir and used for irrigation may accumulate as ground water, perhaps eventually waterlogging the soil, and it may carry dissolved minerals into the irrigated soil, where they accumulate as the water disappears by evapotranspiration. A significant proportion of the water stored in the reservoir may be lost by evaporation, and the concentration of dissolved salts is thereby increased.

The development and use of wells cause progressive changes in both the stock resources and the flow resources of ground water (Thomas and Peterson, 1967). Initially the well causes a withdrawal of water from storage, evidenced by lowering of water levels in nearby idle wells reaching the same aquifer. The depletion of storage will continue, in a progressively expanding area, until (1) additional water from a stream or lake or from rain is induced to enter the aquifer, thus making up at least in part for further discharge by the well, or (2) the natural discharge from the aquifer is reduced by an amount equivalent to the withdrawal from the well. A well can yield a perennial supply only by diminution of flow or of evapotranspiration discharge in some other part of the natural system, but it may draw upon the stock resources for periods ranging up to many years before the flow resources are affected.

Man's occupancy of the land or his development of resources other than water (Thomas, 1951) sometimes modifies the water resource substantially. Changing grasslands and forests to cultivated lands may reduce the permeability and increase the erodibility of the soil; draining of wetlands may lower the water table in a broad surrounding area; constructing impermeable surfaces in urban areas may reduce the natural recharge to ground water; disposing of waste waters from mines, oil fields, and industrial plants may contaminate usable surface-water or ground-water resources; constructing navigation channels may make aquifers vulnerable to the entry of salt water.

INFLUENCE OF HEREDITY

The basis of a water right commonly reflects in some degree the water environment in which it originated. In deserts, water is the limiting factor in man's occupancy of the land: water may then constitute the main object of real property, the land being of secondary importance, so that land titles alone may be valueless. Water in humid regions is as essential to life and prosperity as in arid regions, but since it can more readily be taken for granted, it becomes of secondary consideration and accessory to the land.

REGIONS OF WATER ABUNDANCE

People are likely to be unconcerned about water rights so long as the water supply is more than adequate in both quantity and quality for all needs and yet not enough to cause damage. Under such circumstances it has long been recognized that water should be available to everyone. Justinian, in his Classification of Things (A.D. 534) designated several significant parts of the hydrologic cycle as res communes, incapable of exclusive appropriation:

> By natural law, these things are common to all: air, running water, the sea, and as a consequence the shores of the sea.

The use of running waters through the ages has given rise to frequent disputes. In such controversies a distinction has commonly been made between streams that are navigable and those that are not, reflecting the importance down through the centuries of water transport and commerce. Very generally, navigable (and "floatable") streams or other surface-water bodies are regarded as public waters, since they are accessible to all, and the waters are thus res communes in the broad sense. Use of such waters by individuals is generally permitted, provided that there is no interference with or hindrance to navigation.

Nonnavigable streams are not accessible to the general public except by easement or trespass over the land of the riparian landowners. These waters are res communes in the restricted sense that they are available only to the community of landowners bordering the stream. During the Middle Ages such riparian rights were frequently in dispute because of stream diversions that resulted either in deprivation of the use of water or in damage by flooding. There was considerable diversity in court decisions in such disputes, ranging from a ruling in Scotland in 1624 that a man owning land upon a stream may protect it from diversion by others, irrespective of whether or not he was using the stream, to a ruling in England in 1831 that the person who first appropriates any part of the water flowing through his land to his own use has permanent right to the use of so much as he appropriates (Wiel, 1918).

Today, although there are many variations in detail, there is rather general acceptance in many humid regions of the following principles of the riparian doctrine in the law of watercourses (*Tyler* v. *Wilkinson*, 1827; *Mason* v. *Hill*, 1833; *Wood* v. *Waud*, 1849). The use of a stream is confined primarily to the riparian owners, excluding nonriparian owners or lands, and is so confined without preference because of priority of use or penalty because of nonuse. The use by every riparian must be reasonable (*Dumont* v. *Kellogg*, 1874). By requiring that uses be for "natural purposes" or that each user return the flow to the channel, substantially undiminished in quantity and unimpaired in quality, this doctrine overcomes the advantages that the upstream owners would have by natural position, and it tends to equate the rights of all riparians.

This general acceptance can be traced chiefly to the Code of Napoleon of 1804 whose first application in the Eastern United States is credited to Justices Story (*Tyler* v. *Wilkinson*, 1827) and Kent (*3 Kent Comm.*, 1828).

In addition to the running water that Justinian set apart as res communes, the waters of the earth include ground water, soil water, ponds, marshes, lakes, sheet flows from intense rains, and snow and ice fields. In humid regions these have been rather widely considered as appurtenant to the land, under the Roman maxim "Cujus est solum ejus est usque ad caelum et ad inferos." The French Civil Code (Art. 552), stemming from Napoleon, similarly states that the ownership of land includes ownership of everything above and below the surface.

Within the United States the rights to ground water inherent in landownership vary from State to State. By the "English" or absolute ownership doctrine (no longer accepted in England), the right of each landowner, being absolute, is independent of the rights of all others (*Acton* v. *Blundell*, 1843; *Huber* v. *Merkel*, 1903; *Houston & Tex. Central Ry.*, v. *East*, 1904). For England and Wales the Water Resources Act of 1963 (London, H.M.S.O., July 1963) created 27 River Authorities that possess extensive power relating to regulation of water use, including the licensing of water withdrawals from surface- and ground-water sources, the use of "charging schemes" under which water users will be charged for the water they withdraw, and the licensing of all discharges of wastes to streams or underground strata. The American rule of reasonable use recognizes common rights of landowners overlying a ground-water reservoir and protects them against injury by those who would waste water unnecessarily or export it from the area (*Basset* v. *Salisbury Mfg. Co.*, 1862). Under the California doctrine of correlative rights, not only must the use be reasonable, but the rights of all landowners overlying a common reservoir are correlative, and where the supply is insufficient for all, each is to be accorded a fair and just proportion (*Katz* v. *Walkinshaw*, 1903; *Pasadena* v. *Alhambra*, 1949). The resulting situation has been summarized by Trelease (1959):

> The uncertainties that are inherent in these court-made rules of ground-water law, coupled with the uncertainties of the court-devised classification of ground waters into percolating

waters, underground streams, and underflow of streams (which have no basis in science or in fact) leave the water titles of many well owners dependent on physical supplies, the action or nonaction of his neighbors, and his ability to grab what he can while he can.

REGIONS OF WATER SCARCITY

In the extensive desert regions of north Africa and southwest Asia, communities of men have been of two types: those settled at oases, and nomadic tribes dependent upon occasional and scattered availability of water and vegetation. Many of the principles that govern water rights and water use throughout Islam today originate in the teachings of the prophet Mohammed (A.D. 570–632), and these generally accord rights to water on the basis of actual use and need (Caponera, 1954). The right of thirst is accorded high priority, applied on the general Moslem principles of charity and kindness to fellow beings. This is a human right, like the American "birthright" but of smaller dimension. Effective utilization of limited water supplies is encouraged in several ways (Thomas, 1965). Several of the basic concepts of water rights in Islam are similar to those in the arid Western United States, in which beneficial use is the basis, the measure, and the limit of a water right; and the first in time is the first in right.

When the Western United States was settled, the land suitable for occupancy was generally in the valleys, where rainfall was insufficient for agriculture (Powell, 1878). The lands receiving adequate precipitation are mountainous and generally unsuitable for occupancy. Many of the settlers therefore chose the most suitable land available and appropriated water that had originated elsewhere in quantities sufficient for their needs. This practice was sanctioned in an early decision (*Tartar* v. *Spring Creek Water and Min. Co.*, 1855) of the California Supreme Court:

> ***a prior appropriation of either (wood or water) to steady individual purpose establishes a quasi-private proprietorship, which entitles the holder to be protected in its quiet enjoyment against all the world but the true owner.

Final acceptance of appropriative rights depended upon the "true owner" referred to in this decision. By cessions from various countries and by voluntary purchase, the United States had become the owner, subject to private rights already vested, of huge territories, including land and water. The Constitution gives Congress the power to dispose of and make all needful rules respecting this territory. By legislation in 1866 and 1870, Congress recognized as valid the appropriation system that had grown up among the occupants of public lands. As owner of the public domain, the United States had the power to dispose of the land and water thereon together or separately. Subsequently the Supreme Court (*California Oregon Power Co.*, v. *Beaver Portland Cement Co.*, 1935) held that, after the Desert Land Act of 1877, if not before,

> all nonnavigable waters of the public domain became publici juris, subject to the plenary control of the designated states, including those since created out of the territories named, with the right in each to determine for itself to what extent the rule of appropriation or the common-law rule in respect of riparian rights should obtain. For since "Congress cannot enforce either rule on any state," *Kansas* v. *Colorado*, 206 U.S. 46, 94 (1907), the full power of choice must remain with the state.

However, according to the Pelton Dam decision (*Federal Power Commission* v. *Oregon*, 1955) and several subsequent decisions by the Supreme Court, the Acts of 1866, 1870, and 1877 did not constitute intent to surrender all rights the United States once had to control the use of waters generated by the public domain.

RIVERS IN ARID REGIONS

In several parts of the earth, large rivers flow through fertile but arid plains, constituting an abundance of water in the midst of water-deficient lands. To harness the rivers for use, it has been necessary to create large-scale enterprises that usually were operated by the government. The emergence of big productive water works for irrigation was frequently accompanied by the emergence of big protective water works for flood control. The resulting agrarian economy, which Wittfogel (1956) has called "hydraulic agriculture," required the effective cooperation of large numbers of people (often unpaid labor exacted by force of law) in maintenance of control structures and ditches and in the irrigation and intensive cultivation of crops. This cooperation required organization in depth—planning, record keeping, communication, and supervision—and thus a massive and permanent bureaucracy and a monolithic society. With a minimum of labor-saving tools and animals and a maximum of human labor, the life of the hydraulic farmer was one of unending drudgery. Nevertheless, the great hydraulic civilizations of Egypt, India, China, and the Near East maintained themselves for several thousand years. Wittfogel considers that, before the commercial and industrial revolution, the majority of all human beings lived within the orbit of hydraulic civilization.

SOME PRODUCTS OF MIGRATION

Settlers migrating from Europe to eastern North America found a new environment similar to the old in water abundance and suitable for the concepts of water rights appurtenant to the land that are attributed to the Code Napoleon and the common law of England. As migration proceeded into the arid regions of the West, where land was plentiful but worthless unless a water supply could be assured, different concepts of water rights were developed among the Mormons in Utah, the miners in California, and homesteaders in all Western territories.

In California an act of the State Legislature adopting the English common law in 1850 had a significant effect upon water development in the State (Thomas, 1965). Common law restrictions upon the right to store water contributed to the slow development of large dams on California streams; while much of the spring runoff was wasting to the oceans, landowners could develop wells without restriction, and many of them did so, with resulting overdraft in several ground-water basins. Chief Justice Lucien Shaw of the California Supreme Court (Shaw, 1922) has stated:

> The opponents of the doctrine of riparian rights had pointed out these results with much emphasis and repetition in the political campaign prior to the decision in *Lux* v. *Haggin* and they are still referred to as evidence that the doctrine is contrary to a sound public policy in states having the arid climate of California. The obvious answer on the question of policy is that the objection comes too late, that it should have been made to the legislature in 1850 prior to the enactment of the statute adopting the common law. When that was done the riparian rights became vested, and thereupon the much more important policy of protecting the right of private property became paramount and controlling. This policy is declared in our constitutions, has been adhered to throughout our national history, and it is through it that the remarkable progress and development of the country has been possible.

These problems early in the century gave impetus to comprehensive planning for the water resources (Bailey, 1927; California Division of Water Resources, 1930) and eventually to the adoption and financing of the California Water Plan (California Division of Water Resources Planning, 1957). Today there are about 100,000 irrigation wells in the State that yield nearly one-fourth of the total ground water withdrawn in the United States, and there is still overdraft in some areas. But surplus waters are stored for use in time of need, some are transported long distances to areas of water deficiency, and far less streamflow escapes to the ocean.

In the Southwest some water rights have originated with grants of land and the rights appurtenant thereto made by Spain, Mexico, and the Republic of Texas before the United States had achieved its present boundaries. In determining the rights of holders of title from prior sovereigns, the controlling laws generally are those in effect when the grants were made, and subsequent changes in law commonly recognize rights already vested (Hutchins, 1961, p. 3–6). Because of these rights traceable to former sovereigns, the solution of property rights can be quite complicated (White and Wilson, 1955, p. 10).

To a burgeoning metropolis in the Southwest, one of the most desirable but rare and uncertain water rights is the "pueblo" right, which constitutes a paramount right to all the water needed by a community for its continued growth, but is limited to the towns that received pueblo grants prior to the Treaty of Guadalupe Hidalgo in 1846. This right has been described (Hutchins, 1960) as attaching to all the waters naturally in the watershed in which the pueblo is located: surface water and ground water, including tributaries from source to mouth, and including flood flows that may be stored. The right is perpetual and cannot be lost by nonuse or forfeiture. Thus it hangs like a sword of Damocles over any other inhabitants of the watershed who may be using water or want to use it.

As construed in California the right can extend to encompass growth of a city beyond the original pueblo limits (*Los Angeles* v. *Pomeroy*, 1899). Los Angeles claims such a pueblo right in the Los Angeles River basin, and it was judged superior to that of other riparians, such as the city of Glendale (*Los Angeles* v. *Glendale*, 1943). San Diego also has a pueblo right, deemed superior to any appropriative rights (*San Diego* v. *Cuyamaca Water Co.*, 1930). Subsequently the pueblo right of the town of Las Vegas, N.Mex., was recognized by the Supreme Court of New Mexico (*Cartwright* v. *Pub. Serv. Co.*, 1958), and this introduces complications in a State where appropriation has been accepted as the exclusive basis for water rights. For example, what are the water rights of the city of Albuquerque, which has a history dating from 1706, when it was the pueblo of San Felipe de Albuquerque, and which is situated astride the Rio Grande? Further uncertainty has been introduced by a recent Superior Court decision in California (*Los Angeles* v. *San Fernando et al.*, 1968), which denies the existence of paramount water rights of the pueblo under Spanish law and therefore of the city of Los Angeles as successor in interest; it then lists all parties having mutually prescriptive rights in each of four separate ground-water basins together with the restricted pumping to which they are entitled. This decision is being appealed.

The pueblo right in New Mexico, as in California, is based largely on court decisions in California, without clear evidence of the intent of the former sovereigns (Hutchins, 1960). More broadly, the migrations from Spain to Mexico and northward may well have influenced the local customs and concepts in California, Arizona, New Mexico, and Texas to a degree that is not a matter of record or documentation.

Spain has every climate of the Temperate Zone, ranging from cold and humid to semiarid with hot rainless summers. After the great Moslem invasion of A.D. 711, Spain was subject to the teachings of Mohammed, including the concepts of water rights developed in arid regions. These concepts were especially suited to the semiarid eastern and southern parts of Spain, where Moslem dominance continued until 1492, and where Spain benefited from the introduction by the Moors of efficient systems of irrigation. In subsequent centuries Spain rose to a world power, established a colonial empire, declined in power, and by the early 19th century had lost most of its colonies and been part of Napoleon's empire for several years, thus falling under the influence of the Code Napoleon.

Spain's colonial empire extended well into the boundaries of the present United States, and some water rights in community acequias in New Mexico and near missions in California date from those days. The Commonwealth of Puerto Rico shows the Spanish heritage most clearly in its water rights: the Spanish Law of Waters of 1879 was extended over Puerto Rico in 1886 and was confirmed with slight amendments in 1903 after severance from Spain. Puerto Rico is a tropical but not altogether humid island which, in the southern area where water use is heaviest, is rather like some parts of Spain. There the Spanish Law of Waters has operated for 80 years practically without change. The law is a clear and concise statement of the rights, limitations, and privileges of individuals and of the public in the water resources and is a curious blend of humid-region and arid-region concepts as well. It recognizes certain rights inherent in landownership: the owner of an estate owns all the pluvial waters falling thereon (Art. 1), the waters that rise as springs or headwaters of streams (Art. 5), the water of lakes and ponds on his estate (Art. 17), and the subterranean waters obtained by ordinary wells (Art. 18), which are defined (Art. 20) as wells dug exclusively for domestic use and operated manually; these wells may be used without restriction, even though the waters of his neighbors are diminished thereby. In these and several other articles, the Spanish law is in accord with the water-rights doctrines of humid regions as expressed in the Code Napoleon. Incidental to this importation from other humid regions, Puerto Rico appears to have more laws controlling river navigation than it has river navigation (Art. 134–146).

The Puerto Rican law differs from that in most humid regions and is similar to the General Theory of Waters in Moslem law, in permitting rights to be acquired by actual use of water and in protecting those rights against subsequent appropriators. For example, any landowner may utilize pluvial and other waters flowing intermittently in public channels or along roads (Art. 6, 176, 177); after use for a year he establishes a right superior to that of any subsequent user, on the principle that first in time is first in right (Art. 7); after use for 20 years the appropriator acquires the right to continue the use "indefinitely" (Art. 8), and the owner of the land where these waters originate, by failing to utilize them, loses all right to interrupt the use by these appropriators (Art. 11, 14). A landowner has a right only to the specific quantity of water he actually uses, but this right is valid regardless of fluctuations in the source (Art. 10). Landowners may appropriate large volumes of ground water, provided they do not interfere with preexisting rights to public or private waters (Art. 23).

Concessions are granted in Puerto Rico's public waters, which include rivers, waters flowing through natural beds of perennial and intermittent streams, waters originating on public lands (Art. 4), and ground water underlying public land (Art. 25). The chapter on Special Utilization of Public Waters (Art. 147–225 incl.) is similar to the appropriation system in the arid Western United States, including the requirement for authorization (Art. 147), and the general policy that

> preference shall be given to the projects of greatest importance and utility, and if all other conditions are equal, to those which have first been presented (Art. 157).

Perhaps the greatest weakness of the law today is the inflexibility incorporated into the details concerning preferences in utilization (Art. 160), which express the needs of a centuary ago, when per capita requirements for domestic use were far less than modern standards. Also, concessions for irrigation are granted "in perpetuity" (Art. 188), but the economic importance of water-using industries was not foreseen, and much of the present economic development is based on a low order of preference as to water concessions.

Although the similarities of the Puerto Rican and Western water laws suggest that the appropriation doctrine may have considerable Spanish heritage, other influences are strong. The Mormons in Utah, miners in California, homesteaders throughout the West, the Homestead Acts of Congress, the Colorado State constitution (which adhered to appropriation doctrine, so that it became known as the "Colorado" doctrine), and others are all recognized as having contributed to the development of the appropriation system. And the environment of the West is favorable for originating such concepts, adapted to water scarcity.

EFFECTS OF INCREASING WATER USE

In the United States the aggregate withdrawal use of fresh water in 1965 averaged 270 billion U.S. gallons, or about 1,000,000,000 cubic meters a day, a rate 15 percent greater than in 1960 (Murray, 1968). The withdrawals are from streams, lakes and reservoirs, springs and wells and for industrial, irrigation, municipal, commercial, domestic, and stockwatering uses. These uses have been increasing progressively for several decades, along with population and economic growth.

Water rights become of major concern in times or places of water shortage. As use of water increases in any region, humid or arid, the volume of usable water diminishes, and shortages may occur.

Less than 30 percent of the total water withdrawn is used consumptively and thus returned as vapor to the atmosphere. The principal consumptive use is for irrigation. Increasing consumptive use is likely to reduce the natural resource in times and places of water scarcity and thus is likely to cause or aggravate water "shortages."

All the rest of the water withdrawn is used nonconsumptively, and is thereafter returned to water resources impaired in quality by the addition of floating, suspended, or dissolved materials or by heat, all of which are undesirable to other water users and classed as pollutants. The bulk of the manmade pollution in surface and ground waters comes from water used nonconsumptively under established rights of use, and pollution is likely to increase as nonconsumptive uses increase.

INCREASING CONSUMPTIVE USE

By reducing the quantity of the resource, increasing consumptive use shifts the water economy toward lesser abundance or increasing deficiency. As a corollary, the concepts of water rights developed in environments of abundance become less tenable and may suffer in comparison with those developed in areas of prevailing water deficiency.

Because of mounting demands for water, several Eastern States have examined their water policies and laws critically in recent years. The Water Policy Committee of South Carolina has expressed a typical appraisal of the water concepts developed in humid regions (South Carolina Water Policy Committee, 1954, p.30).

> It is only with the overdevelopment of a stream or other water supply or its curtailment by drought that we realize how outmoded and inequitable our water law has become. It is outmoded in that it recognizes only "domestic uses" of 150 years ago. It is inequitable both to riparian owners and the people of South Carolina as a whole***a riparian owner who early has invested in equipment to use water sees his investment reduced in value as his equipment operates at less and less of its capacity. As an owner in common he has a valuable right; as an individual owner he has a right that decreases in value as it is used in common.

As a possible alternative, many States in humid regions have considered the concepts developed in arid regions, where water scarcity is the rule. The appropriation doctrine does provide specific, exclusive rights, and therefore greater security so long as the supply is available, and in times of drought it provides a means of curtailing use to match the supply. But the axiom "first in time is first in right" seems to give a continuing advantage to hoary pioneers and their successors in interest. Inflexibility is suggested also by the U.S. Supreme Court's definition of appropriation (*Arizona* v. *California*, 1931):

> To appropriate water means to take and divert a specific quantity of water therefrom and to put it to beneficial use in accordance with the laws of the State where such water is found, and by so doing to acquire a right under such laws, a vested right to take and divert from the same source and to use and consume the same quantity of water annually and forever.

Another alternative is to develop a statutory appropriation system for only a part of the water resources, as is done in several States where some waters have been declared by statute to be public waters and subject to appropriation, although other waters are recognized as appurtenant to landownership and therefore privately owned (Hutchins, 1955a). However, this compromise position may become untenable because of the continuity of the hydrologic cycle. As pointed out by Hutchins (1956, p.9),

> Correlation of rights is not feasible in a State which, for example, recognizes exclusive appropriation rights in surface streams and rights of absolute ownership of percolating waters. Even

if such percolating waters are conclusively proved to be physically tributary to a surface stream, the stream appropriator obviously can have no legal claim on them if they are held to be the absolute property of the overlying owner.

One of the humid States that has long had problems of heavy and increasing water use is New Jersey. Ranked the eighth largest State in population and fifth smallest in area, New Jersey's withdrawal use of fresh water is greater per unit area than that of any other State. Growing water demands and conflicts among communities became serious enough by the turn of the century to require State action. In 1907 the State Water Supply Commission was established to regulate the division of surface water for public supply, and its authority was extended in 1910 to cover development of ground water. As summarized by McGuinness (1963, p. 550):

> Regulatory efforts have always followed the principle of equitable allocation among inhabitants, rather than among agencies, in accordance with prevailing riparian doctrine which holds that the water belongs to the people who own the land and not to the State. Thus in effect the State acts under the police power to protect the rights of individuals to use their water. Municipalities as such have no right to divert water, and control of municipal usage is exercised in the interest of equitable apportionment of water among people.
>
> Thus pursued, the State's policies have gained public acceptance, and accordingly the State encountered no serious difficulty when, in 1947, it assumed control over private uses of ground water exceeding 100,000 gpd (U.S. gallons per day) in designated areas. The basis for the control is the argument that by the time a property owner has diverted 100,000 gpd from wells he has exhausted the "riparian" rights he possesses under the common law.

INCREASING NONCONSUMPTIVE USE

Water used nonconsumptively has been withdrawn by the user under established rights and may be recycled and reused several times before it has served all the user's purposes. Eventually the unconsumed water must be disposed of, together with any pollutants added during the nonconsumptive use. Thus increasing nonconsumptive use contributes to the increasing pollution of the Nation's resources. These water resources also receive manmade pollutants from other sources, washed from the atmosphere, or dissolved at the land surface or in the soil, or eroded by overland runoff, so that they are added either to ground-water or surface-water resources, but nonconsumptive use is a major source of undesirable pollutants in water.

Water pollution is only one aspect of the human pollution problem, which has global dimensions and embraces the atmosphere, the hydrosphere, and the lithosphere as far down as man can reach. Each individual must dispose of some wastes, whether by individual or community effort. The average per capita daily waste load of organic materials from food resources is about 100 grams in sewage and 400 grams in garbage. To this basic load must be added the waste end products of mineral, wood and fiber, and other natural resources after use, a load that varies from one individual to another because it increases with increasing affluence and capability to depreciate the "old" and purchase the "new." A further load is the byproducts of the materials and energy used in developing, processing, and maintaining the desired products of our natural resources.

TRENDS IN AMERICAN CULTURE

Only a half century ago the country was preoccupied with the physical scarcity of mineral resources. In succeeding years, the limits of economic scarcity have generally been pushed back, even though the national appetite for resource materials has grown greatly. Technological advances are largely responsible for this progress, and also for the present attitude that the crucial question concerning a specific resource material is whether it can be extracted and put to use economically enough to be competitive with other products suitable for the same purposes. As pointed out by Landsberg (1964, p. 4),

> The natural resources are as important to the nation's survival and welfare as they ever were. Land and its products, water, mineral fuels, and nonfuel minerals still are the indispensable physical stuff that provides the material basis of modern civilization. Indeed, in those uses that serve recreation and the enjoyment of beauty the contributions of land and water are far more than material.

Landsberg summarizes the trends in the U.S. economy, as projected to the year 2000: a tripling of requirements for both energy and metals: almost a tripling for lumber; almost a doubling for farm products and for withdrawal depletions of fresh water; and no basis for estimating other important and fast-growing uses of water, such as for recreation and dilution of wastes— all to serve a population projected to increase at an annual rate of 1.55 percent and to have a gross national product that increases 3.8 percent annually.

With economic growth and increasing use of the natural resources, there are correlative increases in the byproducts of developing and processing those resources and in the end products that result from the various uses of the resources. Some of these byproducts and end products can be reclaimed or reconstituted or otherwise processed so as to be suitable for additional use. But eventually practically all of them become unwanted materials or wastes, and their volume increases in proportion to economic growth and the extraction of natural resources from the earth. Thus, although there is still public concern about scarce resources and continuing search for new sources, awareness and concern have increased about overabundance of unwanted materials: smog, polluted waters, junkyards, garbage dumps and mine dumps, construction wastes, antiquated structures that may become eyesores or slums. The individual initiative that was encouraged to develop the resources of a new continent has been embarrassingly successful: it has provided a plenitude of products and created wealth that permitted the leisure to contemplate the results. But many people view the visual achievements of the American culture with less approbation than was accorded the Creation in the first chapter of Genesis and see the developments of the past as haphazard and unplanned. The desirability of progressive economic growth has been challenged by Boulding (1966, p. 9–10) because of this corollary increase in waste products.

The problems of waste disposal are concentrated especially, as are people and processing industries, in urban areas. The concentration of population in urban areas has been accompanied by modifications of the physical environment in cities. Cities generally modify the natural land surface and the natural pattern of infiltration and runoff from storms by construction of impermeable cover and artificial drains; in some areas there have been man-induced landslides, subsidence of the land surface, erosion, sedimentation, swamps, waterlogging, or vulnerability to flood runoff. It must be admitted that the physical environment as modified by man poses problems that are minor in comparison with the social problems of closely packed living, but to ignore such problems, as most urbanites and most books on urban planning do, is myopic. Clearly the urban environment offers opportunities for research by the earth scientist and also for education of urban officials and planners in the potentialities and limitations of the physical environment. These potentialities and limitations are of critical importance in a major problem of all urban areas: the disposal of the tremendous volume of solid, liquid, and gaseous wastes generated by the people and their industries.

Economic growth with increasing population has been accompanied by— or more likely, has been possible because of—the increasing organization of society. Here the American culture follows the trend of the great hydraulic civilizations of the past, where the control and use of water in large rivers by concentrated populations were predicated upon thorough organization of all available manpower. From individual enterprises comprised of small farms, small businesses, family-owned industries, and local governments, the American trend has been toward big business and big government. In contrast to the hydraulic civilizations, American civilization has been able to move mountains by machines and forms of energy other than manpower. But economic efficiency has been accompanied by concentration of economic power in relatively few large corporations and by centralization of control in government.

PUBLIC RIGHTS IN WATER

Water is one of the resources that have been developed largely by individual initiative, and individual rights to the use of the water are recognized as real property, protected by Federal and State constitutional guarantees that prohibit the deprivation of property without due process of law. There is great variation among individuals as to rights to water: some may own land to which little or no water is appurtenant, or own no land at all; and some may have been born too late or too poor to acquire a water right by priority of use. Even in States that have declared some or all waters within their boundaries to belong to the public, the historic role of the State has been to prescribe conditions under which rights may be acquired to use water, to record the rights and adjudicate conflicting claims, and to allocate water in accordance with rights thus established. Increasingly in recent years the States have exercised their authority to reject proposed developments that are inimical to the public interest and to reserve water for future uses having public significance.

What rights in water are recognized as "common to all," applicable to each member of the mass of population? Although people are becoming increasingly aware of the recreational value of water in its various natural environments, the urban majority of the population may indulge its recreational interests in water only for a few days each year, or even vicariously. Have they any rights in such uses of water, or do the rights of others to water for consumptive use or for power generation, cooling, processing, and waste disposal take precedence?

In recognizing the rights of individuals to use water for specific purposes, our society has generally not defined the degree of responsibility of the right-holder for the effects of such use upon the water resources. The public rights in common have been subordinated to the specific rights of individuals. If the individual is unwilling to assume responsibility for his own pollution, it is at least partly because his pollutants move downstream or downgradient, and thus he does not have to live with them; doubtless pollution throughout the Nation would be substantially reduced if all water users were required to discharge their effluents upstream from the source of their supplies. However, assignment to individuals of responsibilities for their pollution of the water they use will not be an adequate solution. Every man must use some resources and have some wastes to dispose of, but he may not have within his private property the alternatives of disposal least detrimental to mankind. Inevitably, pollution becomes a social problem affecting everyone. The Water Quality Act of 1948 and amendments in 1956, 1961, and 1965; the Clean Water Restoration Act of 1966; the Clean Air Act of 1955 and amendments in 1959, 1960, 1962, 1963, 1965, and 1966; the Air Quality Act of 1967; and the Solid Waste Disposal Act of 1965 are among the evidences of increasing public concern and intent to correct abuses of specific environment.

The public rights in common to water are not specifically mentioned in the U.S. Constitution, and their constitutional protection has been developed over the years by increasingly broad interpretation (Water Resources Law, 1950). One of the early problems arose soon after the invention of the steamboat, when private interests sought to monopolize navigation throughout the State of New York. The U.S. Supreme Court (*Gibbons* v. *Ogden*, 1824) held that under the commerce clause of the Constitution the power of Congress comprehends navigation within the limits of every State in the Union. Congress began exercising this power in the River and Harbor Act of 1826, and the extent of this power has subsequently been defined as embracing all navigable waters as public property (*Gilman* v. *Philadelphia*, 1865), including those suitable for use by small boats (*United States* v. *Appalachian*

Electric Power Co., 1940); it may be invoked both as to nonnavigable reaches of a navigable waterway and as to its nonnavigable tributaries (*Oklahoma* v. *Atkinson,* 1941); the commerce power also extends to flood control (*Jackson* v. *United States,* 1913) and to development of power (*Green Bay & Miss. Canal Co.* v. *Patton Paper Co.,* 1898; *Ashwander* v. *Tennessee Valley Authority,* 1936).

By the property clause of the Constitution, Congress has unlimited power over the use of the public domain, including the power to dispose of land and water thereon together or separately (*California Oregon Power Co.* v. *Beaver Portland Cement Co.*, 1935). This clause was the constitutional foundation for the Reclamation Act of 1902 and for subsequent legislation to develop the public domain for the public welfare. By the general welfare clause of the Constitution,

> Congress has a substantive power to tax and appropriate for the general welfare, limited only by the requirement that it shall be exercised for the common benefit as distinguished from mere local purpose.

As pointed out by the Supreme Court (*United States* v. *Gerlack Livestock Co.,* 1950), this power of Congress to promote the general welfare through large-scale projects for internal improvement is as clear and ample as its power to accomplish the same results through resort to a strained interpretation of the power over navigation.

Thus over the years the Federal Government has used its constitutional powers increasingly to promote the public welfare by enhancing the benefits in common from the waters of the Nation: first as to navigation (*Gibbons* v. *Ogden,* 1824; River and Harbor Act, 1826) and other inchannel uses of water (Federal Water Power Act, 1920) that would qualify as res communes in the Institutes of Justinian; then as to protection against water as a common enemy causing inundations (*Jackson* v. *United States,* 1913; Act of March 1, 1917; Flood Control Act, 1923), erosion (National Erosion Control Act, 1935), and sedimentation (Act of March 1, 1893); and destruction of lives and property; then as to reclamation of arid lands by irrigation (Reclamation Act, 1902); more recently as to reduction of pollution (Water Pollution Control Act, 1948) and protection of waters for various public uses (Taylor Grazing Act, 1934; Water Facilities Act, 1937); to comprehensive planning (River and Harbor Act, 1927; Water Resources Planning Act, 1965), development (Tennessee Valley Authority Act, 1933; Reclamation Project Act, 1939; Flood Control Act, 1944), and conservation of water resources to serve diverse demands and uses. In this increasing promotion of public welfare and assertion of public rights in the water, there is increasing opportunity for conflict with individual property rights in the use of water.

Conflicts among water users as to their respective rights are as old as water scarcity, and they have increased as the water users and their uses of water have increased, wherever the supply becomes insufficient or unsuitable for all. Necessarily the pioneers depended upon separate isolated water supplies developed by individual effort, but increasing population has trended toward group and community action, and as of 1965 about 152 million people, or 78 percent of the total population, were being served by public-supply systems (Murray, 1968). Many States have encouraged the organization of water-utility districts or irrigation districts or conservancy or other districts by enabling legislation; individual water rights thus become pooled, and each shares in the supply. With increasing density of population it becomes increasingly difficult for an individual to obtain his water supply or to dispose of his waste water within the confines of his own property.

Thus the national trends toward big government and big business are reflected in the current trends in development and use of the water resources, whether in comprehensive river-basin planning or in the merger of many individual rights to form water-utility districts. These approaches can lead to more effective management of the resource, provided that management also has an understanding not only of the social and legal difficulties that impel this solution, but also of the natural flow system and its responses to man's actions.

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