A reverence for rivers

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In the years around 450 B.C., that is about 2,400 years ago, the most widely travelled of the time was Herodotus. His book *The Persian Wars* differs from any previous written history in that he was conscious of the influences of geography, climate, and social custom in the direction of development of political and economic history of a state.

In all the intervening time, we seem not to have learned how the political and economic aspects of our lives are related to geography and climate, nor have we been able to bend social custom to accept the constraints placed on us by geography and climate. One of the obvious constraints is the finite nature of nonrenewable resources. Even those resources that are not physically destroyed by use, as oil and coal are destroyed by burning, are usually so geographically dispersed by use that they can never again be collected together in usable concentrations. This happens to many metals on which we depend.

As far as renewable resources, such as water and timber, are concerned, all are parts of operating natural systems that can be deranged with very troublesome results. The hydrologic system of precipitation, streamflow, sediment, dissolved salts, ground water and evapotranspiration is typical of a system that can be deranged. Moreover, such operating systems are subject to natural fluctuations resulting from climate and geography. These fluctuations can be lessened but not eliminated.

The management of resources cannot be carried out successfully if it is looked upon as just another facet of economics, administration, and politics. Yet the latter view describes rather accurately our present approach to resource use (it can hardly be called management).

The view that Herodotus elaborated had little effect on the course of events between the time of Alexander's death and the final conquest of Greece by Rome. Neither he nor any of the administrative and political leaders knew how to use a philosophic view of geography, climate, and social development to guide the direction of history. Again and again the requirements of crisis governed even long-range decisions that might better have been deferred until the crisis had passed and the decision makers could afford a more balanced or philosophic view of the future.

But crisis offers an advantage in that wide attention is attracted to the problem even if its underlying causes are perforce clouded by the immediacy of pressure. There is at least a greater possibility that diverse factions might be persuaded to look more closely at their common problems and perceive what unanimity exists in their joint aspirations.

In suggesting here some aspects of the geographic, climatic, and sociological aspects of our resource problem, I recognize well enough that none of us knows how to put into operation a philosophy of water management, but there may be some merit in examining some of the elements that might be included in such a philosophy.

In choosing three particular elements, out of many possible ones, to mention here, I have chosen one to fit each of the three classes of argument usually marshalled against their consideration. Against philosophic points of view, the contrary arguments include (1) Our technology can fix it; (2) It is politically impossible; and (3) It is an example of the impractical idealism of crackpot environmentalists.

First, in the construction of any engineering project, there always will remain some final increment of risk. Because it cannot be eliminated, it is necessary to know in advance how one will deal with that unusual event when it finally comes to pass. The answer to this will be: "We will build more dams and bigger ones." In other works, our technology will fix it.

Second, in the face of obvious limitations of resources, whether renewable or nonrenewable, continued and indefinite expansion of resource use is patently impossible. Some movement toward a steady-state condition that lies within the bounds of resource availability is not only the crux of a resource management philosophy but is also the acid test of leadership. I do not consider this politically impossible. The public is learning. It may well be the best political course to pursue.

Third, there is a balance or harmony in natural systems which, dictated by the laws of physics, has gradually developed during the 4 billion years of Earth's history. The maintenance of this balance is not only to the advantage of human organization, but should be the object of both our wonder and our admiration. The desire to preserve this harmony must also be incorporated into any philosophy of water management, and I will call this, as did Herodotus, a reverence for rivers. If this is environmental idealism, then let it be said that I am an idealist.

On the first point, any building, every bridge we drive over, every dam that stores water, every highway culvert is designed for a chosen load considered to represent a reasonable choice between the costs of stronger building and the costs of failure. Only in the design of the spillway of a large dam is the maximum possible event used in the calculations. In the design of a storm-water sewer system on city streets, the event is usually that which may be expected on the average once in 15 or 20 years. Small earth dams built by government agencies usually use a spillway design such that failure once every 25 or 30 years is expectable. In all interstate highways where federal money is used, the design criterion for culverts is the 50-year event. When, as will surely happen sooner or later, a more extreme event occurs, it is assumed that the structure will fail or will at least not carry out its designed function.

Water-supply structures such as reservoirs are no exception. The residual risk can be reduced by building more of them and larger ones, but each increment of storage has less effect than the previous one and costs much more. The limit is reached, as on the mainstem of the Colorado River, in which if more storage is provided, the increase in evaporation cancels out any increase in the controlled yield of water.

Interestingly, the schemes ordinarily used for supplying water do not include any definite plans for handling the situation that is sure to arise sooner or later when the normal variance in hyrdologic phenomena brings about the improbably but expectable deficiency. Even the rainfall condition in 1977 is comparable in probability to that faced gladly by many people who play a game of chance such as roulette. At San Francisco, for example, the probability of a recurrence of the lowest rainfall year on record, 1958, is 2%, or 2 chances out of 100. That is to say the probability of such a low rainfall occurring in any year is 1 in 50. At the same precipitation station, the lowest total in 2 successive years was in 1958–1959. In that 2-year period, 26.06 inches fell. The probability of this event is also just about 2%, or 1 chance in 50. Again at that station, the lowest 3-year total was in the years 1958–1960. The probability of occurrence of such a low 3-year total is close to 1%, or 1 chance in 100.

Now turning to the present year, if at the same San Francisco station (Sunset District) the rainfall in the present year reaches 10 inches, then the 3-year total on June 30 will be 44.4 inches. This total will have a probability of 3%, or 1 in 33. The same kind of probability analysis can be made on any other station, groups of stations, or streamflow record. The present drought is obviously serious. It is unusual. But it is expectable on the basis of the past record. In other words, *it will occur again in the future.*

The difficulty we find ourselves in is not due to the fact that the present drought is impossible to imagine. It could not be predicted, but its eventual occurrence was assured. We are caught with minimal plans to deal with an event sure to occur. Whereas for earthquakes the occurrence is not susceptible to probability analysis because the causal mechanisms are not random, for climate the hydrologic phenomena of flood and drought may be treated statistically, and good estimates of probability are available to us. The departure from the mean value is expectable, but the particular year or years in which it will occur cannot be forecast. Such is the nature of hydrologic events.

In a management philosophy and plan, it is far more necessary to minimize impact of dry years than to contend with wet ones. Though the risk of a deficient year is always present, seldom are definite plans on hand to cope with the situation when it finally arises. Rather, at the time of crisis there is a tendency toward grandiose plans to eliminate one further increment of risk, but a residual risk remains. The same crisis will occur again, less often but equally sure. Now is the time to lay plans for meeting an assured future event. It is not the time to plan expensive projects to reduce the risk by some small increment.

There are strategies that might help prepare for such eventualities. They will ameliorate the losses but not eliminate all hardships. However, as in all water development, they require time and advance preparation. One is as follows: There are in various parts of the western states ground-water bodies too deep to be economically developed under usual economic standards, or they have marginal water quality. These, and especially those remnants of the ice-age ground-water bodies not being recharged now, should be saved from ordinary development and reserved only for times of exceptional need. But advance engineering is needed to explore and tap them and to connect to them transmission lines ready for some future contingency.

It is hardly in the public interest progressively to deplete stored but irreplaceable ground-water bodies whose greatest social use might be as unused reserve to be drawn on sporadically only when the need is grave. Such sporadic use would greatly extend the life of such irreplaceable water and would put it to a highly valued use.

In contrast, we are in several regions continuing to pump ground water that is not being replenished. Apparently we will continue to do so as long as present conditions make its withdrawal even marginally economic. In some instances even this slim economic margin is made possible only by public subsidy through price supports.

There are many other strategies. The reuse of treated waste water is an obvious one. In this instance also, even if continued reuse on a permanent basis is uneconomic, advance preparation to reuse treated water in emergencies would be an approach to the problem of the residual risk.

Second, the occurrence of improbable but expectable deficiencies in any resource should remind us that ever-continuing growth in resource use is the antithesis of a philosophy that faces reality. In our economic climate there are few if any precedents for a fundamental re-examination of this matter and its consequences. To face this inevitable future requires the highest level of statesmanship, and crisis may provide the impetus for developing a new outlook.

The course in the past in which any and all persons may presume that they will be provided the usual resources of water, energy, and other public commodities, at any geographic location and forever in time, must eventually be abandoned. It cannot be assumed that if concentration of people continues unabated they will necessarily be supplied with those resources which at an earlier date were either nearly free or at least less expensive.

Finally, a philosophy of water management must pay heed to the fact that the hydrologic system is a highly interconnected plumbing network. Changes made in one part of the system have influences downstream. The continued functioning of the system is of great importance. To test whether the system is operating satisfactorily by economic and legal criteria alone will not guarantee its continued health. What is needed is some deeper feeling.

Speaking of the Persians who dominated Asia Minor in the 5th century B.C., Herodotus said, "They never defile a river with the secretions of their bodies, nor even wash their hands in one; nor will they allow others to do so, as they have a great reverence for rivers." It is the last phrase that deserves our attention. The river is like an organism; it is internally self-adjusting. It is also resilient and can absorb changes imposed upon it, but not without limit. The limit beyond which a river cannot adjust is well illustrated by some of the effects of our national program of channelization, in which we have already dredged, straightened, channelled, revetted, trained, and "improved" more than 16,500 miles of river channels in the United States, quite apart from the thousands of reservoirs already built. On the drawing board of federal agencies are plans to "improve" similarly another 10,000 miles of river channels. As one minor example, the Blackwater River in Missouri was straightened and shortened 60 years ago and has since then continually and progressively lowered its bed by erosion, washing out a succession of bridges built increasingly larger. Downstream from the improved area, flooding has increased. The river has not been able to re-establish its equilibrium.

The great geographer, William Morris Davis, viewed the river system as having a life of its own. Its youthful headwaters, he said, are steep and rugged. It rushes toward the sea, eroding bed and bank on its way. In its central part, it is mature, winding sedately through wide valleys adjusted to its duty of transporting water and sediment. Near its mouth it has reached, in its old age, a nearly level plain through which it wanders in a somewhat aimless course toward final extinction as it joins the ocean that had provided the sustaining waters through its whole life span.

Man's engineering capabilities are nearly limitless. Our economic views are too insensitive to be the only criteria for judging the health of the river organism. What is needed is a gentler basis for perceiving the effects of our engineering capabilities. This more humble view of our relation to the hydrologic system requires a modicum of reverence for rivers.