Physiographic Limitations Upon the Use of Southwestern Rivers

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Southwestern rivers are few and far between and they do not carry much water. Figures from the three large drainage basins of the Southwest...the Great Interior Basin of Nevada and California, the Rio Grande Basin, and the upper and lower parts of the Colorado River Basin...show that surface water runoff from those basins is either nonexistent or very small compared to figures from humid parts of the United States such as the Ohio River Basin, the lower Mississippi, and the Columbia River Basin. (National Research Council, 1968).

Running water is scarce in the Southwest because of the physiography of the region (Hunt, 1967). Events in geologic history determined that the Southwest would stand today high above sealevel, in the rainshadow of the Sierra Nevada Mountains to the west, and almost wholly dependent upon the Rocky Mountains to the east for its water supply. Our modern river, of course, are themselves very young geologic agents, and our famous landscapes have been carved by these rivers only in the later (Cenozoic) part of geologic time.

The Southwest lies entirely west of the 100th meridian, that boundary recognized by John Wesley Powell a century ago as the westernmost limit of reliable rainfall in this country. To the east of the 100th meridian, rainfall can be relied upon to grow crops; west of the 100th, there is a chronic deficit of water, droughts are frequent and inevitable, and lifestyles must be adapted accordingly. Rainfall is the key factor, because all of the water that flows in any drainage basin got there by falling in as rain, either past or present.

Because no natural surface is perfectly flat, even in the initial stages of its development, falling rain lands on a sloping surface and begins to run downhill. Depending on the intensity and duration of the rainstorm and upon the infiltration capacity of the ground surface, a certain amount of rain will sink in and will travel downward through the soil toward the groundwater. The groundwater is simply the stored water from earlier rains.

A very high percentage of the rainfall evaporates or is taken up by plants. What is left (perhaps no more than 3% in the Southwest (Water Resources Council, 1970) moves downhill as surface runoff. Sheetwash coalesces into rills; rills become gullies; gullies flow into fingertip tributaries, and so the water runs through tributary streams of increasing order until it reaches the main stream, which transports the water through its mouth out of the basin and into the sea.

The groundwater, too, moves downslope, slowly, toward a mainstream exit from the basin. Where the top of the water table intersects the ground surface, a spring will occur and a perennial stream will ensue. Few of our Southwestern rivers are perennial. Rather, they are intermittent, receiving discharge from groundwater only along parts of their courses. Many Southwestern tributary streams are ephemeral, dry washes that run only after a rainstorm. None of the major rivers of the Southwest originate in the lowland, Basin and Range Province; all head in mountainous areas on the margins of the basin, remote from population centers. The Little Colorado, the Gila, and the Salt Rivers all head in the high country near the state line region of Arizona-New Mexico. The Rio Grande gets its water from the southern Rocky Mountains, and from Albuquerque seaward, it picks up almost no tributary water. The main Colorado and its partner, the Green River, owe their existence to the melting snowpack of the Front Range and the Wyoming Basin, on the farthest reaches of the basin. Once these rivers leave the high country and enter the desert lowlands, they begin to be used up, to the last drop.

A stream should be appreciated as more than a handy flume for carrying a water supply and removing sewage at the convenience of Man. A stream, to a geomorphologist, is a beautifully and dynamically balanced, open system tending toward a state of near-equilibrium (grade) (Leopold, 1964). The tendency of a stream to adjust its morphometry to changes in the amount of water coming into the system and to the amount and type of sediment available for transport result in a lot of work being done. We call this work erosion, and deposition, and the result of this work is our landscape.

A change in any of several variables such as velocity of the water, depth or width of the channel, bed roughness and so forth will bring a change in the behavior, or regimen, of the stream. Building a dam, for instance, affects the velocity of the water that flows into the lake behind the dam. The streamflow is abruptly checked, and so the river drops its load of sediment. Tributaries to the mainstream above the dam are affected by the change in baselevel and they, too adjust their gradients by silting up their channels. Meanwhile, clear water released below the dam quickly picks up a new laod of sediment, scouring its channel and increasing erosion in the basin below the dam. These are immediate effects. The long-term effects follow from the fact that rivers are the most important elements of our landscapes and are, in fact, responsible for producing nearly all of our landscapes, as well as for providing essential habitats for wildlife and perhaps equally essential refuges for urban Man. Some geomorphologists now are trying to establish a scale against which esthetic values of various riverscapes could be measured, quantitatively (Morisawa and Murie, 1969). Certain stretches of rivers could then be assigned values which might be weighed against their usefulness for engineering projects.

The Colorado River is the major drainage system of the Southwest. Its flow through a channel cross-section at Lees Ferry has been measured and added to the estimated depletion upstream to obtain the so-called virgin flow of the Colorado River over the past 75 years. Those measurements reveal an interesting disparity. The average annual flow of the Colorado River for the years 1896 to 1930 was about 17 million acre feet; during the years 1931 to 1965, the average annual flow was only about 13 million acre feet (an acre foot is the amount of water that will cover one acre to a depth of one foot) (National Research Council, 1968). The Committee on Water of the National Academy of Sciences suggests that the disparity is, most likely, due to differences in measuring methods, and that a figure of 15 million acre feet for the average annual virgin flow of the Colorado River at Lees Ferry is about right. If that is so, then something has to give, for there is not enough water in the river to fulfill the legal allocations under river law (including the Colorado River Compact, the Boulder Dam Project, and the Mexican Treaty). These legal allocations total 17.5 million acre feet per year of Colorado River water.

Present reservoirs along the Colorado River can store 60 million acre feet of water, or nearly five times the average annual flow (National Research Council, 1968). The loss, by evaporation from the lakes in the lower region, mostly behind dams, is well over one million acre feet per year (Water Resources Council, 1970).

While Southwestern river water is being allocated and dammed beyond reason, groundwater resources in the lowland parts of the Southwest are being literally mined, at a frightening rate. In some areas, the water table is being lowered at the rate of 20 feet per year. This water is ancient groundwater that took centuries to accumulate. It is not replaceable, not even by the Central Arizona Project. The Project, when implemented, will bring 1.2 million acre feet of Colorado River water into the Gila River basin, but this imported water will cancel only about half of the annual overdraft of groundwater in that area. The water table in central Arizona had dropped, by 1968, to 250 feet below the surface. Even if pumping were to stop completely, many centuries of desert rains would come and go before the water table could rise to its former depth of about 50 feet (National Research Council, 1968). It should be obvious to the most enthusiastic booster of growth for Arizona that the Central Arizona Project will not provide even enough water for present levels of usage in the central part of the state.

Unrealistic demands upon the water resources of the arid Southwest are not new. In the latter part of the ninetheenth century, John Wesley Powell tried to convince would-be settlers that only a small portion of the land could be reclaimed, even by irrigation. Rain, he said, would not follow the plow, as some ignorant folk believed. If Powell could see the Phoenix area today, he might warn that rain also does not follow the subdivider's bulldozer.

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