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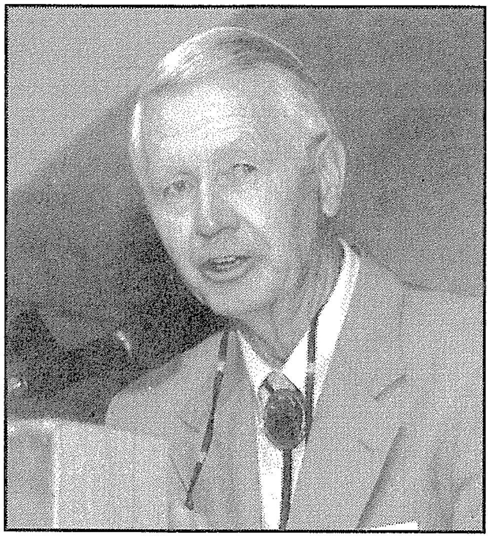

THE MESILLA VALLEY: A CENTURY OF WATER RESOURCES INVESTIGATIONS

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Water supply shortages are often the impetus for water resources investigations. Certainly this has been the case for the last century in the Mesilla Valley.

In the early 1890s water shortages began to occur along the Rio Grande in the Mesilla and El Paso valleys. The people in Juarez complained to the Mexican government, who filed a claim for damages against the United States alleging that the water shortages were due to increasing diversions from the Rio Grande in Colorado and New Mexico. The International Boundary Commission called on W.W. Follett to investigate the allegations. Follett's 1898 report confirmed that the shortages were caused, at least in part, by increased diversions upstream of Mexico. One proposed solution was to construct a dam in the narrows north of El Paso that would back water up in the Mesilla Valley a distance of 15 miles.

In 1904 Professor Charles Slichter, an early groundwater theoretician with the U.S. Geological Survey, investigated the groundwater flow in the narrows at the site of the proposed dam (Slichter 1905). Slichter's research was prompted by a popular local belief that there existed in the narrows an enormous groundwater flow that, if developed, might ease the water shortages. However, measurements of the velocity of groundwater movement by the use of common salt as a tracer indicated a relatively insignificant underflow of only 50 gallons per minute. Slichter also studied the groundwater flows north of the narrows in the Mesilla Valley by drilling test holes that indicated a water-table gradient of 4.64 feet per mile down the valley. He concluded that the velocity of the groundwater was low and that recharge to the groundwater was mainly from the river, with about one-seventh of the underflow coming from precipitation on the bounding mesas.

At about the same time as Slichter's studies, W.T. Lee conducted a reconnaissance study of the water resources of the Rio Grande Valley in New Mexico (Lee 1907). Relying on Slichter's work, Lee concluded that about 132,000 acre-feet per year of river water recharged the Mesilla Valley aquifer, most of which was apparently lost by evaporation from a relatively shallow water table since essentially no flow went out of the valley by way of the narrows.

Lee discussed two reservoir sites: the International site in the narrows and the Engle site near the volcanic neck known as Elephant Butte. Lee thought that the narrows site was good, but without any detailed discussion dismissed it as not having favorable conditions for the storage of water in the southern Mesilla Valley. Lee did not express a preference for the Engle site, but did give a detailed discussion of the geology and the availability of potential dam construction materials. The interplay of power politics, not untypical of water development in the West (Clark 1987), led to the selection of the Elephant Butte site; Elephant Butte Dam was completed in 1916 by the Bureau of Reclamation.

Increased acreages of irrigation, coupled with a more reliable water supply provided by the Leasburg Diversion Dam in 1908, caused groundwater levels to rise in the valley. It has been argued that the notoriously high sediment load of the river had been reduced by the newly constructed irrigation works, causing the previously semi-impervious bed of the river to lose water at a much greater rate than before. In 1921 Bloodgood estimated that 66 percent of the valley had depths to water of 4 feet or less and thus could be classified as "seeped." In response, 226 miles of drains were constructed by the Bureau of Reclamation in the Mesilla Valley, thus lowering the water levels in the area to an average depth to water of about 10 feet.

The Rio Grande Joint Investigation of 1938, conducted by seven federal agencies, provided a comprehensive report on the water resources of the Rio Grande Basin as a whole (Natural Resources Committee 1938). Although the surface-water resources and utilization of the Mesilla Valley were mapped and discussed in detail, the groundwater resources were dismissed in one paragraph on the basis that few data were available.

Probably the most informative period in the various studies of the water resources in the Mesilla Valley was the drought period of the 1950s. The severe stress on the hydrologic system caused by the drought brought to light various idiosyncrasies of the relationships among the river, the canals, the drains, the aquifer, and the uses, many of which are not discernible under normal stresses. During this period the U.S. Geological Survey conducted two studies: one by Conover (1954) in the northern part of the valley and one by Leggat and others (1962) in the southern part of the valley. Also during this period the Agricultural Experiment Station conducted a dozen annual studies of various aspects of the drought.

The first attempt to delineate the hydrogeologic framework of the Mesilla Valley was made by King et al. in 1971. The report describes the stratigraphy, lithology, and water-bearing characteristics of the aquifer system.

The most comprehensive report on the water resources of the Mesilla Valley is the 1981 report by Clyde Wilson and others of the U.S. Geological Survey. The report contains detailed discussions of the geology and the hydrology as well as numerous tables and maps of various aspects of the water resources, such as the quality of water. The report indicates that there are two major aquifers in the valley: the floodplain alluvium and the underlying Santa Fe Group. The Santa Fe Group appears to respond as a leaky-confined aquifer based on the comparison of pumping-test data to leaky-artesian type curves. The storage coefficient of the Santa Fe Group was reported as being very small: on the order of 10^{-4} in the short-term, whereas in the long-term it is thought to be about 0.15 based on previous experience with similar material such as that in the Deming area.

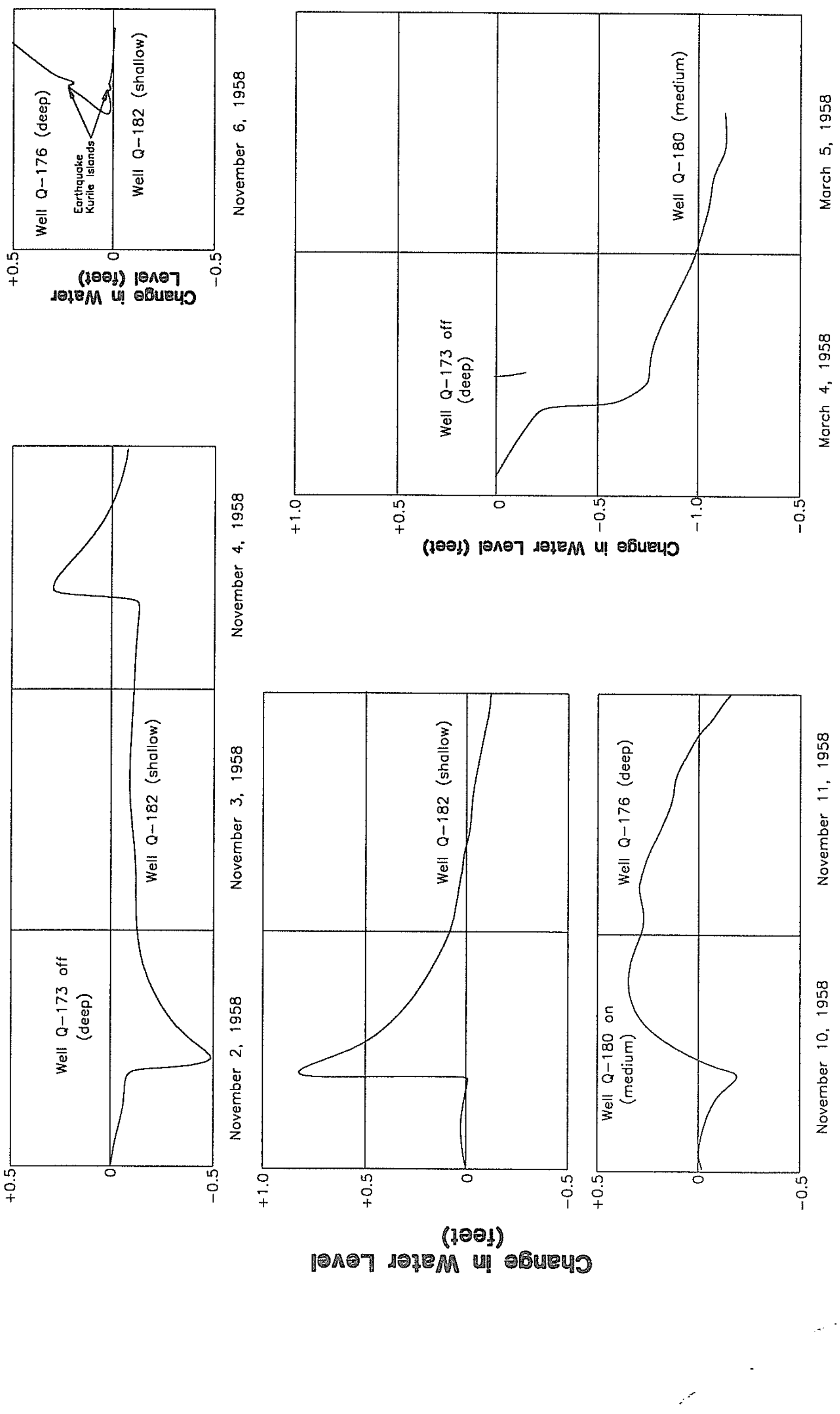
The conundrum posed by Clyde Wilson and others, that the aquifer storage coefficient is small in the short-term but increases with time, was recently explained by the development of the theory of stress-sensitive aquifers by Don Helm (1984). This theory explains how the storage coefficient increases with time in response to stresses produced in the aquifer by pumping. The increased stress results in the deformation and compaction of the aquifer with time. Past evaluations of pumping effects have assumed that the storage coefficient is constant with time; however, this appears to not be the case. The U.S. Geological Survey currently is investigating the complex relationship between levels of stress and the storage coefficient in areas near El Paso where subsidence has occurred.

Figure 1 shows the first documentation that the Mesilla Valley aquifer system is stress sensitive (Leggat et al. 1962). The water-level fluctuations shown are produced by a change in the loading experienced by the aquifer when wells are turned on and off. Normally one expects water levels to decline when a pump is turned on, so when the response is a rise in water levels, it is called a "reverse water-level fluctuation." The importance of this phenomenon relative to the withdrawal of groundwater has only recently been understood. Manifestations of a stress-sensitive aquifer such as reverse water-level fluctuations and an apparent response to pumping as a leaky-artesian aquifer have been noted at various places in the Mesilla Valley. It remains for the exact nature of this stress-dependent process to be determined in the Mesilla Valley.

Substantial refinement to the geohydrologic framework has been given by John Hawley and others in their 1992 report on the valley. This report provides the basis for understanding local aquifer responses and water quality related to the local geologic situation.

I have charted some of the data given in various investigations to provide a better overall view of the nature of the water resources of the Mesilla Valley.

- Figure 2 shows the annual flow (in thousands of acre-feet) in the Rio Grande past El Paso for the period of 1891 to 1979. The wide range of flows before the regulation of the river by the construction of Elephant Butte Dam in 1916 is clearly evident. The reservoir spill in 1942 marks the approximate start of a decrease in average annual flows which culminated in the exceptionally low-flow years of the drought in the 1950s. Even after the drought was apparently over, the average river flow did not return to predrought levels.
- Figure 3 shows the annual stream diversions for the Mesilla Valley for the years 1946 to 1968. Note the effect of the drought on the supply of irrigation water during the 1950s.
- Figure 4 shows the average water elevation for the period 1946 to 1968 for 89 shallow wells drilled by the U.S. Bureau of Reclamation in the Mesilla Valley. As shown on this figure, the annual cycle in water-level fluctuations is 2 to 3 feet. The rise in water levels is associated with the start of the irrigation season, while declines in water levels occur when recharge ceases and the drains are the dominant hydraulic factor. The water-level rise is much lower in the drought years of the 1950s, because the surface-water supply was very low and thus the recharge to the shallow aquifer was also low. In an attempt to regain a full supply of irrigation water, a large number of supplemental wells were drilled in the 1950s. This new draft from groundwater added to the decline in water levels caused by the reduced recharge. During the height of the drought, the normal cycle in groundwater fluctuations largely disappeared. In areas of the valley where substantial pumping of groundwater has continued since the drought, the previous character of the fluctuations has still not returned.
- Figure 5 shows the total annual flow of the drains in the Mesilla Valley, which correlates with groundwater levels; that is, the drain flow is the highest when the groundwater levels are the highest. Furthermore, in addition to draining the shallow aquifer, the drains also drain the river in certain reaches. Therefore, ambient groundwater levels must be considered in any interpretation of drain and/or river flow at any particular point in time. The quality of water produced by the drains of course mirrors the flow rate; that is, an increased flow rate correlates with better-quality water.
- The effect of pumping groundwater is an increase in river losses as well as a decrease in conveyance efficiency of the canals. Figure 6 shows the canal losses as a percentage of the diversion from the Rio Grande. The highest percentage of canal loss occurred in 1956, which correlates with the greater-than-normal depth to water in 1956. Although the rate of leakage from the canals is high, the rate of leakage from the river is even higher, which is why water allocated for downstream projects is "piggybacked," to the extent



Source: Leggat et al., 1962

Figure 1. Fluctuations of water levels due to variations in the load on an aquifer in selected wells in the El Paso city well field northwest of Canutillo (Daniel B. Stephens & Associates, Inc., 10/95).

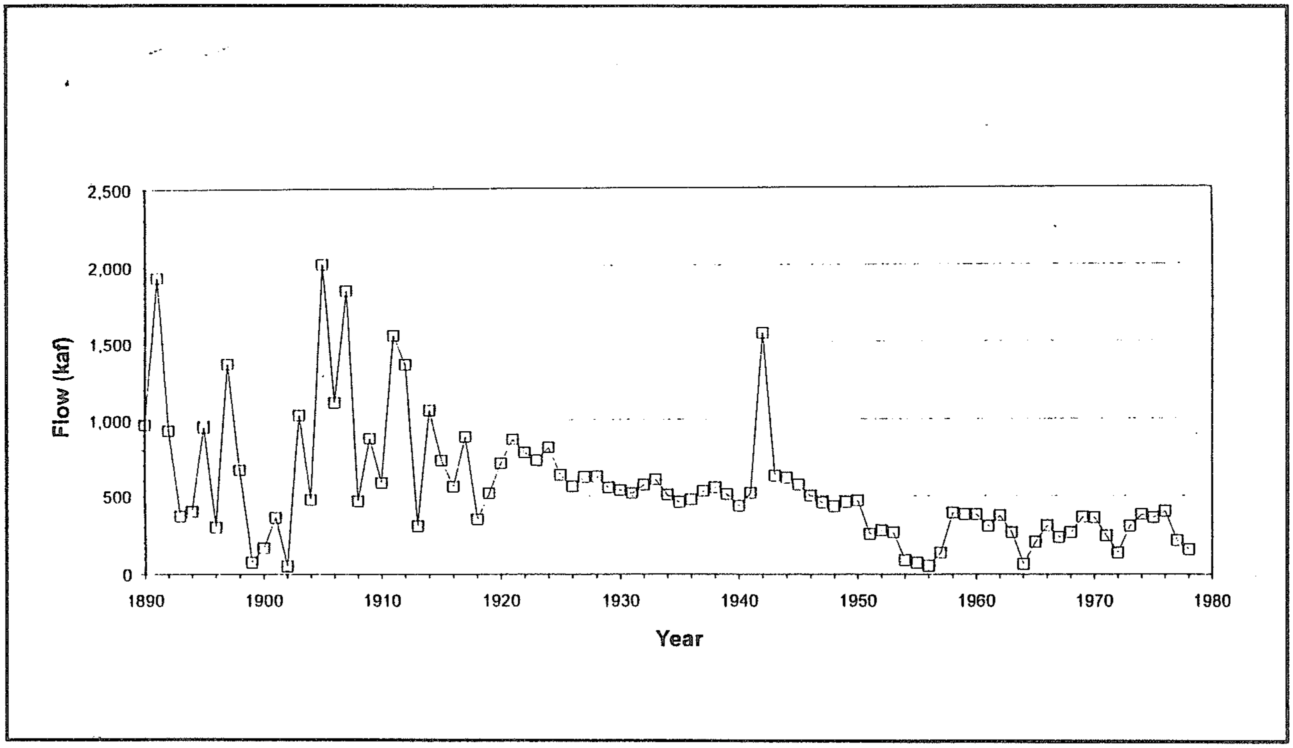


Figure 2. Annual flow at the El Paso Gage on the Rio Grande (Daniel B. Stephens & Associates, Inc., 10/95).

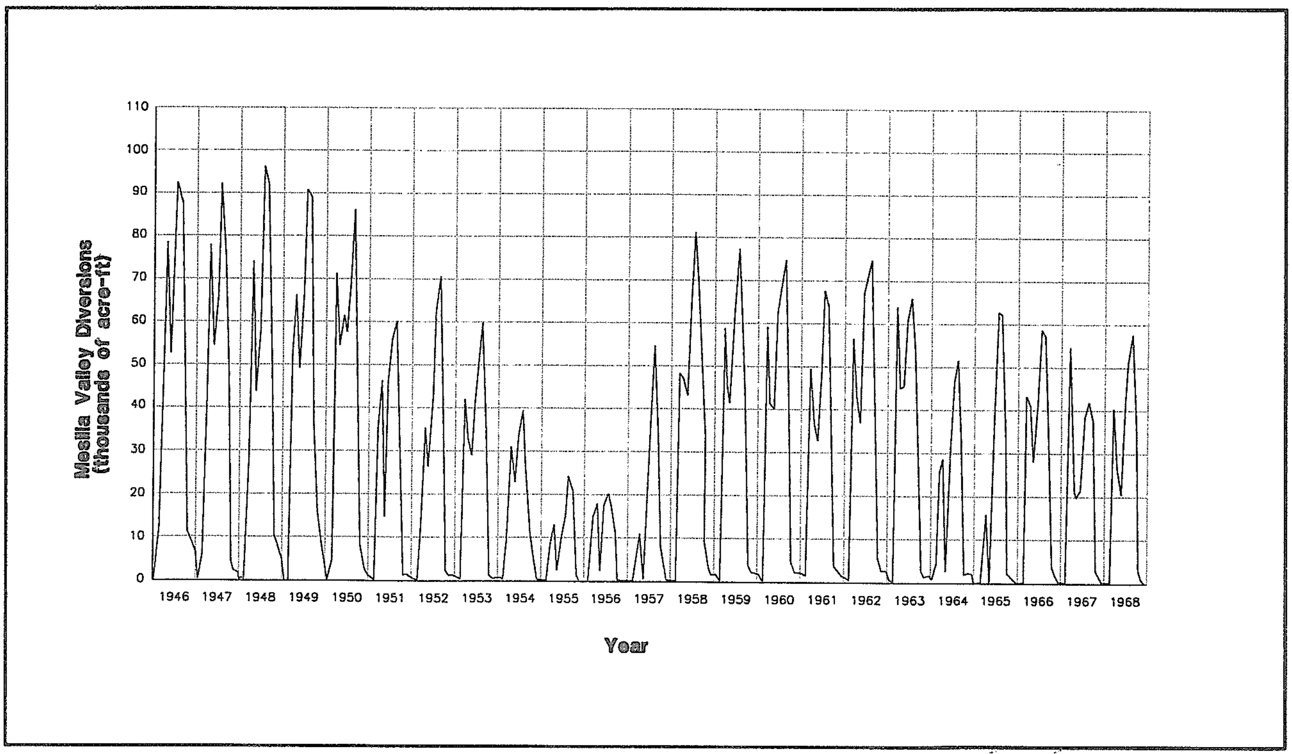


Figure 3. Surface-water diversions from the Rio Grande (Daniel B. Stephens & Associates, Inc., 10/95).

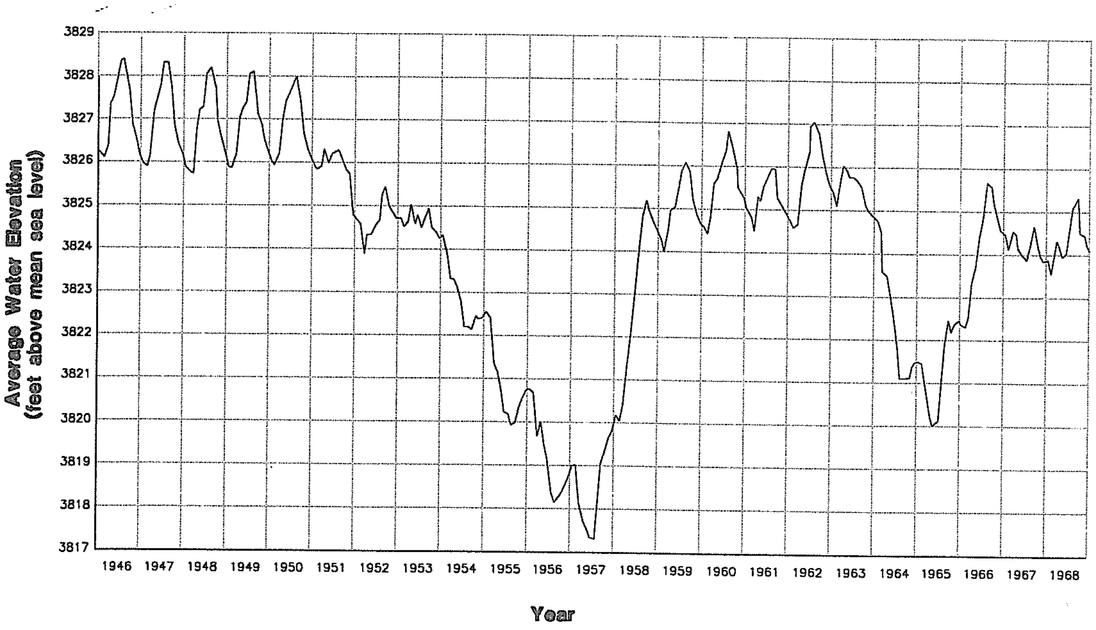


Figure 4. Average water elevation in Bureau of Reclamation wells in the Mesilla Valley (Daniel B. Stephens & Associates, Inc., 10/95).

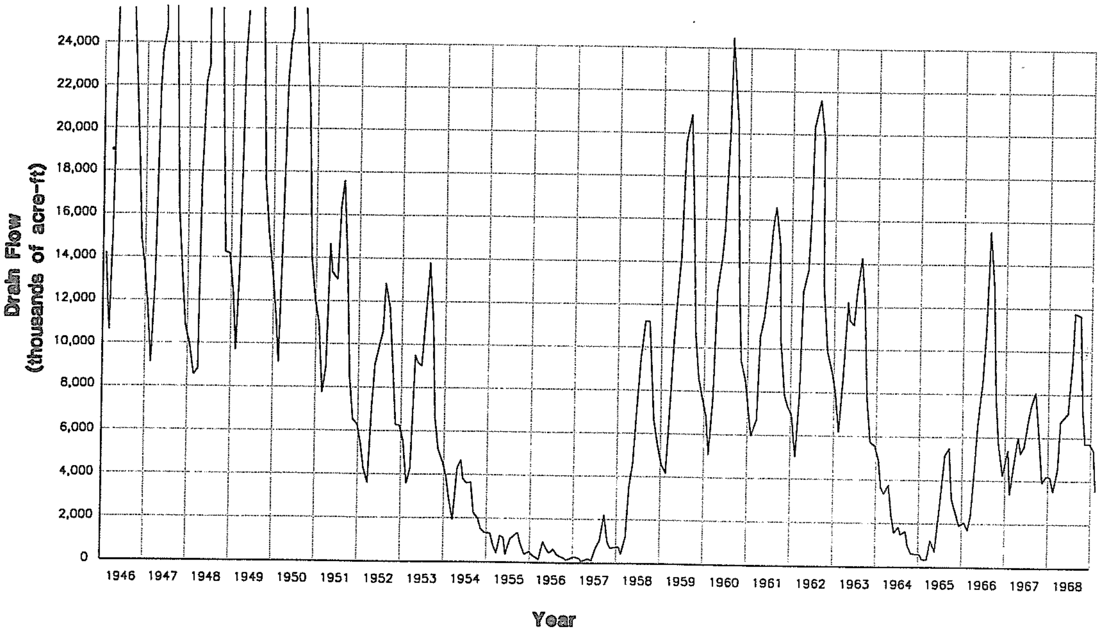


Figure 5. Drain flow for Mesilla Valley (Daniel B. Stephens & Associates, Inc., 10/95).

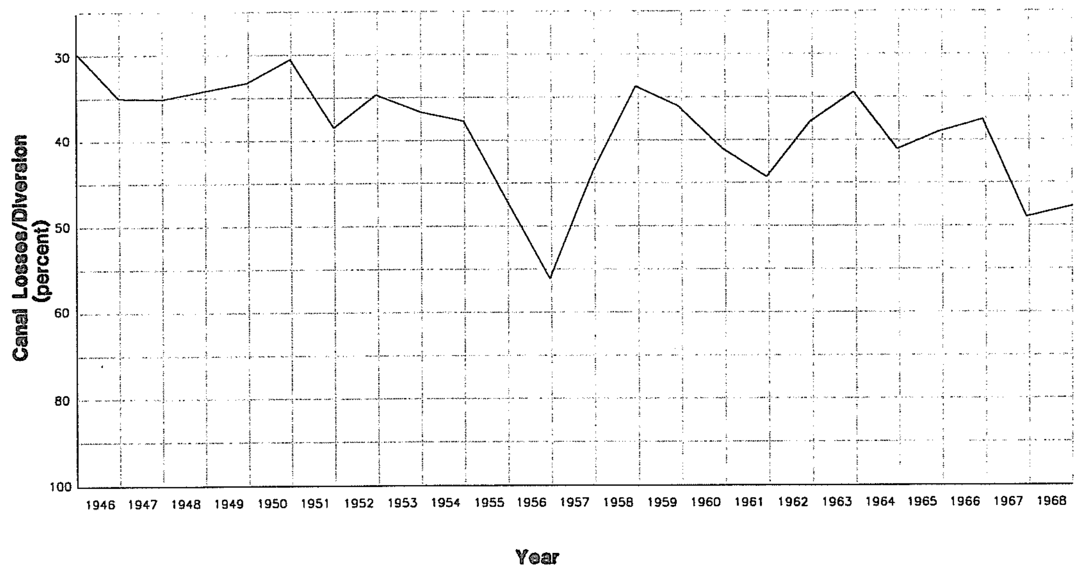


Figure 6. Canal loss as a percentage of diversion for the Mesilla Valley (Daniel B. Stephens & Associates, Inc., 10/95).

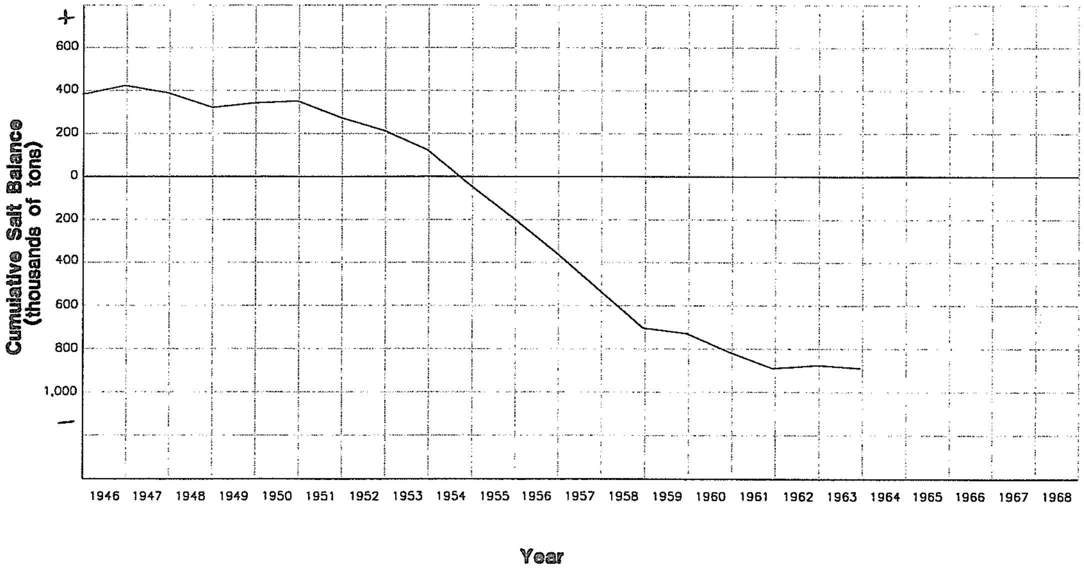


Figure 7. Cumulative salt balance (Daniel B. Stephens & Associates, Inc., 10/95).

possible, in the canals. During the irrigation year, canals leak the most when water is first turned into the canals. The downward leakage begins to build up a recharge mound beneath the canal which, as it approaches the bottom of the canal, then reduces the leakage. The greater the annual average depth to water is, the greater the annual canal losses will be because of the higher recharge mounds that must be created before leakage is reduced. Thus, proposals to drill well fields would result not only in a lowering of groundwater levels but also an associated increase in canal losses.

- Figure 7 shows the cumulative salt balance for the Mesilla Valley. Negative values indicate that salt is being deposited in the valley, whereas positive values indicate that salt is being flushed out of the aquifer. As one would expect, salt was being accumulated in the valley during the drought of the 1950s, when water supplies were short and the drains essentially quit flowing.

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