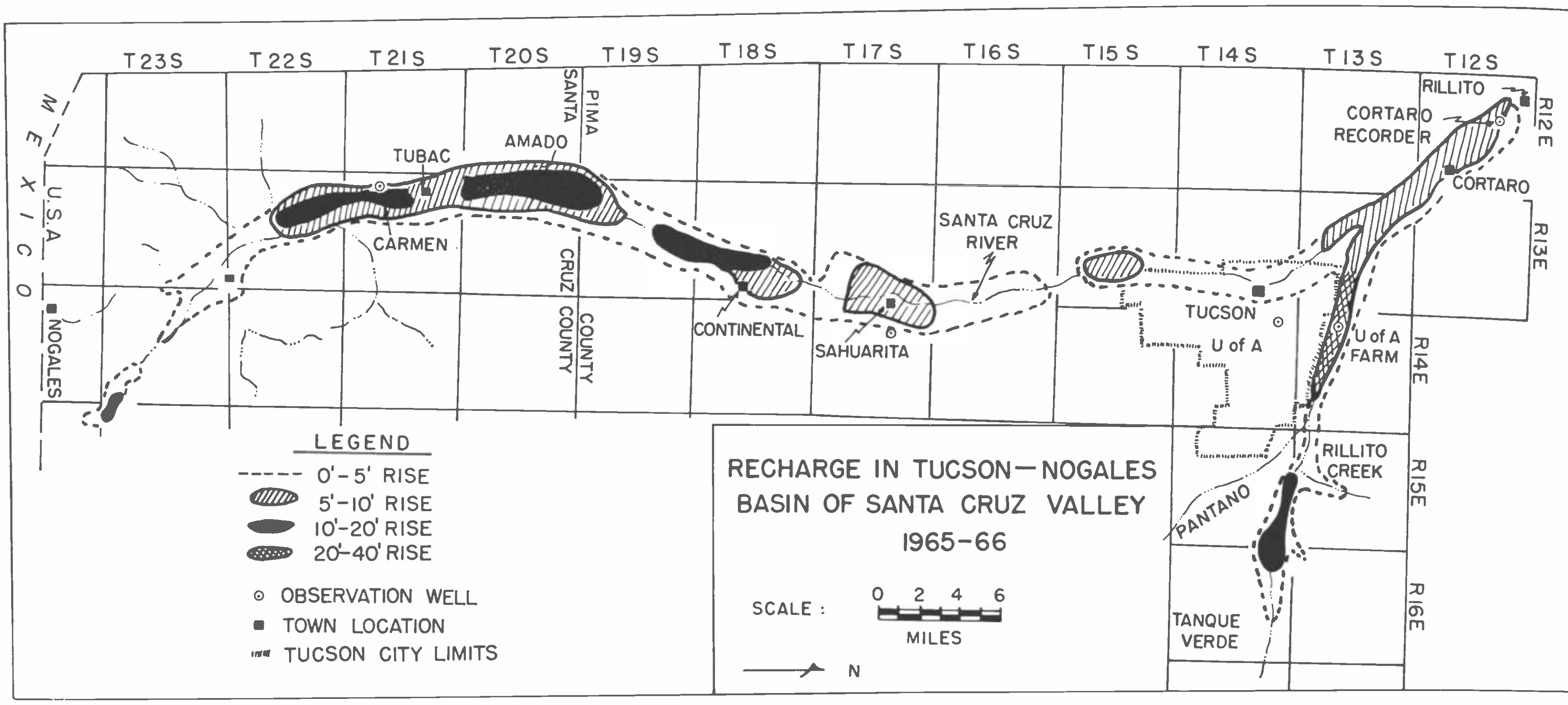
FIGURE I



NATURAL RECHARGE IN TUCSON BASIN

By Wayne Clyma and Richard J. Shaw

Groundwater is the dominant source of water for all uses within the Tucson area. In 1965, groundwater use within the Tucson Basin amounted to 140,000 acre feet. Of this amount, 80,000 acre feet were used by municipal and industrial consumers and 60,000 acre feet were used for agriculture.

Schwalen and Shaw (1) have estimated that the average annual groundwater recharge amounts to 40,000 acre feet in the Tucson Basin. Thus, there is a deficit or annual overdraft of groundwater use of 100,000 acre feet. This overdraft results in the continuous decline of water levels in much of the Tucson Basin. This overdraft is a primary concern of business, industrial, municipal, and professional leaders of the community.

The Agricultural Engineering Department of the University of Arizona has been studying groundwater conditions in the Tucson Basin since 1905. Since 1946, these studies have been intensified through cooperation with the city of Tucson and Pima County. The basic objective of this study has been to make annual measurements of water levels in wells within the Tucson Basin and to inventory the annual use of water within the basin. Schwalen and Shaw (2) have described the procedures used in this study.

The primary use of the data collected by the Agricultural Engineering Department has been to supply information on the annual use of water within the Basin and to determine, for the benefit of the public, the location and depth of existing groundwater supplies within the basin.

With the current concern for planning future water supply needs for the Tucson area, data collected by the Agricultural Engineering Department in the unusually high runoff year, 1965-1966, provides important information pertinent to the discussions of water problems within the area. Analyses of these data show the nature of the water problems within the Tucson Basin and suggests procedures that should be used to solve these problems.

The combination of an unusually large amount of rainfall and snow melt within the basin resulted in exceptional amounts of runoff down the Rillito Creek and the Santa Cruz River during the winter of 1965-1966.

Periods of high flows occurred. But in general, over a period of approximately three months, runoff of several days duration occurred frequently. This unusual volume and duration of runoff resulted in substantial amounts of groundwater recharge to the aquifer through the stream bed.

Figure 1 shows the changes in water

The co-authors are Assistant Agricultural Engineers, Agricultural Experiment Station.

The Tucson Basin extends from the Santa Cruz County line to the Rillito narrows and extends transversely to the end of the groundwater aquifer or the surface drainage-divide.

levels in wells immediately adjacent to the Santa Cruz River and Rillito Creek from the spring of 1965 to the spring of 1966. The rises in water levels along the Santa Cruz River were greater and more extensive than for any prior period of record.

Rises of over 10 feet extended one to three miles wide and as much as 10 miles long from south of Carmen to north of Amado. Other significant rises occurred near Continental and Sahuarita. Rises up to five feet occurred in a continuous reach from about six miles north of Nogales to just south of the Tucson city limits.

Figure 2 shows the decline of water levels from first measurement to the lowest water level of record. The feet of recovery of water levels as of the spring of 1966 also is shown. The ratio of these two changes is the percent recovery and is also presented. This graph shows that from the International Boundary to the Santa Cruz County line, water levels recovered to the highest level ever measured. The aquifer immediately adjacent to the stream was essentially full or at the ground surface. Substantial recoveries, up to 40 percent of the total decline over the years since pumping began, also occurred in wells along the Santa Cruz River from Amado to Rillito.

Figure 1 also shows the rise in water levels along the Rillito Creek from recharge to groundwater caused by runoff during the winter season of 1965-1966. Note that in a large area below the confluence of Tanque Verde and Pantano Wash, rises in excess of 40 feet occurred. At almost all areas along the Rillito rises of five or more feet occurred with some rises of 20 feet.

These rises in water levels along the Santa Cruz River and Rillito Creek are evidence of the potential for recharge of the Tucson Basin aquifer provided water is available for recharge.

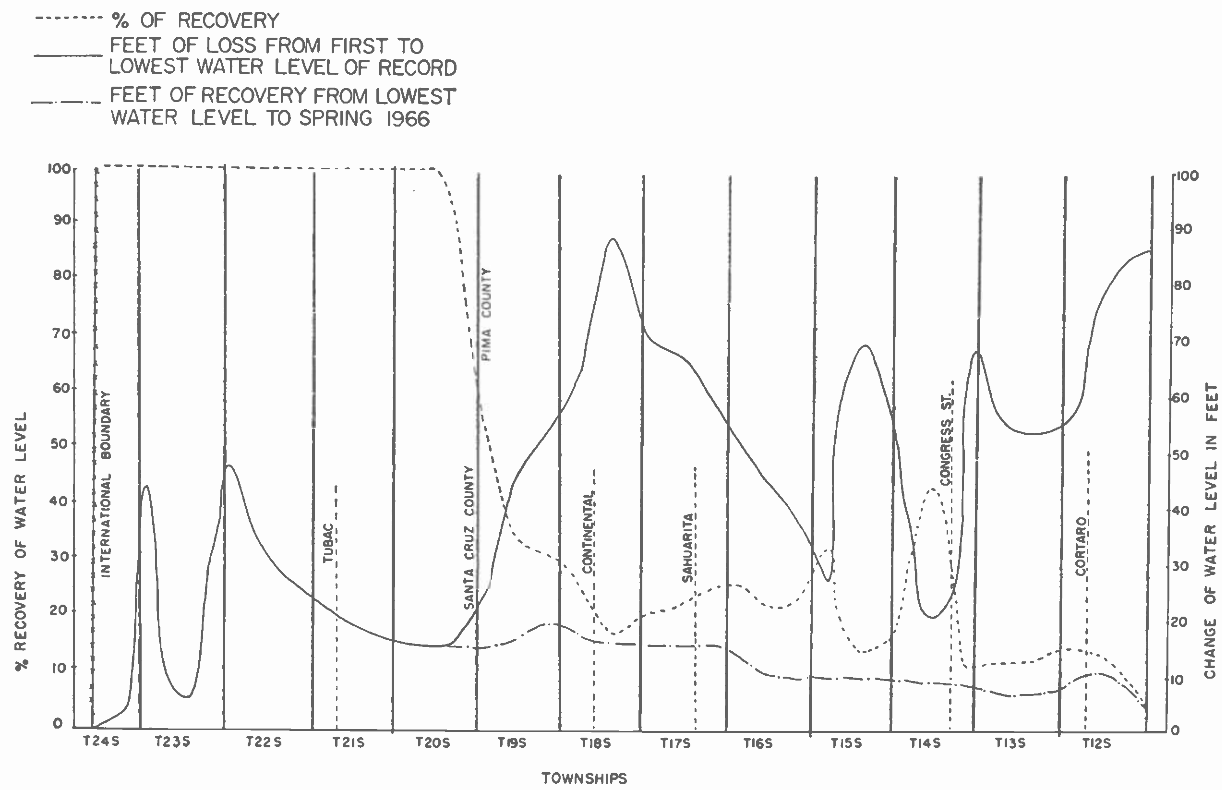
No rise in water levels occurred within the interior of the basin away from the streams. The continuing program of water level measurements has shown that even in 1965-66, when the greatest rise occurred in an area adjacent to the streams, the interior of the basin continued its decline in water levels.

In Figure 3 the University of Arizona Campus well is representative of the wells in the interior basin that have declined continuously since heavy pumping began. The well near

FIGURE 2

HYDROGRAPH SANTA CRUZ VALLEY

SPRING 1966



Sahuarita, Ariz. shows the same continuous decline except the rate of decline decreased during 1965-66. Wells in the interior basin do continue their decline even during years of maximum recharge. Their declines are in direct proportion to the draft on the aquifer. Therefore, these areas should receive minimum pumpage in order to sustain a minimum pumping lift within the time interval that water is expected to be pumped from the area.

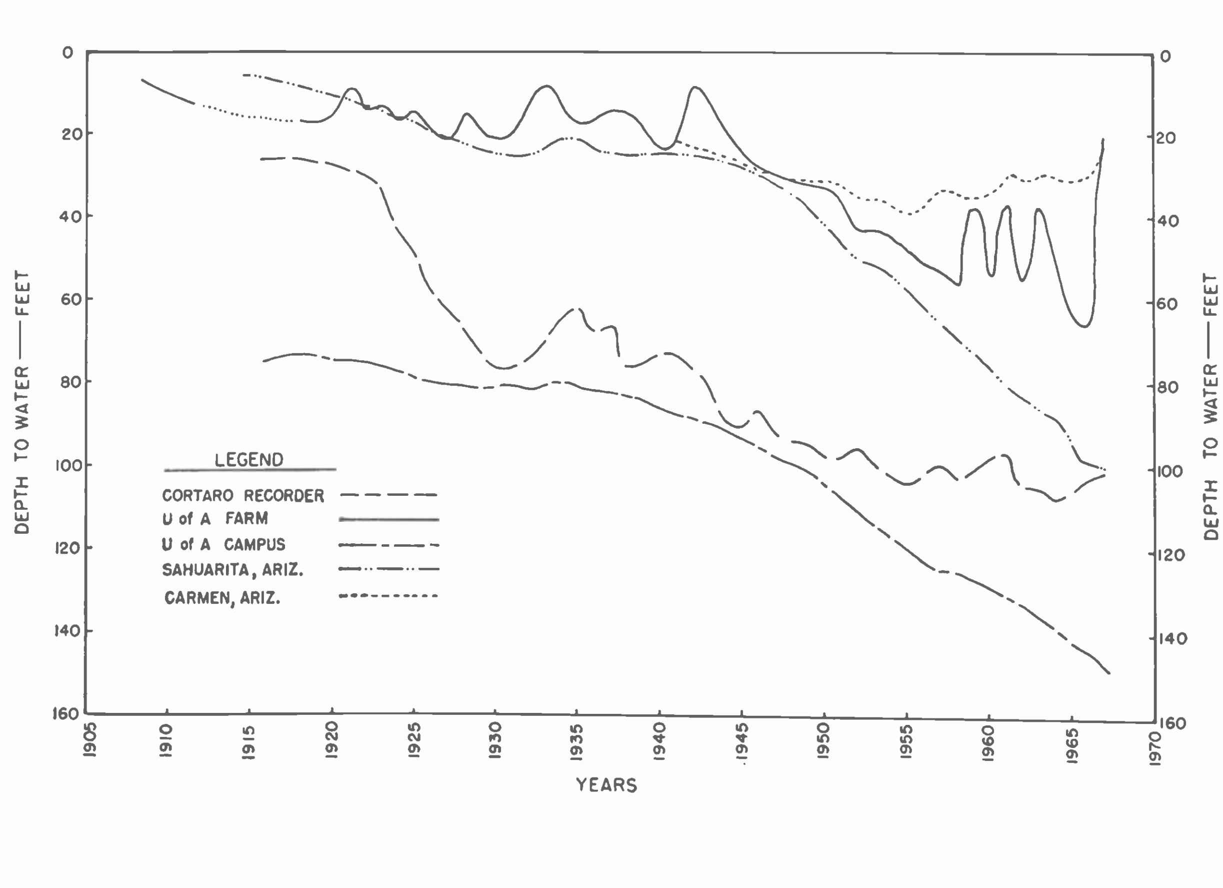
Rise of water levels by recharge from stream flow is shown in Figure 3 by the University of Arizona Farm well which is near the Rillito Creek. Also in Figure 3 the well near Carmen, Ariz. in Santa Cruz County indicates the effects of recharge from stream flow. The water level rose higher than any level previously recorded. This well is near the Santa Cruz River.

The Cortaro recorder well is near the river and responds to recharge from the river (Figure 3). The small undulations represent river recharge. However, since approximately 1947 no continuous decline in water levels has occurred. This is the approximate

(Continued on Page 17)

FIGURE 3

HYDROGRAPHS OF REPRESENTATIVE WELLS IN TUCSON BASIN AND SANTA CRUZ COUNTY



plied to the soil each year as layby treatments in cotton. The soil contained 20% sand, 57% silt, and 23% clay. Persistence of herbicides in the soil was evaluated by determining their effects on cotton (Table 2) and other plants. In some years residues of monuron and diuron persisted after cotton harvest, in other years little or no residues remained.

Herbicides did not affect crop yield in the first 7 years of this test. In the eighth year the yield from plots treated annually with 1.6 lb./A monuron was lower than that from untreated plots. In the ninth year the yield from plots treated with 1.6 lb./A of either monuron or diuron was lower than that from the untreated plots. Possibly these decreases resulted from accumulation, but we believe that they may have resulted from persistence or injury from that years treatment. Cotton yield generally was not affected by annual herbicide applications, although yields from all plots decreased because of continuous cotton production. A similar test is now in progress with herbicides such as *a,a,a*-trifluoro-2,6 - dinitro - N,N - dipropyl - *p* - toluidine (trifluralin), dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA), and 2,4-bis (isopropylamino)-6-methylmercapto-s-triazine (prometryne).

Lack of Irrigation Prolongs Residues

Although herbicide residues do not normally accumulate in irrigated croplands and persistence can be minimized, *each year thousands of acres of crops are affected by herbicide residues.* One reason for crop injury is the belief that all herbicides disappear from irrigated croplands with time. Residues of many herbicides usually decrease with time if the land is irrigated. When land is fallow without irrigation, however, loss of herbicides may be extremely slow. Herbicides applied in a crop may remain despite 1, 2, or more years of fallow.

When using herbicides, each grower should determine if residues which may affect the next crop persist. If used as recommended, herbicides usually will not create a residue problem. However, conditions in a field or on a farm may cause herbicides to persist. Persistence may occur in fields with variable soils or in those that receive improper or too little irrigation after treatment. This problem increased in areas with little rainfall and low temperatures. The grower should recognize these hazards and adapt his cultural practices to minimize possible injury to crops.

Water Recharge...

(Continued from Page 15)

date that rapid growth in the population of Tucson resulted in sewage flows down the Santa Cruz River sufficient to stabilize water levels. Thus, sewage recharge has equaled water pumped from this section of the Tucson Basin and the river is the method of supplying the water to the aquifer.

A study by Schwalen, et al. (3) showed that for 1961-1965, an average annual recharge of approximately 70,000 acre feet resulted from above normal flood flows in the Rillito Creek and Santa Cruz River. In the 1965-1966 season, the volume of recharge was approximately 150,000 acre feet for Rillito Creek area and the reach of the Santa Cruz River from Santa Cruz County line to Rillito narrows. This volume is substantially greater than the average annual recharge rate to the basin. It is the greatest recovery in water levels ever measured during the over 60 years that studies have been made within the Tucson Basin. The 1965-66 data provide strong evidence of the potential for recharge within the Tucson Basin.

Surface storage of water in the arid Southwest is subject to heavy losses from evaporation, and incurs the high expense of reservoir construction. Storage of water within underground basins should be considered as an alternate means for storing water for future use. The groundwater aquifer that has been dewatered by the years of pumping is an excellent storage site for water.

The Tucson Basin aquifer has a very large potential for rapid rate of recharge and has also the capability of very large volumes of recharge. Large volumes can be recharged provided that: (1) Natural runoff water is available, or (2) Additional sources of water are obtained. Various proposals have been made for obtaining the additional water. Increasing natural runoff by treating the watershed, and importation of water through the Central Arizona Project, are two such proposals.

The source of water that is a renewable supply within the Tucson Basin comes from natural recharge in Santa Cruz and the Rillito Creek areas and underflow from the mountains. For optimum utilization of this resource, wells to recover this water should be located adjacent to the recharge areas. This means that wells for optimum utilization of the groundwater should be located immediately adjacent to the Santa Cruz River and Rillito Creek. This permits maintaining water levels at a relatively low level so that maximum recharge occurs. If the water level in the aquifer rises to the stream bed surface, the rate of natural recharge is substantially decreased. If the water level is maintained a distance below the bottom of the stream bed, then maximum infiltration occurs. If the recharge rate for the Rillito Creek area was continued on an annual basis with no controlled pumping to remove the water, the volume of recharge would be on the order of 50,000 acre feet annually. With controlled pumping to maintain the maximum rate of infiltration within the streambed, the average annual recharge volume can exceed 500,000 acre feet.

SUMMARY

Water level data are very important for determining the availability and supply of our groundwater resources. These data also provide the only means for determining future needs for increased water supplies. Within the Tucson Basin an average annual overdraft of groundwater of approximately 100,000 acre feet occurs. In some years this overdraft is less because of a high volume of recharge for that year. Except for 1965-66, overdraft occurs every year and results in continuous declines of water levels in much of the area.

Proper management of water supplies within the Tucson Basin requires recognition that an overdraft of groundwater exists. Supplemental sources of water are required. Importation of water and water harvesting within the basin are possible sources of additional water. Data indicate that the depleted groundwater reservoir is an excellent storage site. The stream beds, especially Rillito Creek, are an excellent location for introducing water in the groundwater reservoir.

REFERENCES

1. **Schwalen, H. C. and R. J. Shaw. "Progress Report on Study of Water in the Santa Cruz Valley Arizona." Report Number 205, Department of Agricultural Engineering, The University of Arizona, Tucson, Nov., 1961, pp. 16-18.**
2. **Schwalen, H. C. and R. J. Shaw. "Water in the Santa Cruz Valley." Bul. No. 288, Arizona Agricultural Experiment Station, 1957.**
3. **Matlock, W. G., H. C. Schwalen and R. J. Shaw. "Progress Report on Study of Water in the Santa Cruz Valley." Report Number 233, Department of Agricultural Engineering, The University of Arizona, Tucson, Sept., 1965. pp. 25-27.**