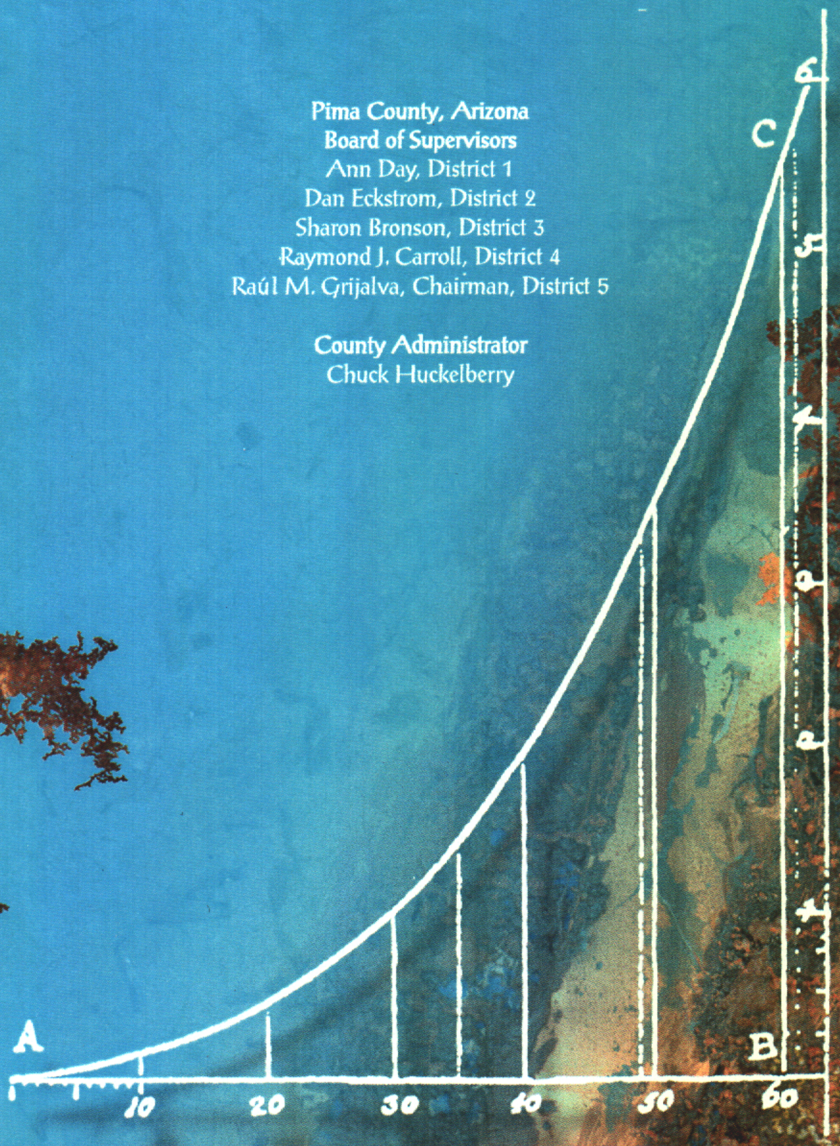
DRAFT

Groundwater Level Changes in the Tanque Verde Valley UPDATE

Sonoran Desert Conservation Plan 2002

Pima County, Arizona
Board of Supervisors
Ann Day, District 1
Dan Eckstrom, District 2
Sharon Bronson, District 3
Raymond J. Carroll, District 4
Raúl M. Grijalva, Chairman, District 5

County Administrator
Chuck Huckelberry



MEMORANDUM

Date: February 25, 2002

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Groundwater Level Changes in the Tanque Verde Valley**

I. Background

In early 2001, a study on *Groundwater Level Changes in the Tanque Verde Valley* was issued. Three months later a response was forwarded by the City of Tucson. County staff responded in writing to clarify misunderstandings in the letter by Tucson Water. Attached is the final version of the *Groundwater Level Changes in the Tanque Verde Valley* study.

II. Summary of Purpose and Method

In 1990 a study by Dr. Stromberg of Arizona State University showed that groundwater levels directly influence mesquite bosque vigor and existence. Pima County examined groundwater levels along the Tanque Verde Creek since the Stromberg study was conducted in 1990 to evaluate the impacts on this important biological resource as part of the Sonoran Desert Conservation Plan. The study area encompasses the mesquite bosque along Tanque Verde Creek from approximately Wentworth Road to Sabino Canyon Road. This is the same area as used in the Stromberg study; the same wells were used for groundwater level data.

County staff analyzed annual groundwater elevations from December 1987 through December 1999, a 12 year period, based on public data files for 17 wells in the study area. The dates overlap and extend beyond the period of the Stromberg study, in order to examine groundwater stresses since that 1990 study. The depth-to-water ranges from 6 to 161 feet. According to the Stromberg study, mesquites are stressed when water depths are between 16 and 59 feet, while near-lethal and lethal stress occurs in mesquites at water levels greater than 59 feet.

Water levels in wells 1 through 3 were generally less than 16 feet; levels in wells 4 through 10 were between 16 and 59 feet; and in wells 11 through 17, levels were generally greater than 59 feet. Wells 1,3,4,7,8,10,11,16 and 17 are at or close to the elevation of the mesquite bosque. Areas of former mesquite bosque were interpreted from 1941 aerial photographs.

The authors constructed longitudinal profiles along the axis of Tanque Verde Creek for several years between 1947 and 1956 to show water level changes as a result of pumping. The 1947 groundwater surface varies between 10 and 20 feet below ground surface. Staff compared 1999 water levels to 1947 water levels. Water levels in wells upstream of Tanque Verde Loop Road are similar to 1947 conditions, while downstream of Houghton Road the 1999 water levels are lower than 1947 by up to 60 feet.

III. Study Findings

Some of the findings of the attached study include:

- Groundwater depletion along Tanque Verde Creek upstream of Sabino Creek was well underway by 1947. Groundwater depletion increased in the late 1980's.

- Declines in the water table during the late 1980's occurred due to drought and increased consumer demand for water in the Tanque Verde Valley. Observed declines led to 1990 investigations of water stress in mesquite trees by Stromberg (1992).

- A "last on, first off" policy was adopted for wells n the area, But this report finds that adoption of this policy has not been sufficient to restore the water table in the reach below Houghton Road, where a substantial acreage of mesquite woodland exists. Water levels rose in this area following the January 1993 flood event and the delivery of CAP in 1992. For the period 1988 to 1998, reported groundwater withdrawals averaged some 9960 AF/yr, from three water companies and over 400 private wells.

- Water budget analysis suggests that the current usage perpetuates the depleted aquifer conditions. The estimated average annual recharge to the entire northeast area is 9,900 AF/yr. Average pumpage along the study reach of Tanque Verde Creek alone is 9,956 AF/yr not counting pumpage occurring elsewhere in the northeast area bounded by Sabino Canyon Road, Speedway Boulevard and the National Forest. A healthy riparian forest of 3000 acres would require an estimated 7,500 AF/yr, however water levels in some areas remain too low to support vigorous mesquite bosque, let alone restoration of perennial stream flow. Current (1999) water levels are similar to those which existed at the time of the Stromberg.

- A passive result of the dewatering and lowering regional aquifer in the Tanque Verde Valley has been the formation of perched aquifers, which may be maintaining some of the mesquite bosque north of Tanque Verde Creek. The perched aquifer conditions may be mitigating the impacts of pumping in the vicinity of the greatest declines in the regional aquifer. However, while the bosque is undeniably adaptive to natural groundwater fluctuations, trees may experience greater stress from the more extreme fluctuations resulting from the perched aquifer formation.

IV. Study Recommendations

Some of the suggestions and recommendations of the attached study include:

- Decreased pumping by Tanque Verde Valley well users could improve habitat conditions along Tanque Verde Creek.

- Additional use of renewable supplies could be facilitated if Metropolitan and Forty-Niner's water utilities connected to Tucson Water's potable and reclaimed delivery systems.

- Extensions of the reclaimed system to the Tanque Verde Valley would also reduce demands, if the community is willing to pay the price.

- Growth should be linked both to groundwater availability, and to the vigor and longevity of the existing ecosystem.

- Property owners should be encouraged to utilize the Pima County Floodprone Land Acquisition Program for their undevelopable properties and the program should be funded appropriately.

- Developers should continue to be accountable to riparian mitigation standards.

- A more complete analysis of the study area wells (i.e. perforation intervals) might reveal the presence of confined and/or perched aquifers. Additionally, a survey of private wells could document the occurrence of cascading (and hence perched) groundwater. Since groundwater levels obtained from wells are influenced by the type of aquifer that is being tapped, this information could explain areas of good mesquite vigor where water levels appear to be at lethal levels, and areas of poor mesquite vigor where water levels appear to be adequate.

- A comprehensive assessment should be made of the historical impact of land development and the resulting physical removal of vegetation over time.

- Natural recharge processes would benefit from further study using microgravity techniques.

- An ongoing biologic assessment of the bosques around the monitor wells such as was done in the Stromberg study, would allow a more detailed comparison of water levels and mesquite vigor. The Stromberg study focused on mature mesquite trees, and recommended further study on the stress response of young mesquite. Early warning stress indicators should be monitored in a timely manner to determine whether the mesquite are being stressed to such a degree that existence of the bosque is threatened.

V. Conclusion

Pima County will continue to assess and look for ways to contribute to the protection of the resources in the Tanque Verde area. I have directed the Flood Control District to improve the level of stewardship on County-owned lands at the confluence of the Agua Caliente and Tanque Verde Creek, along with County lands upstream. The Flood Control District is also pursuing a follow up study to develop and implement a plan to monitor the health of the trees and the availability of both surface and groundwater at lands owned by the Flood Control District.

Attachment

GROUNDWATER LEVEL CHANGES IN THE TANQUE VERDE VALLEY

Table of Contents

Table of Contents (cont'd)

List of Figures

List of Tables

Appendices

Groundwater Level Changes in the Tanque Verde Valley
November, 2001
by Elizabeth Hill and Julia Fonseca

Introduction

The Tanque Verde Valley is a regionally significant riparian ecosystem (Figure 1). It is identified as a conservation site by The Nature Conservancy's *Ecological Analysis of Conservation Priorities in the Sonoran Desert Ecoregion (2000),* largely on the basis of the mesquite woodlands and cottonwood-willow woodland found there.

Tanque Verde Creek is the major drainage in the Tanque Verde Valley. Historically, Tanque Verde Creek below Coronado National Forest supported an aquatic fauna that included native fish and leopard frogs. The endangered Gila Topminnow, for instance, was collected from Tanque Verde Creek as recently as 1941 and from a spring "50 feet west of Tanque Verde Creek at the Tanque Verde Ranch" in 1943 (Minckley, 2000). Today, perennial flow is no longer present outside of the Coronado National Forest.

A survey of dry washes in metropolitan Tucson found eastern Tanque Verde Creek to have the highest species richness of riparian birds and neotropical migrants (Frederick, 1996). This study also found that total canopy cover, mesquite density and absence of bank stabilization were factors which correlated positively with species richness for birds. The dark-toned areas on Figure 2 show riparian vegetation associated with the valley floor. Mesquite trees in these shallow groundwater areas exhibit a much higher density and size than in xeric upland areas, forming bosques (spanish for 'woodlands').

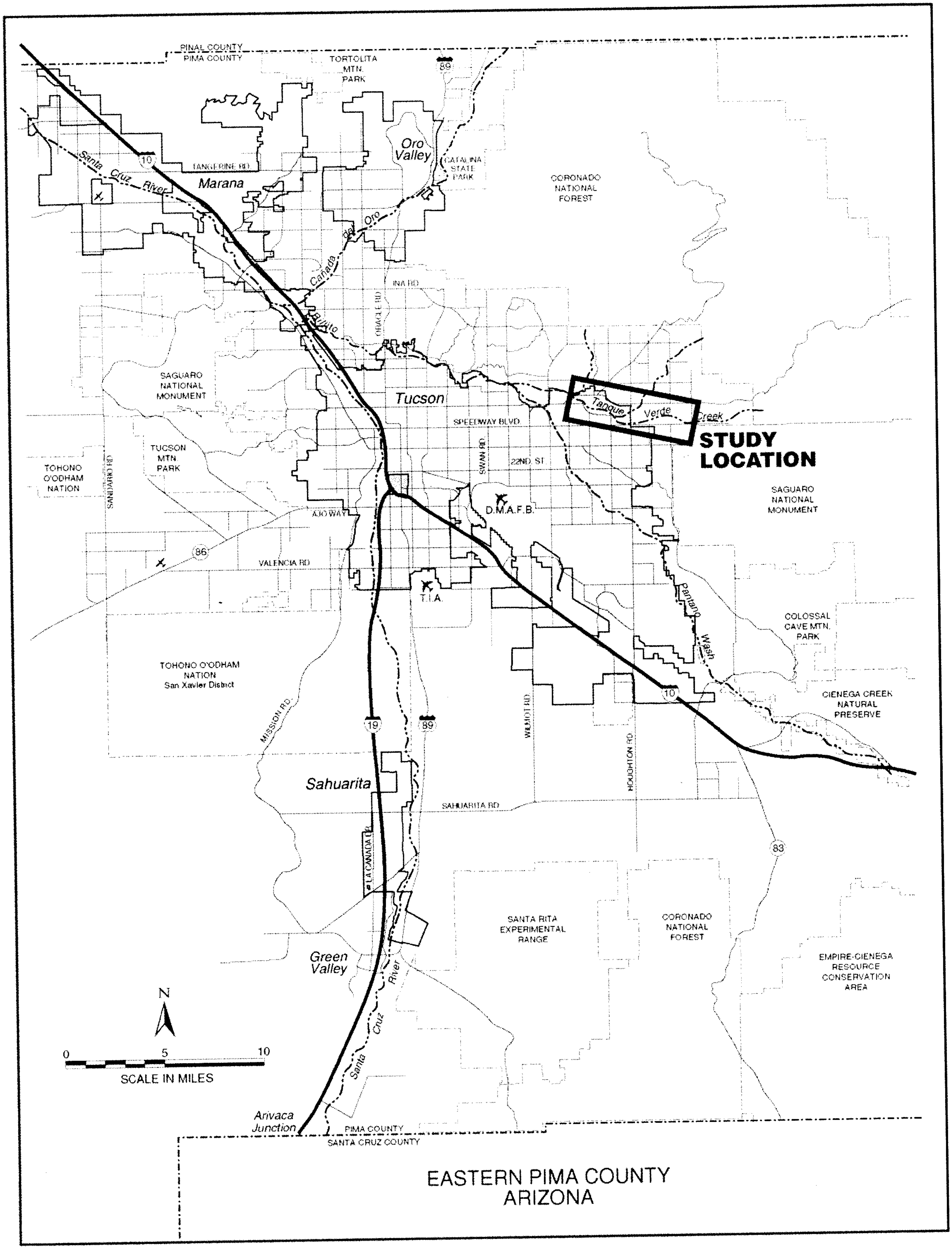
The mesquite bosque, a once abundant riparian plant community associated with ephemeral and perennial streams in the American Southwest, has declined substantially in the last century. Because the bosque is so closely linked to groundwater depth, declining water levels are a factor in the degradation and loss of this riparian habitat. Groundwater pumping in excess of the amount of natural recharge contributes to water table decline. Additionally, in urbanizing areas, physical removal of vegetation occurs due to development. The Tanque Verde Valley, as a result of its scenic beauty, semi-rural qualitites, and proximity to metropolitan Tucson, has experienced increasing development and loss of mesquite bosque over the last 5 to 6 decades. The remaining bosque is threatened by continued urban development and groundwater levels lowered by pumping of wells in the area.

In 1990, a study of groundwater decline and its effect on mesquite bosque vigor was conducted along a six mile reach of the Tanque Verde Creek (Stromberg et al., 1992, Appendix 1). The report found that as groundwater depths fell from 16 to 59 feet, mature mesquite trees exhibited increasing signs of stress. Stresses included decreased leaflet size, leaflet number, and canopy height. At water levels less than 16 feet, the trees were measurably healthier, with large leaflets, tall stature and greater vegetation volume. At water levels deeper than 59 feet, trees showed evidence of near-lethal stress. Figure 3 illustrates how water stress affects mesquite woodlands. Measurements for the study were taken in May, June, August and October, 1990. Summer rains and seasonal surface flow temporarily reduced stress, but did not offset the effects of groundwater decline. The study prompted Tucson Water to adopt a "last on, first off" policy for their wells along Tanque Verde Creek.

Portions of a recently published report on hydrologic and riparian resources in Saguaro National Park East, concerned a mesquite bosque located along the northern boundary of the Park in a tributary (Monument Wash) to Tanque Verde Creek (Baird, et al., January, 2001). The study found that the bosque is being negatively impacted by groundwater withdrawals in the down-gradient hydraulically connected alluvium of Tanque Verde Creek.

Purpose

Stromberg showed that groundwater levels directly influence mesquite bosque vigor and existence. The purpose of this report is to examine groundwater levels along the Tanque Verde Creek since the Stromberg study was conducted in 1990 and evaluate the impacts on this important biological resource. The study area encompasses the mesquite bosque along Tanque Verde Creek from approximately Wentworth Road to Sabino Canyon Road. This is the same area as used in the Stromberg study, as are the wells used for groundwater level data. Groundwater pumping data was obtained for an area within a 1-mile radius of the Creek, from 1-mile upstream of Wentworth Road to 1-mile downstream of the Sabino Creek confluence. Natural recharge data was obtained for the drainage area contributing to Tanque Verde Creek at the Sabino Creek confluence.



Pima County Graphic Design

Figure 1. Location Map

Figure 2. Location of wells used in this study

Pima County Graphic Design 1/01 pc

Healthy mesquite bosque, Cienega Creek (groundwater level at approximately 20 feet).

Canopy dieback, Tanque Verde Creek at Pantano Wash November 1999 (groundwater level at approximately 50 feet).

Former mesquite bosque, Casa Grande (groundwater level at approximately 100 feet).

Figure 3. Decline of Mesquite Bosques

Pima County Graphic Design 1/01 pc

Tanque Verde Creek

Tanque Verde Creek forms the major drainage system in the Tanque Verde Valley. Downstream from Houghton Road Tanque Verde Creek flows from Pima County into the City of Tucson.

Figure 2 shows an aerial photo of the study area (1998). Tanque Verde Creek has natural earthen banks upstream of Houghton Road, except for a few isolated locations where bank stabilization has been constructed by individual property owners. Hydro-mesoriparian habitat has been mapped across much of the floodplain from Wentworth Road to Houghton Road. The presence of a significant stand of continuous riparian vegetation is one of Tanque Verde Creek's most distinguishing characteristics (Pima County Flood Control, 2001).

The Agua Caliente Wash drains naturally into Tanque Verde Creek downstream of Houghton Road. Residential development north and south of the channel is generally sparse, with large properties. Exceptions occur along the north bank with the moderately dense Forty-Niner's Country Club Estates, and residential subdivisions along the south bank downstream of Houghton Road.

Pima County has constructed limited stabilization in the vicinity of the Houghton Road bridge. The channel is fully bank stabilized between the bridges at Tanque Verde Road and Sabino Canyon Road, and the Sabino Creek confluence has been fully stabilized with soil-cement.

Groundwater Levels

We examined annual groundwater elevations for a 12 year period (December 1987-December 1999) from Tucson Water public data files for 17 wells in the study area, the same wells as used in the Stromberg study. The dates overlap and extend beyond the period of the Stromberg study, in order to examine groundwater stresses since that 1990 study.

The 17 well locations are shown on Figure 2 and the wells are described in Appendix B. For ease of reference, Tucson Water well names have been numbered simply from 1 to 17, beginning at Wentworth Road and proceeding downstream. Water surface elevations in wells located upstream of Houghton Road are generally higher; the direction of groundwater movement is generally westerly.

Groundwater profiles in Figure 4 show the water surface elevations generated for the 12 year period. Groundwater profiles in Figure 5 show the depth-to-water below land surface. The depth-to-water ranges from 6 to161 feet. According to the Stromberg study, mesquites are stressed when water depths are between 16 and 59 feet, while near-lethal and lethal stress occurs in mesquites at water levels greater than 59 feet. As shown on Figure 5, only water levels in wells 1-3 are generally less than 16 feet; in wells 4-10, levels are between 16 and 59 feet; and in wells 11-17, levels are generally greater than 59 feet. Wells 1,3,4,7,8,10,11,16 and 17 are at or close to the elevation of the mesquite bosque. Areas of former mesquite bosque were interpreted from 1941 aerial photographs.

Figure 6 is based on work by Schwalen and Shaw (1957). The top map is a plan view showing groundwater table contours in spring 1956. The authors constructed longitudinal profiles along the axis of Tanque Verde Creek for several years between 1947 and 1956 to show water level changes as a result of pumping. The 1947 groundwater surface varies between 10 and 20 feet below ground surface. We have superimposed 1999 water levels on the Figure 6 profile to compare with 1947 water levels. As Schwalen and Shaw state, the 1947 water levels reflect groundwater depletions. Our review of 1941 aerial photographs shows much of the Tanque Verde corridor was used for irrigated agriculture at that time.

Inspection of Figure 6 water levels shows that 1999 water levels in wells upstream of Tanque Verde Loop Road are similar to 1947 conditions, while downstream of Houghton Road the 1999 water levels are lower than 1947 by up to 60 feet.

Groundwater Level Influences

I. Central Arizona Project

Two significant dates of Central Arizona Project (CAP) water delivery are noted on Figures 4 and 5, with delivery beginning in November 1992, and phasing out approximately two years later in October1994. As CAP water was introduced to the potable water delivery system, Tucson Water began taking water supply wells out of production, notably in their Central Wellfield.

The graphs in Figure 7, extracted from a City of Tucson report (1996), illustrates the general effect CAP water delivery had on pumping in the Central Wellfield, and on total area pumping. A continuous hydrograph of Well B-052A, located in the Central Wellfield near Grant/Craycroft, shows a rise in water surface elevation during CAP delivery and supply well shutdown. In 1993, with CAP water supplementing the delivery system, there was a significant decrease in total area pumping, when compared to previous years. Inspection of Figure 5 Depth-to-Water in 1993 shows that the reduction in pumping coupled with a very wet year resulted in rising water surface levels in the deeper wells. However, in the dry year of 1994 when consumer demand increased (Figure 7) and CAP was being phased out, water levels declined in the deeper wells. (Figure 5). Shallow wells did not show consistent water level fluctuations for those years.

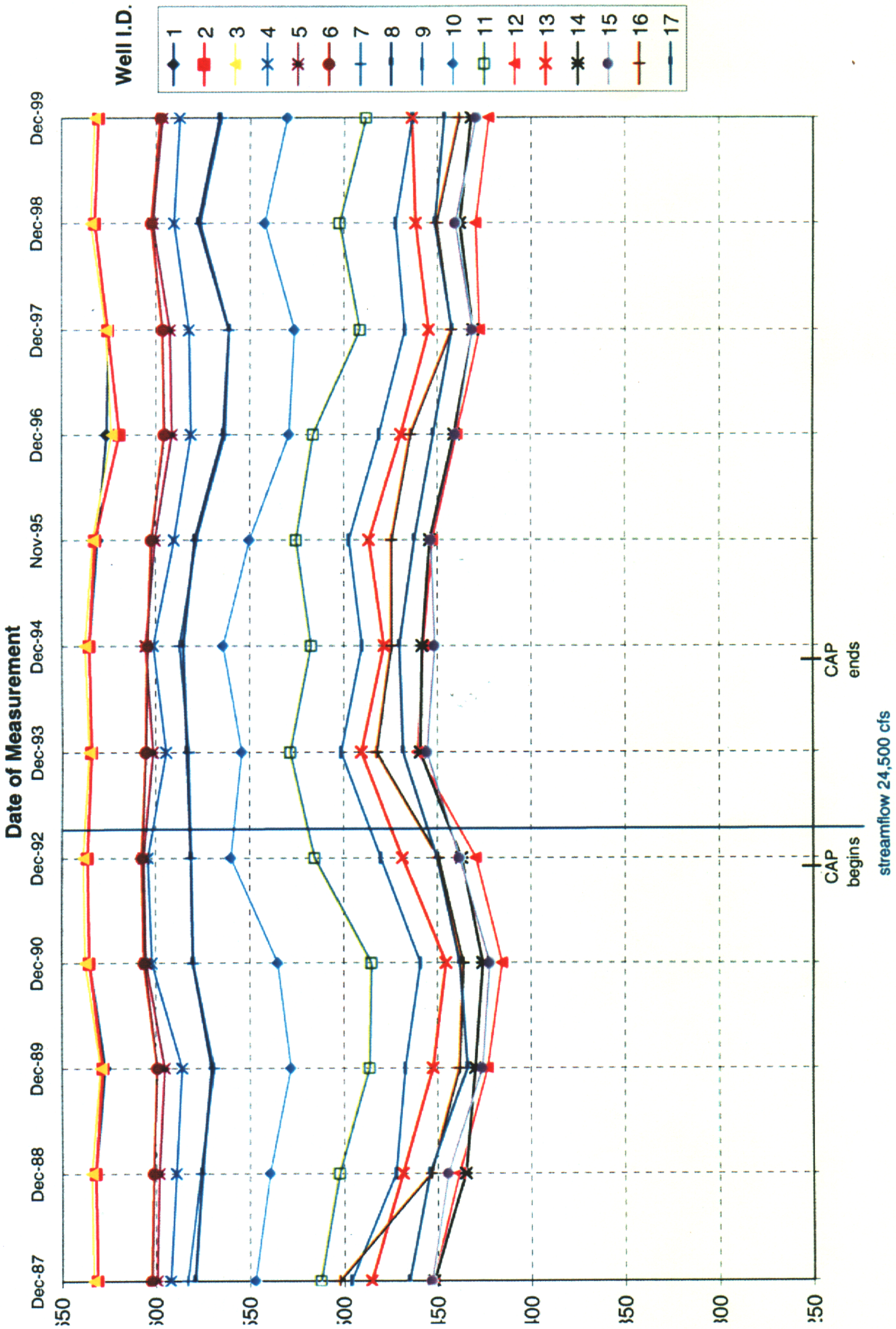


Figure 4. Water surface elevations

Pima County Graphic Design 1/01 pc

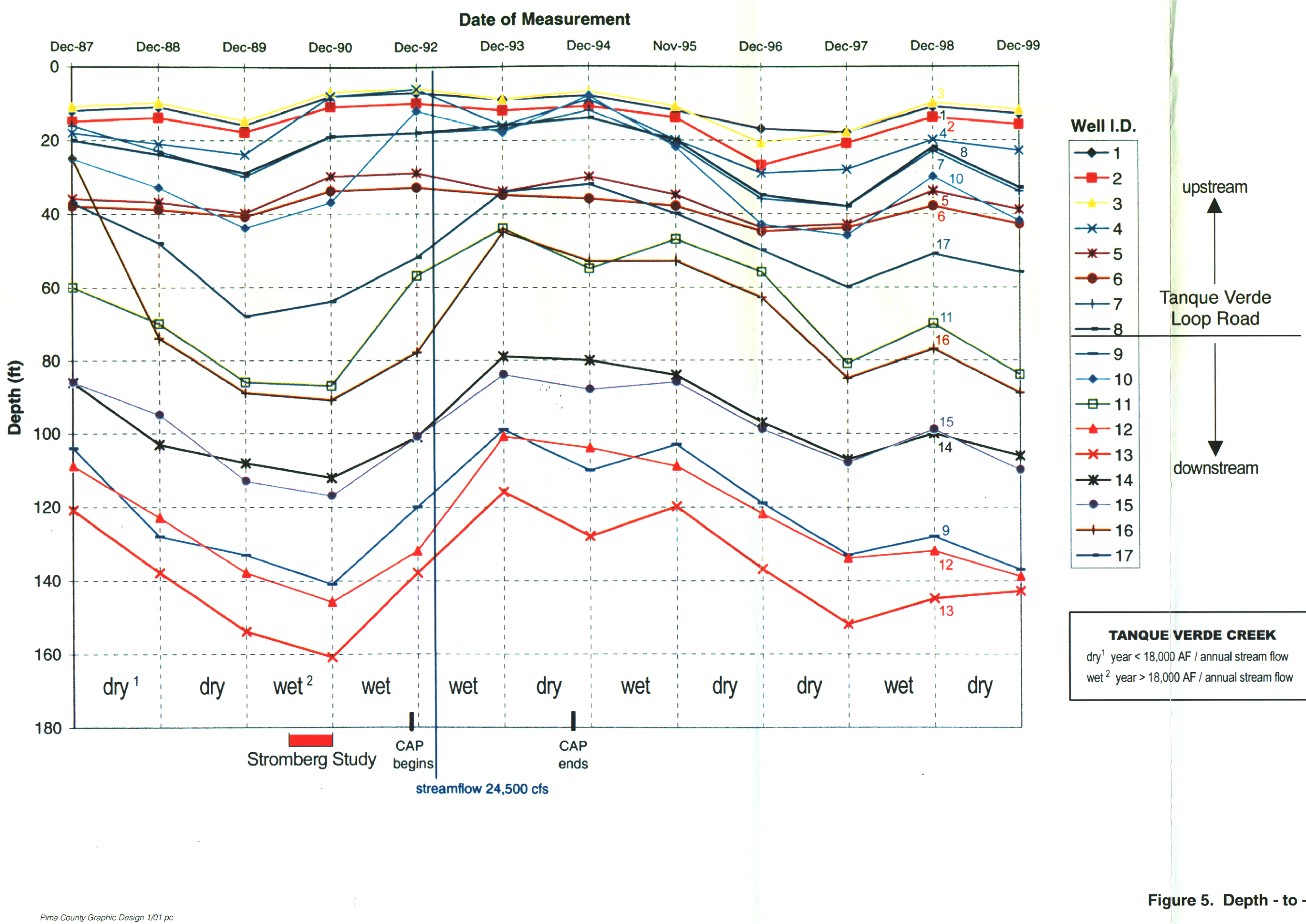


Figure 5. Depth - to - Water below land surface

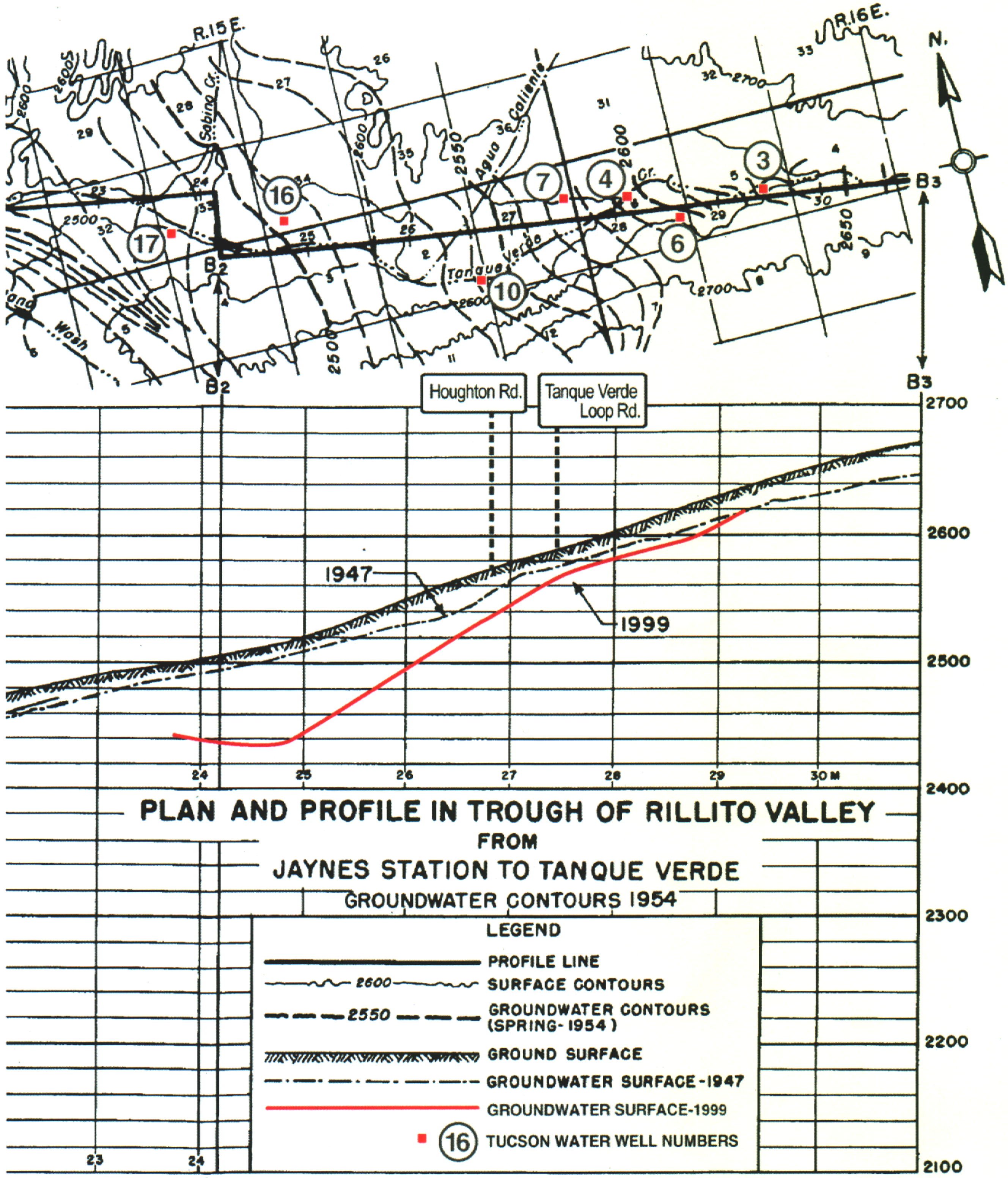


Figure 6. Water Levels in 1947 and 1999

Pima County Graphic Design 1/01 pc

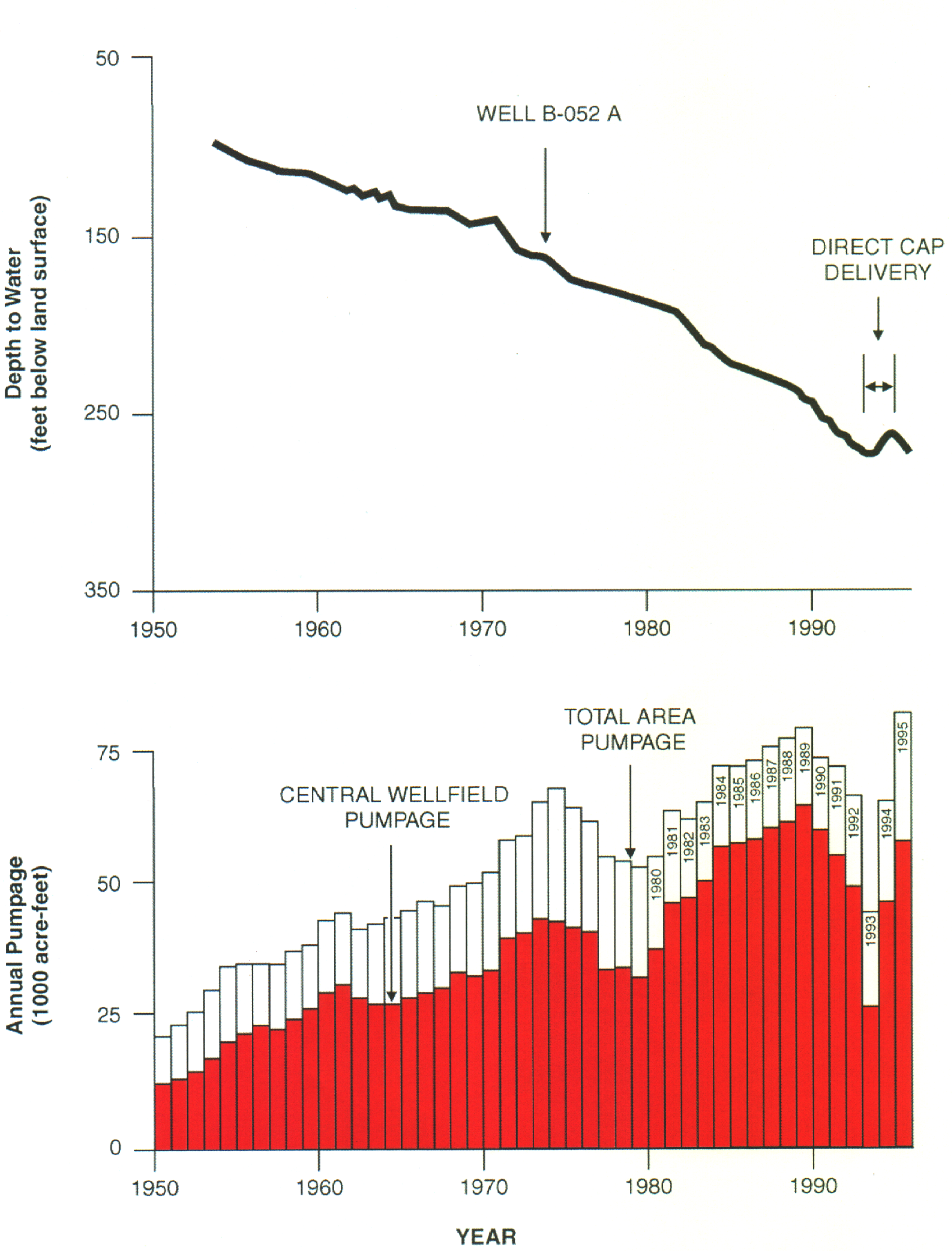


Figure 7. Tucson Water Central Wellfield Pumpage and Hydrographs of Well B-052 A

II. Streamflow

The United States Geological Survey operates a gauging station at Site #09484500 located at the intersection of Sabino Canyon Road and Tanque Verde Creek (Figure 2). The Tanque Verde Creek streamflow data shown in Figure 8 are for Water Years (October 1 to September 30).

Total annual streamflow in acre-feet (AF) was available for eight years, 1991 to 1999 (Figure 8, top). Water Year 1993 was significant with over 100,000 AF.

Annual peak streamflow in cubic feet per second (cfs) was available for the 12 year study period (Figure 8, bottom). Water Year 1993 was significant with a peak flow of 24,500 cfs, while the peaks in the previous years are much less than the 100 year event for the gauging station.

"Wet" and "dry" years are labeled on Figure 5 and refer to an average annual discharge of approximately 18,000 AF (calculated from the 18 year period of record at the gauging station). A"dry" year thus refers to less than18,000 AF average annual runoff. A multi-year drought was occurring prior to and during the beginning years of the graph, 1987 to 1990. Water years 1994, 1996 and 1997 were also extremely dry.

III. Natural Recharge

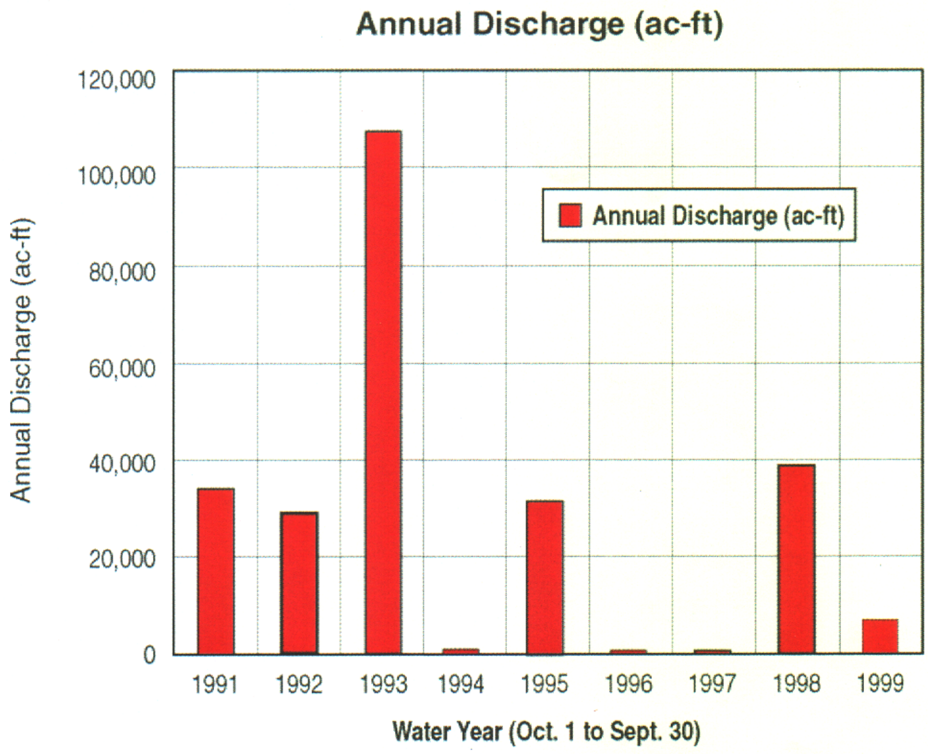
The majority of groundwater recharge occurs by channel infiltration of streamflow which is augmented by overbank flooding and storage. As the annual streamflow data for the Tanque Verde Creek shows, extreme variability has occurred within the 12 year study period. This variability is an inherent characteristic of stream runnoff in Arizona, where technically speaking drought conditions exist 60 to 80 percent of the time (Eychanor et al, 1991).

Average annual infiltration has been calculated by others along various reaches and tributaries of Tanque Verde Creek. For an area bounded at the downstream end by Sabino Creek, there could be an estimated 7,500 AF/yr channel infiltration (Burkham 1970), augmented by 2,400 AF/yr mountain front infiltration (Osterkamp 1973), resulting in a potential average recharge credit of 9,900 AF/yr (inclusive of Sabino Canyon). This estimated value fluctuates in response to the extreme variability of yearly rainfall events.

In order to visually describe the effect of runoff on aquifer recharge, "wet" and "dry" years can be compared to the fluctuating depth-to-water profiles on Figure 5. Very generally, there appears to be a decline in water levels following "dry" water years such as 1994, 1996 and 1997, and a rise in water levels following "wet" water years such as 1993 and 1995, suggesting that streambed recharge affects groundwater levels along the Creek. All of the wells do not exhibit this rise-and-fall response trend, however, and it is possible that another variable such as groundwater pumping may be influencing water levels.

Despite the unusually prolonged rainfall and runoff events of Dec. 1992 and January 1993, and reduced municipal pumping (Table 3), water levels declined between December 1993 and December 1994 at wells downstream of Houghton Road.

Since October 1994, after the CAP deliveries were discontinued and rainfall was average or below average, the net result has been a decline in water levels. In the reach upstream of Houghton Road, where the groundwater table is generally shallow, water levels in wells have declined below levels associated with mesquite stress in the Stromberg study, despite the wet "El Nino" winter of 1998.



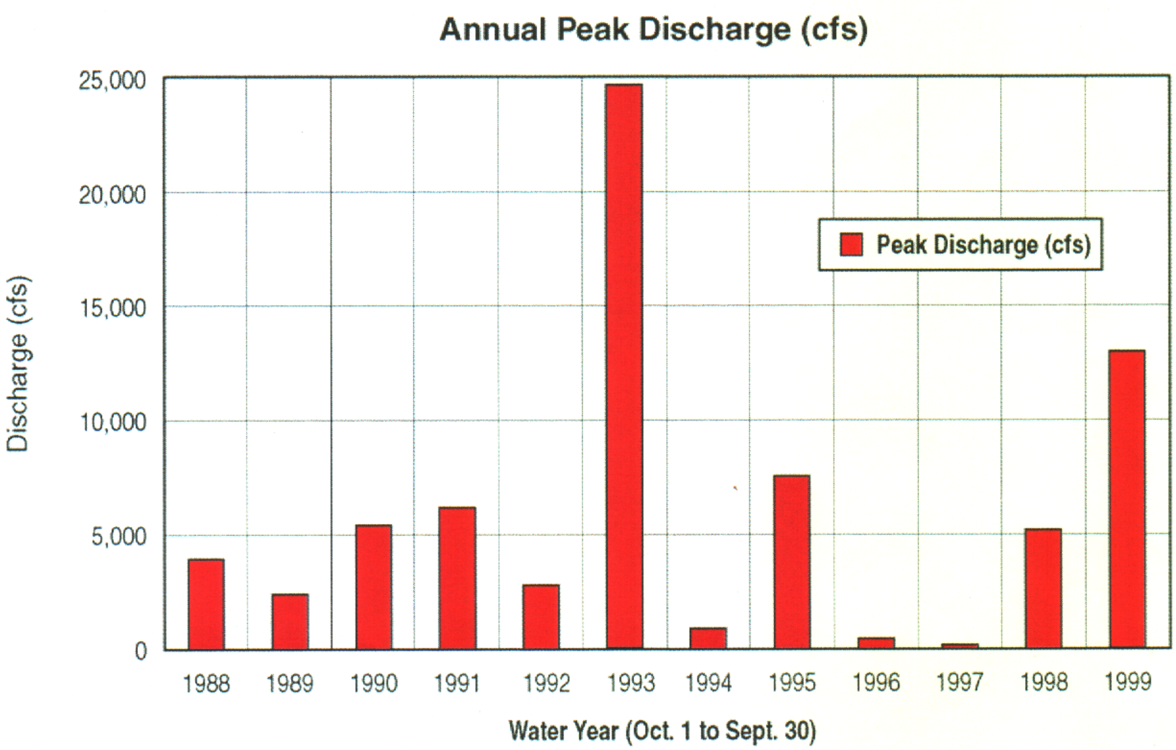


Figure 8. Tanque Verde Creek USGS Gauge #984500

Pima County Graphic Design 1/01 pc

Hydrogeology and Pre-Development Conditions

The Tanque Verde Valley aquifer system consists of two geologic formations. The uppermost unit is an extremely permeable deposit of stream channel alluvial sediments associated with Tanque Verde Creek. It is less than 100 feet thick and extends laterally to 3,000 feet from the channel.

The second geologic unit, beneath the channel deposits, is a trough of less permeable sediments extending roughly from Tanque Verde Loop Road on the east to approximately Sabino Canyon Road on the west, at a depth of approximately 600 feet. A structural feature which bounds this trough to the east has resulted in shallow depths to bedrock which sustain comparatively shallow water levels east of Tanque Verde Loop road. The western end of the trough is delimited by a deep fault near Sabino Canyon Road, which partially insulates the Tanque Verde Valley from the down-gradient Tucson Basin and Tucson Water Central Wellfield.

In a natural system under equilibrium conditions, the recharge to the aquifer, over time, would have been balanced by an equal amount of discharge. Discharges occurred in the form of base flows along perennial and intermittent flow reaches, evaporation from moist soil, and transpiration of groundwater-dependent plants. Each of these water uses is vital to a riparian system: streamflow sustains fish and frogs and aquatic snakes and turtles. Moist soil is needed for aquatic plants and riparian tree germination. Transpiration is needed to cool the leaves of riparian plants during the day.

Under pre-development conditions, the regional water table intersected the stream channel of Tanque Verde Creek and largely filled the upper stream deposits aquifer. This appears to be the condition of the aquifer in March 26, 1941 photographs (on file at Pima County Floodplain Management Division), which show continuous flow along the Creek. The preceding winter had been a wet one. During times of drought, the lower formation would have yielded water to the stream deposits aquifer to sustain flows for the Gila topminnow and a high water table for the cottonwood and other riparian plants.

The ability of the water to move from the lower formation to the upper formation made the Tanque Verde riparian area less vulnerable to droughts, even after groundwater pumping began to reduce base flow. The regional aquifer still intersected the stream deposits along some reaches of Tanque Verde Creek as late as 1947, according to water level data published by Schwalen and Shaw (1957) (Figure 6). The effects of the 1950s drought upon Tanque Verde Creek, which was a severe drought with a recurrence interval measured in excess of several hundred years (Swetnam and Betancourt, 1998), exemplifies the resilience that a connection to the regional aquifer can provide. During the 1950's drought, water levels recorded by Schwalen and Shaw (1961) along Tanque Verde Creek declined relatively little. For instance, a well in the Woodland Road area , near well 16 of this study, declined from 13.1 feet below ground in 1956 to a low of 21.4 feet in 1956 (Schwalen and Shaw, 1961). Depth to water in December 1999 was 90 feet near this location.

I. Historic Groundwater Withdrawal

Increasing development in the Tanque Verde Valley over the past 6 decades has brought increased use of local groundwater. The compromised Tanque Verde Valley regional aquifer has suffered declines due to over withdrawal (Figure 6) and has differentiated in some areas into regional and perched water zones.

The dessication of the shallow alluvial deposits aquifer and lowering of the water table into the lower formation caused perennial and even intermittent stream conditions along Tanque Verde Creek to disappear. In some areas, a perched water table was created as the regional water table declined. These perched systems are inherently more vulnerable to drought because they are disconnected from the regional aquifer. The thickness and lateral extent is small relative to the regional aquifer, and therefore they cannot provide the resilience to droughts that a regional aquifer can.

Most private well users in the Tanque Verde Valley utilize the shallow channel deposits and perched zones for their water needs. Recharge of these deposits is dependent upon infiltration of runoff, which is highly variable with rainfall. Withdrawals increase in dry years when recharge potential is low.

The major delivery company Tucson Water has served the area for many years. Wells built prior to 1980 take their water in part from the upper channel deposits, as well as from the lower formation. In the 1980's Tucson Water targeted the lower formation as a source of high quality, low cost groundwater. To supply increasing consumer demands, five new wells were constructed in 1988 and were permitted by the Arizona Department of Water Resources (ADWR) to withdraw a total of approximately 11,000 AF/yr (1989).

Groundwater levels in the Tanque Verde Valley basin have also experienced negative effects from the many years of pumping in the down-gradient Central Wellfield. The large water level declines in the Central Wellfield have resulted in declines along the aquifer edge at the Tanque Verde Valley basin fault near Sabino Canyon Road, causing increased groundwater movement out of the Tanque Verde Valley. (ADWR staff, pers. comm.)

III. Recent Groundwater Withdrawal

Several major water users and many private well users are responsible for ongoing groundwater withdrawals in the Tanque Verde Valley. For the study period pumpage data was obtained from Pima Association of Governments (PAG). Withdrawal data in Tables 2 and 3 were compiled by PAG from the Arizona Department of Water Resources Well Registry CD-ROM Version 5 for all non-exempt wells (pumpage greater than 35 gpm) within a one mile radius of Tanque Verde Creek from Wentworth Road to Sabino Creek (Appendix C and D). The following table shows the major users and their average annual withdrawal amounts.

TABLE 1: Average Annual Pumpage by Water User

Major Water User	Average Annual Pumpage (1988-1998)
Tucson Water	7,018 AF
MDWID	985 AF
49ers Country Club Estates	775 AF
Others (private)	867 AF
Exempt Wells	311 AF
TOTAL	9,956 AF

Tucson Water is the principal entity pumping wells located along Tanque Verde Creek. Metropolitan Domestic Water Improvement District (MDWID) and Forty-Niners Country Club Estates are the second and third biggest users of groundwater from the study area.

Tucson Water has stated that groundwater pumping in the northeast area of the Tucson basin primarily supports local water demand and development and that additional groundwater supply is conveyed from other portions of the Central Wellfield to satisfy the current northeast area demand (City of Tucson, 2001).

Table 3 shows total annual pumpage by water users for 10 years, from 1988 to 1998.

Figure 9 shows the locations of all registered non-exempt wells used for this report, along with water user jurisdictional boundaries. Exempt wells, which are pumped at a rate of less than 35 gallons per minute (gpm), are not shown on Figure 9. There are approximately 300 exempt wells in the Tanque Verde Valley, each pumping an estimated one AF per year (Pima County, 2000).

Table 2: Total Annual Pumpage by Water User (See Figure 9)

	Number of Wells	Total Reported Annual Withdrawals (AF)										
		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Tucson Water	36	9746	11262	7797	4765	4998	3581	7772	6331	6326	7724	6892
MDWID / HUB	5	919	1005	848	896	907	996	1055	1100	1055	1062	992
49ers CC Estates	6	780	857	575	681	653	773	864	821	862	833	825
Others	133	1177	2035	833	848	805	838	709	615	649	499	534
Exempt wells[2]	311	311	311	311	311	311	311	311	311	311	311	311
Total[1]	491	12933	15470	10364	7501	7674	6499	10711	9178	9203	10429	9554

Note: Well identification and withdrawal data obtained using ADWR Well Registry CD-ROM version 5. Base map, including washes and streets, created using Pima County Land Information System (PCLIS).

[1]Total number of registered water production wells. Includes non-exempt wells (>35 gpm pump capacity) and exempt wells (<35 gpm). Owners of exempt wells are not required to submit withdrawal data to ADWR. Not every well reported pumpage and some did not pump any amount.

[2] Estimated pumpage is 1 AF per well (Pima County, 2000)

The average rate of withdrawal by the major water users over the 10 year period is 9,956 AF/yr. In "dry" years 1994 and 1997, the actual withdrawal amounts are in excess of the estimated average 9,900 AF/yr recharge for the Tanque Verde Valley to Sabino Creek (see Natural Recharge Section). These withdrawal amounts do not account for the needs of riparian plants in the form of evapotranspiration.

Vegetation mapping recently completed for the Sonoran Desert Conservation Plan indicates that there is around 3000 acres of riparian vegetation overlying the Tanque Verde-Agua Caliente shallow groundwater zone defined by PAG (2000). Estimated consumptive use for dense to medium dense mesquite woodland would be 20 to 30 inches per year in Tucson, based on Arizona Dept. of Water Resource estimates (1991). At even a minimal use rate of one foot per year, it can be seen that water demand by riparian vegetation constitutes 3000 AF/yr, a considerable portion of the water budget. Healthy riparian woodlands of this type would have a water demand closer to 7,500 AF/yr.

Area Development

As previously mentioned, the Tanque Verde Valley is subject to increasing development pressure due to its semi-rural qualitites and proximity to metropolitan Tucson. In an area bounded by the National Forest, Speedway Blvd.,and Sabino Canyon Road, population has increased by 30% since 1990. The 2000 census indicates population increased from 28,351 to 36,938 persons.

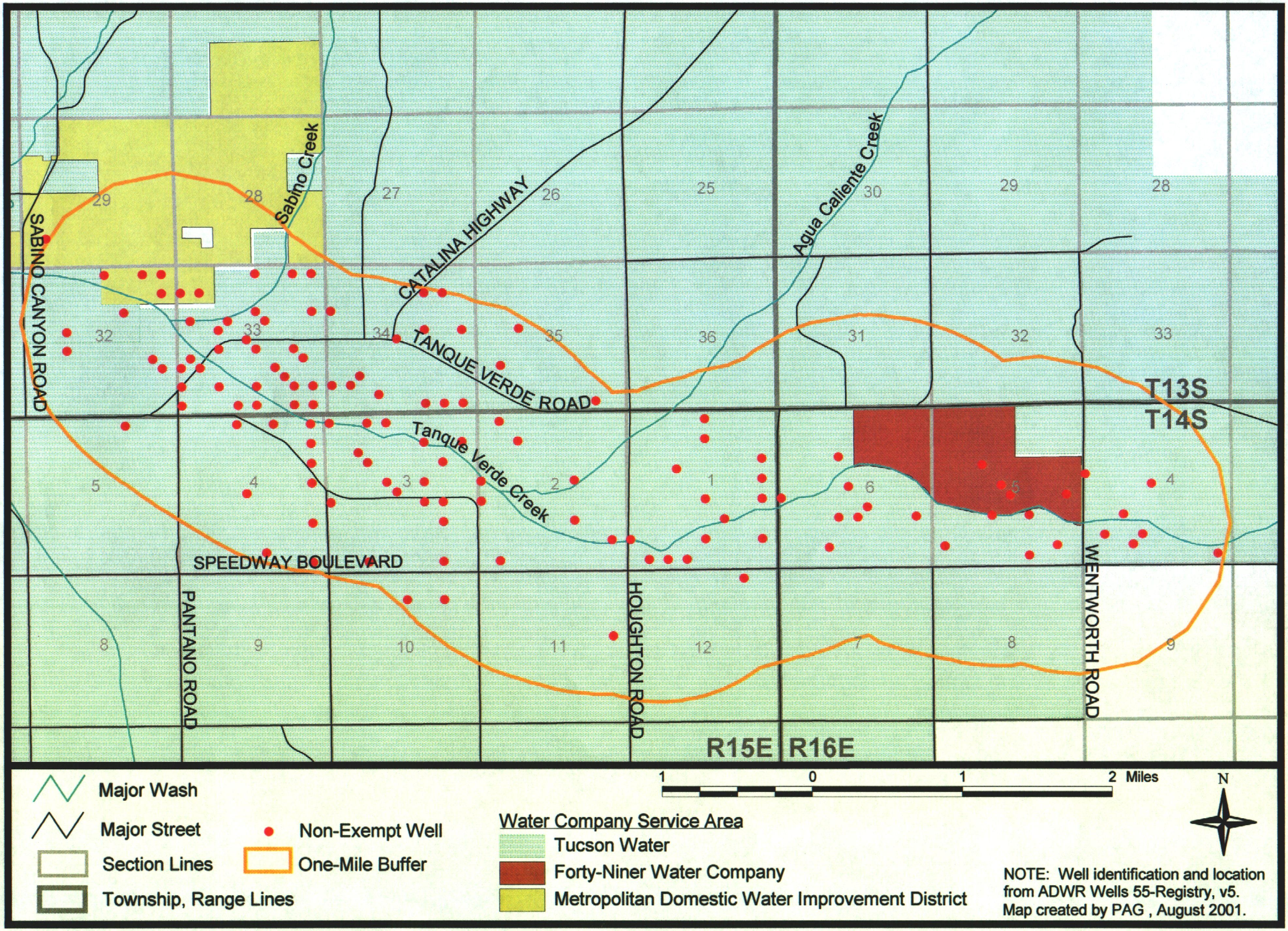


Figure 9. Non-Exempt Wells and Water Companies within One Mile of Tanque Verde Creek, Wentworth Rd to Sabino Creek

Discussion

In the three years following the 1990 measurements of water stress to mesquites by Stromberg, water levels in the Tanque Verde Creek generally rose, probably in response to decreased local pumping by Tucson Water and natural groundwater recharge which occurred during "wet" years 1991, 1992 and 1993. The shallowest groundwater levels in the period 1990 to present generally were measured in December, 1993 (Figures 4 and 5).

Since December 1993, water levels have generally declined. The declines are more apparent in the lower reaches of the Tanque Verde Creek than the upper reaches.

Compared to water levels measured in 1990 by Stromberg and others, water levels today are little different than those demonstrated to be associated with stress to mature mesquite trees along Tanque Verde Creek. As the study mentioned, near-lethal stress occurs in mesquite at depths-to-water greater than 59 feet. Data from December 1999 shows seven (#9,11,12,13,14,15,16) of the seventeen sampled wells had depths-to-water greater than 59 feet.

Figure 10 shows a depth-to-water plot of ten wells that are in mesquite and former mesquite bosque, as determined from historic aerial photographs, typical of healthy riparian and aquatic ecosystems. Two wells, 11 and 16, have current water levels that are in excess of the limit of mesquite survival. However, recent field observation of mesquite around Well 11 did not show mortality or severe dieback that would be associated with these water depths. Also a young stand of cottonwood trees is present in the channel bottom near Wells 10 and 11. It is possible that a perched aquifer is sustaining this portion of the mesquite bosque, and Well 10 is tapping a perched aquifer. Wells 4,7,8,10, and 17 suggest current water levels that would indicate increasing stress to mesquite. These wells are located in mesquite bosque near Houghton Road and along Tanque Verde Loop Road.

It is possible that some of the Stromberg study observations of near-lethal water stress to mesquites might have been affected by the rate of groundwater decline. Mesquite could survive deeper groundwater levels than 59 feet, if the rate of decline were quite gradual. However, canopy cover and aboveground biomass of the mesquite would still decline greatly. In addition, many other biotic components of riparian ecosystems are lost as groundwater declines. Conversely, many desirable ecosystem components would recover as groundwater levels increase.

Conclusions

Groundwater depletion along Tanque Verde Creek upstream of Sabino Creek was well underway by 1947. Groundwater depletion increased in the late 1980's. Declines in the water table during the late 1980's occurred due to drought and increased consumer demand for water in the Tanque Verde Valley. Observed declines led to 1990 investigations of water stress in mesquite trees by Stromberg (1992). The confirmation of water stress to riparian trees, coupled with outcry from shallow well owners, led the City Council to adopt a "last on, first off" policy for wells in this area.

This report finds that adoption of this policy has not been sufficient to restore the water table in the reach below Houghton Road, where a substantial acreage of mesquite woodland exists. Water levels rose in this area following the January 1993 flood event and the delivery of CAP in 1992. For the period 1988 to 1998, reported groundwater withdrawals averaged some 9960 AF/yr, from three water companies and over 400 private wells.

Water budget analysis suggests that the current usage only perpetuates the depleted aquifer conditions. The estimated average annual recharge to the entire northeast area is 9,900 AF/yr. Average pumpage along the study reach of Tanque Verde Creek alone is 9,956 AF/yr not counting pumpage occurring elsewhere in the northeast area bounded by Sabino Canyon Road, Speedway Boulevard and the National Forest. A healthy riparian forest of 3000 acres would require an estimated 7,500 AF/yr, however water levels in some areas remain too low to support vigorous mesquite bosque, let alone restoration of perennial stream flow. Current (1999) water levels are similar to those which existed at the time of the Stromberg.

A passive result of the dewatering and lowering regional aquifer in the Tanque Verde Valley has been the formation of perched aquifers, which may be maintaining some of the mesquite bosque north of Tanque Verde Creek. The perched aquifer conditions may be mitigating the impacts of pumping in the vicinity of the greatest declines in the regional aquifer. However, while the bosque is undeniably adaptive to natural groundwater fluctuations, trees may experience greater stress from the more extreme fluctuations resulting from the perched aquifer formation.

Groundwater withdrawals in the Tanque Verde Valley primarily support local water demand, and are currently inadequate, requiring supplements by other groundwater sources. The link that exists between increasing development, physical vegetative loss and local groundwater extraction should be carefully considered in future policy making.

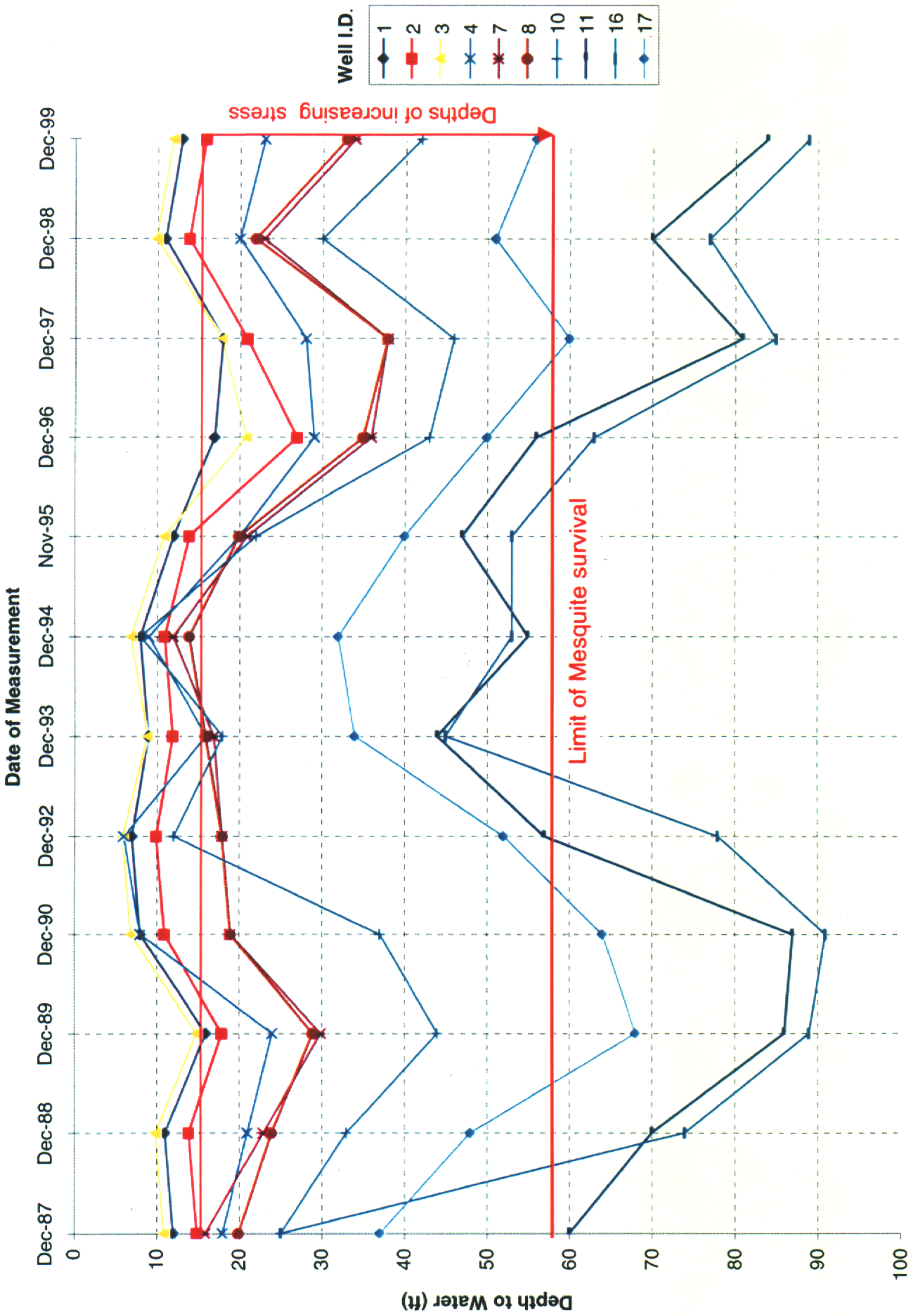


Figure 10. Depth to Water in Mesquite and Former Mesquite Bosque

Pima County Graphic Design 1/01 pc

Recommendations

I. Groundwater

The Tanque Verde Valley's unique hydrogeology would allow for management of groundwater resources to promote shallow groundwater conditions and restoration of riparian and aquatic habitats. The Tanque Verde Valley is somewhat insulated from the extreme groundwater depletions which have occurred in the central Tucson Basin, and the Tanque Verde Valley enjoys large periodic recharge events derived from the adjacent mountains. From a conservation perspective, even though the stream no longer flows, the area has regionally significant riparian resources. Decreased pumping by all Tanque Verde Valley well users could improve habitat conditions along Tanque Verde Creek.

Several considerations bode well for the potential to restore the aquifer. The first is that alternate sources of water exist for drinking and irrigation needs of the human population in theTanque Verde Valley. Tucson Water has indicated they will begin to shut down wells in the Central Wellfield as CAP blended water becomes available to consumers from the Clearwater Renewable Resource Facility. The resulting increase in Central Wellfield water levels may positively affect Tanque Verde Valley water levels, to the extent of the hydraulic connection between the two aquifers. This effect would be enhanced and the time frame possibly shortened, by reducing pumping in the Tanque Verde Valley itself.

Additional use of renewable supplies could be facilitated if Metropolitan and Forty-Niner's water utilities connected to Tucson Water's potable and reclaimed delivery systems. Extensions of the reclaimed system to the Tanque Verde Valley would also reduce demands, if the community is willing to pay the price.

II. Development

Growth should be linked both to groundwater availability, and to the vigor and longevity of the existing ecosystem.

Property owners should be encouraged to utilize the Pima County Floodprone Land Acquisition Program for their undevelopable properties and the program should be funded appropriately. Developers should continue to be accountable to riparian mitigation standards. The jurisdictions should pursue riparian preservation within the legal context of conservation easements and similar binding property vehicles.

Overbank flooding and storage would be benefitted by limiting future structural bank stabilization except in areas of vulnerability and, to the extent reasonably possible while still providing public safety, removing existing stabilization.

III. Future Study

A more complete analysis of the study area wells (i.e. perforation intervals) might reveal the presence of confined and/or perched aquifers. Additionally, a survey of private wells could document the occurrence of cascading (and hence perched) groundwater. Since groundwater levels obtained from wells are influenced by the type of aquifer that is being tapped, this information could explain areas of good mesquite vigor where water levels appear to be at lethel levels, and areas of poor mesquite vigor where water levels appear to be adequate.

A comprehensive assessment should be made of the historical impact of land development and the resulting physical removal of vegetation over time.

Natural recharge processes would benefit from further study using microgravity techniques.

The locations and depths of the 17 wells used in this study are not optimal in terms of correlating groundwater levels with mesquite vigor. Establishing a series of monitoring wells in the mesquite bosques would more directly determine water levels associated with the plant communities. The possibility that existing large irrigators along the channel may be locally mitigating the reduced availability of water to the riparian areas through incidental recharge might be considered.

An ongoing biologic assessment of the bosques around the monitor wells such as was done in the Stromberg study, would allow a more detailed comparison of water levels and mesquite vigor. The Stromberg study focused on mature mesquite trees, and recommended further study on the stress response of young mesquite. Early warning stress indicators should be monitored in a timely manner to determine whether the mesquite are being stressed to such a degree that existence of the bosque is threatened.

Acknowledgements

This report was substantially improved by reviews given to drafts by Mr. Mike Block (Metro Water District), Dr. Juliet Stromberg (ASU), Mr. Sheldon Clark (Haley & Aldrich, Inc.), Mr. Greg Hess (PAG), and Tucson Water staff. Credit goes to Peter Corrao in Pima County Graphic Services.

Special thanks also to Staffan Schorr (PAG) for his technical contributions and review.

References

Arizona Department of Water Resources, Phoenix Office, 1991. Hydrologic Survey of the San Pedro Watershed.

Arizona Department of Water Resources, Phoenix Office, 2001. Personal communication regarding the Tucson Active Management Area Regional Groundwater Model.

Baird, K., R. MacNish, D.P. Guertin, 2001. An Evaluation of Hydrologic and Riparian Resources in Saguaro National Park, Tucson, Arizona.

Burkham, D.E., 1970. Depletion of Streamflow by Infiltration in the Main Channels of The Tucson Basin, Southeastern Arizona. Geological Survey Water Supply Paper 1939-B.

City of Tucson, 1988-1999. Annual Static Water Level Basic Data.

City of Tucson, 1989. Northeast Area Water Level Decline Report, Tucson Water Planning Division.

City of Tucson, 1996. Assessment of CAP Water Recharge Alternatives. Compilation by Pima County Flood Control District in a document entitled Central Wellfield Recharge Alternatives.

City of Tucson, March, 2001. Comment letter addressing the Pima County report "Draft Groundwater Level Changes in the Tanque Verde Valley".

City of Tucson, August, 1989. Mayor and Council Memorandum re: Tanque Verde/Rillito River Water Table Decline (City-Wide).

Eychaner, J.H., M.R. Rehmann and A.J. Brazel, 1990. National Water Summary, 1988-89. Floods and Droughts: State Summaries. U.S. Geological Survey Water Supply Paper 2375. pp. 181-188.

Frederick, T.M. 1996. Patterns of Habitat Use by Birds and Lizards in Urban River Corridors of Tucson, Arizona. M.S. Thesis, Renewable Natural Resources, University of Arizona.

Marshall, R.M., S. Anderson, M. Batcher, P. Comer, S. Cornelius, R. Cox, A. Conclor, D.Gori, J. Hunke, R. Paredes Aquilar, I.E. Parra, S. Schwartz, 2000. An Ecological Analysis of Conservation Priorities in the Sonoran Desert Ecoregion. Prepared by the Nature Conservancy Arizona Chapter, Sonoran Institute, and Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora with support from the Department of Defense Legacy Program, Agency and Institutional partners.

Minckley, W.L. 2000. Pima Co. Fish. Database dump for Pima County, Arizona (includes AGFD Records, not checked). Taxonomy corrected by W.L. Minckley, 23 August 2000.

Osterkamp, W.R. 1973. Ground-Water Recharge in the Tucson Area, Arizona. Map.

Pima Association of Governments (PAG), 2000. Water Usage along Selected Streams in Pima County. Sonoran Desert Conservation Plan, Pima County.

Pima County, 2000. Riparian Element Report 2000. Riparian Protection, Management and Restoration. Riparian Element, Sonoran Desert Conservation Plan. Preliminary, September 2000.

Pima County Flood Control District, 2001. Floodplain Primer.

Pima County, 2001. Climatic Variability in Pima County, Arizona, and It's Signifiance to the Sonoran Desert Conservation Plan.

Rogers, S.R., 1987. Hydrogeologic Investigation of the Northeast Area of the Tucson Basin, Structure and Stratigraphy, Tucson Water Open File Report WRS-97-1, October 1987.

Stromberg, J.C., J.A.Tress, S.D. Wilkins, S.D. Clark, 1992. Response of Velvet Mesquite to Groundwater Decline. Journal of Arid Environments, 23:45-58.

Schwalen, H.C., R.J. Shaw, October, 1957. Groundwater Supplies of Santa Cruz Valley of Southern Arizona Between Rillito Station and the International Boundary, Bulletin 288.

Schwalen, H.C., R.J. Shaw, 1961. Progress Report on Study of Water in the Santa Cruz Valley, Arizona. Dept. of Agricultural Engineering, Agricultural Experiment Station, University of Arizona, Tucson, Arizona.

Swetnam, R.S. and J.L. Bentancourt, 1998. Mesoscale disturbance and ecological response to decadal climatic variability in the American Southwest. Journal of Climate 11:3128-3147.

United States Geological Survey, 1967-1974, 1991-1999. Water Resources Data-Arizona. Water-Data Report AZ-Yr-1.

APPENDIX A

Journal of Arid Environments (1992) 23: 45–58

Response of velvet mesquite to groundwater decline

Juliet C. Stromberg*, James A. Tress†, Scott D. Wilkins* & Sheldon D. Clark‡

**Center For Environmental Studies, Arizona State University, Tempe, AZ 85287, U.S.A. †SWCA Environmental Consultants, 1602 East Ft. Lowell Road, Tucson, AZ 85719 U.S.A. ‡Groundwater Resources Consultants, Inc., 1735 East Ft. Lowell Road, Tucson, AZ 85719 U.S.A.*

(*Received 14 May 1991, accepted 22 May 1991*)

Mesquite (*Prosopis velutina*) bosques are groundwater-dependent riparian woodlands that were once widespread in the American Southwest. Groundwater withdrawal from the aquifer below an ephemeral creek in the Sonoran Desert of Arizona created the opportunity to quantify relationships between groundwater depths and bosque traits. Temporal and spatial variation in plant water potential, leaflet size, leaflet number, canopy height, and live and dead vegetation volume all indicate that the bosque requires a shallow aquifer and that bosque traits change continuously with groundwater depth. The bosque had high water potentials, large leaflets (>7 cm^2), tall stature (>12 m), and large vegetation volume (>2 m^3/m^2) only where the water table was <5 m below the surface. Trees became increasingly stressed as groundwater declined to 15–18 m. Summer rains and seasonal surface flow temporarily reduced water stress and increased leaflet size for some trees, but did not offset effects of groundwater decline. Trees in areas of greatest groundwater decline (18–30 m) were under sublethal stress, as evidenced by low stem water potentials (<−4 MPa), reduced leaflet size (<5·5 cm^2), and high levels of canopy mortality (>45%). These deepest groundwater levels are in the range of those documented to be lethal to mesquite in other bosque systems.

APPENDIX B

Description of Wells Used in This Study

Well #	Tucson Water Well Name	Cadastral Location	Max Depth Cased (ft BLS*)	Status (1997)
Township 14 South Range 16 East				
1	E-020A	(D-14-16)05 DBD1	49	Continuous Recorder
2	E-022A	(D-14-16)05 DBD3	43	Water Level Monitor
3	CL-033A	(D-14-16)05 DBD4	47	Water Level Monitor
4	TV-001A	(D-14-16)06 BDA	106	Not in Use
5	D-053A	(D-14-16)06 DAD1	103	Water level Monitor
6	WR-051A	(D-14-16)06 DAD3	60	Water Level Monitor
Township 14 South Range 15 East				
7	D-062A	(D-14-15)01 ADA1	128	Monitor
8	D-063A	(D-14-15)01 ADA2	87	Monitor
9	D-118A	(D-14-15)02 CCD	839	Active Production Well
10	C-075A	(D-14-15)02 DDA1	500	Datalogger
11	C-075B	(D-14-15)02 DDA2	625	Active Production Well
12	SD-001A	(D-14-15)03 CAB	532	Continuous Recorder
13	C-085A	(D-14-15)03 DDC	545	Active Production Well
14	C-083A	(D-14-15)04 BAA	402	Datalogger
15	C-083B	(D-14-15)04 BAA	640	Active Production Well
Township 13 South Range 15 East				
16	C-084A	(D-13-15)34 CCA	300	Continuous Recorder
17	C-073A	(D-13-15)33 CBC	100	Datalogger

*Below Land Surface

APPENDIX C

ADWR Pumping Records for Non-Exempt Wells within One mIle of Tanque Verde Creek, Wenthworth Rd to Sabino Canyon Confluence (sorted by well owner)

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
801906	13-15-33	SW	NW		ARANOW, WILLARD,F	8
801313	14-15-4	NE	NE	SE	BAKER, MARY,S	3
626378	14-15-1	SW	SE	SE	BARTELS,P H	1
624223	13-15-33	SW	SE	NW	BECKER,W R	2
530916	13-15-33	SW	SW	SW	BENNETT, JAMES,H	0
801967	13-15-34				BENNETT,J H	9
801968	13-15-33				BENNETT,J H	35
801293	13-15-33	NW	SW		BOYLIN, BENJAMIN,	0
800437	13-15-33	SE	SE	SW	CAMPBELL,L C	10
801131	14-15-3	NE	SW	SE	CASA ONE HOLDING,	3
520583	13-15-33	SE	SW	SW	CELLA, PAUL,W	0
800736	13-15-33	SE	SW	SW	CELLA, PAUL,W	8
625958	14-15-3	NE	NW	SE	CIENEGA LTD,	0
625959	14-15-3	NW	SE	SE	CIENEGA LTD,	0
625960	14-15-3	NW	SE	NW	CIENEGA LTD,	0
625961	14-15-3	NW	NE	NW	CIENEGA LTD,	0
625962	14-15-3	NW	NE	NE	CIENEGA LTD,	0

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
* *For Years 1988-1998.*

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
625963	14-15-3	NW	SE	SE	CIENEGA LTD,	0
618075	13-15-33	NW	NW	SW	CONNOR,P T	1
619256	14-15-3	SE	NW	NE	CONWAY,W E	7
625709	13-15-33	NW	SW		COONAN,A A	1
580900	13-15-33	SE	NW	SE	CRARY	0
604250	14-16-4	NW	SW	SW	CROSBY, WILLIAM,	17
622717	14-15-10	NE	NW	SW	CUDDEBACK, WM,G	0
628874	14-15-2	SW	NW	NW	CURRIER JR,G	5
800922	13-15-35	SW	NW	SE	DECARLO, DANIEL,C	3
524177	14-15-4	NE	SE	SE	DIXON, THOMAS,J	4
801104	14-15-4	NE	SE	NE	DIXON,T J	1
801176	14-16-6	SW	SE		DORAN,T E	1
801135	14-16-4	SW	SE	NE	DORRIS, JOHN,W	2
608182	14-16-4	SE	SE	SE	DRYDEN,S M	11
608183	14-16-4	SE	SE	SE	DRYDEN,S M	0
801134	14-16-4	SW	NE	SW	DYBVIG, DAVID,	1
600039	14-16-6				ELLIOTT	0
606494	13-15-33				EMMERSON, DAVID,	2
527986	13-15-33	SW	NE	NW	EMMERSON, DAVID,A	0
803452	14-15-1	SW	SW	NW	ERWIN, ELDON,	5

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
* *For Years 1988-1998.*

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
801181	14-16-5	SE	SE		FERGANCHICK,B	2
801182	14-16-5	SE	SE		FERGANCHICK,B	0
557971	13-15-33	SE	SW	NW	FORD, RODGER & AMY,	10
628080	13-15-33	SE	SW	NW	FORD,R	29
503963	14-16-5	SW	NE	SE	FORTY NINER WATER CO.	97
558500	14-16-5	SE	NE	NE	FORTY NINER WATER CO.	48
581364	14-16-5	SE	NW	NW	FORTY NINER WATER CO.	0
617300	14-16-5	SE	NE	NE	FORTY NINER WATER CO.	260
617301	14-16-5	NE	NW		FORTY NINER WATER CO.	240
617302	14-16-5	NW	NW		FORTY NINER WATER CO.	130
502740	14-15-1	NE	NW	SW	GAMBURG,M	2
575575	14-16-6	SW	NE	SE	GARDNER	0
801241	14-16-6	SW	NE	SE	GARDNER	9
801928	13-15-34	SE	SE	SW	GOEBEL,G M	2
803490	14-15-1	SE	NW	NW	GONDA, GERALD,	0
526006	14-15-3	NE	SE	NW	GRIGGS, DENIS,	0
612943	14-15-3	SW	NW	NW	GRIGGS,D C	0
501580	13-15-33	SE	SE	NE	HAMILTON	8
524769	13-15-33	SE	SE	NE	HAMILTON	5
620736	13-15-33	SE	SE	NE	HAMILTON	16

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
801159	13-15-33				HASSEY,N E	2
801239	14-15-3	NE	SW	SE	HAYMORE, F. LANT & A,	0
627915	13-15-33	SW	SE	SE	HELLER, ANITA,P	0
623019	13-15-33	NE	SE	NE	HELLER,C J	1
616963	13-15-33	SW	NW	SE	HENKEL, JOHN,H	1
620857	14-16-6				HILL,L G	2
610266	14-16-4				HOUSTON,J	5
527836	13-15-32	NE	NE	NE	HUB WATER CO	0
616904	13-15-32	NE	NW	NW	HUB WATER CO	197
616905	13-15-32	NE	NE	NE	HUB WATER CO	260
629424	13-15-34	NE	NE	SW	KARTCHNER, MARK,	0
801497	13-15-34	SW	SE		KHALSA, GURUBHAI,S	3
801498	13-15-34	SW	SE		KHALSA, GURUBHAI,S	1
527101	13-15-33	SW	SW	NW	KNIGHT, DORIS,	0
609943	13-15-33	SE	NE		KOEPKE, GLENN,	15
629213	13-15-33				LASON,D L	3
800848	14-15-3	SE	NE	NW	LOVE,E H	4
638875	13-15-34	SW	SW	NW	MAJESKY,R L	5
801627	13-15-33	NE	NE	NE	MATHEWS JR,W R	5
524460	13-15-33	NE	NE	NW	MATHEWS, WILLIAM JR,	0

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
* *For Years 1988-1998.*

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
801039	14-15-1	NW	SE		MEAD,O O	9
613764	14-15-4				MENICK, FRED,	5
616902	13-15-33	NW	NW	SE	METROPOLITAN DOMESTIC WAT	282
616903	13-15-29	SW	SW	NE	METROPOLITAN DOMESTIC WAT	245
581131	14-15-3	NW	NW	NW	METZ	0
613644	14-15-3	NW	NW	NW	METZ, RICHARD,E	18
506124	14-15-1	SW	SE	SW	MEYER	3
621623	14-15-1	SE	SW	NW	MILLER, NOLA,E	7
621624	14-15-1	SE	NW	SE	MILLER,N E	0
581365	13-15-33	SE	SE	SE	MOONEY	0
800803	13-15-33	SE			MOONEY	8
582429	14-15-4	NE	NE	NE	NORTH	0
582850	13-15-33	NW	SE	SW	OATES	0
621041	14-15-3	SW	SE	SW	OATES, WALTER,	2
617984	13-15-33	NW	SE	SW	PALSER, WALTER DEAN,	3
621014	14-15-1	SE	SE	NE	PARK,W G	1
621346	14-15-1	SE	NE	NE	PARK,W G	6
628505	14-15-1	NE	SE	SE	PARK,W G	0
643146	13-15-32	NE	NE	NW	PHILLIPS,M K	0
582690	13-15-33	SE	SE	NW	PIERSON	0

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
801133	13-15-33	SE	SE	NW	PIERSON	4
627073	14-15-3	NW			PIMA COUNTY,	3
626292	13-15-34	SE	SW	SE	PIONEER TRUST CO,	73
626294	13-15-34	SE	SE	SE	PIONEER TRUST CO,	12
626295	14-15-2	NW	NW	NE	PIONEER TRUST CO,	0
626297	14-15-2	NW	NE	SW	PIONEER TRUST CO,	27
626298	14-15-3	NE	NE	SE	PIONEER TRUST CO,	69
626299	14-15-3	NE	NW	SE	PIONEER TRUST CO,	0
618412	13-15-32	NE	NE	SE	PORTER, WILLIAM,W	1
618413	13-15-32	NE	NE	SE	PORTER, WILLIAM,W	4
548666	13-15-33	SE	SE	NW	POZEZ, MITCHELL,	1
643147	13-15-33	SE	SE	NW	POZEZ, MITCHELL,	7
524534	14-15-4	NE	NW	NE	PROTELL, ROBERT,	0
606058	13-15-32	NW	SE	SW	RANCHO DEL RIO CORP,	2
618919	13-15-33	NW	SE		RICE,G M	6
621379	14-16-6	SW	SE		RYAN, ROBERT,C	7
625819	14-16-6	SE	NW	SW	SABBAGH,A H	24
625820	14-16-6	SE	NW		SABBAGH,A H	0
625821	14-16-5	NW	SE		SABBAGH,A H	0
625822	14-16-5				SABBAGH,A H	0

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
526049	14-15-1	SW	SW	NW	SEAL	0
801373	14-15-1	SW	SW	SE	SHARER, KEVIN,	4
521442	14-15-3	SE	NE	SW	SHEPHERD, PAUL,R	0
628973	14-15-3	SE	NE	SW	SHEPHERD,P R	1
623270	14-15-2	NE	SW	SE	SIMMONS,L M	28
617197	13-15-33	NE	SW	NW	SIMONS,B W	1
623480	13-15-33	NE	SW		SIMONS,R S	5
634014	14-16-6	NW	NE		SLADE,J	2
621657	13-15-32	SE	NE		SOTTNEK,L L	0
600345	13-15-34	SW			SPEAR,H D	1
631270	14-16-6	SW	NW	NW	STACKHOUSE,H L	0
628567	14-16-4	SW	SW	NE	STACY,R E	3
604914	14-15-4	SE	SW		STARK,R W	30
611932	14-15-3				STEPHENS, CECIL,	0
611930	14-15-3				STEPHENS,C	0
611931	14-15-3				STEPHENS,C	1
631269	14-16-6	SW	NW	NW	STOCKHOUSE,H L	2
801036	14-15-2	NW	SW	SW	SWAIM,R J	1
621625	14-16-5	SW	SW		SWENSRUD	1
502836	13-15-32	SW	NE	NW	TACK ROOM LTD, THE	68

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
532441	13-15-33	SE	NW	NW	TANKERSLEY, RON,	0
626683	13-15-33	SE	NW	NW	TANKERSLEY,R	1
626684	13-15-33	SE	NW	NW	TANKERSLEY,R	1
510879	14-15-2	SW	SW	SE	TUCSON WATER	602
513567	14-15-11	NE	SE	SE	TUCSON WATER	818
513674	14-15-4	NW	NE	NE	TUCSON WATER	411
513675	14-15-4	SE	SE	SE	TUCSON WATER	746
626408	13-15-32	SE	NE	SE	TUCSON WATER	0
800356	14-15-5	NE	NW	NE	TUCSON WATER	600
502179	14-15-2	SE	SE	NE	TUCSON, CITY OF	326
555780	14-15-12	NE	NE	NW	TUCSON, CITY OF	49
619968	14-15-4	SE	NE	SE	TUCSON, CITY OF	647
619972	14-15-3	SW	SE	SW	TUCSON, CITY OF	324
619975	14-15-3	SE	SE	SW	TUCSON, CITY OF	330
620072	14-15-10	NE	NE	SW	TUCSON, CITY OF	674
620080	13-15-35	SE	SE	SW	TUCSON, CITY OF	1212
522786	14-15-12	NE	NE	NW	TUCSON, CITY OF,	0
523906	13-15-32	NE	SW	NE	TUCSON, CITY OF,	232
619862	13-15-34	NW	SW	NW	TUCSON, CITY OF,	0
619934	14-16-6	NW	SE	NE	TUCSON, CITY OF,	0

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
619957	13-15-33	NE	NW	NW	TUCSON, CITY OF,	3
619960	14-16-5	SE	SW	SE	TUCSON, CITY OF,	0
619965	13-15-33	SW	NW	SW	TUCSON, CITY OF,	0
619967	14-15-2	SE	SE	NE	TUCSON, CITY OF,	0
619973	14-15-4	NW	NE	NE	TUCSON, CITY OF,	2
619974	13-15-34	SW	SW	NE	TUCSON, CITY OF,	0
620071	14-15-10	NE	NE	SW	TUCSON, CITY OF,	0
620079	13-15-35	SE	SE	SW	TUCSON, CITY OF,	36
620087	14-16-6	SE	NE	SE	TUCSON, CITY OF,	0
620088	14-16-6	SE	NE	SE	TUCSON, CITY OF,	0
620092	13-15-34	NE	NW	SE	TUCSON, CITY OF,	0
620093	13-15-34	NE	SE	SE	TUCSON, CITY OF,	0
620094	13-15-35	NW	SE	SW	TUCSON, CITY OF,	5
620096	14-15-1	NE	SE	NE	TUCSON, CITY OF,	0
620097	14-15-1	NE	SE	NE	TUCSON, CITY OF,	0
620098	14-15-1	NE	SE	NE	TUCSON, CITY OF,	0
620118	14-16-5	SE	NW	SE	TUCSON, CITY OF,	0
620119	14-16-5	SE	NW	SE	TUCSON, CITY OF,	0
620120	14-16-5	SE	NW	SE	TUCSON, CITY OF,	0
803492	14-15-1	NE	NW	NW	TURNER, WILLIAM,H	3

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

ADWR Registry ID	Cadastral Location	Acre 160	Acre 40	Acre 10	Well Owner	Average Reported Annual Withdrawals (ac-ft)*
501108	13-15-34	NE	SW	SE	VISTA DE SIERRAS,	0
627581	14-16-4	SW	SE		WARD,S	2
610672	13-15-32	NE	NW		WOODDELL,R D	4
503670	14-15-2	SE	NW	SE	WOOTTON, JAMES,C	31
801204	14-15-2	SE	SE	NE	WOOTTON, JAMES,C	13
508096	13-15-34	SW	SW	NW	ZIEHLER	89
801298	13-15-34	SW	SW	NW	ZIEHLER	0
531337	13-15-33	SE	NE	NW	ZIMMERMAN, LINDA,	0
621611	13-15-33	SE	NE	NW	ZIMMERMAN, LINDA,	5

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

APPENDIX D

ADWR Pumping Records for Non-Exempt Wells within One Mile of Tanque Verde Creek, Wentworth Rd to Sabino Canyon Confluence (sorted by cadastral location)

Cadastral Location	*Acre 160*	*Acre 40*	*Acre 10*	*ADWR Registry ID*	*Well Owner*	*Average Reported Annual Withdrawls (ac-ft) **
13-15-29	SW	SW	NE	616903	METROPOLITAN DOMESTIC WAT	245
13-15-32	SW	NE	NW	502836	TACK ROOM LTD, THE	68
13-15-32	NE	SW	NE	523906	TUCSON, CITY OF,	232
13-15-32	NE	NE	NE	527836	HUB WATER CO	0
13-15-32	NW	SE	SW	606058	RANCHO DEL RIO CORP,	2
13-15-32	NE	NW		610672	WOODDELL,R D	4
13-15-32	NE	NW	NW	616904	HUB WATER CO	197
13-15-32	NE	NE	NE	616905	HUB WATER CO	260
13-15-32	NE	NE	SE	618412	PORTER, WILLIAM,W	1
13-15-32	NE	NE	SE	618413	PORTER, WILLIAM,W	4
13-15-32	SE	NE		621657	SOTTNEK,L L	0
13-15-32	SE	NE	SE	626408	TUCSON WATER	0
13-15-32	NE	NE	NW	643146	PHILLIPS,M K	0
13-15-33	SE	SE	NE	501580	HAMILTON	8
13-15-33	SE	SW	SW	520583	CELLA, PAUL,W	0
13-15-33	NE	NE	NW	524460	MATHEWS, WILLIAM JR,	0
13-15-33	SE	SE	NE	524769	HAMILTON	5
13-15-33	SW	SW	NW	527101	KNIGHT, DORIS,	0
13-15-33	SW	NE	NW	527986	EMMERSON, DAVID,A	0

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

Cadastral Location	Acre 160	Acre 40	Acre 10	ADWR Registry ID	Well Owner	Average Reported Annual Withdrawls (ac-ft) *
13-15-33	SW	SW	SW	530916	BENNETT, JAMES,H	0
13-15-33	SE	NE	NW	531337	ZIMMERMAN, LINDA,	0
13-15-33	SE	NW	NW	532441	TANKERSLEY, RON,	0
13-15-33	SE	SE	NW	548666	POZEZ, MITCHELL,	1
13-15-33	SE	SW	NW	557971	FORD, RODGER & AMY,	10
13-15-33	SE	NW	SE	580900	CRARY	0
13-15-33	SE	SE	SE	581365	MOONEY	0
13-15-33	SE	SE	NW	582690	PIERSON	0
13-15-33	NW	SE	SW	582850	OATES	0
13-15-33				606494	EMMERSON, DAVID,	2
13-15-33	SE	NE		609943	KOEPKE, GLENN,	15
13-15-33	NW	NW	SE	616902	METROPOLITAN DOMESTIC WAT	282
13-15-33	SW	NW	SE	616963	HENKEL, JOHN,H	1
13-15-33	NE	SW	NW	617197	SIMONS,B W	1
13-15-33	NW	SE	SW	617984	PALSER, WALTER DEAN,	3
13-15-33	NW	NW	SW	618075	CONNOR,P T	1
13-15-33	NW	SE		618919	RICE,G M	6
13-15-33	NE	NW	NW	619957	TUCSON, CITY OF,	3
13-15-33	SW	NW	SW	619965	TUCSON, CITY OF,	0
13-15-33	SE	SE	NE	620736	HAMILTON	16
13-15-33	SE	NE	NW	621611	ZIMMERMAN, LINDA,	5

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
* *For Years 1988-1998.*

Cadastral Location	*Acre 160*	*Acre 40*	*Acre 10*	*ADWR Registry ID*	*Well Owner*	*Average Reported Annual Withdrawls (ac-ft) **
13-15-33	NE	SE	NE	623019	HELLER,C J	1
13-15-33	NE	SW		623480	SIMONS,R S	5
13-15-33	SW	SE	NW	624223	BECKER,W R	2
13-15-33	NW	SW		625709	COONAN,A A	1
13-15-33	SE	NW	NW	626683	TANKERSLEY,R	1
13-15-33	SE	NW	NW	626684	TANKERSLEY,R	1
13-15-33	SW	SE	SE	627915	HELLER, ANITA,P	0
13-15-33	SE	SW	NW	628080	FORD,R	29
13-15-33				629213	LASON,D L	3
13-15-33	SE	SE	NW	643147	POZEZ, MITCHELL,	7
13-15-33	SE	SE	SW	800437	CAMPBELL,L C	10
13-15-33	SE	SW	SW	800736	CELLA, PAUL,W	8
13-15-33	SE			800803	MOONEY	8
13-15-33	SE	SE	NW	801133	PIERSON	4
13-15-33				801159	HASSEY,N E	2
13-15-33	NW	SW		801293	BOYLIN, BENJAMIN,	0
13-15-33	NE	NE	NE	801627	MATHEWS JR,W R	5
13-15-33	SW	NW		801906	ARANOW, WILLARD,F	8
13-15-33				801968	BENNETT,J H	35
13-15-34	NE	SW	SE	501108	VISTA DE SIERRAS,	0
13-15-34	SW	SW	NW	508096	ZIEHLER	89

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

Cadastral Location	Acre 160	Acre 40	Acre 10	ADWR Registry ID	Well Owner	Average Reported Annual Withdrawls (ac-ft) *
13-15-34	SW			600345	SPEAR,H D	1
13-15-34	NW	SW	NW	619862	TUCSON, CITY OF,	0
13-15-34	SW	SW	NE	619974	TUCSON, CITY OF,	0
13-15-34	NE	NW	SE	620092	TUCSON, CITY OF,	0
13-15-34	NE	SE	SE	620093	TUCSON, CITY OF,	0
13-15-34	SE	SW	SE	626292	PIONEER TRUST CO,	73
13-15-34	SE	SE	SE	626294	PIONEER TRUST CO,	12
13-15-34	NE	NE	SW	629424	KARTCHNER, MARK,	0
13-15-34	SW	SW	NW	638875	MAJESKY,R L	5
13-15-34	SW	SW	NW	801298	ZIEHLER	0
13-15-34	SW	SE		801497	KHALSA, GURUBHAI,S	3
13-15-34	SW	SE		801498	KHALSA, GURUBHAI,S	1
13-15-34	SE	SE	SW	801928	GOEBEL,G M	2
13-15-34				801967	BENNETT,J H	9
13-15-35	SE	SE	SW	620079	TUCSON, CITY OF,	36
13-15-35	SE	SE	SW	620080	TUCSON, CITY OF	1212
13-15-35	NW	SE	SW	620094	TUCSON, CITY OF,	5
13-15-35	SW	NW	SE	800922	DECARLO, DANIEL,C	3
14-15-1	NE	NW	SW	502740	GAMBURG,M	2
14-15-1	SW	SE	SW	506124	MEYER	3
14-15-1	SW	SW	NW	526049	SEAL	0

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

Cadastral Location	Acre 160	Acre 40	Acre 10	ADWR Registry ID	Well Owner	Average Reported Annual Withdrawls (ac-ft) *
14-15-1	NE	SE	NE	620096	TUCSON, CITY OF,	0
14-15-1	NE	SE	NE	620097	TUCSON, CITY OF,	0
14-15-1	NE	SE	NE	620098	TUCSON, CITY OF,	0
14-15-1	SE	SE	NE	621014	PARK,W G	1
14-15-1	SE	NE	NE	621346	PARK,W G	6
14-15-1	SE	SW	NW	621623	MILLER, NOLA,E	7
14-15-1	SE	NW	SE	621624	MILLER,N E	0
14-15-1	SW	SE	SE	626378	BARTELS,P H	1
14-15-1	NE	SE	SE	628505	PARK,W G	0
14-15-1	NW	SE		801039	MEAD,O O	9
14-15-1	SW	SW	SE	801373	SHARER, KEVIN,	4
14-15-1	SW	SW	NW	803452	ERWIN, ELDON,	5
14-15-1	SE	NW	NW	803490	GONDA, GERALD,	0
14-15-1	NE	NW	NW	803492	TURNER, WILLIAM,H	3
14-15-10	NE	NE	SW	620071	TUCSON, CITY OF,	0
14-15-10	NE	NE	SW	620072	TUCSON, CITY OF	674
14-15-10	NE	NW	SW	622717	CUDDEBACK, WM,G	0
14-15-11	NE	SE	SE	513567	TUCSON WATER	818
14-15-12	NE	NE	NW	522786	TUCSON, CITY OF,	0
14-15-12	NE	NE	NW	555780	TUCSON, CITY OF	49
14-15-2	SE	SE	NE	502179	TUCSON, CITY OF	326

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
** For Years 1988-1998.*

Cadastral Location	Acre 160	Acre 40	Acre 10	ADWR Registry ID	Well Owner	Average Reported Annual Withdrawls (ac-ft) *
14-15-2	SE	NW	SE	503670	WOOTTON, JAMES,C	31
14-15-2	SW	SW	SE	510879	TUCSON WATER	602
14-15-2	SE	SE	NE	619967	TUCSON, CITY OF,	0
14-15-2	NE	SW	SE	623270	SIMMONS,L M	28
14-15-2	NW	NW	NE	626295	PIONEER TRUST CO,	0
14-15-2	NW	NE	SW	626297	PIONEER TRUST CO,	27
14-15-2	SW	NW	NW	628874	CURRIER JR,G	5
14-15-2	NW	SW	SW	801036	SWAIM,R J	1
14-15-2	SE	SE	NE	801204	WOOTTON, JAMES,C	13
14-15-3	SE	NE	SW	521442	SHEPHERD, PAUL,R	0
14-15-3	NE	SE	NW	526006	GRIGGS, DENIS,	0
14-15-3	NW	NW	NW	581131	METZ	0
14-15-3				611930	STEPHENS,C	0
14-15-3				611931	STEPHENS,C	1
14-15-3				611932	STEPHENS, CECIL,	0
14-15-3	SW	NW	NW	612943	GRIGGS,D C	0
14-15-3	NW	NW	NW	613644	METZ, RICHARD,E	18
14-15-3	SE	NW	NE	619256	CONWAY,W E	7
14-15-3	SW	SE	SW	619972	TUCSON, CITY OF	324
14-15-3	SE	SE	SW	619975	TUCSON, CITY OF	330
14-15-3	SW	SE	SW	621041	OATES, WALTER,	2

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
* *For Years 1988-1998.*

Cadastral Location	Acre 160	Acre 40	Acre 10	ADWR Registry ID	Well Owner	Average Reported Annual Withdrawls (ac-ft) *
14-15-3	NE	NW	SE	625958	CIENEGA LTD,	0
14-15-3	NW	SE	SE	625959	CIENEGA LTD,	0
14-15-3	NW	SE	NW	625960	CIENEGA LTD,	0
14-15-3	NW	NE	NW	625961	CIENEGA LTD,	0
14-15-3	NW	NE	NE	625962	CIENEGA LTD,	0
14-15-3	NW	SE	SE	625963	CIENEGA LTD,	0
14-15-3	NE	NE	SE	626298	PIONEER TRUST CO,	69
14-15-3	NE	NW	SE	626299	PIONEER TRUST CO,	0
14-15-3	NW			627073	PIMA COUNTY,	3
14-15-3	SE	NE	SW	628973	SHEPHERD,P R	1
14-15-3	SE	NE	NW	800848	LOVE,E H	4
14-15-3	NE	SW	SE	801131	CASA ONE HOLDING,	3
14-15-3	NE	SW	SE	801239	HAYMORE, F. LANT & A,	0
14-15-4	NW	NE	NE	513674	TUCSON WATER	411
14-15-4	SE	SE	SE	513675	TUCSON WATER	746
14-15-4	NE	SE	SE	524177	DIXON, THOMAS,J	4
14-15-4	NE	NW	NE	524534	PROTELL, ROBERT,	0
14-15-4	NE	NE	NE	582429	NORTH	0
14-15-4	SE	SW		604914	STARK,R W	30
14-15-4				613764	MENICK, FRED,	5
14-15-4	SE	NE	SE	619968	TUCSON, CITY OF	647

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
* *For Years 1988-1998.*

Cadastral Location	Acre 160	Acre 40	Acre 10	ADWR Registry ID	Well Owner	Average Reported Annual Withdrawls (ac-ft) *
14-15-4	NW	NE	NE	619973	TUCSON, CITY OF,	2
14-15-4	NE	SE	NE	801104	DIXON,T J	1
14-15-4	NE	NE	SE	801313	BAKER, MARY,S	3
14-15-5	NE	NW	NE	800356	TUCSON WATER	600
14-16-4	NW	SW	SW	604250	CROSBY, WILLIAM,	17
14-16-4	SE	SE	SE	608182	DRYDEN,S M	11
14-16-4	SE	SE	SE	608183	DRYDEN,S M	0
14-16-4				610266	HOUSTON,J	5
14-16-4	SW	SE		627581	WARD,S	2
14-16-4	SW	SW	NE	628567	STACY,R E	3
14-16-4	SW	NE	SW	801134	DYBVIG, DAVID,	1
14-16-4	SW	SE	NE	801135	DORRIS, JOHN,W	2
14-16-5	SW	NE	SE	503963	FORTY NINER WATER CO.	97
14-16-5	SE	NE	NE	558500	FORTY NINER WATER CO.	48
14-16-5	SE	NW	NW	581364	FORTY NINER WATER CO.	0
14-16-5	SE	NE	NE	617300	FORTY NINER WATER CO.	260
14-16-5	NE	NW		617301	FORTY NINER WATER CO.	240
14-16-5	NW	NW		617302	FORTY NINER WATER CO.	130
14-16-5	SE	SW	SE	619960	TUCSON, CITY OF,	0
14-16-5	SE	NW	SE	620118	TUCSON, CITY OF,	0
14-16-5	SE	NW	SE	620119	TUCSON, CITY OF,	0

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
* *For Years 1988-1998.*

Cadastral Location	Acre 160	Acre 40	Acre 10	ADWR Registry ID	Well Owner	Average Reported Annual Withdrawls (ac-ft) *
14-16-5	SE	NW	SE	620120	TUCSON, CITY OF,	0
14-16-5	SW	SW		621625	SWENSRUD	1
14-16-5	NW	SE		625821	SABBAGH,A H	0
14-16-5				625822	SABBAGH,A H	0
14-16-5	SE	SE		801181	FERGANCHICK,B	2
14-16-5	SE	SE		801182	FERGANCHICK,B	0
14-16-6	SW	NE	SE	575575	GARDNER	0
14-16-6				600039	ELLIOTT	0
14-16-6	NW	SE	NE	619934	TUCSON, CITY OF,	0
14-16-6	SE	NE	SE	620087	TUCSON, CITY OF,	0
14-16-6	SE	NE	SE	620088	TUCSON, CITY OF,	0
14-16-6				620857	HILL,L G	2
14-16-6	SW	SE		621379	RYAN, ROBERT,C	7
14-16-6	SE	NW	SW	625819	SABBAGH,A H	24
14-16-6	SE	NW		625820	SABBAGH,A H	0
14-16-6	SW	NW	NW	631269	STOCKHOUSE,H L	2
14-16-6	SW	NW	NW	631270	STACKHOUSE,H L	0
14-16-6	NW	NE		634014	SLADE,J	2
14-16-6	SW	SE		801176	DORAN,T E	1
14-16-6	SW	NE	SE	801241	GARDNER	9

Note:
ADWR Well Registry (5th edition) used to identify wells and calculate average annual pumpage.
* *For Years 1988-1998.*