GROUNDWATER CONDITIONS IN SOPORI BASIN

Prepared for

Pima County Regional Flood Control District

by

Pima Association of Governments Watershed Planning

June 2005

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June 2005

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Purpose and Scope

The purpose of this study was to assemble and summarize existing information about the subsurface hydrology of the Sopori groundwater basin. This work was completed under Element 1101 of Pima Association of Government's (PAG) 2004-2005 Overall Work Program, which includes hydrologic data compilations in outlying areas such as the Sopori Basin.

This report summarizes published reports and public datasets pertaining to the subsurface hydrology of Sopori Basin. It includes descriptions of the hydrogeology of the basin, recharge, the number and type of wells, well installation frequency, changes in water levels through time, shallow groundwater areas, groundwater pumping, grandfathered irrigation rights and water quality. Data sources and limitations also are discussed.

This report is intended to provide a broad understanding of the groundwater conditions in Sopori Basin based on existing information. The findings within this report could be used as preliminary information for future hydrologic studies.

Study Area

The Sopori study area is located approximately 40 miles south of Tucson and is bounded by the Cerro Colorado Mountains to the north, the Tumacacori Mountains to the south and east, and the Twin Peaks divide that separates Sopori from the Arivaca watershed to the west. Arivaca Junction lies at the eastern end of the basin, where Sopori Basin joins the Upper Santa Cruz Basin. Sopori Basin and a small portion of Upper Santa Cruz River Basin are included within the study area. The entire study area is located within the Santa Cruz Active Management Area (AMA), though most of it is not included in the AMA groundwater model. The Sopori groundwater basin and watershed straddle the boundary between Pima County and Santa Cruz County, but the majority of both are located within Pima County. The Sopori watershed extends for 167 square miles. Papalote Wash begins in the upper portions of the watershed and drains into Sopori Wash, which is the main drainage feature in the study area. Sopori Wash is a tributary of the Santa Cruz River.

The study area is shown in Figure 1. The study area boundary roughly follows with the watershed boundary. The boundary was drawn to include the majority of registered wells in the alluvial areas of the watershed. The northern portion of the watershed, which drains the Sierrita Mountains, was not included in this study because few wells exist there. The study area includes small areas immediately outside of the watershed in order to include clusters of wells in the study. The eastern boundary was extended to the confluence with the Santa Cruz River on the east side of Interstate 19; therefore, the study area includes a small portion of the Santa Cruz River Basin (Figure 3).

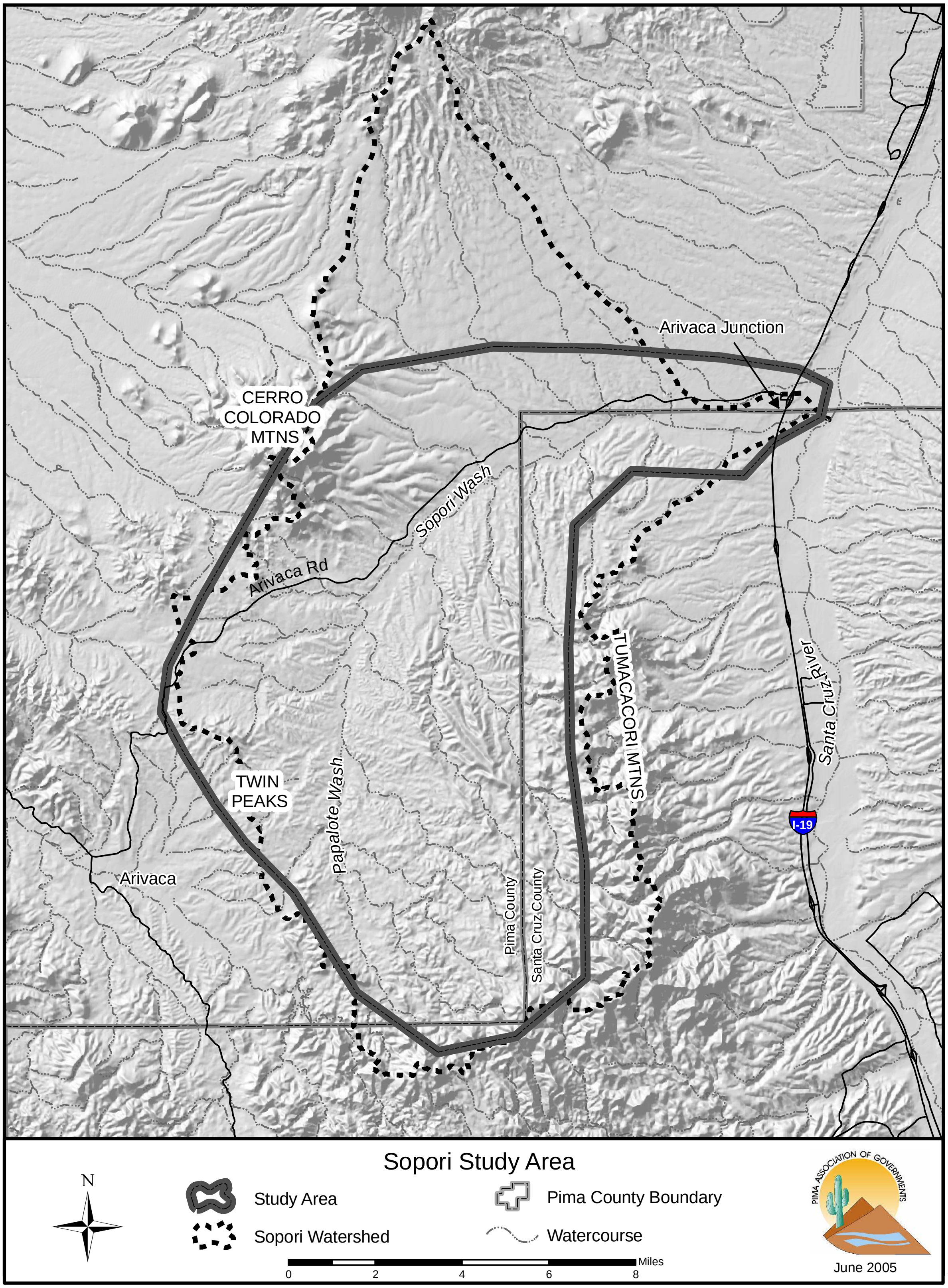


Figure 1. Sopori Study Area.

Land Ownership

The majority of land in Sopori Basin is Arizona state trust land. There are also private land, Pima County land, and federal land in the study area. Figure 2 shows landownership in the study area. The private lands are generally located along Sopori Wash and Papalote Wash. Pima County recently acquired Rancho Seco, which is located in the western portions of Sopori Basin. In addition to purchasing most private parcels within the ranch, Pima County acquired the grazing rights to the state trust and federal lands. The majority of federal land in the basin is associated with the Coronado National Forest, which is located to the south and east of the study area.

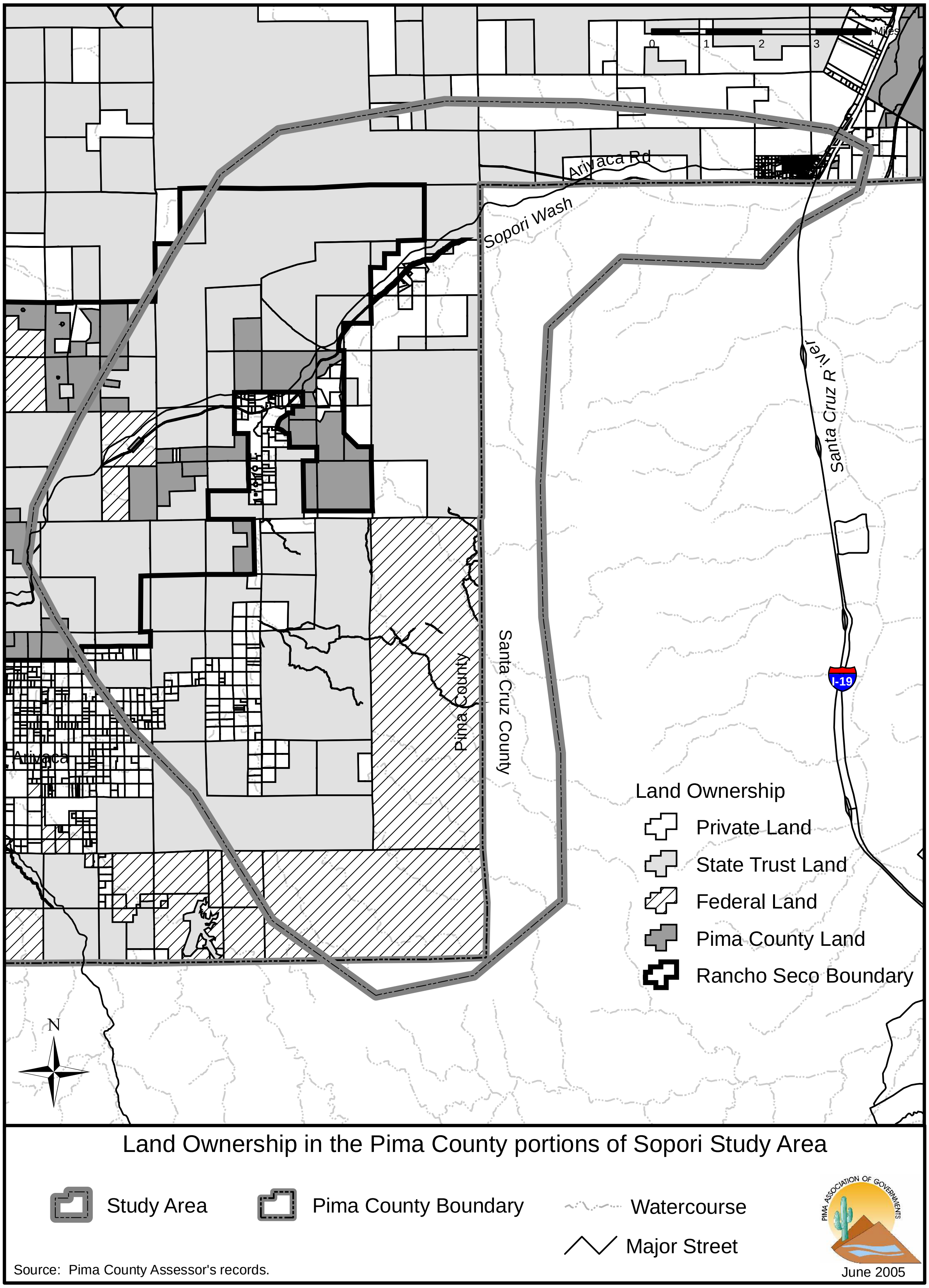


Figure 2. Land Ownership in Pima County Portions of Sopori Study Area.

Hydrogeology

The Sopori Basin is an isolated, alluvial groundwater basin that is bounded by bedrock hills and mountains. The primary geologic units include Jurassic granitoid, volcanic and sedimentary rocks, Cretaceous volcanic rocks, Oligocene/Miocene volcanic rocks, Miocene sedimentary rocks and semi-consolidated alluvium, and unconsolidated Holocene alluvium (Peterson, et. al., 2001; Drewes, 1980), as shown in Figure 3. While some of the bedrock units might be water-bearing, the semi-consolidated and unconsolidated alluvium deposits are probably the principal water-bearing units in the basin.

Geologic mapping suggests that several faults exist in the area, though most are buried or suspected (Drewes, 1980). Figure 3 shows their locations. A large, north-trending fault exists along the western side of the Upper Santa Cruz Basin and extends north of Sopori Wash towards Green Valley. Another fault, the north-northeast trending Sopori Wash Fault, is mapped along the bedrock-alluvium interface on the eastern margins of Sopori Basin. It crosses Sopori Wash in Sections 3 and 4 of Township 20 South, Range 12 East. Differences in hydrologic properties of the basin fill in the Upper Santa Cruz Basin suggest that this fault crosses the river basin and connects with the Elephant Head and Pantano Wash Faults to the east (Halpenny and Halpenny, 1988). These faults, especially the Sopori Wash Fault, mark the presumed boundary between the relatively shallow Sopori Basin and the much deeper Upper Santa Cruz Basin. Figure 4 shows the general locations of Sopori Basin and Upper Santa Cruz River Basin.

A major hydrologic disconnect probably exists between the Sopori Basin and the Upper Santa Cruz River Basin (ADWR, 2005). The feature could be fault-controlled, given the location of the Sopori Wash Fault shown in Figure 3. A dramatic decline in water level from west to east in T20S-R12E Sections 5, 4, and 3 gives evidence of this discontinuity. Changes in groundwater levels are discussed later in this report.

The thickness of the alluvial deposits in Sopori Basin ranges from a thin veneer along the flanks of the surrounding mountains to nearly 1,000 feet near the Upper Santa Cruz Basin (Oppenheimer and Sumner, 1980; Cooley, 1973, Drewes, 1980). Gettings and Houser (1997) report that the Sopori subbasin contains about 165 feet of upper basin fill and over 2100 feet of Nogales Formation, based primarily on interpretations of geophysical data. The small thickness of upper basin fill in the Sopori Basin is probably a function of tectonic uplift and erosion following deposition (Gettings and Houser, 1997). Drillers logs from wells in the center of the basin indicate that most wells in the area are less than 250 feet deep and do not penetrate bedrock. According to the ADWR Wells55 Registry (described in the Well Inventory section), there is only one well (55-625246) drilled to depths deeper than 1,000 feet. However, no driller log was available for this well to indicate the type of material it is drilled into or whether it penetrates bedrock.

Bedrock outcrops were included on the Drewes (1980) map of surficial geology (Figure 3). Two granitoid outcrops are present where the Sopori Wash Fault crosses Sopori Wash and an outcrop of volcanic rock is present to the west of Sopori Wash in the north-central portions of Sopori Basin. Other outcrops might exist, but they were not included on the geologic maps used for this study. Detailed mapping of these outcrops, along with an investigation on subsurface geology, might provide a better understanding of the hydrogeology of the basin and how groundwater moves through the area. Areas with shallow bedrock generally are associated with shallow groundwater and riparian vegetation. A better knowledge of the subsurface geology of the basin would help Pima County determine where to focus future conservation efforts.

The Sopori Wash floodplain (Holocene alluvium) is relatively narrow at its headwaters and is constricted by shallow bedrock near Sopori Ranch. Downgradient from Sopori Ranch, however, the floodplain becomes much broader and flatter. Riparian vegetation is supported by shallow groundwater and soil moisture within the Holocene alluvium. Shallow wells tapping into this material could potentially cause drawdown of the aquifer, thus decreasing the water available for the riparian vegetation. Wells that pump from the older alluvium might be capturing groundwater before it reaches the riparian habitat, causing an indirect impact on water levels in the Holocene alluvium. While wells located near the Holocene alluvium might have greater impact on water levels in the unit, wells pumping farther away might also be impacting groundwater conditions. Figure 5 shows the Holocene alluvium in relation to parcel boundaries and registered wells in the Pima County portions of the study area.

Groundwater in the basin flows to the north-east and east, generally following Sopori Wash before merging with flow in the Upper Santa Cruz Basin. Groundwater flow is constricted by shallow bedrock near Sopori Ranch in Section 4 of Township 20 South, Range 12 East, and the gradient of the water table increases east of the ranch where the Sopori Basin meets the Upper Santa Cruz Basin. The Sopori groundwater system contributes 1000 AF of groundwater to the Upper Santa Cruz Basin each year (Travers and Mock, 1984). Current modeling efforts by ADWR suggest a slightly higher contribution from Sopori Basin (ADWR, 2005). Groundwater elevation contours are shown and discussed in the Changes in Water Levels section of this report.

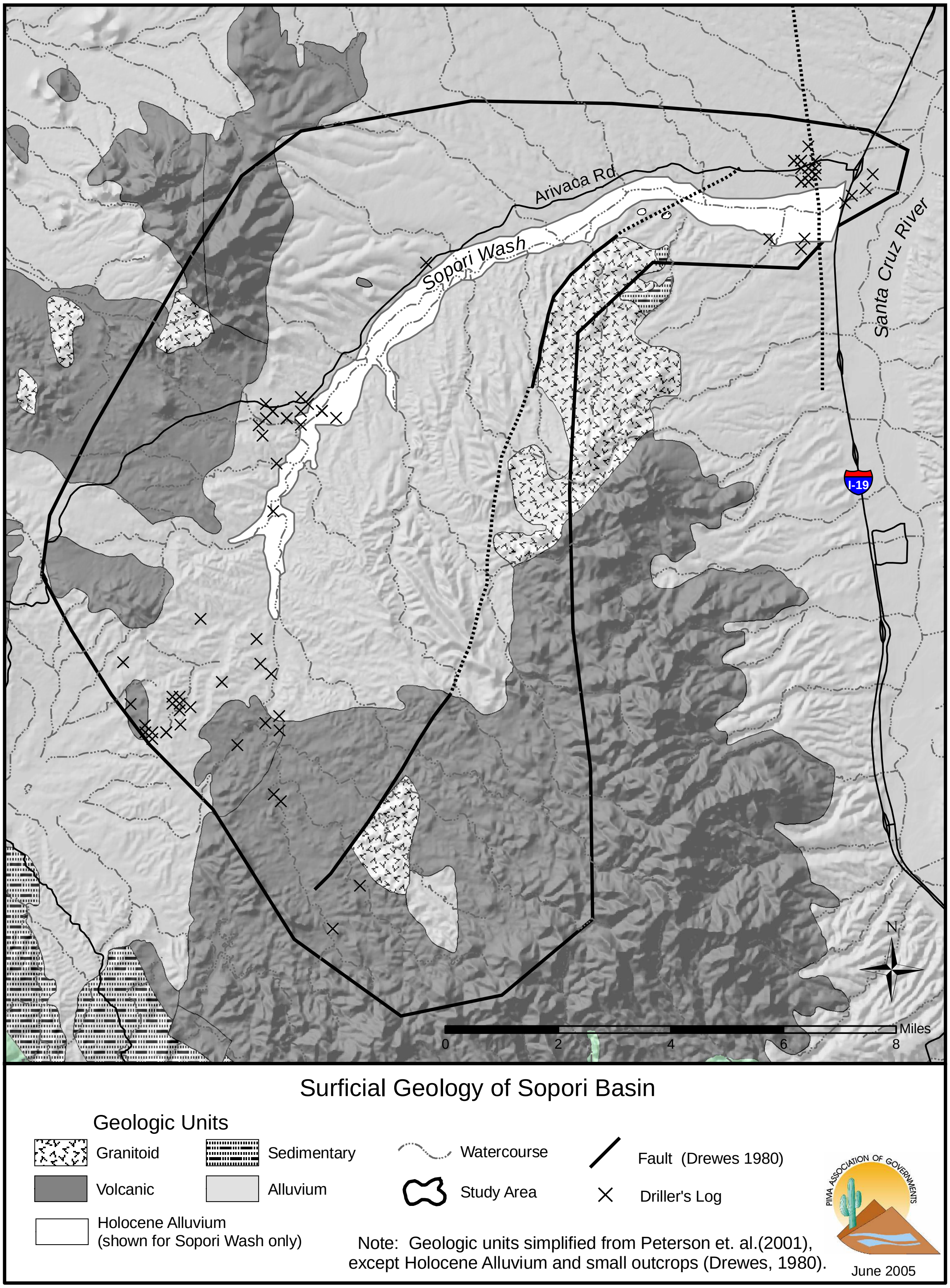


Figure 3. Surficial Geology of Sopori Basin

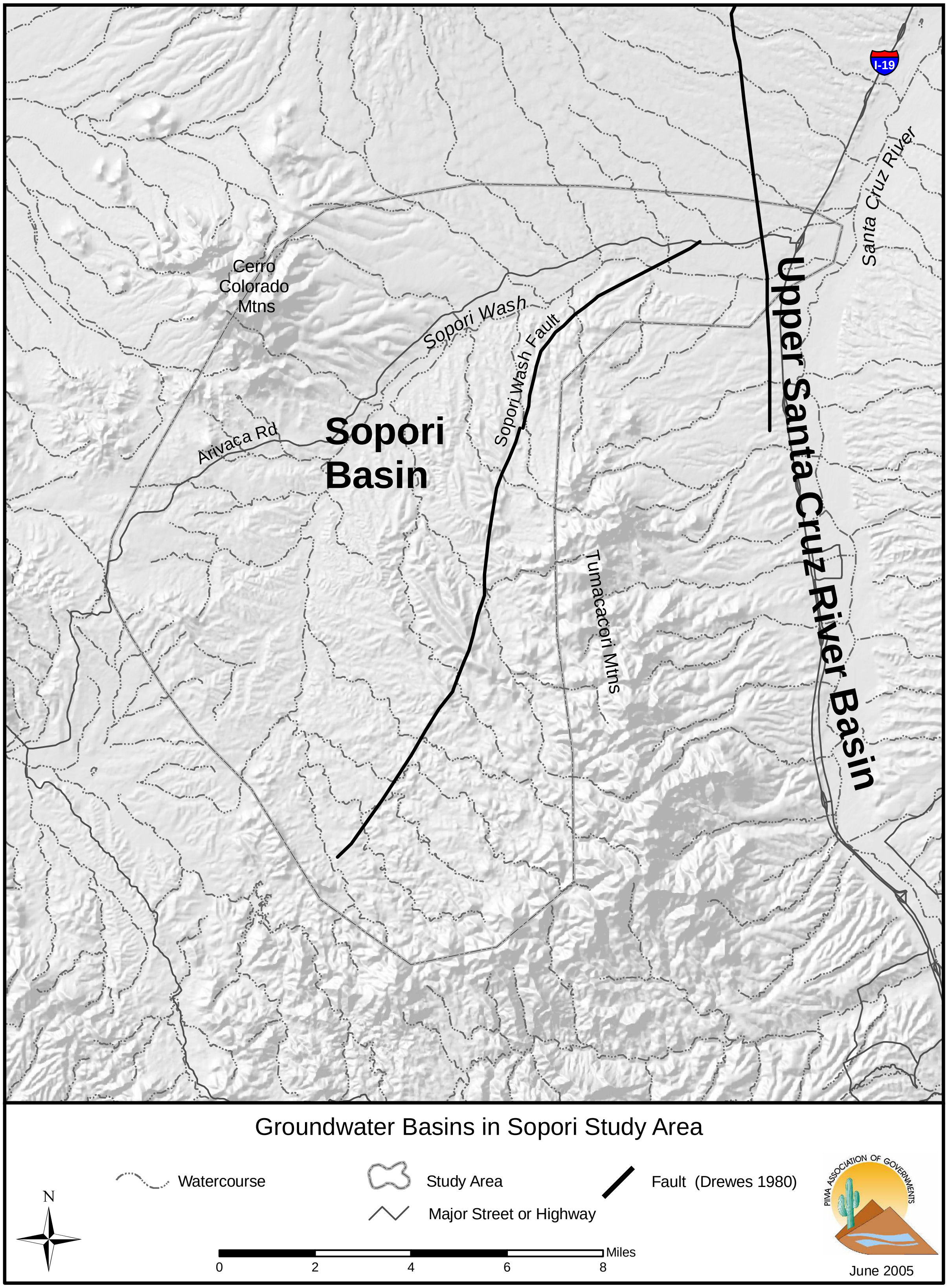


Figure 4. Groundwater Basins in Sopori Study Area.

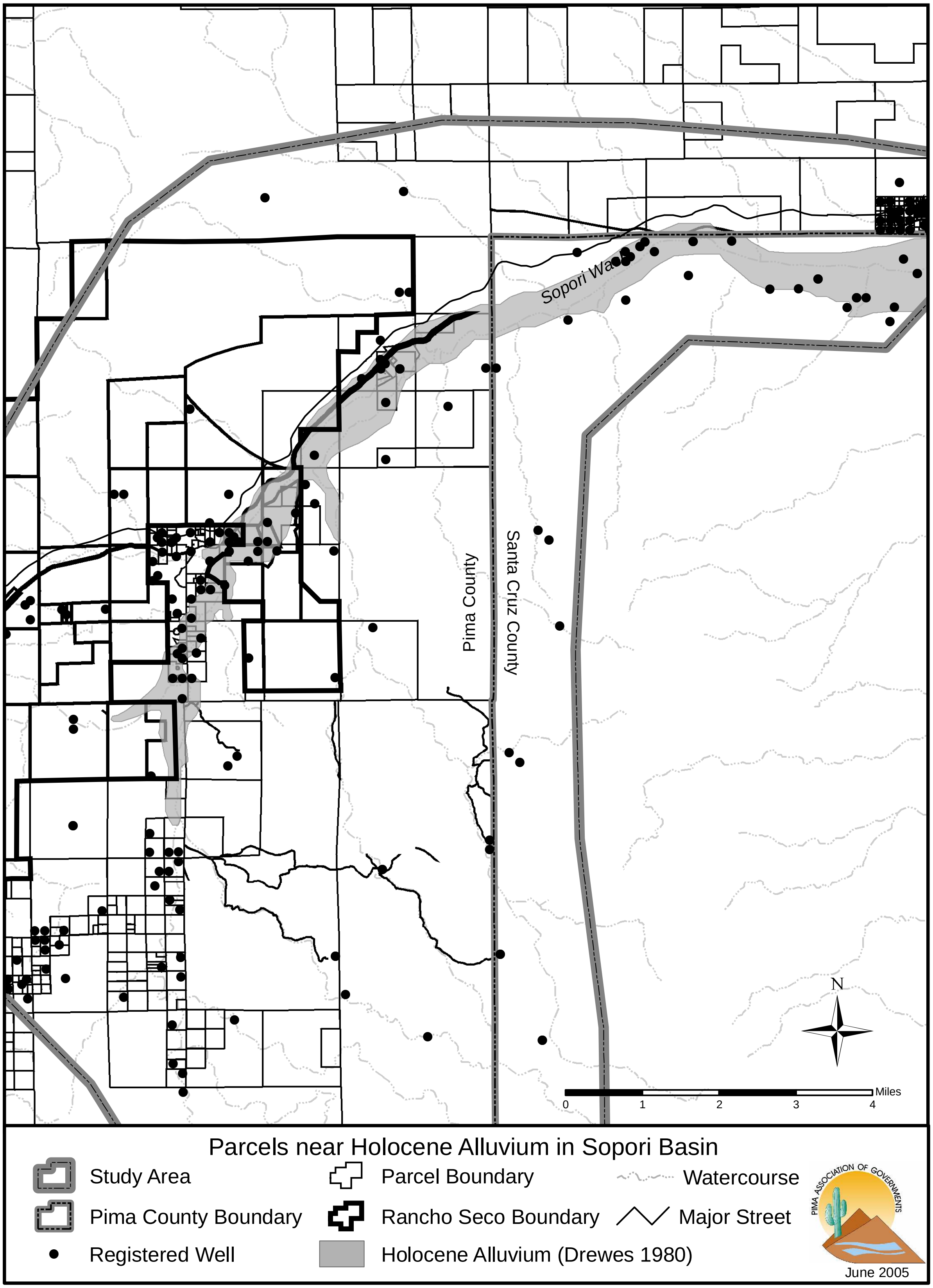


Figure 5. Parcels near Holocene Alluvium in Sopori Basin.

Recharge

Natural recharge in Sopori Basin has two primary components: stream channel recharge and mountain-front recharge. Mountain-front recharge is from infiltration along small stream channels at the bedrock-alluvium interface and from subsurface seepage from consolidated bedrock (Osterkamp, 1973). Stream channel recharge is the amount of water that infiltrates larger stream channels and eventually reaches the aquifer. The infiltrated water is depleted during percolation through the unsaturated zone; therefore, the average annual recharge to the aquifer is less than the average annual infiltration along a stream (Burkham, 1970). Much of the water that does not reach the aquifer is consumed by evapotranspiration (ET). No data is available to describe potential inputs from bedrock units and faults in the basin.

No site specific estimates for recharge rates in the Sopori Basin were available for this investigation. Osterkamp (1973) compiled data from the region and provided estimates of recharge along mountain-fronts and stream channels throughout Eastern Pima County, including the Sopori watershed. Using the Osterkamp estimates, the estimated average annual recharge rate in the Sopori Basin is approximately 2,000 acre-feet per year (AF/yr).

In addition to recharge, groundwater flow in the Upper Santa Cruz River Basin contributes to the water budget of the study area. However, the rate of contribution is unknown. Determining groundwater flow in the Upper Santa Cruz River Basin was outside the scope of this study.

Well Inventory

Groundwater data for this investigation were compiled from the Arizona Department of Water Resources (ADWR) Wells55 Registry and the ADWR Groundwater Site Inventory (GWSI) database. Reported annual groundwater pumping data from 1984 to 2002 were included on the ADWR Well Registry CD-ROM and were used to evaluate pumping trends for this study.

The data sources used for this hydrologic assessment have limitations that could lead to inaccurate or incomplete conclusions. The Wells55 Registry relies exclusively on information provided by the well owner and/or the well driller. The information is not verified by ADWR. ADWR does not guarantee the accuracy of the information contained within the Well Registry because the information might be incomplete (ADWR, 2003). Well locations in the Wells55 Registry are reported by township, range, and quarter-quarter-quarter section, therefore, at best, the well locations are accurate to within 10 acres. The GWSI database is considered to be more accurate than the Wells55 Registry because the GWSI wells have been field verified by ADWR personnel. PAG staff did not field verify the well data used in this study.

Locations of registered wells are shown in Figure 6. A total of 263 registered water production wells are located in Sopori Basin. Unregistered wells likely exist in the basin, but PAG did not attempt to identify the number or locations of wells which were not included in either of the databases.

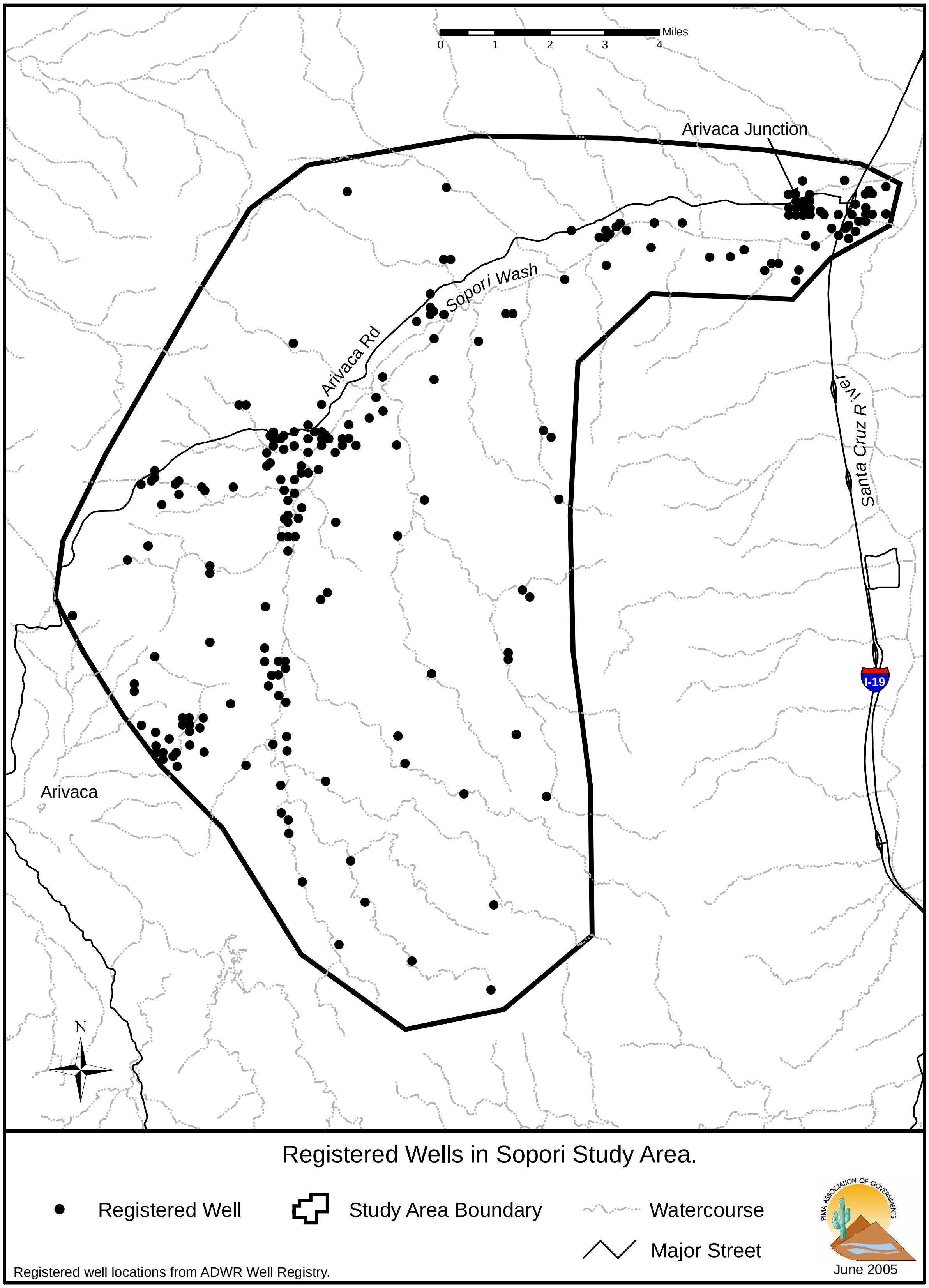


Figure 6. Registered Wells in Sopori Study Area.

Figure 7 shows the distribution of well types and Figure 8 shows the distribution of well water uses. The vast majority of wells in the basin are exempt wells, but there are also many non-exempt wells. Exempt stock wells are generally located in the upland areas away from Sopori Wash, while exempt domestic wells are primarily located closer to the wash and floodplain. Non-exempt irrigation wells are present primarily along the floodplain near Arivaca Junction and near Moyza Ranch Road. Well Type and well water use definitions are included in Appendix A.

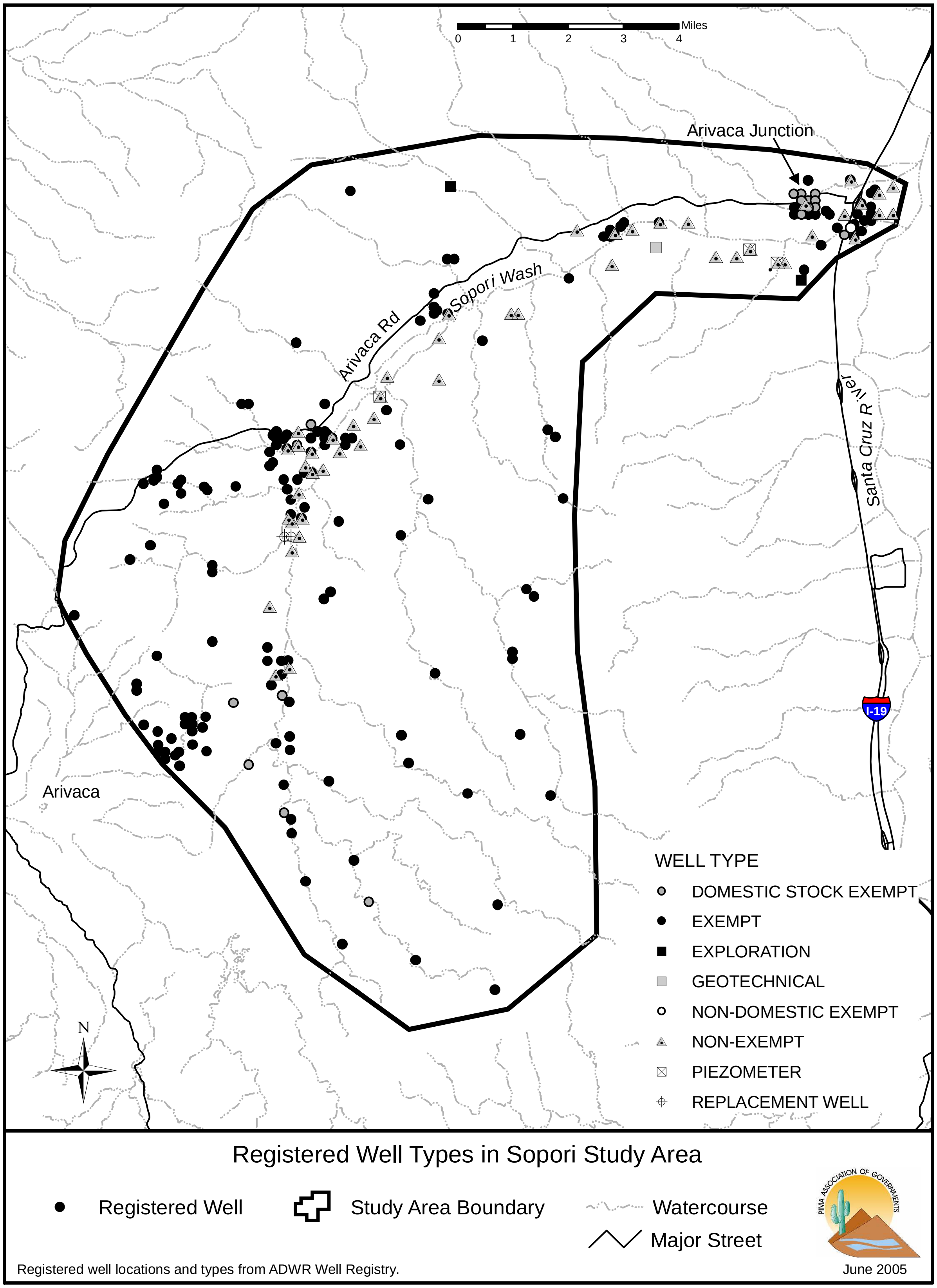


Figure 7. Registered Well Types in Sopori Study Area.

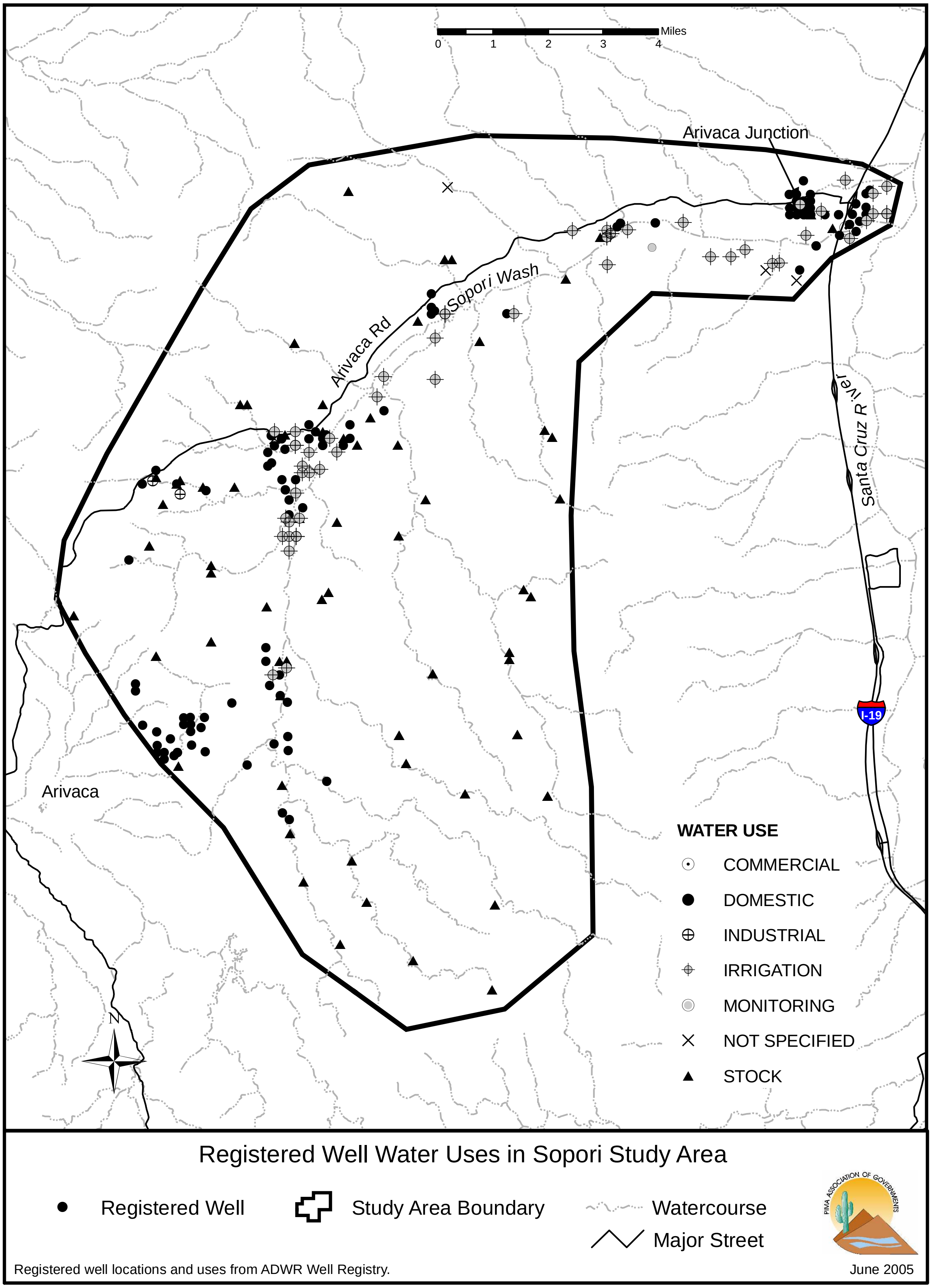


Figure 8. Registered Well Water Uses in Sopori Study Area.

Figure 9 shows the well installation frequency in the Sopori study area. Water uses listed in the Wells55 Registry indicate that groundwater development in the Sopori Basin was primarily for irrigation and livestock until the mid-1970s, when new residents began moving into the area and installing wells for domestic purposes. Wells were first installed in areas near the Santa Cruz River and Amado. Later, groundwater development began to increase further into the watershed along Sopori Wash and Papalote Wash. While wells are scattered throughout the basin, there are three distinct clusters of wells (see Figure 11): near Arivaca Junction; in the center of the basin near Moyza Ranch Road.; and near the boundary with the Arivaca watershed near Twin Peaks. These well clusters correspond with clusters of residential properties shown on the Pima County GIS parcel database and on aerial photographs. Well installations peaked in the late 1970s and early 1980s, but have since declined to just a few wells being installed each year.

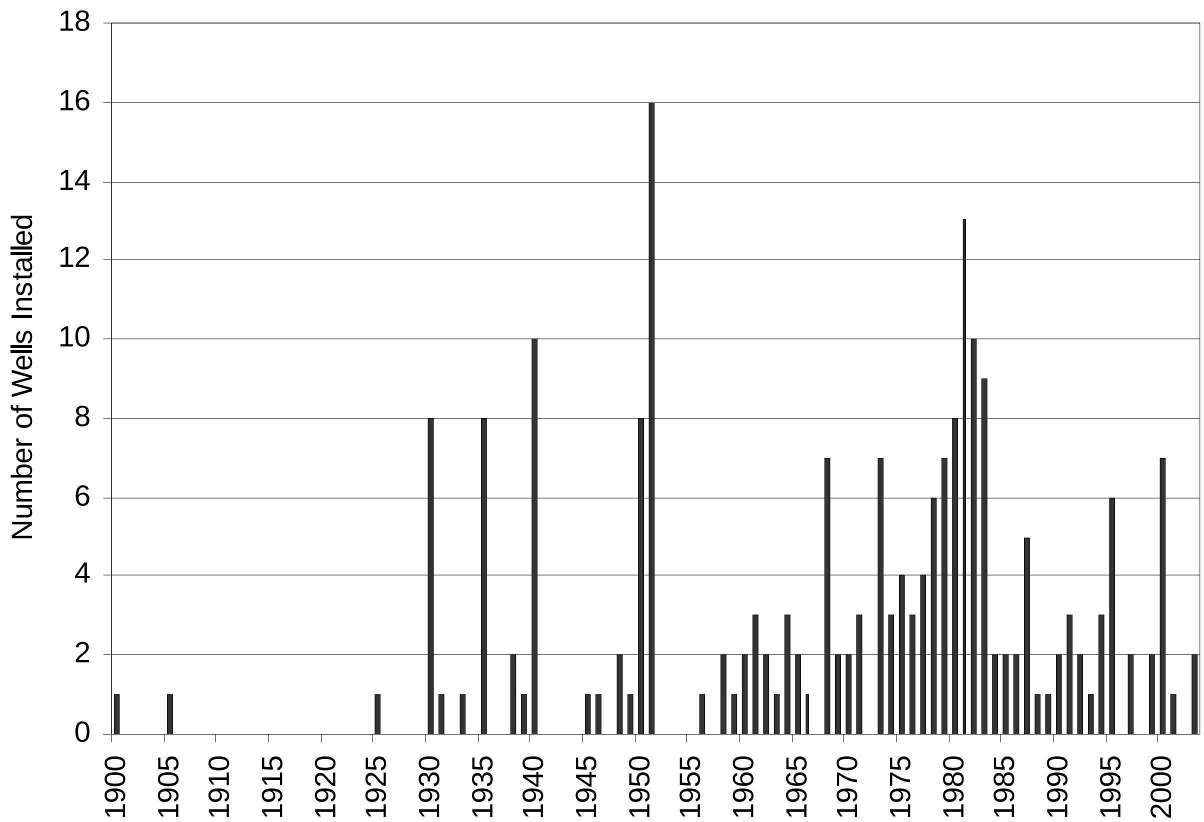


Figure 9.   Well Installation Frequency in Sopori Study Area.

Groundwater Pumping

Wells designated with the well types "non-exempt" or "service" are required to report their annual pumping data to ADWR, while other types (i.e., "exempt") are not. Reported pumping data were included in the ADWR Well Registry CD-ROM. Fifty-seven wells had pumping data for at least one year between 1984 and 2002.

The reported annual groundwater pumping rates for each water use sector is shown on Figure 10. Irrigation wells have remained the leading groundwater pumpers in the Sopori Basin since the mid-1980s when ADWR began recording pumping rates, and were likely the dominant pumpers prior to the mid-1980s as well. Annual reported pumping for irrigation uses gradually decreased from the mid-1980s to the mid-1990s, before increasing again by the early-2000s. Pumping from non-exempt domestic wells has remained fairly consistent since 1984.

ADWR estimates that the average exempt well pumps groundwater at a rate of 0.5 AF to 1.0 AF per year (ADWR, pers. comm., 2003). 202 exempt wells are located within the study area. Using the conservative estimated pumping rate of 0.5 AF per year, the total estimated pumping rate for exempt wells in the basin is approximately 101 AF for 2003. Total non-exempt pumping in 2003 was reported to be 3,192 AF. Many exempt well records did not include installation dates and, therefore, could not be assigned to a specific year prior to 2003. These records were added to the 2003 total as a way to provide an estimate of total annual pumpage by exempt wells in the study area for the year 2003. These undated wells account for a relatively small number of records and don't affect the overall trend shown in Figure 10. Estimated pumping from exempt wells has remained fairly consistent since the mid-1980s.

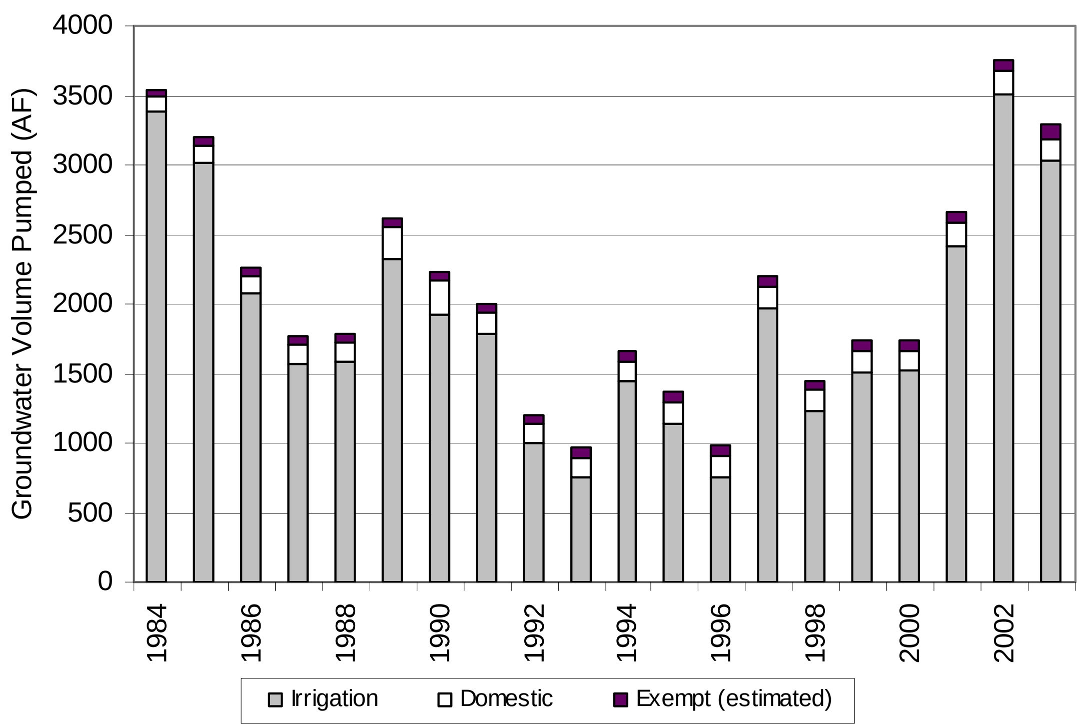


Figure 10. Annual Groundwater Pumpage by Water Use Sector in Sopori Study Area.

Clusters of wells were grouped into subareas to gain an understanding of pumping trends in specific areas within the Sopori Basin (Figure 11). Figure 12 shows a pumping hydrograph for each subarea. The majority of groundwater pumping in the Sopori watershed occurs near Arivaca Junction. A higher number of irrigation wells are located in Subarea 1 than in the other areas. Most wells in Subarea 3 are exempt domestic wells and, therefore, contribute only a small amount to the total pumpage in the basin. Irrigation in the Arivaca Junction area is the dominant groundwater use in the Sopori Basin.

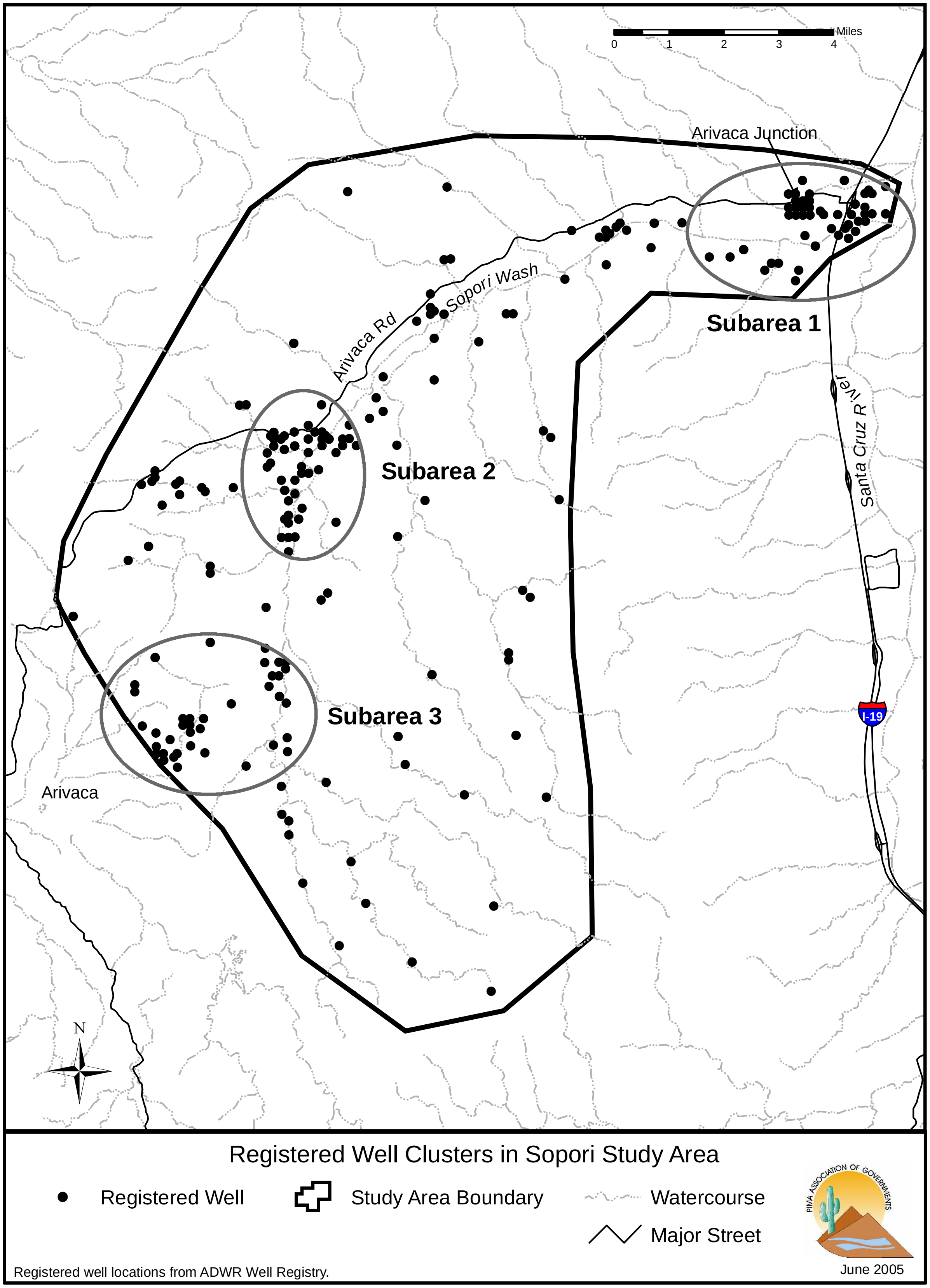


Figure 11. Registered Well Clusters in Sopori Study Area.

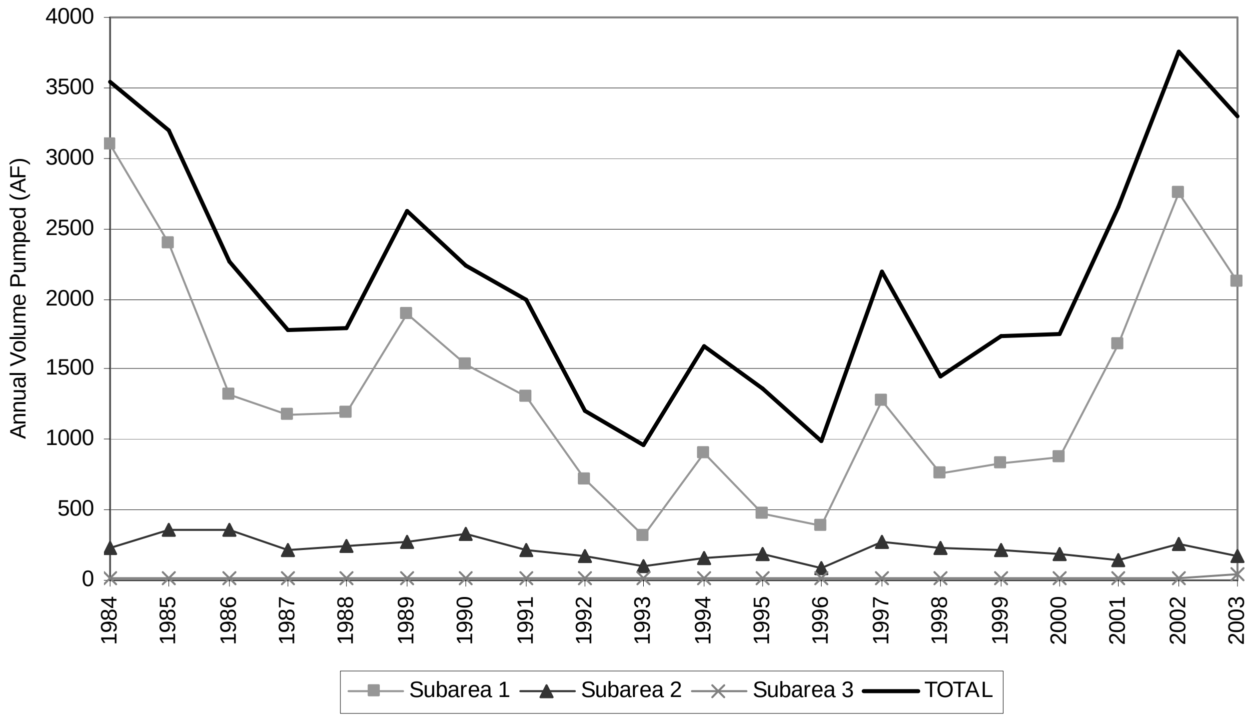


Figure 12. Subarea Annual Groundwater Pumpage in Sopori Study Area.

Grandfathered Irrigation Rights

ADWR issued Certificates of Irrigation Grandfathered Rights (IGFRs) to farmers in the early 1980s if two or more acres of land were irrigated between 1975 and 1980. With few exceptions, no new land greater than two acres in size can be irrigated within an AMA (ADWR, 1999). There are many land parcels within the Sopori Basin that have IGFRs, primarily along Sopori Wash (Figure 13).

According to the online ADWR Annual Water Withdrawal and Use Reports, the maximum volume of groundwater allocated in 2003 to IGFRs in the study area was close to 7,700 AF, which includes 2,159 AF associated with parcels east of I-19. However, no right used its full allocation. The wells supplying water for the IGFRs pumped 3,142 AF of groundwater in 2003.

The largest IGFR certificates for lands in the Sopori Basin are held by Inscription Canyon Ranch (also known as Sopori Ranch) (2237 AF), Carrow Co. /Hooker (665 AF), and Marley Ranch (428 AF). The remaining volume was allocated to certificates with smaller rights, ranging from 20 AF to 280 AF. A water right for 160 AF was transferred to Pima County during its acquisition of Rancho Seco earlier this year. The right was formerly held by Carrow Co. /Hooker. Middleton Ranch is located at the edge of the study area on the east side of Interstate 19 and was allocated a maximum of 2159 AF of groundwater in 2003. The pumping wells that supply water for one of the Middleton Ranch IGFRs, however, are located outside of the study area and were not included in the well inventory and pumping assessment of this study. The largest rights in the study area are associated with land located east of Sopori Basin within the Upper Santa Cruz Basin. A table of grandfathered irrigation rights in the study area is included in Appendix B.

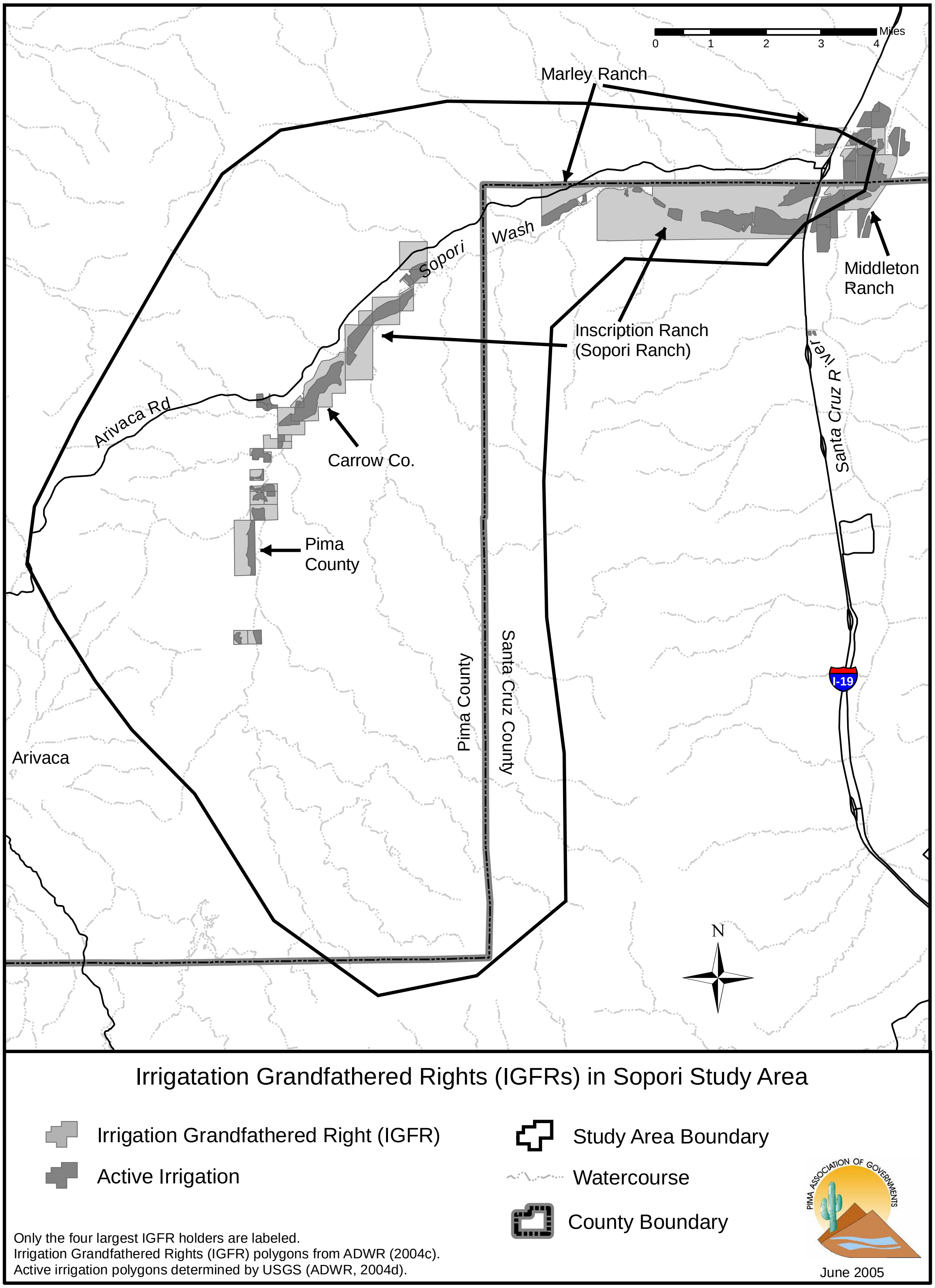


Figure 13. Irrigation Grandfathered Rights (IGFRs) in Sopori Study Area.

Changes in Groundwater Levels

Hydrographs

Water level data from the GWSI database were used to assess changes in water levels in the Sopori Basin through time. The database includes a fairly comprehensive array of water level data for Sopori, particularly for the years 1982 and 1995. Water level hydrographs have been compiled to show water level changes between 1950 and 1995 at selected individual wells in Sopori Basin. The locations of the selected GWSI wells are shown on Figure 14 and their hydrographs are shown on Figure 15.

The hydrographs indicate that a groundwater depression exists along Sopori Wash near Arivaca Junction in Sections 1, 2, and 3 of T20S, R12E. Depths to water are less than 50 feet below the land surface nearest the river (Hydrograph A), and gradually get deeper further away from the river to the west (Hydrographs B through F). Water levels in wells located along the Sopori Wash floodplain west of Sopori Ranch are typically less than 50 feet below the surface (Hydrographs G through J). The hydrograph for the well located near the western edge of the basin indicates depth to water between 100 feet and 150 feet (Hydrograph K).

According to the hydrographs from GWSI wells near Arivaca Junction, groundwater levels declined tens of feet during the 1960s and especially the 1970s before recovering to pre-1950s water levels by the 1990s. Groundwater levels upgradient from Sopori Ranch have remained fairly consistent through time.

A map of water level changes in the Upper Santa Cruz Basin between 1953 and 1982 showed a 20-foot bowl-shaped depression in the water table along Sopori Wash near Arivaca Junction (Murphy and Hedley, 1982). The water level decline was also illustrated on the map in a hydrograph for an irrigation well located at the center of the depression. Although the well was not identified, it was shown to be located in the vicinity of the wells associated with Hydrographs C, D, and E. The depression was likely created by groundwater pumping for irrigation.

Water levels in several irrigation wells located between the headquarters and Arivaca Junction rebounded 30 feet between 1982 and 1995. The rebound in water levels coincides with a period of declining groundwater pumping from the wells. Irrigation pumping, however, has increased to mid-1980s levels since 1995. No post-1995 GWSI water level data were available for these irrigation wells, but it is likely that water levels have declined again in response to the increased pumping.

Groundwater Elevation Contours

GWSI data were used to create groundwater elevation contours in the Sopori Basin for the years 1982 and 1995, shown in Figure 16. These years were the only years with a sufficient number of data points for contouring. The data points used to create each set of contours also are shown in Figure 16. The 2.5 mile long groundwater depression is defined by the two 3,000-foot contours: one on the west side and one on the east side. The most apparent changes occurred under the Sopori Wash floodplain near Arivaca Junction, where decreased groundwater pumping between 1982 and 1995 allowed water levels in the depression to rebound. This is illustrated by the west 3,000-foot contour moving eastward, and the east 3,000-foot contour moving westward. The hydraulic head gradient is highest east of the Sopori Ranch headquarters, where Sopori Basin meets the deeper and larger Upper Santa Cruz Basin. Faults locations are included in Figure 16 to show the presumed boundary between Sopori Basin to the west of the faults and Upper Santa Cruz Basin to the east.

The contours, however, have limitations when used to compare water level changes in certain areas of the basin. Many well points used for contouring did not have data for both 1982 and 1995. Different data distributions produce different contour configurations. This is apparent near Sections 3 and 4 of T20S, R12E where a higher hydraulic head gradient exists. More data points were available in this area for 1982 than for 1995; therefore, the certainty of the 1995 contours is less than that of the 1982 contours. Fortunately, though, data was available for both years for a number of GWSI wells in the study area and changes in water levels at those specific locations could be accurately identified. Water levels in areas upgradient from Sections 3 and 4 of T20S, R12E, in the heart of Sopori Basin, have remained fairly consistent through time.

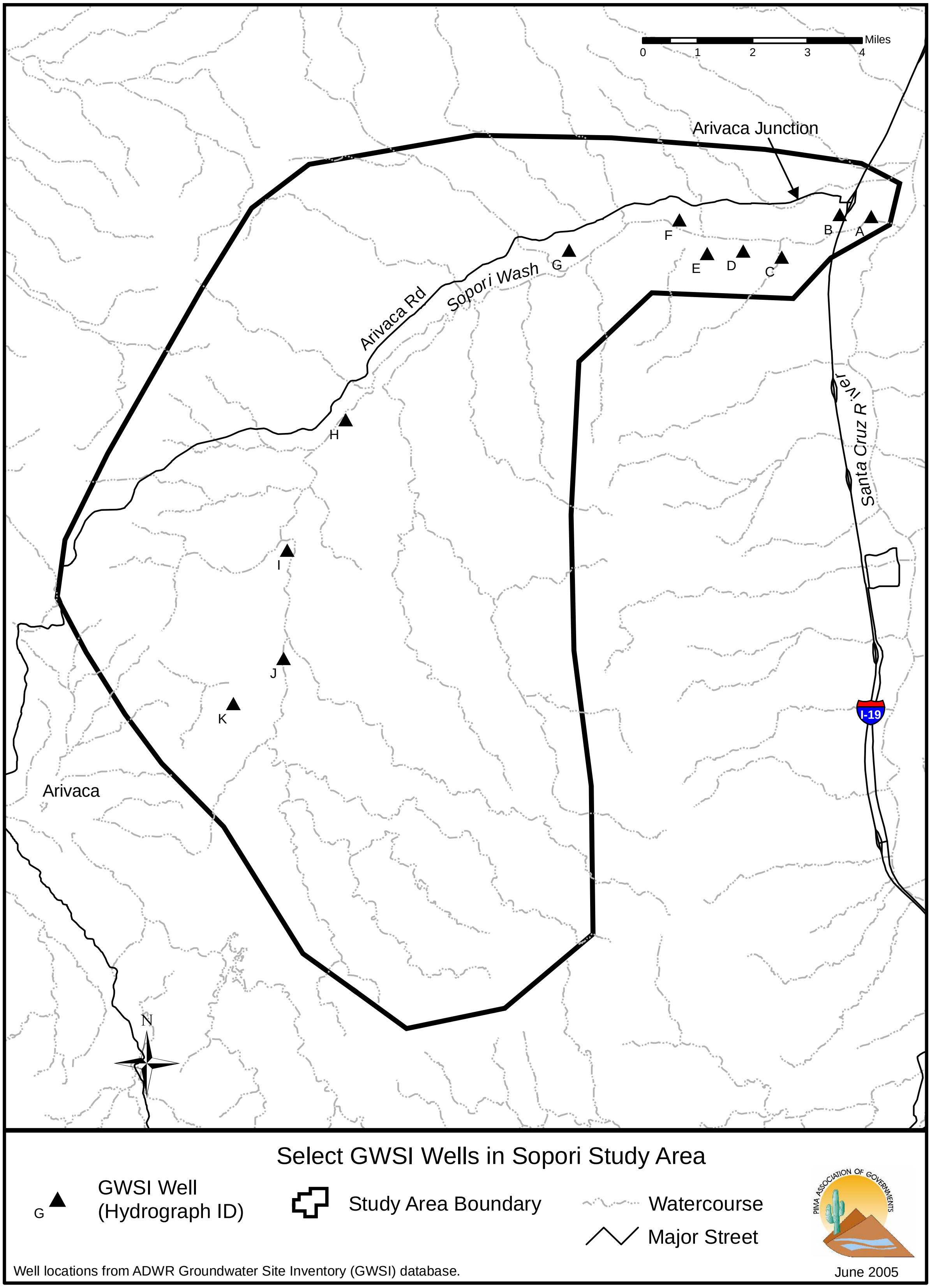


Figure 14. Select GWSI Wells in Sopori Study Area.

Figure 15. Hydrographs from Selected GWSI Wells in the Sopori Basin

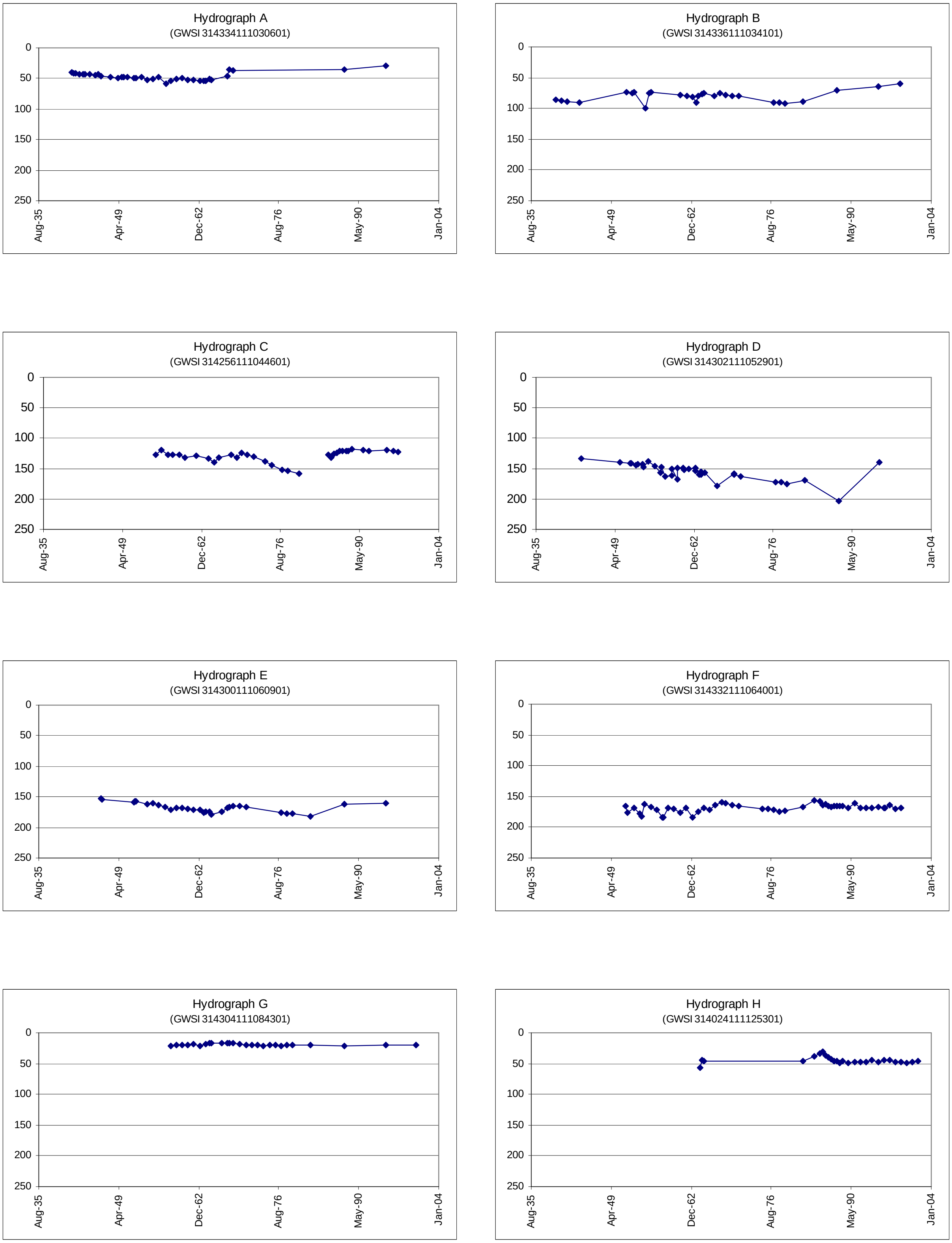
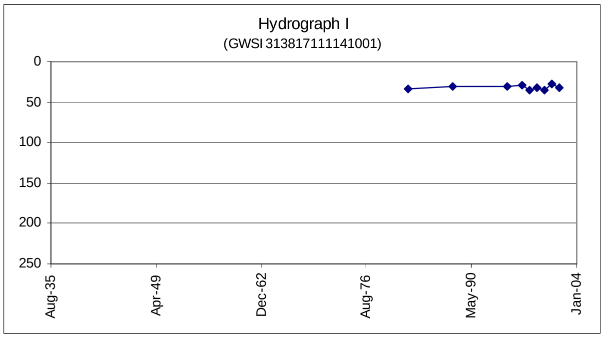
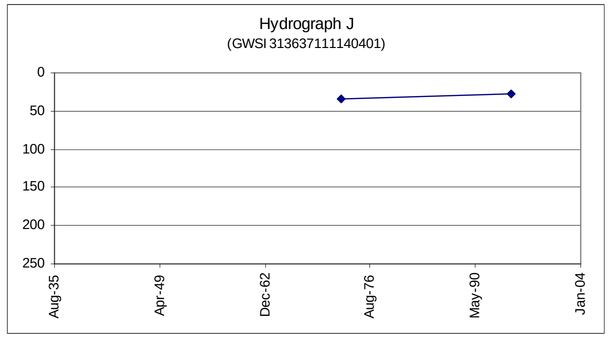
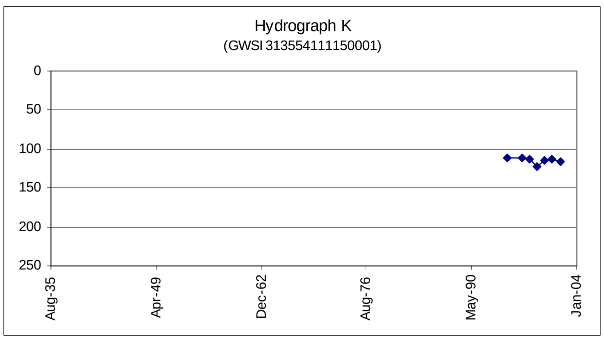


Figure 15. (Continued)







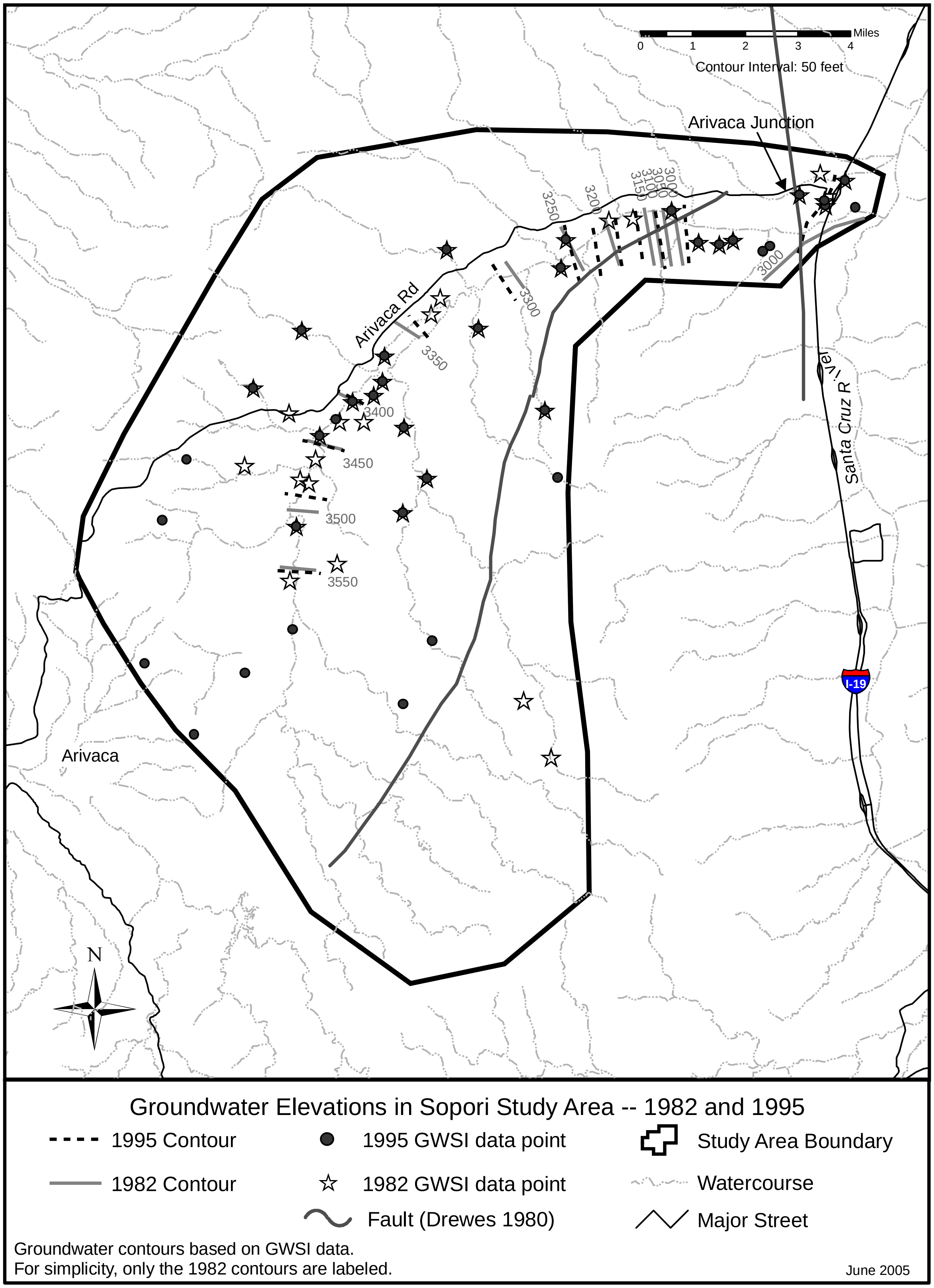


Figure 16. Groundwater Elevations in Sopori Study Area – 1982 and 1995.

Shallow Groundwater Areas

Portions of Sopori Basin have shallow groundwater levels that support riparian vegetation. As seen in Figure 17, there are two shallow groundwater areas in the Sopori Basin. PAG (2000) used recorded water levels and the aerial extent of riparian vegetation to identify and delineate areas in eastern Pima County with depths to groundwater less than 50 feet. Because the smaller area is located in Santa Cruz County, it was not identified in PAG (2000). This study used 1995 GWSI data to identify this area, which is probably associated with groundwater being forced to the near surface by shallow bedrock, as discussed in the Hydrogeology section of this report.

Springs might discharge groundwater to the surface in the study area, but their locations were not shown on the data sources used for this study. There is a surface water right associated with the so-called Sopori Spring, which is located near the Sopori Ranch headquarters, but this is a French Drain water harvesting feature instead of a natural spring (ADWR, 2005).

Water Quality

ADWR collected water samples from wells throughout the Tucson AMA in 1981-82 and created a series of maps showing various groundwater characteristics, including water quality (Murphy and Hedley, 1982). These maps indicate that the Sopori Basin has good quality groundwater. Water samples were collected from 19 wells in the study area. Specific conductance (a measure of dissolved solids) and fluoride concentrations were analyzed in all samples, and major anions and cations were analyzed in 4 of the 19 samples. The results for major anions show that the groundwater is bicarbonate-type water, with a minor presence of sulfate and chloride. The groundwater has low concentrations of the cations sodium, calcium, and magnesium, though water from a well drilled into bedrock at the western boundary showed a higher concentration in all three cations, especially magnesium. Specific conductance ranged from 260 microSiemens per centimeter (μS/cm) to 475 μS/cm in the alluvium, and 550 μS/cm to 760 μS/cm in the bedrock. One water sample taken from near Arivaca Junction had a specific conductance of 890 μS/cm, which is consistent with nearby groundwater along the Santa Cruz River. Fluoride concentrations ranged from zero mg/L to 0.8 mg/L throughout the basin, with a few wells near Arivaca Junction having concentrations of over 1.0 mg/L. The groundwater in the Santa Cruz River Basin near Arivaca Junction generally has higher specific conductance, higher concentrations of fluoride, and higher concentrations of major anions and cations than the groundwater in the Sopori Basin.

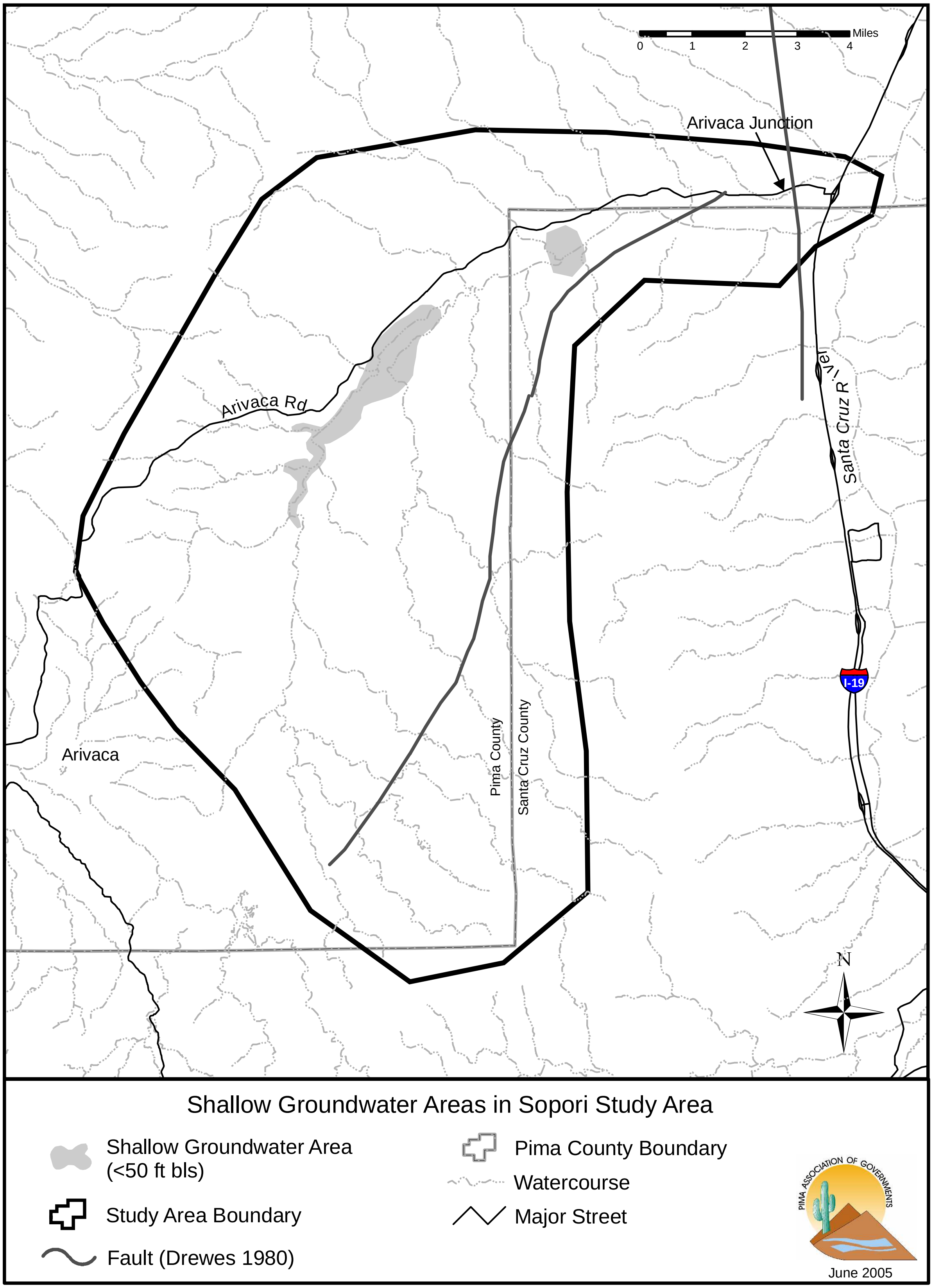


Figure 17. Shallow Groundwater Areas in Sopori Study Area.

Conclusions and Recommendations

The Sopori Basin has a relatively small groundwater system. The majority of wells in the basin were drilled for domestic use, but from a total volume standpoint, the vast majority of groundwater pumping is for irrigation use. The largest impacts to the system occur near Arivaca Junction, where there are many active irrigation wells.

Groundwater conditions in areas upgradient from Sopori Ranch, within the heart of Sopori Basin, have remained relatively stable over time. This is a very different scenario than in the lower portions of the study area, near Arivaca Junction, where water levels have declined between 20 and 30 feet. Drought and increased groundwater pumping by domestic wells and unutilized grandfathered irrigation rights are potential threats to the upper portions of the basin.

According to available information, the Sopori groundwater system is overallocated. The combined maximum grandfathered irrigation allocations are at least two or three times the estimated annual recharge rate. While wells serving these rights did not pump their full allocation, the actual pumping rate in 2003 was one and a half times the estimated recharge rate. This suggests that some irrigation wells are pumping water from aquifer storage and are, therefore, mining groundwater, as illustrated by the groundwater depression near Arivaca Junction (Figure 13). The impact of groundwater pumping near Arivaca Junction is probably partially alleviated by subsurface flow in the Upper Santa Cruz River Basin, but determining subsurface flows in the Upper Santa Cruz River Basin was outside the scope of this study.

Riparian ET can be a significant component of the water budget of a small groundwater basin, such as Sopori. At the time of this study, a detailed inventory of vegetation and comprehensive assessment of riparian transpiration (ET) had not been conducted for the Sopori study area. A regional mapping effort for Pima County's Sonoran Desert Conservation Plan included the Sopori area, but that inventory does not always delineate vegetation in high resolution. In addition, knowledge of ET rates for the plant assemblages used in the regional inventory is lacking. A study on ET rates for these plant assemblages would be very useful. In addition, an understanding of the potential for growth of riparian areas in the basin would help determine how much water might be needed to sustain riparian habitats if the land was rested and the vegetation was allowed to increase in size and extent.

If springs are located within the study area, they are not included on published maps or in the data sources used for this study. An inventory of springs in the Sopori Basin would help Pima County to better understand the hydrogeology of the area and to identify additional areas to consider for future conservation.

Possible relationships between groundwater pumping and changes in water levels in the basin might be characterized through the use of a groundwater flow model, such as MODFLOW. A model would help describe how the groundwater system is influenced by groundwater pumping in the basin. A model also might help determine a range of possible recharge rates in the basin, based on known or estimated values for hydrologic properties of the aquifer and water budget components.

Decreasing groundwater pumping in Sopori study area might allow water levels near Arivaca Junction to rebound and increase the groundwater contributions to the Santa Cruz River Basin. The riparian habitat in Pima County's Canoa Ranch property might benefit from additional groundwater flow from Sopori causing a rise in the water table immediately downstream from the Sopori Wash confluence. A rise in water levels also might increase the flow extent of the intermittent reach of the Santa Cruz River that flows into Canoa Ranch during several months each year. Water levels in Sopori Basin, west of the faults, would presumably rise by decreasing groundwater pumpage in that basin. Riparian vegetation in Sopori Basin, including the mesquite bosque near Sections 3 and 4 of T20S, R12E, would benefit from a rise in water level. Retiring grandfathered irrigation water rights in the study area is probably the most effective method of reducing pumpage.

The Arivaca wastewater treatment facility is located at the eastern end of the study area, between I-19 and the Santa Cruz River. Future studies in the area should include an assessment of the facility, how much water currently recharges the aquifer below it, and how much water might be recharged in the future. Water levels under Canoa Ranch, which is located downgradient from the treatment facility in the Upper Santa Cruz River Basin, might be influenced to some degree by this operation.

Because portions of the Sopori groundwater basin and watershed are located in Santa Cruz County, coordination between Pima County and Santa Cruz County would help alleviate possible conflicts in land use planning by the two jurisdictions.

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Appendix A

Definitions of ADWR Well Types

Exempt: Groundwater pumping wells, with pump capacities less than or equal to 35 gallons per minute (gpm)

Non-exempt: Groundwater pumping wells, with pump capacities greater than 35 gpm

Domestic stock exempt: Exempt wells used for domestic stock purposes

Exploration: Wells used for mining exploration, geotechnical, cathodic protection, grounding, heat pump, and direct push purposes that will be filled and abandoned before the drill rig leaves the site. These wells are not used for groundwater pumping.

Monitor or piezometer: Monitor, piezometer, or other environmental wells designed for hydrologic data collection purposes, not groundwater pumping.

Non-domestic exempt: Exempt wells that are not used for domestic or domestic stock pumping purposes.

Non-service: Non-exempt wells that are used for non-service purposes, like mining dewatering or stock watering.

Replacement: New wells that replaced previously registered wells

Service: Wells used for city, town, private water company, and irrigation district customers located within their respective service areas.

Withdrawal Permit: Granted for new withdrawals of groundwater used for non-irrigation uses in AMAs from non-exempt wells.

Source: http://www.water.az.gov/adwr/Content/Publications/files/gwmgtovw.pdf, Retrieved Oct 21, 2003.

Appendix B

Grandfathered Groundwater Rights in Sopori Basin

Certificate	Excluded*	Status**	Acres	Certificate Holder	Cadastral Location
58-100028.0001	1	AC	3.5	Bracamonte	T20-R11-29
58-100028.0001	0	AC	34.6	Bracamonte	T20-R11-29
58-100028.0001	1	AC	4.4	Bracamonte	T20-R11-29
58-100028.0001	1	AC	0.3	Bracamonte	T20-R11-29
58-100028.0001	1	AC	0.4	Bracamonte	T20-R11-29
58-100054.0002	1	AC	7.1	Atwill	T20-R11-14
58-100054.0002	0	AC	31.5	Atwill	T20-R11-14
58-100054.0002	1	AC	21.5	Atwill	T20-R11-14
58-100249.0003	1	AC	24.5	Kay	T20-R11-32
58-100249.0003	0	AC	12.0	Kay	T20-R11-32
58-100336.0001	1	AD	1.1	Fox	T20-R11-28
58-100336.0001	0	AD	18.2	Fox	T20-R11-28
58-100336.0001	1	AD	2.2	Fox	T20-R11-28
58-100336.0001	0	AD	11.8	Fox	T20-R11-28
58-100336.0001	0	AD	4.4	Fox	T20-R11-28
58-100336.0002	8	EF	5.3	B&M Farms	T20-R10-21
58-101759.0000	1	AA	30.1	Truitt	T21-R11-17

Certificate	Excluded*	Status**	Acres	Certificate Holder	Cadastral Location
58-101759.0000	0	AA	10.8	Truitt	T21-R11-17
58-102086.0003	1	AC	15.3	Cooper	T20-R11-11
58-102086.0003	0	AC	12.1	Cooper	T20-R11-11
58-102086.0003	1	AC	3.0	Cooper	T20-R11-11
58-102086.0003	1	AC	1.6	Cooper	T20-R11-11
58-102086.0004	0	AC	31.3	Miller	T20-R11-11
58-102086.0004	1	AC	0.5	Miller	T20-R11-11
58-102086.0004	1	AC	1.9	Miller	T20-R11-11
58-102961.0002	8	II	34.7	?Stedman?	T20-R13-6
58-102961.0003	0	AW	114.3	El Cazador Co	T20-R13-6
58-102961.0004	1	E0	3.8	Henson Farms	T20-R13-6
58-102961.0004	0	E0	8.6	Henson Farms	T20-R13-6
58-102961.0004	1	E0	2.9	Henson Farms	T20-R13-6
58-102961.0004	8	E0	1.2	Henson Farms	T20-R13-6
58-102969.0003	1	AC	7.4	Rueb	T20-R11-33
58-102969.0003	0	AC	13.4	Rueb	T20-R11-33
58-103908.0000	1	AA	209.6	Carrow Co (Hooker)	T20-R11-21
58-103908.0000	0	AA	194.1	Carrow Co (Hooker)	T20-R11-21
58-103908.0000	1	AA	0.5	Carrow Co (Hooker)	T20-R11-21

Certificate	Excluded*	Status**	Acres	Certificate Holder	Cadastral Location
58-103924.0001	1	AC	1936.0	Inscription Canyon Ranch	T20-R12-3
58-103924.0001	0	AC	94.4	Inscription Canyon Ranch	T20-R12-3
58-103924.0001	0	AC	6.9	Inscription Canyon Ranch	T20-R12-3
58-103924.0001	0	AC	1.1	Inscription Canyon Ranch	T20-R12-3
58-103924.0001	0	AC	1.6	Inscription Canyon Ranch	T20-R12-3
58-103924.0001	0	AC	10.0	Inscription Canyon Ranch	T20-R12-3
58-103924.0001	0	AC	226.8	Inscription Canyon Ranch	T20-R12-3
58-103924.0001	0	AC	28.4	Inscription Canyon Ranch	T20-R12-3
58-103924.0001	0	AC	146.7	Inscription Canyon Ranch	T20-R12-3
58-103925.0002	1	AC	145.2	Sopori 12500 Invest. LLC	T20-R11-22
58-103925.0002	0	AC	16.4	Sopori 12500 Invest. LLC	T20-R11-22
58-103925.0002	1	AC	41.2	Sopori 12500 Invest. LLC	T20-R11-22
58-103925.0002	0	AC	75.5	Sopori 12500 Invest. LLC	T20-R11-22
58-103925.0002	1	AC	44.3	Sopori 12500 Invest. LLC	T20-R11-22
58-103925.0002	1	AC	235.3	Sopori 12500 Invest. LLC	T20-R11-22
58-103925.0002	0	AC	66.2	Sopori 12500 Invest. LLC	T20-R11-22
58-103925.0002	0	AC	19.5	Sopori 12500 Invest. LLC	T20-R11-22

Certificate	Excluded*	Status**	Acres	Certificate Holder	Cadastral Location
58-104773.0000	1	E0	22.1	Dunbar	T20-R11-32
58-104773.0000	0	E0	5.8	Dunbar	T20-R11-32
58-104773.0000	0	E0	1.3	Dunbar	T20-R11-32
58-104773.0000	0	E0	2.3	Dunbar	T20-R11-32
58-106310.0002	0	AC	41.5	Vasquez, et al	T20-R13-6
58-106541.0000	1	E0	28.8	Lem	T20-R11-33
58-106541.0000	0	E0	7.5	Lem	T20-R11-33
58-106541.0000	0	E0	2.0	Lem	T20-R11-33
58-107042.0000	1	AA	61.3	AZ SLD	T20-R11-32
58-107042.0000	0	AA	28.2	AZ SLD	T20-R11-32
58-107042.0000	1	AA	0.6	AZ SLD	T20-R11-32
58-107044.0000	1	AA	26.2	AZ SLD	T20-R11-15
58-107044.0000	0	AA	15.3	AZ SLD	T20-R11-15
58-107956.0000	1	AA	88.2	Marley Ranch	T19-R13-31
58-107956.0000	0	AA	25.5	Marley Ranch	T19-R13-31
58-107956.0000	1	AA	13.0	Marley Ranch	T19-R13-31
58-107959.0000	1	AA	200.0	Marley Ranch	T20-R12-5
58-107959.0000	0	AA	71.9	Marley Ranch	T20-R12-5
58-107959.0000	1	AA	0.9	Marley Ranch	T20-R12-5

Certificate	Excluded*	Status**	Acres	Certificate Holder	Cadastral Location
58-108301.0000	1	E0	13.1	Nusbaum	T20-R11-21
58-108301.0000	0	E0	5.6	Nusbaum	T20-R11-21
58-108301.0000	0	E0	2.8	Nusbaum	T20-R11-21
58-109371.0001	1	AC	11.7	Oswald	T19-R13-31
58-109371.0001	0	AC	29.2	Oswald	T19-R13-31
58-109372.0001	1	AC	61.1	Oswald	T19-R13-31
58-111374.0000	1	E0	4.2	Goreczny	T20-R12-5
58-111374.0000	0	E0	4.0	Goreczny	T20-R12-5
58-112497.0003	0	AC	18.9	Pell	T21-R11-17
58-112497.0003	1	AC	21.1	Pell	T21-R11-17
58-112929.0000	0	AA	15.9	Middleton Ranch	T19-R13-31
58-112929.0000	1	AA	35.0	Middleton Ranch	T19-R13-31
58-112929.0000	0	AA	17.3	Middleton Ranch	T19-R13-31
58-112929.0000	1	AA	74.3	Middleton Ranch	T19-R13-31
58-112929.0000	0	AA	133.8	Middleton Ranch	T19-R13-31
58-112929.0000	0	AA	54.8	Middleton Ranch	T19-R13-31
58-113464.0000	1	E0	35.2	Browning	T20-R11-28
58-113464.0000	0	E0	6.5	Browning	T20-R11-28
58-113464.0000	1	E0	13.4	Browning	T20-R11-28

Certificate	Excluded*	Status**	Acres	Certificate Holder	Cadastral Location
58-114035.0001	1	AC	98.5	Carrow Co (Hooker)	T20-R11-28
58-114035.0001	0	AC	25.5	Carrow Co (Hooker)	T20-R11-28
58-114036.0001	0	AC	10.0	Tool	T20-R11-28
58-114036.0001	1	AC	10.1	Tool	T20-R11-28
58-160039.0000	1	AA	122.6	Middleton Ranch	T20-R13-5
58-160039.0000	0	AA	25.4	Middleton Ranch	T20-R13-5
58-160039.0000	0	AA	1.1	Middleton Ranch	T20-R13-5
58-160039.0000	0	AA	49.6	Middleton Ranch	T20-R13-5
58-160048.0000	0	AA	71.7	Pima County	T21-R11-5
58-160048.0000	1	AA	169.1	Pima County	T21-R11-5
58-160064.0005	0	E0	2.6	Holmes	T20-R11-32
58-160064.0005	1	E0	7.9	Holmes	T20-R11-32
58-160064.0005	0	E0	0.7	Holmes	T20-R11-32
58-160064.0005	0	E0	4.6	Holmes	T20-R11-32
58-160064.0005	0	E0	0.0	Holmes	T20-R11-32
58-160064.0005	1	E0	1.9	Holmes	T20-R11-32
58-160064.0005	0	E0	0.2	Holmes	T20-R11-32

Source: ADWR’s Arizona Grandfathered Groundwater Rights CD-ROM and scanned documents available through ADWR’s Online Imaged Records Database.

* Excluded Codes
0 = Irrigated portion of right
1 = Non-irrigated portion of right
8 = Withdrawn

** Status Codes
AA = Active; not yet conveyed and still capable of being used for original intended purpose.
AC = Full Conveyance; all acres conveyed to one new owner.
AD = Partial Conveyance; land split among multiple new owners.
AW = Partial Conveyance / Data and Fee Missing; split of right, data and fee missing.
E0 = Exempt; due to the Small Rights Amendment.
EF = Active Exempt to file; data and fee missing.
II = Withdrawn; voluntary.

Codes Source: ADWR's Arizona Grandfathered Groundwather Rights (GFRs) CD-ROM Database Guide