

Water Usage Near Shallow Groundwater in Pima County

PROJECT REPORT

March 2007

Prepared by Pima Association of Governments
for Pima County Regional Flood Control District

SUMMARY:

As part of Pima Association of Governments' (PAG) 2006-2007 Overall Work Program, PAG updated a portion of the *Water Usage Along Selected Streams in Pima County* report, which PAG created in 2000. The updated report and datasets show current potential water usage in these critical areas. Deliverables include the shapefiles, spreadsheets and maps that accompany this memorandum. The purpose of this report is to provide updated information about the location and pumping history of wells located in Pima County near shallow groundwater areas, generally located near drainages.

This memorandum documents our data sources, the methodology used to identify pumping wells and to remove duplicate records, and our methods for estimating pumping volumes. Our results are provided on several maps including Figure 1 (also provided as a plate), which shows the shallow groundwater areas in addition to all registered pumping wells in the region. Subsequent figures show more detailed views of the following sub areas; Rincon Valley, Arivaca and Sopori Wash areas, northeastern Tucson, San Pedro River, and southeast Tucson.

For this investigation, PAG relied on available data to make general conclusions about the number of wells near shallow groundwater areas, the density of wells and the pumping volumes. Over 2,200 wells were found to be located near shallow groundwater areas in eastern Pima County. The greatest number of non-exempt wells (those that are permitted to pump greater than 35 gpm), were located in the northeastern part of the Tucson basin. These areas also contained those non-exempt wells that pumped the largest volumes between 1999 and 2005.

Additional investigations are necessary before any site-specific conclusions can be made based on the presented information. The limitations of the analysis are described in the last section of this memorandum, but the most significant limitation is the lack of pumping volumes available for exempt wells or for any wells outside the Tucson Active Management Area. Understanding and controlling groundwater pumping near shallow groundwater areas is critical to efforts to sustain riparian areas that rely on those

groundwater resources. However, the threat to riparian areas cannot be fully understood until accurate estimates of withdrawal volumes are obtained.

BACKGROUND:

Pima County Regional Flood Control District (PCRFCDD) requested that Pima Association of Governments create a dataset to document wells near shallow groundwater in Pima County. The deliverables are listed by file name in the attached letter. This memo consists of a 2006 update of the report *Water Usage Along Selected Streams in Pima County, AZ*, which PAG created for Pima County in 2000 as part of the supporting documentation for the Sonoran Desert Conservation Plan (SDCP). This report updates the number of wells and the pumping volumes of wells located near the areas defined as shallow groundwater in the 2000 SDCP report. Withdrawals near shallow groundwater areas are important to watershed management in the arid Southwest due to rapid growth of development, the reliance of the rare riparian areas on the few shallow groundwater tables, and the interception of recharge by wells in these areas. It was not within the scope of this project to determine current water levels or to a change in water levels at these shallow groundwater areas. PAG could not compare water levels because, although this attribute is included in the ADWR databases, water level data is an inconsistently available field for well records and is documented in the ADWR databases only once, at well installation. The purpose of this project was to identify potential pumping wells located within one mile of shallow groundwater areas (those areas where the groundwater table is not more than 50-feet deep) and provide calculations of withdrawal volumes for those wells.

DATA SOURCES:

PAG merged data from Arizona Department of Water Resources' (ADWR) Wells-55 and Ground Water Site Inventory (GWSI) to create the dataset for this project. Table 1 lists the various data fields supplied by each data source. The GWSI database is ADWR's main repository for statewide well information. GWSI consists of field data that have

either been collected by personnel from the ADWR Hydrology Division's Basic Data Section or the U.S. Geological Survey. The information in GWSI is constantly being updated by ADWR through ongoing field investigations and through continued monitoring of a statewide network of water level monitoring sites. The information contained in the Wells-55 Web site has not been verified by the State of Arizona and ADWR is unable to guarantee the accuracy of this information.

METHODOLOGY:

PAG received the GWSI (updated July 2006) and Wells-55 (updated February 2006) databases from ADWR in July 2006. These GIS databases included information such as well location, exemption status, ownership, use, pumping volumes, well depth, installation date, pumping rate, well type, water provider and pump year. From ADWR's CDs, PAG joined together the GWSI shapefile, the Wells-55 shapefile, and the pumping database file. The metadata file created by PAG (metadata.doc) contains additional details on the processing of the GIS datasets that resulted in points and attributes included in the final shapefile (2006wells_shgw_1mi_all).

Identification of Pumping Wells:

To calculate pumping volumes, wells were identified as exempt or non-exempt based on various well descriptions reported to the ADWR database. The dataset was modified to create new columns for the data source and exemption status. Exempt wells are defined as wells with pump capacities less than or equal to 35 gallons per minute (gpm) or one acre-foot (AF) per year, using ADWR's standard assumption. The exempt category includes domestic stock exempt and non-domestic exempt wells. Non-exempt wells include the categories: service, non-service, replacement, and withdrawal permit (drainage and mining). Non-pumping well types were excluded from the database. Wells outside an Active Management Area (AMA) are not required to report pumping rates, but in some cases they were identified as pumpers based on other fields in the database. Numerous wells were not included in the study because the following attributes indicated that they were non-pumping wells.

- welltype = cathodic, recovery, soil vapor extraction, mineral exploration, geotechnical, injection, exploration, monitor, or piezometer
- siteuse = unused, anode, heat res, observation, recharge, test, water-quality monitoring, or well destroyed
- wateruse = unused or observation
- wateruse1 = remediation or monitoring
- wateruse2 = test, other - mineral explore, or monitoring
- cancelled = y
- welluse1 = abandoned, capped, destroyed, mineral exploration, geotechnical, cathodic, test, monitor, piezometer or observation
- welluse2 = abandoned, capped, destroyed, monitor, observation, recharge, or recovery

To filter out the above well types, we used the ArcMap tool “search by attribute” to select and remove wells fitting the description from the dataset. Wells with well types of “other” or having no description were removed by hand if no other database fields indicated pumping. “Replacement” wells were treated as new wells. This filter was applied to all wells in Arizona so that pumping wells could be shown on the map regardless of proximity to shallow groundwater. Only active pumping wells are used for this project; thus the removal of capped and cancelled wells, given a lack of a capped date (more discussion in the Limitation Section of this report).

Removal of Duplicate Records:

Although registration numbers for each well are unique, there were instances of up to nine duplications of a well record in the merged database. Cleanup involved extensive hand removal of duplicate records for wells in the study area. Each removed well record was documented for future reference. Duplication of well records was found by comparing registration numbers in the records. Multiple records for the same well registration number were compared to capture any unique information given in each field, such as whether the well was cancelled, replaced, or had pumping volumes, before duplicates were removed or merged. Wells sharing locations were not considered duplicates because several wells could be plotted at the same point on the map given the

data's precision level. Each step of the process was checked more than once for quality assurance.

Identification of Shallow Groundwater Areas:

For this report, we used the 22 shallow groundwater areas previously identified by PAG in 2000 for the SDCP. These areas are shown in Table 2 and Figures 1-6. In addition, the Rincon Valley is identified in this report as an area of special interest. This area overlaps and expands some of the nearby shallow groundwater areas. The Lower Santa Cruz River was not included in the focus area for this report as it was in the 2000 Report. Shallow groundwater areas were defined as places where the water table was less than 50 feet below the ground surface. Areas within one mile of shallow groundwater areas were included in the study. In order to work with the dataset, the shallow groundwater polygons in the original shapefile were divided into separate shapefiles for each shallow groundwater area.

Estimation of Pumping Volumes:

Wells were selected by location and exported to Excel spreadsheets for each shallow groundwater area. The number of wells within one mile and the subtotals of withdrawal were made for each area separately and cumulatively and are shown in Table 2. Calculations were made for exempt wells with assumed rates and non-exempt wells with reported rates from 1994-1998 and again from 1999-2005. The 1994-1998 and 1999-2005 well pumping totals were averaged by the number of years and number of wells. Different software and methodology was used in the 2000 Water Users Report, so the results cannot be directly compared. Maps (Figures 1-6) show all pumping wells with shallow pumpers distinguished by a yellow point in contrast to non-shallow wells in pink. In the shallow groundwater areas, non-exempt wells are distinguished from exempt wells by a cross mark through their point. Tabular analysis includes only the wells within a one-mile buffer of shallow groundwater.

FINDINGS:

The results were evaluated to determine the distribution of wells near shallow groundwater in terms of number of wells, their withdrawal volumes, their locations within Tucson AMA (TAMA), their exemption status and the changes in withdrawal from 1994 to 2005. Figure 1 displays pumping wells in a map of the Tucson region in addition to major drainages, shallow groundwater areas, the TAMA boundary, and the Pima County boundary. Table 2 shows the estimates for water withdrawals near each of the shallow groundwater areas.

Number of Wells:

As of 2006, there were 2,215 wells near shallow groundwater in Pima County. We were unable to report a change in the number of wells from 1994 to 2005 or make a comparison to the 2000 Report due to data limitations (refer to Limitations Section). Some shallow groundwater areas had very few wells whereas others had hundreds. A minimum of four wells were found in every shallow groundwater area. Figures 2 through 6 display detailed well maps for the various regions of the Pima County TAMA area.

Exemption Status:

A total of 418 wells were found to be non-exempt whereas the majority, 1,797 wells, was found to be exempt. While there are more exempt wells than non-exempt wells, more water is pumped by the non-exempt wells on average. However, pumping rates for non-exempt wells were not available for those wells outside the AMA. Non-exempt wells pumped, on average, 26.53 acre-feet (AF) per well between 1994 and 1998, but only 19.98 AF per well between 1999 and 2005. In contrast, ADWR assumes 1 AF (35gpm) withdrawal rates for exempt wells. ADWR used this same assumption rate at the time of PAG's 2000 Report as well. Note that because there are so many more exempt wells than non-exempt wells, the total pumpage may actually be greater for exempt wells even though withdrawal is less at each well.

Location:

The number of wells in each of the shallow groundwater areas varied widely, though the number of wells is densest in northeastern Tucson where the highest volumes are withdrawn. The majority of the areas (16 of 23) contained less than 30 non-exempt wells. The largest numbers of non-exempt wells (areas with between 72 and 110 non-exempt wells) were located in the shallow groundwater areas of Tanque Verde Creek Area 1, Tanque Verde Creek 2, Sabino Canyon and Agua Caliente Canyon. In addition, compared to other shallow groundwater areas, Tanque Verde Creek 2 and Agua Caliente Canyon have the largest number of exempt wells, with 310 and 363 wells, respectively.

Since 1994, three shallow groundwater areas remained consistently lower in pumping volumes (under four AF average per year) than the other Pima County areas for both exempt and non-exempt wells. These are Cocio Wash, Posta Quemada Canyon, and Sutherland Wash 2. Of these, only Sutherland Wash 2 has any reported pumpage from non-exempt wells.

Nine of the 23 shallow groundwater areas lay at least partially outside the TAMA where annual withdrawals are not reported. Of those areas outside the TAMA, only two areas, the San Pedro River and Davidson Canyon, have a large number of wells (103 and 133 respectively). The rest of the shallow groundwater areas outside the TAMA have fewer than 50 wells each.

Reported Pumping Volumes from Non-Exempt Wells:

Since 1994, the reported pumping volume in shallow groundwater areas has decreased. A comparison of the 1994-1998 to 1999-2005 totals reveals that the average withdrawal from non-exempt wells decreased 6.55 AF. There were four shallow groundwater areas that decreased about 10 AF or greater in reported annual average use between the two time periods and three areas that increased in use. However, this may not reflect actual pumping volume since unreported well withdrawals far outnumber the reported withdrawals.

From the results of numbers of wells and withdrawals, it appears that the northeastern part of the Tucson Basin is associated with the largest amounts of shallow groundwater pumping. The largest average non-exempt withdrawals from 1994-1998 were 56 AF in the Agua Caliente Canyon followed closely by Tanque Verde Creek Area 1 with 55 AF. These areas also contained the largest pumpers of non-exempt wells from 1999-2005, with 39 AF and 38 AF, respectively.

LIMITATIONS:

Data and methodology limitations were encountered when conducting this investigation. The types of limits include inconsistent data availability for wells, poor cross-listing of wells between ADWR databases, changes in PAG report data processing, and difficulty assigning wells to shallow groundwater areas. Each limitation is explained below.

Data Inconsistency and Cross-Listing Comparisons:

Not all well records contained complete attribute fields due to variations in source information. This was the case for every field of data including registration number, location, exempt status, pumping volumes, cancellation date, installation date, well depth etc. If the registration number was not available, other data were cross referenced to determine if duplicate well records were listed. The few wells with no location information were excluded from this report. Non-located wells account for only about 0.05% of the entire ADWR database, which probably had minimal impact on the results of this study.

Pumping information was not available for all the wells. ADWR relies on non-exempt well owners to submit their annual withdrawal amounts for the Wells-55 database by March 31 each year. Therefore, when a well record lists zero as an annual pumping volume, we assume that is not an absence of reported pumpage. Many wells in the GWSI database could not be cross-listed in the Wells-55 database, and since the Wells-55 database provided pumping volumes and status of wells as either exempt or non-exempt, some assumptions had to be made. Since non-exempt wells are required to report

withdrawal rates to the state, wells listed only in the GWSI database were assumed to be exempt. For non-exempt wells within an AMA with no pumping information, the pumping volume was assumed to be zero. For this report, non-exempt volume estimates were not included for wells outside of the TAMA since those areas did not report pumping volumes to ADWR.

2000 and 2006 Report Comparisons:

The maps and calculations included in this report only include wells that do not show a cancellation date. If a well was cancelled some time between 1994 and 2005, but it pumped water for a period within those dates, those withdrawals could not be included in our calculations. The date of well installation was not consistently available either, but exempt well withdrawal averages were made assuming consistent use over the time period regardless of when the well was installed. Due to the lack of availability of cancellation and installation dates, the total number of wells during one time series could not be compared to the later time series in this study. To do this comparison, a full analysis of an older version of the database would have been required.

In addition, PAG could not use the 2000 water users report for comparison of well numbers or pumping volumes because of differences in GIS software and methods of data processing used, such as removal of duplicate wells. The 2000 Report was created as a water usage report which incorporated information from utility databases not used in this study and, therefore, reflected different withdrawal calculations. The calculations may also differ from 2006 results because it is unknown if capped or duplicate wells were considered in the 2000 report. The 2000 report does not include a total number of wells to compare to and we cannot sum the shallow groundwater area totals of wells to make a comparison to 2006 results because of the overlap of wells within one mile of more than one shallow groundwater area that may have been included in the 2000 tables. In addition, the databases of wells from the 2000 Report were not documented with metadata when processed so it is difficult to reanalyze the old datasets without re-processing all the old databases.

Well Assignment to Shallow Groundwater Areas:

In order for PAG to assign each well to only one shallow groundwater area, PAG would have to determine which wells impacted which shallow groundwater areas. To assess this impact, additional hydrological information would be needed such as surface slope, well depth and other influences that were not in the scope of this project. Thus, the one-mile buffer was used as an area of reasonable concern of withdrawal impact. This method is consistent with past reports. Some wells impact and lay within one mile of more than one shallow groundwater area. Thus in Table 2, a well's pumpage may have contributed to the withdrawal total of more than one shallow groundwater area. For the total number of wells and total withdrawals in Table 2, each well contributed only one pumping volume.

DISCLAIMERS:

The following disclaimers are provided by ADWR.

GWSI Data:

Every new well is required by law to be registered with the state. This information may be incomplete because well registration, while required, is voluntary. The well owner or the well driller reports all of the well information to ADWR. The well locations in this database will not match the actual well locations on the ground. The positional accuracy is limited because the well locations are reported to ADWR by township, range, section and section subdivision down to the nearest ten acres (quarter-quarter-quarter section). In order to map these locations every section in the state has been subdivided into 64 10-acre cells, 16 40-acre cells and four 160-acre cells with a label point assigned to the center of each cell. These center points are then used to represent the approximate locations of the wells. There can be more than one well on a location point because all wells within the same 10-acre cell are assigned to the same label point. Some wells do not have corresponding location points. Non-located wells

account for only about 0.05% of the entire Well Registry database. Annual reported well pumping amounts are reported only for wells within groundwater basins that have been designated as AMAs or Irrigation Non-expansion Areas (INA) with a pump capacity greater than 35 gallons per minute. Annual reports are required to be submitted by the well owners by March 31 of the following year.

Wells-55 Data:

The information contained in the Wells-55 Web site has not been verified by the State of Arizona, and the ADWR is unable to guarantee the accuracy of this information. ADWR will not assume any liability for damages resulting from use or misuse of this information. ADWR does not provide software training, support or application development with this information.

FUTURE PROJECT POTENTIAL:

Arizona Wells, a SAHRA project, will soon complete the merging of the Wells-55 and GWSI databases with Web downloads available to the public, which will save a significant part of the process for Water User reports. Additionally, if legislation requires that well owners report withdrawal rates regardless of whether their wells are exempt or non-exempt or if they are located outside an AMA, the results of future studies will better represent true water use.

Elements excluded from this report which were analyzed or requested in the past included GWSI hydrographs, water use systems near shallow groundwater or streams, and wells near streams.

TABLE 1: DATABASE ATTRIBUTES

Fields in the 2006 database of wells near shallow groundwater in Pima County.

<u>Field Names</u>	<u>Definition</u>	<u>Source</u>
DEPTH_TO_W	Depth to Water in Well	ADWR GWSI
HOLE_DEPTH	Hole Depth	ADWR GWSI
LATITUDE	Well Latitude	ADWR GWSI
LONGITUDE	Well Longitude	ADWR GWSI
SITEUSE	Site Use	ADWR GWSI
WATERUSE	Water Use	ADWR GWSI
WELL_ALTIT	Well Altitude	ADWR GWSI
WL_ELEVATI	Water Level Elevation	ADWR GWSI
WL_MEAS_DA	Date of Well Measurement	ADWR GWSI
WELL_DEPTH, WELLDEPTH	Well Depth	ADWR GWSI and Wells-55
REGISTRATI, REGISTRY_1	Registry #	ADWR GWSI and Wells-55
UTM_EASTNA, UTM_NORTHN, UTMY, UTMX	Well UTM	ADWR GWSI and Wells-55
LASTNAME, FIRSTNAME, OWNER	Well Owner Name	ADWR GWSI and Wells-55
ADDRESS	Owner Address	ADWR Wells-55
APPROVED	Approval Date	ADWR Wells-55
BASIN	Basin	ADWR Wells-55
CANCELLED	Cancellation Status of Well	ADWR Wells-55
CASINGDEEP	Casing Depth	ADWR Wells-55
CASINGTYPE	Casing Type	ADWR Wells-55
CASINGWIDE	Casing Width	ADWR Wells-55
CITY	City of Owner	ADWR Wells-55
COMPANY	Company Owner Name	ADWR Wells-55
COUNTY	County	ADWR Wells-55
DRAWDOWN	Draw-Down in Well	ADWR Wells-55
DRILLER	Driller	ADWR Wells-55
DRILLOG	Drill Log	ADWR Wells-55
INSTALLED	Installed Date	ADWR Wells-55
PROGRAM	Program	ADWR Wells-55
Pump 1985	Withdrawal Amount (AF) 1985	ADWR Wells-55
Pump 1986	Withdrawal Amount (AF) 1986	ADWR Wells-55
Pump 1987	Withdrawal Amount (AF) 1987	ADWR Wells-55
Pump 1988	Withdrawal Amount (AF) 1988	ADWR Wells-55
Pump 1989	Withdrawal Amount (AF) 1989	ADWR Wells-55
Pump 1990	Withdrawal Amount (AF) 1990	ADWR Wells-55
Pump 1991	Withdrawal Amount (AF) 1991	ADWR Wells-55
Pump 1992	Withdrawal Amount (AF) 1992	ADWR Wells-55

Pump 1993	Withdrawal Amount (AF) 1993	ADWR Wells-55
Pump 1994	Withdrawal Amount (AF) 1994	ADWR Wells-55
Pump 1995	Withdrawal Amount (AF) 1995	ADWR Wells-55
Pump 1996	Withdrawal Amount (AF) 1996	ADWR Wells-55
Pump 1997	Withdrawal Amount (AF) 1997	ADWR Wells-55
Pump 1998	Withdrawal Amount (AF) 1998	ADWR Wells-55
Pump 1999	Withdrawal Amount (AF) 1999	ADWR Wells-55
Pump 2000	Withdrawal Amount (AF) 2000	ADWR Wells-55
Pump 2001	Withdrawal Amount (AF) 2001	ADWR Wells-55
Pump 2002	Withdrawal Amount (AF) 2002	ADWR Wells-55
Pump 2003	Withdrawal Amount (AF) 2003	ADWR Wells-55
Pump 2004	Withdrawal Amount (AF) 2004	ADWR Wells-55
Pump 2005	Withdrawal Amount (AF) 2005	ADWR Wells-55
PUMPOWER	Power of Pump	ADWR Wells-55
PUMPRATE	Pump Rate	ADWR Wells-55
PUMPTOTAL	Total Withdrawal Amount (AF) (1984-2005)	ADWR Wells-55
PUMPTYPE	Pump Type	ADWR Wells-55
STATE	State of Owner	ADWR Wells-55
SUBBASIN	Sub-basin	ADWR Wells-55
TESTRATE	Tested Rate of Pump	ADWR Wells-55
TOWNSHIP, NORTHSOUTH, RANGE, EASTWEST, SECTION, ACRE160, ACRE40, ACRE10	Well Cadastral Location (Public Land Survey System) with Quarter Sections	ADWR Wells-55
WATERLEVEL	Water Level	ADWR Wells-55
WATERSHED	Watershed	ADWR Wells-55
WATERUSE1 , WATERUSE2, WATERUSE3	Water Use	ADWR Wells-55
WELLTYPE	Well Type	ADWR Wells-55
WELLUSE1, WELLUSE2	Well Use	ADWR Wells-55
ZIPCODE	ZIP Code of Owner	ADWR Wells-55
EXEMPTSTAT	Exempt Status	PAG
SHALLOWGWR	Data Sources (Database)	PAG

Table 2: Water Usage Near Shallow Groundwater Areas

	Reach Name	# Non-exempt wells within one mile	1994-1998 Avg. reported annual withdrawals per non-exempt well (acre-feet)*	1999-2005 Avg. reported annual withdrawals per non-exempt wells (acre-feet)*	# Exempt wells within one mile ***	Estimated potential annual withdrawals from exempt wells (acre-feet) ****	AMA
1	Agua Caliente Canyon	72	55.87	38.74	310	310	Tucson
2	Agua Verde Creek	2	0	0	44	44	Tucson (partial)
3	Arivaca Area	30	4.18	4.15	225	225	Tucson
4	Box Canyon	8	15.05	31.57	52	52	Tucson
5	Cienega Creek (lower1)	4	NA**	NA**	21	21	outside
6	Cienega Creek (lower2)	4	2.15	17.57	77	77	Tucson (partial)
7	Cienega Creek (upper)	6	NA**	NA**	21	21	outside
8	Cocio Wash	4	0	0	1	1	Tucson
9	Davidson Canyon	0	0	0	133	133	Tucson (partial)
10	Davidson Canyon (upper)	0	NA**	NA**	18	18	outside
11	Gardner Canyon	5	NA**	NA**	41	41	outside
12	Pantano Wash	9	12.49	2.45	56	56	Tucson
13	Posta Quemada Canyon	0	0	0	4	4	Tucson
14	Rillito Creek Area	52	15.25	16.01	84	84	Tucson
15	Rincon Creek	14	12.78	26.59	103	103	Tucson
16	Sabino Canyon	100	29.83	28.19	219	219	Tucson
17	San Pedro River	33	NA**	NA**	70	70	outside
18	Sopori Wash	28	24.86	24.06	65	65	Santa Cruz
19	Sutherland Wash 1	3	1.31	1.22	26	26	Tucson
20	Sutherland Wash 2	2	2.21	2.28	3	3	Tucson
21	Tanque Verde Creek Area 1	74	54.51	38.49	363	363	Tucson
22	Tanque Verde Creek2	110	34.89	21.99	208	208	Tucson
23	Rincon Valley	27	22.45	26.65	278	278	Tucson
	All Shallow Groundwater Areas*****	418	26.53	19.98	1,797	1,797	Tucson (partial)

TOTAL WELLS:*** 2,215**

Note: Numbers and types of exempt and non-exempt wells based on ADWR Wells-55 and GWSI databases.

* Pumping data for non-exempt wells are based on data reported to ADWR in Wells-55 database, 1994-2005. If a non-exempt well is within an AMA and no pumping data are reported, pumping is assumed to be zero. Calculations used only current wells, not capped, due to a lack of date of well cancellation.

** NA = Not available. Reported pumping data for wells are not necessarily available if reach is not within an AMA.

*** GWSI wells which are not cross-listed in Wells-55 database are assumed to be exempt because they have no reported exemption status or reported withdrawal amounts as required by the state for non-exempt wells.

**** ADWR assumes exempt wells pump 35 gallons per minute or one AF per year.

***** Some wells lay within one mile of more than one shallow groundwater area, so the sum off all the areas above may be more than the true total listed here. For the actual total, each well contributed only one pumping volume amount.

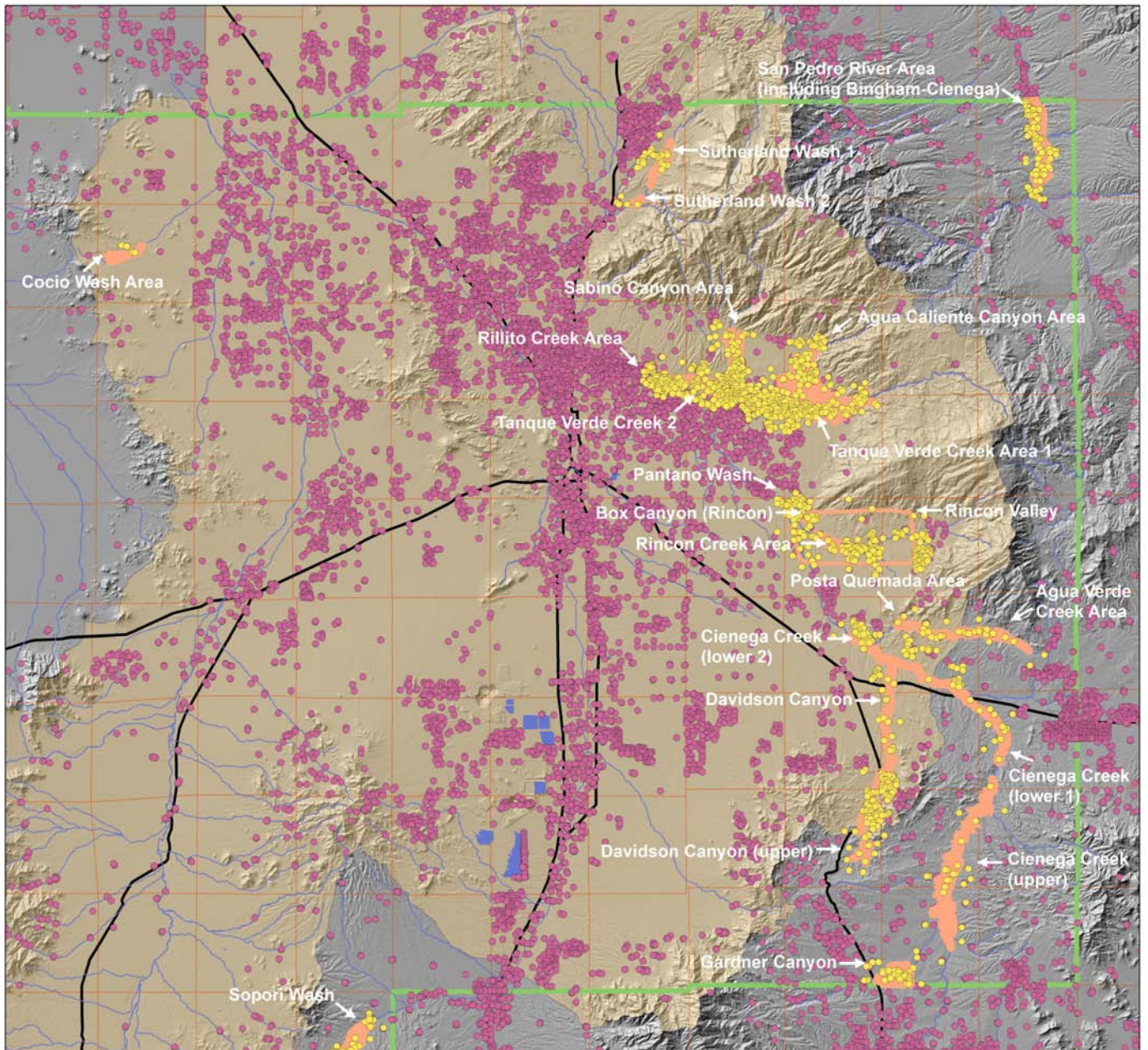
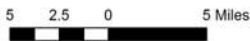


Figure 1
Wells Near Shallow Groundwater

Prepared by Pima Association of Governments
 Watershed Planning Department
 for Pima County Regional Flood Control District
 Displayed at 1:270,000

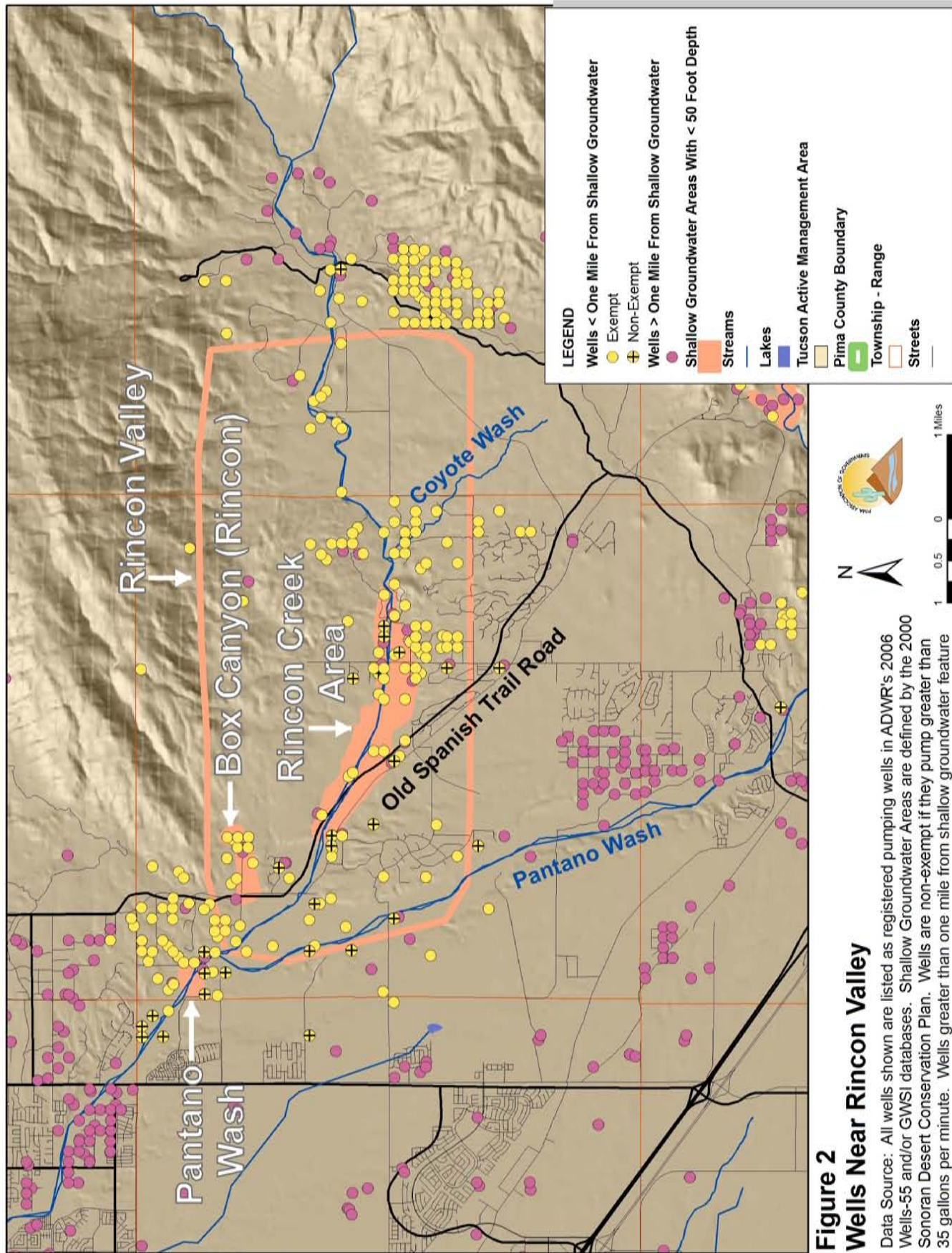


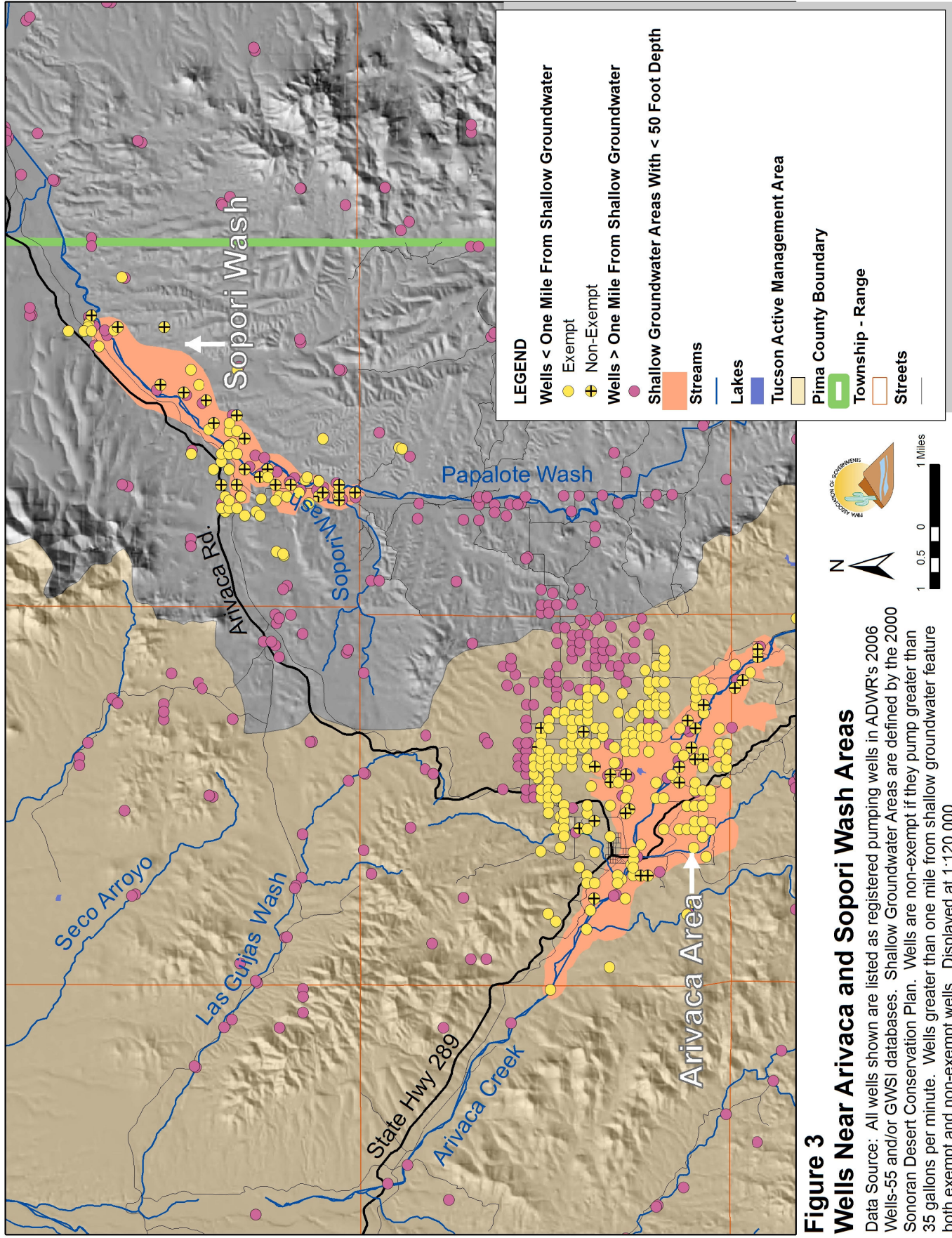
LEGEND*

- Wells < One Mile From Shallow Groundwater
- Wells > One Mile From Shallow Groundwater
- Shallow Groundwater Areas With < 50 Foot Depth
- Streams
- Lakes
- Tucson Active Management Area
- Pima County Boundary
- Township - Range
- Interstate

*Data Source: All wells shown are listed as registered pumping wells in ADWR's 2006 Wells-55 and/or GWSI databases. Shallow Groundwater Areas defined by 2000 Sonoran Desert Conservation Plan.

Figure 1 is also included in larger format.





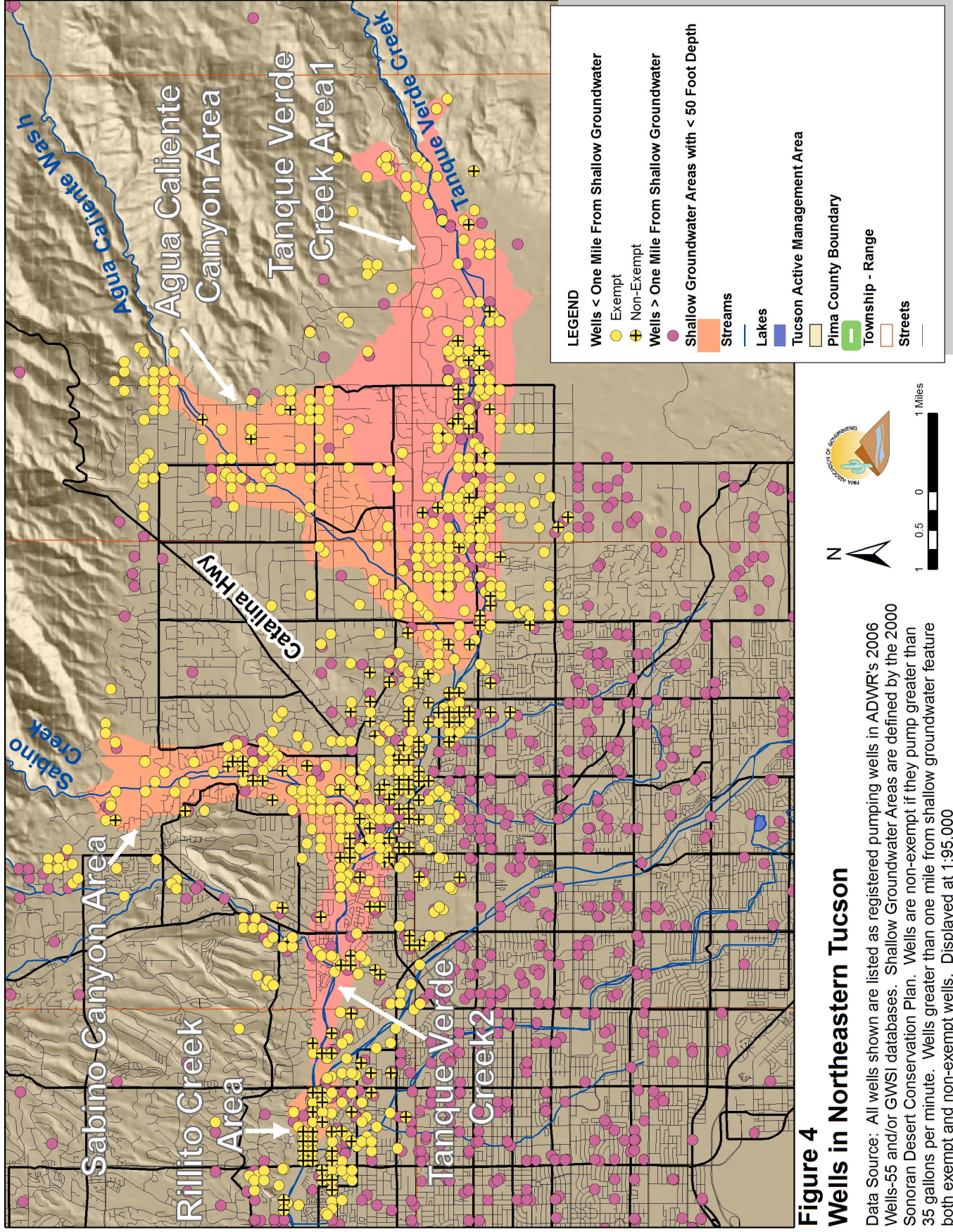


Figure 4

Wells in Northeastern Tucson

Data Source: All wells shown are listed as registered pumping wells in ADWR's 2006 Wells-55 and/or GWSI databases. Shallow Groundwater Areas are defined by the 2000 Sonoran Desert Conservation Plan. Wells are non-exempt if they pump greater than 35 gallons per minute. Wells greater than one mile from shallow groundwater feature both exempt and non-exempt wells. Displayed at 1:95,000

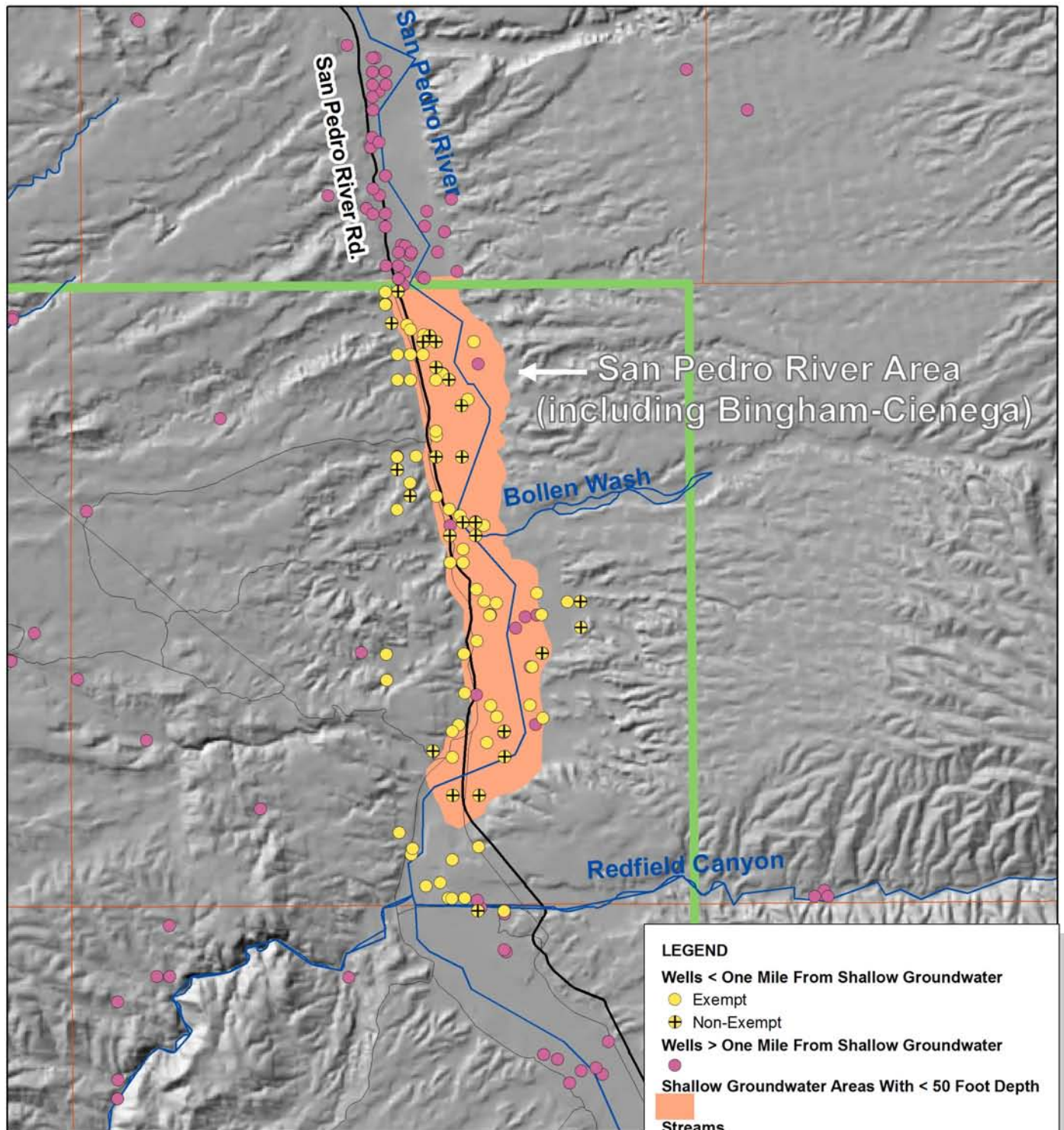
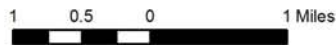


Figure 5
Wells Near San Pedro River



Data Source: All wells shown are listed as registered pumping wells in ADWR's 2006 Wells-55 and/or GWSI databases. Shallow Groundwater Areas are defined by the 2000 Sonoran Desert Conservation Plan. Wells are non-exempt if they pump greater than 35 gallons per minute. Wells greater than one mile from shallow groundwater feature both exempt and non-exempt wells. Displayed at 1:80,000

LEGEND

- Wells < One Mile From Shallow Groundwater
 - Exempt
 - ⊕ Non-Exempt
- Wells > One Mile From Shallow Groundwater
 -
- Shallow Groundwater Areas With < 50 Foot Depth
 -
- Streams
 -
- Lakes
 -
- Tucson Active Management Area
 -
- Pima County Boundary
 -
- Township - Range
 -
- Streets
 -

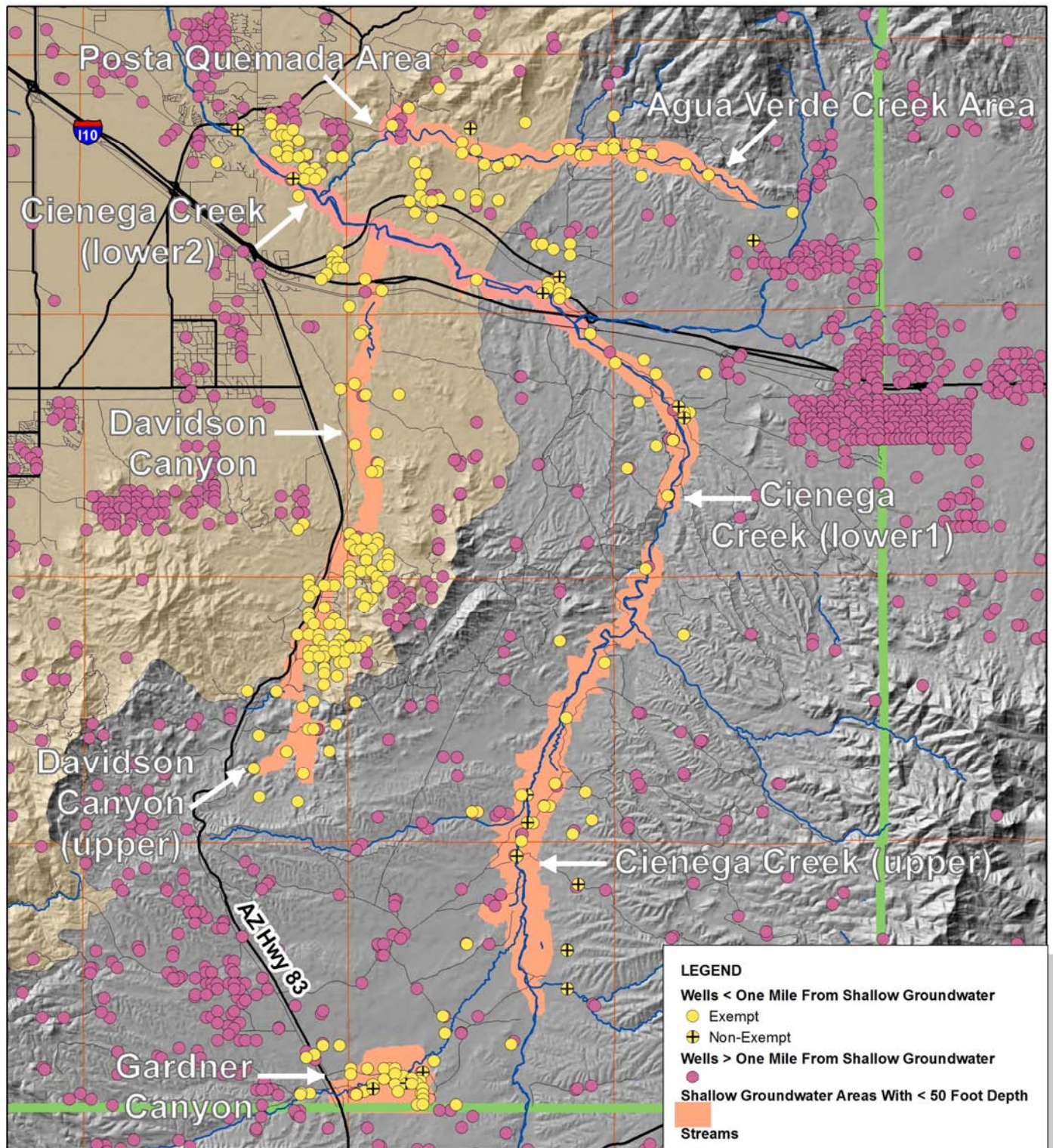


Figure 6
Wells Southeast of Tucson

2 1 0 2 Miles



Data Source: All wells shown are listed as registered pumping wells in ADWR's 2006 Wells-55 and/or GWSI databases. Shallow Groundwater Areas are defined by the 2000 Sonoran Desert Conservation Plan. Wells are non-exempt if they pump greater than 35 gallons per minute. Wells greater than one mile from shallow groundwater feature both exempt and non-exempt wells. Displayed at 1:180,000.