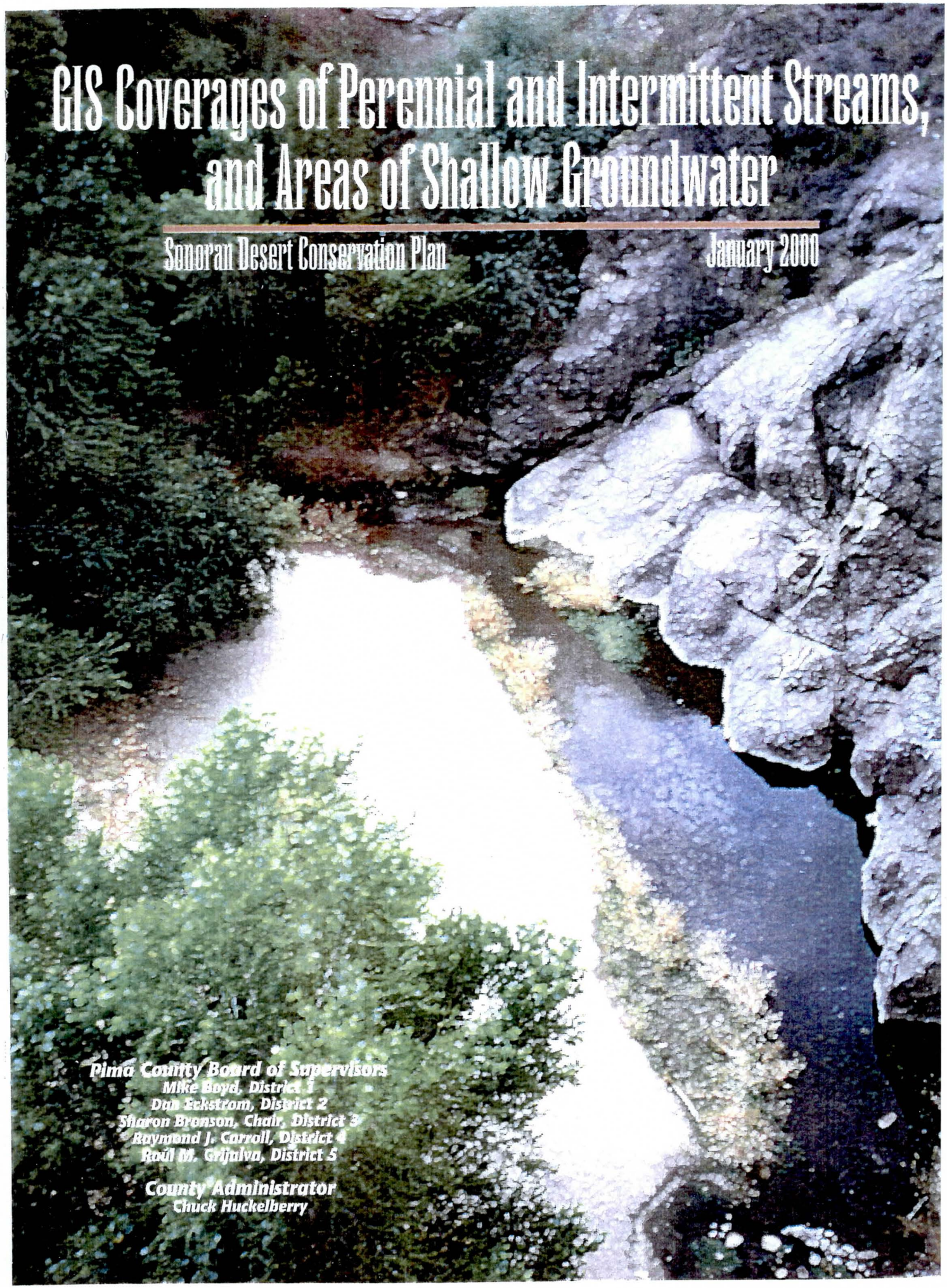
GIS Coverages of Perennial and Intermittent Streams, and Areas of Shallow Groundwater

Sonoran Desert Conservation Plan

January 2000



MEMORANDUM

Date: January 26, 2000

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

From: C.H. Huckelberry
County Administrator

Re: *Coverages of Perennial Streams, Intermittent Streams and Areas of Shallow Groundwater*

I. Report

The attached final project report entitled *GIS Coverages of Perennial Streams, Intermittent Streams, and Areas of Shallow Groundwater* was prepared by the Pima Association of Governments as part of the Sonoran Desert Conservation Plan. This report is the fifteenth in the Conservation Plan technical series and was undertaken to fill a data gap that otherwise might have limited the quality of the broad biological evaluation the County began last week.

With the attached document and the Geographic Information System file that is now a part of the County library of over 1000 coverages, the scientific community has access to mapping that better differentiates perennial, ephemeral and intermittent watercourses, and provides more comprehensive coverage of shallow groundwater sources.

This data is significant to the Sonoran Desert Conservation Plan because riparian habitat is one of the most important and least protected of the habitat types in Pima County. Previous technical reports have emphasized the need for Riparian Restoration initiatives that have a long term goal of effecting some level of recovery of natural functions within riverine systems.

II. Perennial and Intermittent Streams

The attached report defines streams to include springs, ponds, pools, wetlands, rivers, and washes. United States Geological Survey distinctions apply so that:

- a perennial stream is one that has continuous flow;
- an intermittent stream is one that has flow at certain times of the year; and
- an ephemeral stream has a channel above the water table, and flows only in direct response to precipitation.

As a result of the attached study, fifty-five perennial stream reaches and eighty-two intermittent stream reaches were identified across 74 different streams.

III. Shallow Groundwater

Shallow groundwater is defined for purposes of the report as groundwater within 50 feet of the land surface. At this depth, groundwater can sustain mesquite bosques. Depth-to-groundwater ranges for other Sonoran riparian tree species are also described in the report. Nearly one hundred potential shallow groundwater sites are listed within the report, and many of the larger zones are mapped.

IV. Conclusion:

The purpose of the attached study is to identify and map intermittent streams, perennial streams and shallow groundwater so that these data layers are available to carry out the regional biological evaluation in a timely and comprehensive manner.

The Pima Association of Government staff, working with a Technical Advisory Committee and the public, exceeded expectations in delivering the extensive GIS product described in detail within the report. In addition to filling a significant data gap, the text of the report provides an index of relevant literature; it identifies tree species and other environmental features associated with each stream reach; it provides justifications for the delineations of water sources; and the report makes recommendations for future research priorities.

These work products have been forwarded to the consultants who are undertaking the biological evaluation for the Sonoran Desert Conservation Plan. County staff will continue to work with the Pima Association of Governments to maintain and improve the database of water resources described within the attached study.

Attachment

SONORAN DESERT CONSERVATION PLAN

GIS Coverage Of Perennial Streams

Intermittent Streams

and

Areas of Shallow Groundwater

FINAL PROJECT REPORT

January 2000

Prepared by Pima Association of Governments for Pima County

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December 1999

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Acknowledgments

PAG would like to thank the following people who made this project possible: Julia Fonseca at Pima County Flood Control District for including the project in PAG's work program for the District and for providing guidance on various aspects of the project; Charles Huckleberry and Maeveen Behan at the Pima County Administrator's Office for including this project in PAG's work program; and Pima County Flood Control District and Pima County Wastewater Management Department for providing funding for this project.

In addition, the following people generously served on this project's Technical Advisory Committee: Julia Fonseca at Pima County Flood Control District; Doug Duncan at the U.S. Fish and Wildlife Service; Dave Gori at the Nature Conservancy; Steven Hopp at the Ecology and Evolutionary Biology Department of the University of Arizona; Lin Lawson at Arizona Department of Environmental Quality; Tom Maddock at the Hydrology and Water Resources Department of the University of Arizona; Scott Richardson at Arizona Game and Fish Department; and Danielle Stearns at Dames and Moore (Environmental Planning Advisory Committee representative). They provided guidance and additional technical information for areas under question.

PAG would also like to thank the staff at Pima County Technical Services, especially John Regan and Steve Whitney, for providing tremendous technical support and much-needed server space.

Finally, PAG would like to extend a special thanks to all the people who provided information for this project. We relied heavily on the support and input from numerous people and agencies. PAG is especially thankful to Bob Lefevre at the U.S. Forest Service and Karen Simms at the Bureau of Land Management for providing an extraordinary amount of information. PAG would also like to thank Neva Connolly at the Flood Control District for offering technical assistance and data entry services at various times throughout the project.

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SONORAN DESERT CONSERVATION PLAN

GIS COVERAGE OF PERENNIAL AND INTERMITTENT STREAMS, AND SHALLOW GROUNDWATER

FINAL PROJECT REPORT – January 2000

Prepared by Pima Association of Governments for Pima County

INTRODUCTION

Background and Problem Statement

Pima County, in its work on the Sonoran Desert Conservation Plan (SDCP), determined that preserving and restoring riparian and aquatic habitats would be very important to the goals of the SDCP. These habitats can be found in and along perennial streams, intermittent streams, and areas of shallow groundwater. Riparian vegetation could be restored to many of these areas if the vegetation is not presently found there.

In its effort to identify aquatic and riparian habitats, Pima County reviewed existing GIS coverages and found the following limitations:

- The present wash coverage from Pima County's Land Information System (PCLIS) did not differentiate between types of watercourses (i.e., perennial, ephemeral, or intermittent)
- The perennial streams GIS coverage from the Arizona Game and Fish Department and the general streams coverage from the State Land Department (Arizona Land Resource Information System - ALRIS) contained errors, and were incomplete
- No comprehensive coverages showing intermittent streams or areas of shallow groundwater were available from any local, state, or federal agency.

Purpose and Scope

The purpose of this project was to create, in ArcView shapefile format, three GIS coverages:

- Perennial Streams;
- Intermittent Streams;
- Areas of Shallow Groundwater.

The study area encompassed all of Pima County, excluding the Tohono O'Odham Reservation, with emphasis on eastern Pima County. Pima County's Land Information System served as the base map for this project.

The project relied on data that were already available, including reports, maps, aerial photography, and previous studies, as well as input from a technical advisory committee and the general public. The opportunity for field verification of sites by project staff was very limited.

Project Oversight and Funding

Pima County funded this project through its annual contribution to the Pima Association of Governments (PAG) Water Quality Planning work program. The project was completed by PAG, with oversight by Pima County Flood Control District, the Pima County Administrator's Office, and a Technical Advisory Committee.

Limitations

GIS coverages created for this project are based almost entirely on existing data that PAG was able to obtain within the time and budget constraints of this project. With only a few limited exceptions, the data in the coverages have not been field-verified by PAG.

PAG did not find any relevant data for the vast majority of the watercourses in Pima County, and it is very likely that some of those watercourses (particularly those in high mountain areas with an annual snowpack) include reaches that are perennial or intermittent. In addition, streams are very dynamic, and the precise locations of the downstream and upstream limits of intermittent or perennial reaches are very difficult to identify without many years of detailed monitoring data. Such data were available for very few streams in Pima County.

Finally, recent and reliable groundwater level data are fairly sparse on a county-wide scale. Any delineation of shallow groundwater is thus approximate at best. It is also possible that additional areas of shallow groundwater exist in the county in places where wells have not been drilled. In addition, groundwater levels fluctuate over time. In many parts of the county, groundwater levels have declined significantly in recent decades. It is therefore possible that some shallow groundwater areas shown in the coverages are no longer shallow.

Despite these limitations, PAG believes that the coverages are as complete as feasible. The literature search was extensive, and most of the pertinent information available was probably obtained. In addition, substantial efforts were undertaken to solicit input from both the general public and local experts. The input that has been received suggests that it is unlikely that PAG has overlooked any major surface water sources in Pima County. However, as explained later in this report, a number of areas which were likely to contain shallow groundwater were not included in the coverages.

Definitions

Definitions of perennial, intermittent and ephemeral streams were obtained from United States Geological Survey Water-Supply Paper #1541-A (Langbein and Iseri, 1960):

- Perennial: one which flows continuously;
- Intermittent: one which flows only at certain times of the year when it receives water from springs or from some surface source such as melting snow in mountainous areas;
- Ephemeral: one that flows only in direct response to precipitation, and whose channel is at all times above the water table.

For purposes of this project, the term "stream" included any washes, rivers, canyons, wetlands, pools, ponds, and springs., including effluent-dependent waters. Man-made lakes, ponds, canals, ditches and impoundments were not included.

"Shallow" groundwater was defined as groundwater within 50 feet of the land surface. This depth was based on research identifying the water needs of various types of riparian vegetation (ADWR, 1994). There was no attempt to distinguish between localized perched aquifers and regional aquifers.

PROJECT APPROACH AND METHODOLOGY

The general approach to this project was to conduct an extensive literature and data search, convene a technical advisory committee to review the list of information compiled, transfer the data that was obtained to an ArcView GIS shape file, and submit the draft results for review by the Technical Advisory Committee and the general public. The general public was also given an opportunity to participate and provide information via an internet questionnaire.

Perennial and intermittent streams were addressed first, because they were determined to be a higher priority by Pima County. The shallow groundwater coverage was begun after the streams coverages were completed.

The project approach was based on tasks that were defined in the project proposal (Appendix A). The methods, assumptions, and other information relevant to particular tasks in the proposal are discussed below.

Data Sources

A complete list of data sources is in Appendix B. From these data sources, a preliminary list of possible locations of surface water or shallow groundwater was prepared. The types of data sources included:

- Existing literature (agency reports, theses/dissertations, local publications)
- Existing maps
- Electronic databases and GIS coverages
- Aerial imagery
- Field notes

Technical Advisory Committee

The Technical Advisory Committee (TAC) consisted of local experts in hydrology, biology, and ecology from the University of Arizona, Arizona Department of Environmental Quality (ADEQ), Arizona Fish and Game, US Fish and Wildlife Service, The Nature Conservancy, and private consultants.

The role of the TAC was to:

- Review data source lists and provide additional data;
- Help determine site criteria and review methodology;
- Provide support on reach/site identification;
- Review draft and final deliverables (GIS coverages and associated maps and reports); and

- Answer questions that arose during the project, which included:

    - Which definitions should be used;
    - How to define the length of a reach, considering seasonal and annual variations in flow;
    - How to resolve conflicting information;
    - What criteria should be used to determine "shallow" groundwater;
    - What information should be included in the coverage and associated database;
    - What criteria and documentation would be necessary to classify a stream as perennial;
    - How to classify, and whether to include, high-elevation watercourses and bedrock pools.

The following people served on the TAC:

Doug Duncan, US Fish and Wildlife Service
Julia Fonseca, Pima County Flood Control District
Dave Gori, The Nature Conservancy
Steven Hopp, University of Arizona Dept. of Ecology and Evolutionary Biology
Lin Lawson, Arizona Department of Environmental Quality
Tom Maddock, University of Arizona Dept. of Hydrology and Water Resources
Scott Richardson, AZ Game and Fish
Danielle Stearns, Dames and Moore

Public Meetings

This project was presented to PAG's Water Quality Subcommittee on November 18, 1999. This committee serves several purposes, including advising PAG on water-related matters, and facilitating the exchange of information among the local jurisdictions and between government and the general public. The project was also presented to PAG's Management Committee and Regional Council in November. These meetings are open to the public as well. PAG staff also presented a poster session at the December 11, 1999, meeting of the Sonoran Desert Conservation Plan Steering Committee, which was well attended by members of the public interested in the plan.

Web Page

PAG and Pima County jointly developed a web page and an associated web form to provide the general public with an opportunity to inform project staff about any stream locations that might otherwise be missed through the literature review. The web form could be reached from the following sites:

WWW.CO.PIMA.AZ.US/CMO/SDCP

and

WWW.PAGNET.ORG

A hardcopy of the questionnaire posted on the web is included as Appendix C.

Criteria for Including a Location

For a stream reach to be included in the coverage, PAG required reliable documentation that the location met the definition of perennial or intermittent. Reliable documentation included: reports, databases, studies, and maps from reputable sources; aerial photographs; first-hand knowledge of members of the Technical Advisory Committee; field notes; and personal, direct observations. The Technical Advisory Committee recommended that a "minimum map unit" (i.e., a minimum length of flow necessary to be included in the coverage) not be established. Instead, all areas meeting the criteria were included in the coverage, regardless of their sizes. A separate springs coverage already existed for Pima County, and it was not necessary to duplicate the springs coverage for this project. However, if PAG obtained evidence of surface flow at a spring, the site was included in the appropriate coverage.

In many cases, documentation on a particular reach was fairly limited, particularly with respect to the upstream and downstream limits of flow, which can vary substantially from season to season and from year to year. In addition, some reaches had conflicting information as to whether they were perennial or intermittent. With the recommendation of the Technical Advisory Committee, PAG decided to be fairly "liberal" in delineating intermittent reaches, in order to err on the side of not missing a reach worthy of protection, but fairly "conservative" in designating a stream as perennial. The conservative approach to perennial streams was chosen in response to concerns that, if one stream was incorrectly identified as perennial, then the integrity of the entire perennial coverage could be questioned by future users. A "level of certainty" field (1 = low, 3 = high) was also included in the streams and shallow groundwater databases as an aid to users of the data. The criteria for certainty, defined in Table 1, were generally followed, although flexibility was necessary, given that the criteria were somewhat subjective, and that many sites did not clearly fall within one of the categories.

Table 1. Criteria for Assigning a Certainty Level to Database Records

Streams

Level 3 – H IGH CERTAINTY. At least one very reliable source with specific site information, including location, stream flow measurements and observations, and vegetation inventory. Stream reach easily categorized using available information.
Level 2 – MODERATE CERTAINTY. At least one source with site information, including location, stream flow observations, and vegetation inventory. Some information may be missing, questionable, or not specific. Stream reach categorized with minimal difficulty using available information.
Level 1 – LOW CERTAINTY. One source with questionable site information. Stream reach not easily categorized using available information.

Level 3 – H IGH CERTAINTY. Aerial imagery and well data were used to delineate the shallow groundwater area. Riparian vegetation was visible using aerial imagery. Well database(s) included data for many wells in the selected area. Where available, riparian assessment results were used to confirm the presence of riparian vegetation.

Level 2 – MODERATE CERTAINTY. Aerial imagery and well data were used to delineate the shallow groundwater area. Riparian vegetation may or may not have been visible using aerial imagery. Well database(s) included data for several wells in selected area. Where available, riparian assessment results were used to confirm the presence of riparian vegetation. In some areas, riparian assessment results were the only source of information for the area.

Level 1 – LOW CERTAINTY. Only aerial imagery was used to delineate the shallow groundwater area. Riparian vegetation was visible using aerial imagery. The well database(s) did not include data for any wells in the selected area. No riparian assessment results were available for the area.

In the case of shallow groundwater, PAG relied on existing data from groundwater level measurements in wells. The bulk of the groundwater level data were provided by the Arizona Department of Water Resources (ADWR) and Tucson Water. With the concurrence of the Technical Advisory Committee, a depth to groundwater of 50 feet (or less) below the land surface was considered to be shallow. This was based on a 1994 ADWR document, *Arizona Riparian Protection Program Legislative Report*, which stated that mesquite forms bosques in areas where depth to groundwater ranges from about 7 to 50 feet. This document included a table that listed depth-to-groundwater ranges for several Sonoran riparian tree species, including Fremont Cottonwood and Goodding Willow, and Velvet or Honey Mesquite bosques. This table, which was based on data provided by a number of researchers for several streams in Arizona, suggested that cottonwoods and willows required depths to groundwater which were significantly less than 50 feet. However, a depth of 50 feet was chosen as the criteria in order to ensure identification of areas that might be capable of supporting mesquite bosques.

Therefore, the locations of wells at which water levels of 50 feet or less had been measured were included in the shallow groundwater coverage. There was no attempt to distinguish between localized perched aquifers and regional aquifers.

Databases and GIS Coverages

Information obtained from the literature and other data sources was recorded in three electronic databases that were developed for this project: a perennial streams database, an intermittent streams database, and a shallow groundwater database. The databases were created

using Microsoft Access, and subsequently exported to a ".dbf" format and imported to ArcView GIS. For each of the locations, pertinent information (if available) about the sites, such as vegetation types, presence of fish or amphibians, and the location and nature of flows, was recorded in the appropriate database. Table 2 lists the fields in each database. Examples of the input forms used to create the database are included in Appendix D. The forms contained all the fields included in the attribute table of each GIS coverage.

Table 2. Database Fields.

Perennial Streams	Intermittent Streams	Shallow Groundwater
Record #	Record #	ID
Perennial Reach ID	Intermittent Reach ID	Area Name
Perennial Reach Name	Intermittent Reach Name	General Location
General Location	General Location	Cadastral Location
Cadastral Location (T-R-S)	Cadastral Location (T-R-S)	Watershed Name and Number
Watershed Name and Number	Watershed Name and Number	USGS Quadrangle
USGS Quadrangle	USGS Quadrangle	Tree Species
Discharge	ADEQ Designated Use	Trees – Seedlings
ADEQ Designated Use	Tree Species	Trees – Mature
Tree Species	Trees – Seedlings	Trees – Old/Decrepit
Trees – Seedlings	Trees – Mature	Estimated depth to water
Trees – Mature	Trees – Old/Decrepit	Well depth to water
Trees – Old/Decrepit	Environmental Features	Environmental Features
Environmental Features	References	References
References	Level of Certainty	Level of Certainty
Level of Certainty	Notes	Notes
Notes		

In addition to creating the databases, PAG staff delineated the streamflow extents on USGS 7 ½ minute quadrangles. The locations delineated on the quadrangles were used to create the ArcView GIS shape files, via on-screen digitizing and arc manipulation. Coverages contained on the Pima County Land Information System (PCLIS) CD-ROM, including Township-Range-Section, roads, streams, topography, and washes, were used as the base map. Where available, the existing Pima County washes coverage was used for locations of intermittent and perennial stream reaches. The appropriate arcs within the washes coverage were copied into the new perennial and intermittent coverages, and subsequently trimmed to the correct location by deleting and adding nodes as needed. Where PCLIS line work was incomplete or incorrect, the stream coverage from the Arizona Land Resource Information System (ALRIS) was used. Where both PCLIS and ALRIS were incomplete, streamflow extents were digitized by PAG.

The data in the shallow groundwater coverage consists of separate shape files for each data source; each source was queried to identify only those wells with water levels less than 50 feet. The data from ADWR were subdivided into separate shape files for the Groundwater Site Inventory (GWSI) and Wells-55 Registry data sets. These data were further divided into separate shape files corresponding to five-year increments beginning in 1980. The purpose of this was to allow the user to evaluate the validity of the data, given that water level declines might have occurred since the date that the measurements had been made. The Wells-55 Registry data did not include water level measurement dates; therefore, it was assumed that the water

levels were measured on the dates listed for the construction of the well. The GWSI data that PAG requested only included wells with water levels less than 75 feet. All of the shape files were provided to Pima County without any assessment by PAG as to the validity of the data.

Other data provided to Pima County included Tucson Water information, PAG data, and Metro Water District data. For the Tucson Water data, only the water level measurements made during the winter 1997 – 1998 monitoring period were obtained. Additional data were supplied by Metro Water District, for Catalina State Park and the Canada del Oro areas, and by PAG, for the lower Cienega Creek basin. Only the most recent Metro Water District and PAG data available were used.

In addition to the shape files showing well locations with groundwater levels of less than 50 feet, PAG created a coverage of selected areas of "suspected" shallow groundwater. These are areas that, based on available literature, field notes, maps, GIS coverages, and aerial photographs, appeared to support riparian vegetation. It was beyond the scope of this project, given the available time and resources, to complete this coverage for the entire county. Therefore, the effort was focused on areas deemed a priority by the Technical Advisory Committee. These priority areas were selected from the list of sites that had been identified during the literature review as possible locations of shallow groundwater. The priority areas selected from this list were those that were possibly threatened by future development or those with high resource values. The Technical Advisory Committee agreed that the focus of the shallow groundwater coverage should be the low-elevation, arid alluvial basins, rather than localized areas of shallow groundwater in mountainous or bedrock regions, because areas of shallow groundwater at low elevations typically support riparian vegetation that is distinctly different from surrounding vegetation and provides important habitat for wildlife. Some areas were left off or taken off the priority list because they had already been included in one or both of the streams coverages. For some areas, PAG recorded shallow groundwater locations as point coverages in ArcView, based on available data provided by the United States Forest Service Riparian Area Survey and Evaluation System (RASES). For these sites, PAG used point locations of riparian vegetation, provided by RASES, as indicators of shallow groundwater. The shallow groundwater database created by PAG only includes the priority areas which were included in the shape files; it does not include records for the individual well locations, or for the other suspected areas which were not delineated.

Well data and aerial imagery were used to delineate the selected areas of suspected shallow groundwater. Water level data from ADWR's Well 55-registry and GWSI, Tucson Water's 1999 static water level data, Metropolitan Water Improvement District, and PAG's 1998 Cienega Creek monitoring report were used to confirm the presence of shallow groundwater in the suspected areas. The aerial imagery included multispectral ortho photographs (1998), USGS digital ortho quads (various dates from the 1990s), 1-foot resolution grayscale ortho photographs (1998), and 1:400 scale blue line aerial photographs (1998 and 1999). For most suspected areas, riparian vegetation was visible in the aerial imagery. The zones with riparian vegetation were sketched on USGS 7.5 minute quadrangles; in general, these zones appeared to follow the land surface elevation contour lines corresponding to what appeared to be the geologic floodplain.

After the suspected shallow groundwater areas were sketched on the quadrangles, they were screen-digitized into the GIS coverage using the Pima County Land Information System "topo" theme. Land surface elevation contour lines were followed. In some cases, well data indicating water levels less than 50 feet were used to extend the areas of shallow groundwater beyond the riparian vegetation zones visible on the aerial imagery. In addition, well data indicating water levels greater than 50 feet were used in some cases to limit the extent of the polygons, if no other data indicated they should be extended. However, ADWR Wells-55 data were not used for this purpose, because of past experience indicating that the well data are often unreliable. Therefore, some areas of suspected shallow groundwater encompass locations of registered wells with reported water levels of greater than 50 feet. PAG also checked the delineated areas vs. the ADWR GWSI data, which is believed to be more reliable because it is field verified. The GWSI data tended to support the delineations, although some areas included GWSI well locations with water levels greater than 50 feet. These locations were not excluded because the presence of riparian vegetation suggested that water levels might at times be within 50 feet of the surface. Where available, the Pima County "riparian" and "bedrock" coverages were also used to better define the suspected areas. Metadata files that explain the shape files and document the information sources used were created in Pima County Land Information System format.

RESULTS AND DISCUSSION

Perennial and Intermittent Streams Identified

The perennial streams and intermittent streams identified in Pima County for this project are shown on Tables 3 and 4, respectively, and together on Figure 1 (for eastern Pima County only). The streams are also listed in Appendices E and F, along with selected information from the databases. Fifty-five perennial stream reaches and eighty-two intermittent stream reaches on a total of 74 different streams were identified.

Table 3. Perennial Streams in Pima County.

Apache Spring	Montosa Canyon
Arivaca Creek	Nogales Spring
Bingham Cienega	Posta Quemada
Buehman Canyon (3 reaches)	Quitobaquito (Pond and Springs)
Bullock Canyon	Romero Canyon
Canada del Oro	Ruelas Canyon
Cienega Creek (9 reaches)	Sabino Creek (3 reaches)
Cinco Canyon	San Pedro River (2 reaches)
Davidson Canyon	Santa Cruz River (effluent dependent)
Edgar Canyon	Scholefield Spring
Empire Gulch (2 reaches)	Simpson Spring
Espiritu Canyon	Tanque Verde (upper)
Honey Bee Canyon	Wakefield Canyon (4 reaches)
Lemmon Creek	Wild Burro Canyon (5 reaches)
Little Nogales Spring	Wild Cow Spring
Mattie Canyon	Youtcy Canyon (2 reaches)

Table 4. Intermittent Streams in Pima County.

Agua Verde Creek	Madera Canyon
Alder Canyon	Madrona Canyon
Arivaca Creek	Mattie Canyon
Ash Creek	Miller Creek
Atchley Canyon	Molino Canyon
Barrel Canyon	Mud Spring Canyon
Bear Canyon (2 reaches)	Paige Creek (2 reaches)
Bear Creek	Palisade Canyon Creek
Bootlegger Spring	Peck Basin
Box Canyon	Pima Canyon
Brown Canyon	Rincon Creek
Buehman Canyon (2 reaches)	Romero Canyon (2 reaches)
Bullock Canyon (3 reaches)	Rose Canyon Creek
Canada Agua	Sabino Canyon
Canada del Oro	San Pedro River (3 reaches)
Cargodera Canyon	Santa Cruz River
Chiminea Canyon	Smitty Spring
Chimney Canyon	Soldier Canyon
Cienega Creek (8 reaches)	Sutherland Wash
Davidson Canyon (3 reaches)	Sycamore Canyon
Deer Creek	Tanque Verde Creek (5 reaches)
Distillery Canyon	Thomas Canyon
East Fork Sabino Canyon	Turkey Creek
Espiritu Canyon	Unnamed Spring
Finger Rock Canyon	Unnamed tributary to Ash Creek
Florida Canyon	Ventana Canyon (3 reaches)
Gardner Canyon	Wakefield Canyon
Geesaman Wash	West Fork Sabino Creek
La Milagrosa Canyon	Youtcy Canyon (2 reaches)

Information Available for Perennial and Intermittent Streams

Most of the stream reaches identified in this project had fairly limited documentation available to identify the upstream and downstream limits of flow. Appendix G includes descriptions of the information used, and the basis for deciding where to define these limits, for each perennial and intermittent stream. For many of the stream reaches, very little information was available to verify the presence and location of flow. This was particularly true of the intermittent reaches; 10% of the intermittent reaches were level-1 certainty, 64% were level 2, and 26% were level 3. The perennial streams had better documentation; only three of the 55 (<6%) were level-1 certainty, 36% were level 2, and 58% were level 3. The perennial and intermittent streams with the least information available (i.e., level-1 certainty) are listed on Table 5. The certainty levels for all the streams are included in Appendices E and F, and are shown for streams in eastern Pima County on Figures 2 and 3.

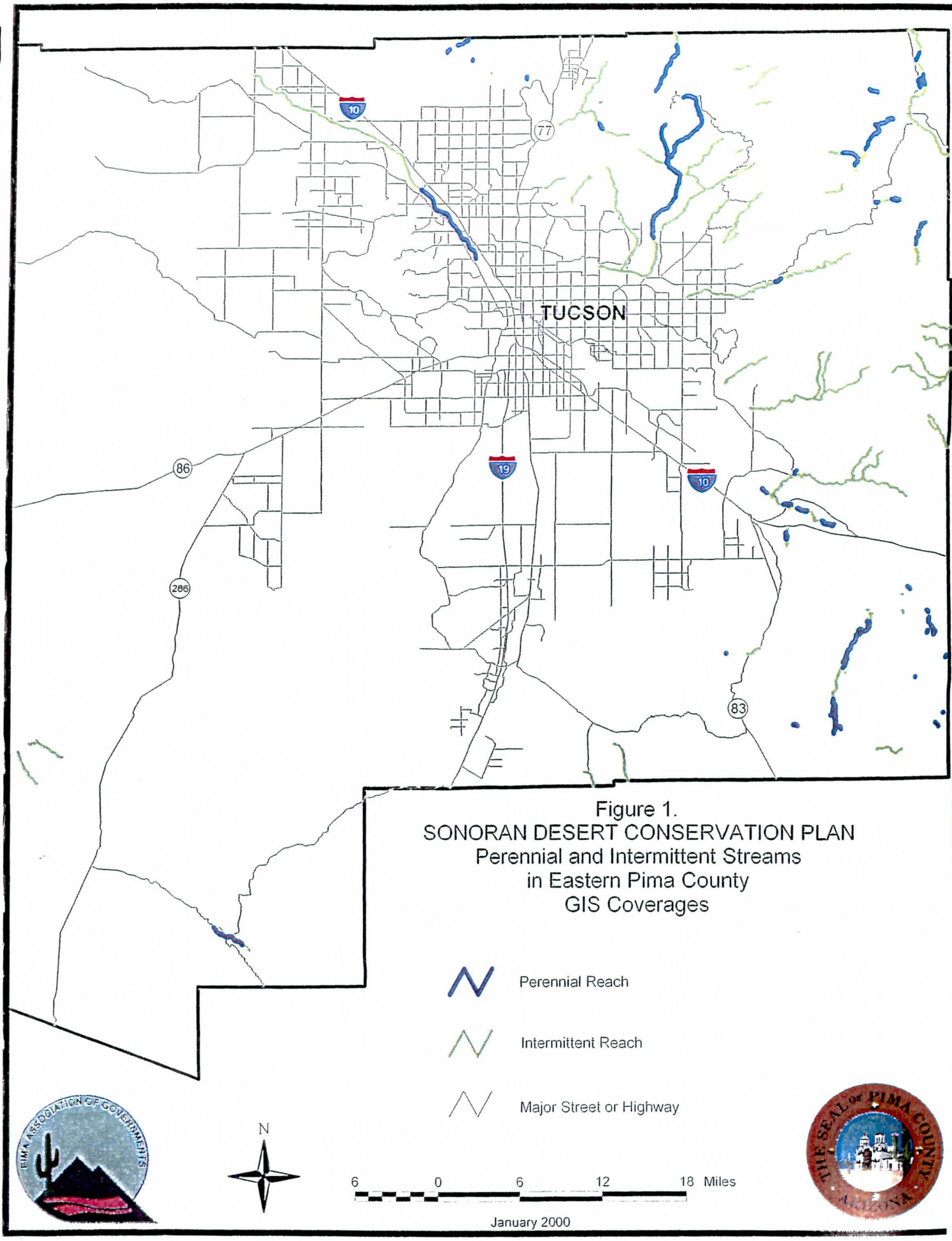

Figure 1.
SONORAN DESERT CONSERVATION PLAN
Perennial and Intermittent Streams
in Eastern Pima County
GIS Coverages

January 2000

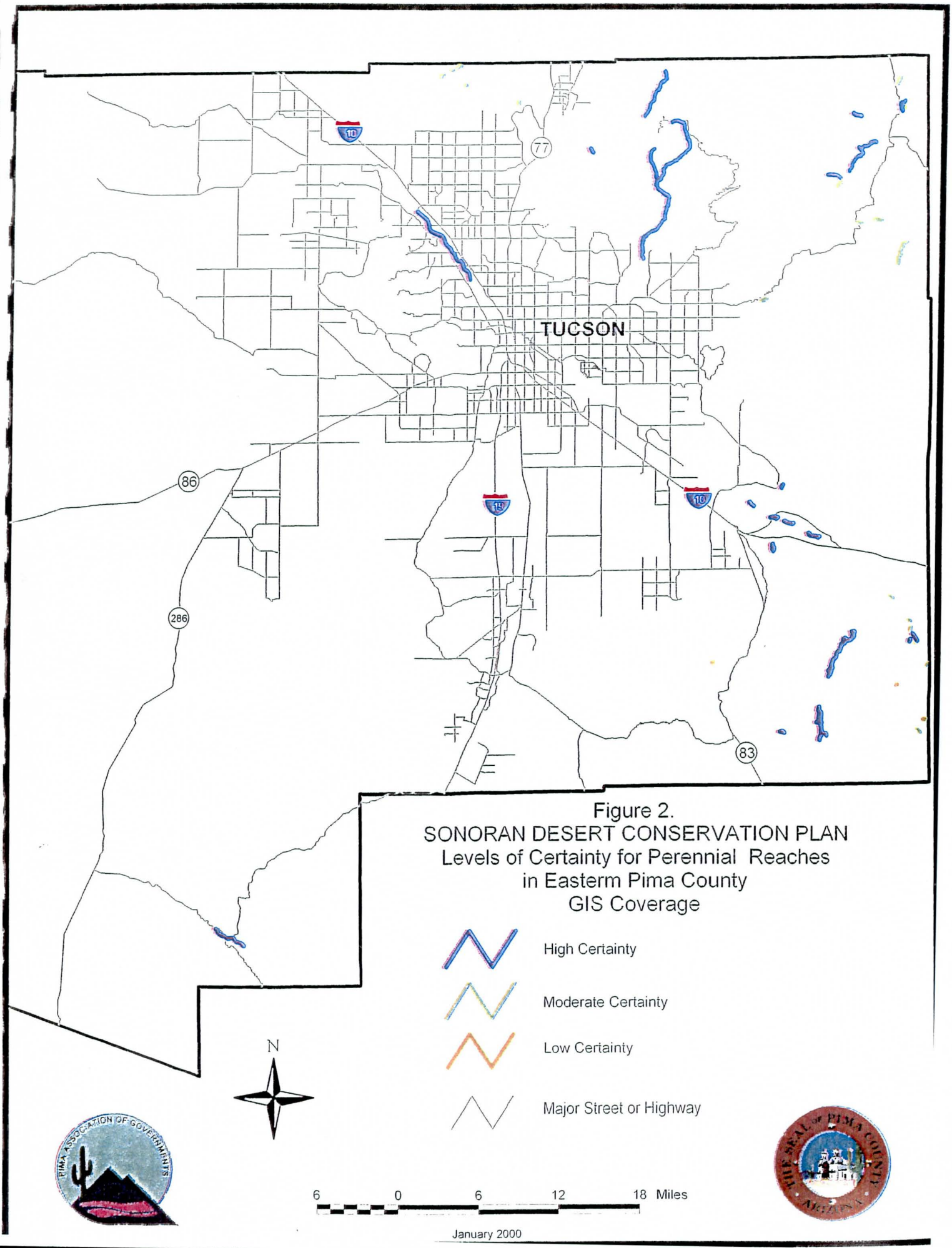

Figure 2.
SONORAN DESERT CONSERVATION PLAN
Levels of Certainty for Perennial Reaches
in Easterm Pima County
GIS Coverage

January 2000

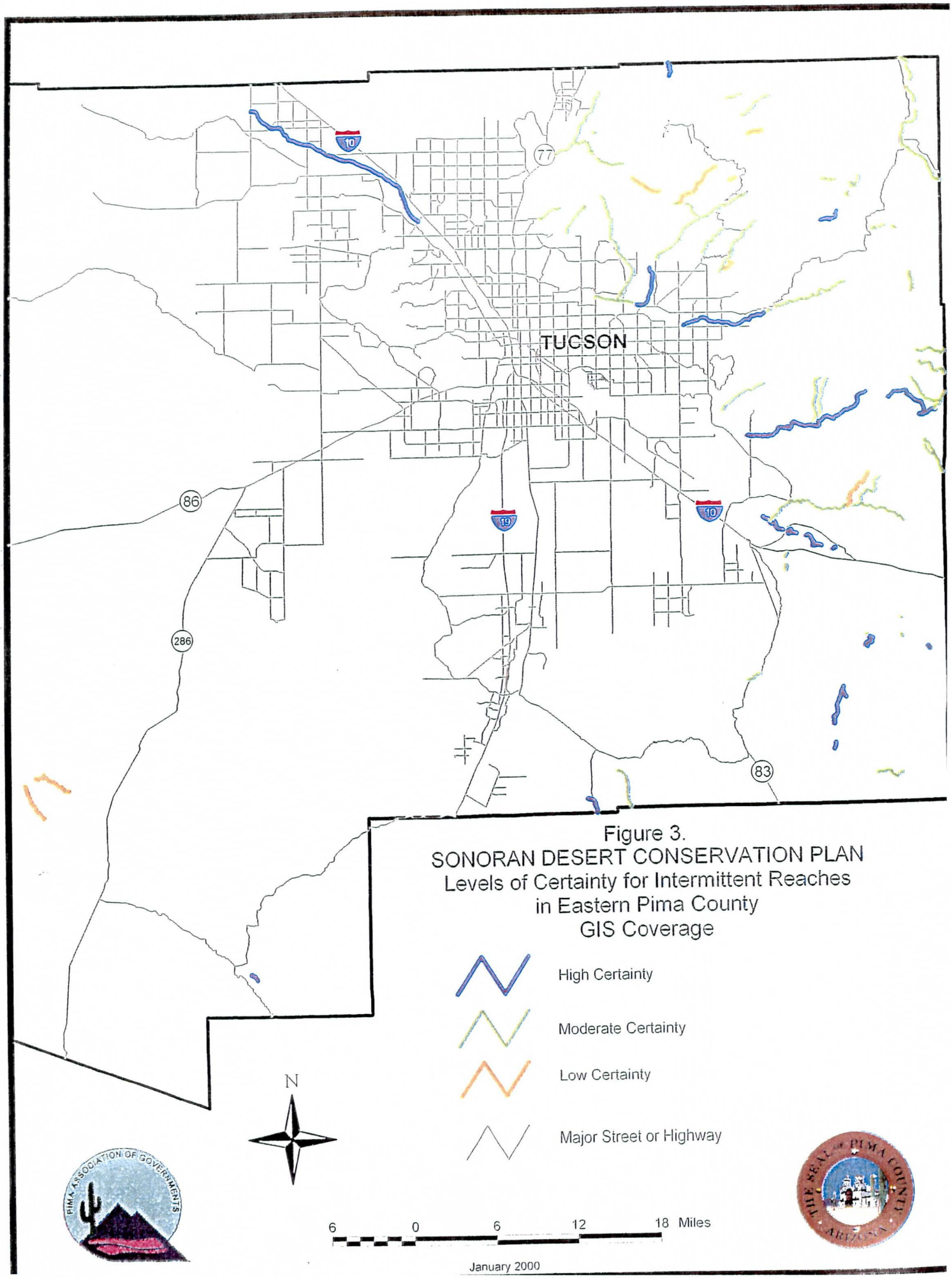

Figure 3.
SONORAN DESERT CONSERVATION PLAN
Levels of Certainty for Intermittent Reaches
in Eastern Pima County
GIS Coverage

January 2000

Table 5. Perennial and Intermittent Streams in Pima County with the Least Available Information

Perennial Streams	Intermittent Streams
Apache Spring	Brown Canyon
Wild Cow Spring	Chimney Canyon
Scholefield Spring	La Milagrosa Canyon
	Palisade Canyon Creek
	Peck Basin
	Rose Canyon Creek
	Thomas Canyon
	West Fork Sabino Creek

Sites of Possible Streamflow that were not Included

Several sites of possible streamflow were brought to PAG's attention by members of the public, via the web site or at the Steering Committee meeting. Several sites were also noted as possible streamflow sites by one or more members of the Technical Advisory Committee. The sites listed below are sites of possible streamflow for which PAG did not find any documentation that intermittent or perennial flows were present. The sites include:

- Several locations in the Tucson Mountains, mostly on the eastern slope
- Abandoned clay quarry near the intersection of Greasewood and 22nd
- Altar Wash
- The Hombre drainage (Altar watershed?)
- Tres Pipas (tributary to Espiritu)
- Various sites in the Sierrita Mountains
- Shaw Canyon
- Unnamed canyon in Tortolita Mountains
- Montrose Canyon

Locations of Perennial and Intermittent Streams in Pima County

The perennial and intermittent streams in Pima County are located in a variety of locations and environments. Most of the streams identified by this study are located in eastern Pima County, particularly in the upper elevations and along the slopes of major mountain ranges on the margins of the Tucson basin, and within the Cienega Creek watershed southeast of Tucson. Thirty-eight streams with perennial and/or intermittent reaches had flows that originated within the Coronado National Forest or Saguaro National Park in the Santa Catalina, Rincon, or Santa Rita Mountains. This is roughly half the total number of streams identified. Relatively few perennial or intermittent streams were located west, southwest, or northwest of Tucson. The only perennial stream identified west of the Tohono O'odham Reservation (the

reservation was not included in the study area) was Quitobaquito Springs in Organ Pipe National Monument. No intermittent streams were identified west of the reservation.

The greater number of perennial and intermittent streams identified in eastern Pima County is most likely due to the presence of higher land elevations and greater precipitation. However, to some extent, the distribution of identified stream reaches could have been influenced by the availability of data. For example, more streams might have been identified in eastern Pima County, which includes the bulk of the human population, a major university, and numerous parks, preserves and National Forest lands, because more data were available for these areas.

Many streams in Pima County appear to be located partly or entirely within protected areas, such as lands administered by the National Forest Service, the National Park Service, and Pima County Parks and Recreation. These include Quitobaquito Springs, Lemmon Creek, Sabino Creek, Cienega Creek, and others. However, parks and forest lands often contain privately held "in-holdings" which do not appear on the regional GIS covers illustrating jurisdictional boundaries. Also, many activities occurring outside park and forest lands can impact water resources within these lands. In addition, National Forest Service and Bureau of Land Management lands are open to multiple use activities such as mining, grazing, and recreation, which have the potential to impact riparian areas.

A number of perennial and intermittent stream reaches in Pima County are clearly outside protected areas. These include Davidson Canyon south of Interstate 10, the San Pedro River, portions of Arivaca Creek, several streams draining the northeast side of the Santa Catalina Mountains, Agua Verde Creek, Wakefield Canyon, Rincon Creek, Tanque Verde Creek, and others.

Designated Uses

In several cases, the findings of this study contradict the designated uses defined by ADEQ in state rules developed under the Clean Water Act. Davidson Canyon contained perennial and intermittent reaches, and Sutherland Wash contained intermittent reaches, but both have been designated as ephemeral by ADEQ (Arizona Administrative Code, 1996). Also, Rose Canyon has been designated as warmwater, whereas it might be more appropriately classified as coldwater. Finally, Tanque Verde has been designated as ephemeral below Wentworth Road, but digital aerial photography from the spring of 1998 showed flow extending beyond this point. Many of the perennial and intermittent streams did not have designated uses. In these cases, the Tributary Rule (R18-11-105) applies if the stream is tributary to a listed surface water. For unlisted tributaries that are ephemeral, the aquatic and wildlife [ephemeral] and partial-body contact standards apply. For unlisted waters that are not ephemeral or effluent dependent, the water quality standards established for the nearest downstream surface water which is not ephemeral or effluent-dependent apply, in addition to the aquatic and wildlife [cold water fishery] and fish consumption standards, if salmonids are present in the tributary, or the aquatic and wildlife [warm water fishery] and fish consumption standards, if salmonids are not present.

Areas of Shallow Groundwater

Wells indicating shallow groundwater were identified throughout the county. The locations these wells are shown on Figure 4 for eastern Pima County only. In addition, a number of areas were identified as suspected of having shallow groundwater, based on the initial research conducted for the project, or from input from the TAC or members of the public. These are listed on Table 6.

Polygons were delineated only for suspected shallow groundwater areas that were determined to be "priority" areas by the TAC; these are noted with an " * ". In many cases, polygons were not delineated for priority shallow groundwater areas if these areas had already been represented in the intermittent or perennial stream covers. In at least one case (Canada del Oro), a polygon was not delineated for a priority area because available well data indicated that depth to groundwater was greater than 50 feet. For some areas, PAG recorded suspected shallow groundwater locations as point coverages in ArcView, based on available data provided by the United States Forest Service Riparian Area Survey and Evaluation System (RASES). For these sites, PAG assumed that locations of riparian vegetation indicated areas of shallow groundwater. The RASES sites recorded as points are noted on Table 6 by "**". Appendix H contains summaries of the shallow groundwater areas delineated as polygons or points in ArcView. These areas are also shown on Figure 4 for eastern Pima County only. Appendix I is a download of information in the shallow groundwater database that PAG created for the areas that were delineated as polygons or points. Areas on Table 6 that are not identified by "*" or "**" were not delineated, and are not included in the database that PAG created.

Shape Files and Metadata

The information that PAG obtained for perennial streams, intermittent streams, and shallow groundwater areas was used to create a number of ArcView GIS shape files. Metadata files were also created to explain the shape files and document the information sources used. The shape files, metadata files, databases, and other relevant files were provided, along with this report, to Pima County for use in developing the Sonoran Desert Conservation Plan. A list of the files provided is included as Appendix J.

Table 6. List of Suspected Shallow Groundwater Areas

Agua Caliente*	Madera Canyon
Agua Verde*	Madrona Canyon
Alamo Canyon	Mattie Canyon
Alder Canyon	Mescal Wash
Altar Wash	Miller Creek
Arivaca Creek*	Molino Basin
Arrieta Wash**	Montrose Canyon
Ash Creek	Mud Springs Canyon
Barrel Canyon	Murphy Canyon
Batamote Wash	North Canyon
Bear Canyon	Oak Tree Canyon
Bingham Cienega*	Paige Creek
Box Canyon*	Pantano Wash*
Buehman Canyon	Papago Wash
Bullock Canyon	Penitas Wash
Canada Agua Canyon	Pima Canyon
Canada del Oro	Posta Quemada*
Canyon de Salto	Proctor Wash
Cargodera Canyon	Quitobaquito
Cedar Canyon**	Rillito Creek*
Champurrado Wash	Rincon Creek*
Chiminea Canyon	Romero Canyon
Chimney Canyon	Ruelas Canyon
Cienega Canal	Sabino Creek*
Cienega Creek (lower)*	San Luis Wash**
Cienega Creek (upper)*	San Pedro River*
Cocio Wash*	Scholefield Canyon
Cocoraque Butte	Shaw Canyon
Davidson Canyon*	Silverbell Mtns area
Distillery Canyon	Soldier Canyon
East Fork Apache Canyon**	Sopori Wash*
Edgar Canyon	Sutherland Wash*
Empire Gulch	Tanque Verde Creek*
Esperanza Wash	Thomas Canyon
Esperero Canyon	Turkey Creek
Espiritu Canyon	Ventana Canyon
Finger Rock Canyon	Wakefield Canyon
Florida Canyon	Waterman Mtns area
Fraguita Wash**	Waterman Pass
Fresnal Wash**	Wild Burro Canyon
Gardner Canyon*	Yellow Jacket Wash
Honey Bee Canyon	Youtcy Canyon
Jalisco Wash	
La Miligrosa Canyon	

* - Polygon delineated in ArcView
** - Point location in ArcView

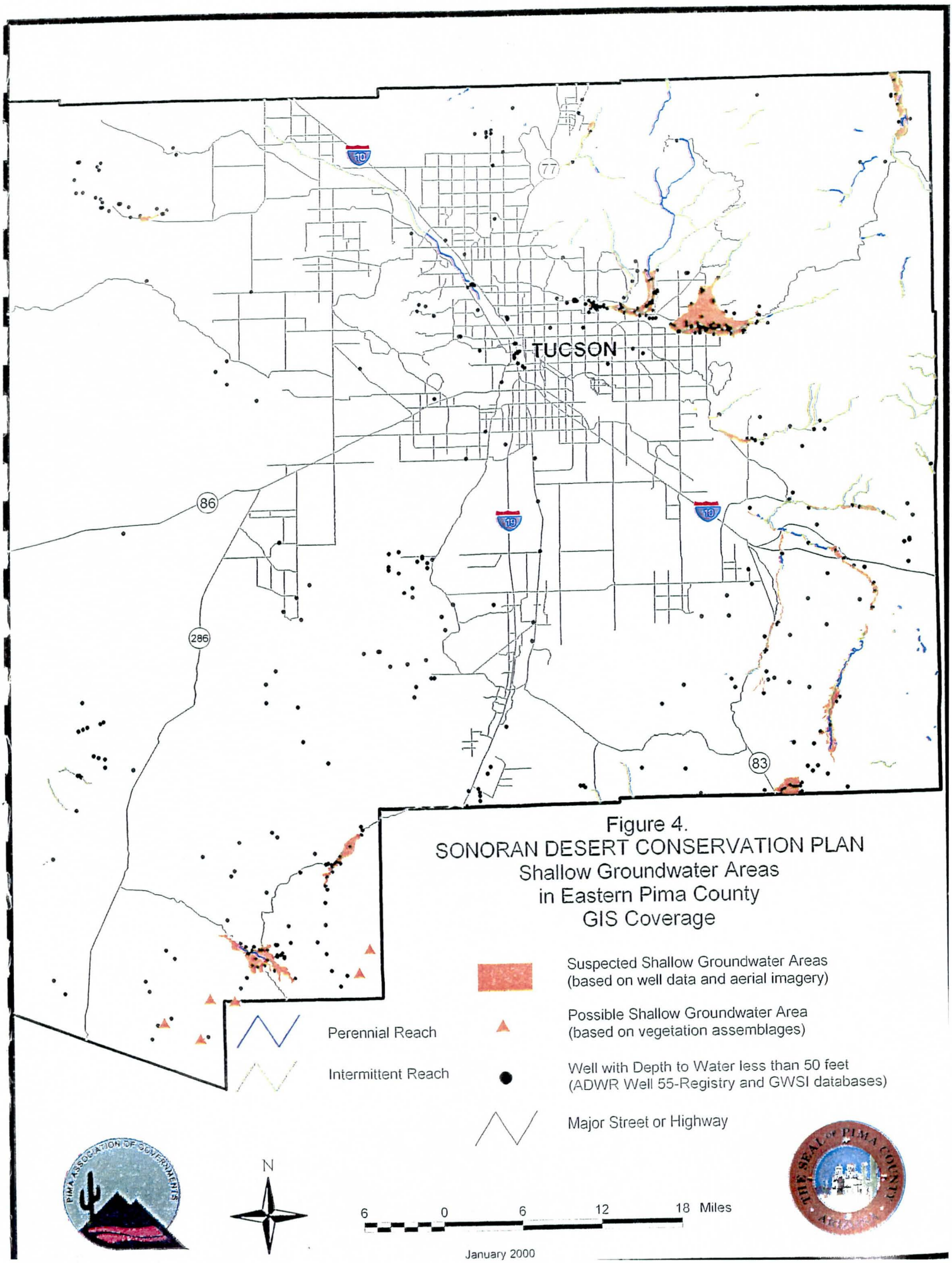

Figure 4.
SONORAN DESERT CONSERVATION PLAN
Shallow Groundwater Areas
in Eastern Pima County
GIS Coverage

January 2000

RECOMMENDATIONS

Ideally, all of the stream reaches identified in this report should be monitored on a monthly basis for a length of time (probably several years) sufficient to encompass a wide range of meteorological conditions and long-term trends. This would permit a reliable delineation of representative variations in the upstream and downstream flow extents, as well as a calculation of a long-term mean discharge.

A specific value of streamflow extent monitoring, particularly for low-discharge streams, is that it would provide a direct measure of the variability in aquatic habitat, which would reflect variations in surface water and groundwater conditions. This monitoring would also provide an opportunity to thoroughly document riparian habitat and wildlife conditions in the areas.

Implementation of this recommendation would require a substantial investment of time and resources, however, and is probably not feasible at this time. Nevertheless, it would be appropriate to explore the possibility that grant opportunities might be available for such an effort. At a minimum, the stream reaches that are outside of protected areas should be studied in the field to characterize the stream conditions, local wildlife, wildlife habitats, and vegetation.

On a regional scale, several areas in Pima County appear to warrant follow-up studies to obtain information on perennial streams, intermittent streams, and shallow groundwater. Streams or shallow groundwater locations identified or reported in these areas generally had little information available. In addition, it is possible that as-yet unidentified perennial or intermittent streams are located in these areas. Some of these areas are likely to face development pressures. Therefore, PAG recommends that additional research be conducted in the following "data gap" areas:

- San Pedro River tributaries draining the north and east slopes of the Santa Catalina and Rincon Mountains;
- Western slope of the Whetstone Mountains
- Arivaca area
- Altar Valley
- Eastern slopes of the Baboquivari Mountains
- Sierrita Mountains
- Silverbell Mountains
- Waterman Mountains
- Tortolita Mountains
- Tucson Mountains
- Northeastern Tucson Basin.

A number of major perennial and intermittent streams identified in the county had very little information available. We would recommend that the following, because they lack data and because they potentially have a high habitat value, receive the highest priority for further

investigation. Further investigation should include monthly or quarterly discharge and flow-extent monitoring:

- Agua Verde Creek
- Arivaca Creek
- Davidson Canyon
- Rincon Creek
- San Pedro River

Several smaller streams and springs also have little information available, and are not known to be monitored at this time. The following are recommended for further investigations, which should include at least one site inspection to determine the extent of flow and document aquatic and riparian habitat conditions:

- Bootlegger Spring
- Apache Spring
- Scholefield Spring
- Simpson Spring
- Smitty Spring
- Unnamed spring tributary to Cienega Creek
- Wild Cow Spring
- Barrel Spring
- Wakefield Canyon

A number of shallow groundwater areas have limited information. Of these, PAG recommends that Sopori Wash receive the highest priority for additional study, because it has been reported by several sources as having valuable habitat and possible development pressures. In addition, shallow groundwater and riparian vegetation areas should be delineated for all the remaining locations listed on Table 6, using any aerial photography that is available.

Davidson Canyon and Sutherland Wash are incorrectly identified as ephemeral under the surface water designated uses in state rules. Evidence of perennial or intermittent flow in these streams should be thoroughly documented and compiled, and ADEQ should be petitioned to change the designated uses of these streams from "aquatic and wildlife – ephemeral" to "aquatic and wildlife – warmwater". Additional study is also warranted to determine if a change in designated use is appropriate lower Tanque Verde Creek. ADEQ (Lawson, 2000) has indicated that it will probably be possible to make petitions for another six months. Therefore, ADEQ should be contacted as soon as possible to take advantage of the opportunity to include the changes in the current review. Otherwise, the changes should be made during the next triennial review. In addition, the possibility of assigning designated uses to streams currently lacking them should be explored, and the suitability of Unique Water status for many of the streams should be evaluated. Rose Canyon will likely be re-designated as a cold water fishery, because ADEQ expects to divide cold water and warm water fisheries at the 5000-foot elevation level.

The streams and groundwater coverages should be overlaid with Pima County's parcel coverage, and the locations of "unprotected" parcels, such as privately owned or State Trust lands, bordering on perennial or intermittent streams or shallow groundwater, should be identified. Lands slated for uses which might adversely impact the streams or shallow groundwater should also be identified.

Regional data available for groundwater level declines and groundwater pumping should be compared to the groundwater level data in the coverage prepared for this project. Areas identified as shallow groundwater locations should be reconsidered if more recent evidence indicates that the water level has dropped below 50 feet.

If invited by the Tohono O'odham Nation, a similar inventory of shallow groundwater and perennial and intermittent streams could be conducted on Nation lands.

This report and the GIS coverages should be widely distributed to, and reviewed by, land management agencies and personnel working on the Sonoran Desert Conservation Plan. Following this review, the report and data should be updated with any additional information that is provided.

REFERENCES

Arizona Administrative Code, 1996. Title 18. Environmental Quality. Chapter 11. Department of Environmental Quality Water Quality Standards. Appendix B – List of Surface Waters and Designated Uses.

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Lawson, L., 2000. Comments on initial draft of this report, via interoffice electronic communication dated January 3, 1999, from ADEQ to PAG.

Shallow Groundwater Area Name

Sutherland Wash

General Location Using Place Names

Santa Catalina Mtns W; through Catalina State Park

Legal Land Description (TRS)	USGS Watershed Code and Name	USGS Topo Name
11-14-33,34/12-14-3,4	15050301 Upper Santa Cruz	Oro Valley, Ariz.

List of Tree Species

fremont cottonwood, arizona ash, velvet mesquite, hackberry tree

Tree Species, Young Seedlings	Tree Species, Mature Trees	Tree Species, Old Decadent
mesquite, hackberry	cottonwood, ash, mesquite, hackberry	cottonwood, ash

Estimated Range of Depth to Water

<50

Wells - Depth to Water *dtw (owner, date (ref))*

30.79 (Catalina State Park, 2/2/99(Metro Water))

List of Other Environmental Resource Features

References Used (Author, Date)

USFS RASES 1998; Fonseca 1996; Metro Water 1999; Donkersley 1999; ADWR databases; DOQ Oro Valley; Tucson Water 1998

Certainty Level

2

Notes

tree species identification, ages (USFS RASESF;Fonseca)

Intermittent Reach Name	GIS ID Number
Ash Creek	I-039

General Location Using Place Names
Rincon Mtns E; Happy Valley S

Legal Land Description (TRS)	USGS Watershed Code and Name	USGS Topo Name
15-18-23,25,26,36	15050203 Lower San Pedro	Galleta Flat West, Ariz.

Designated Use

List of Tree Species
arizona sycamore, fremont cottonwood, juniper, hackberry tree, mesquite

List of Other Environmental Resource Features

References Used (Author, Date)	Certainty Level
USFS RASES 1998; Danzer 1996; Schorr 1999	2

Notes: observations:
Tree species identification (USFS RASES 1998; Danzer 1996)

Notes: Flow -- miscellaneous:
Flow observations (Schorr 1999); several pools present along reach 10/99

Perennial Reach Name	GIS ID Number
Cienega Creek (upper)	P-006a

General Location Using Place Names

Sonoita Valley; near Cienega Ranch; Mattie Canyon to the Narrows

Legal Land Description (TRS)	USGS Watershed Code and Name	USGS Topo Name
18-17-12,13,14,23/18-18-6,7	15050302 Rillito	Spring Water Canyon, Ar

Description of Flow

2.56 - 6.43 cfs (BLM, 12/1-5/88 and 6/6/89)

Designated Use

aquatic&wildlife warmwater, full body contact, fish consumption, agricultural livestock watering

List of Tree Species

goodding willow, fremont cottonwood, arizona ash, mesquite

List of Other Environmental Features

gila topminnow, gila chub, longfin dace, leopard f

References Used (Author, Date)

BLM 1988-89; BLM 1993; Forrest 1992; ADEQ water quality standards 1996; Weedman and Young 1997

Certainty Level: 3

Notes: observations:

Fish observations (Forrest); tree species identification, tree ages, and stream flow observations/measurements (BLM)

Notes: flow -- miscellaneou

APPENDIX D. DATABASE INPUT FORMS

Does any of the following vegetation grow along the stream?

Cottonwood	○ Yes	○ No	○ Don't know
Willow	○ Yes	○ No	○ Don't know
Mesquite	○ Yes	○ No	○ Don't know
Sycamore	○ Yes	○ No	○ Don't know
Ash	○ Yes	○ No	○ Don't know
Walnut	○ Yes	○ No	○ Don't know
Maple	○ Yes	○ No	○ Don't know
Cattails	○ Yes	○ No	○ Don't know
	○ Yes	○ No	○ Don't know

Do you know of any books, articles, or studies that describe this site?
If so, please list the author, title and year published.

Do you know the depth to groundwater for this area? (perhaps from a private well)
If so, please indicate below the general location or address of the property that the well is located the depth to water, and the date of measurement, if available.

(Information below is optional)

Additional comments or information :

Please include your contact information so we may call/email you if we have any questions.

THANK YOU FOR TAKING THE TIME TO PARTICIPATE IN THIS EFFORT!!!

Submit Form

Water Quality

SDCP STREAM FLOW LOCATION INFORMATION FORM

Name of site:

General description of site location and directions to site:

If you know the Township/Range/Section of the site, please enter it here:

T. Select **S.** **R.** Select **E.** **Section:** Select **Section ¼:** Select

If you are unsure of the stream location, you can use Pima County's MapGuide website to access online coverages showing roads, county boundaries, National Forest and Park boundaries, Township/Range/Section information, and other useful locational information. If you are unable to acce this information, please call PAG at (520) 792-1093, and we would be happy to help you determine the location of your stream.

Click here for the Pima County MapGuide site

What is the approximate distance, in feet, that the stream usually flows during wet seasons?

Select

What is the approximate distance, in feet, that the stream usually flows during dry seasons?

Select

Describe the stream characteristics:

depth of flow:

width of channel:

How would you described the flow? select

Are there bedrock outcrops in the area around or near the flowing reach?

- ○ **Yes**
- ○ **No**

Can you identify, based on area landmarks, the location of beginning and end of flow? (i.e. upstream/downstream, of a confluence, near sharp bend in channel, trail markers, GPS coordinates, etc.)

What time of year did you make this observation?

Do you have a map, such as a topographic or National Forest map, that you could locate the beginning and end of flow on?

- ○ **Yes, If so, please fax or snail mail us a copy!**
- ○ **No**

Are any of the following types of animal life located in or near the stream?

Fish	○ **Yes**	○ **No**	○ **Don't know**
Other water dependent animals	○ **Yes**	○ **No**	○ **Don't know**
Waterfowl	○ **Yes**	○ **No**	○ **Don't know**

APPENDIX C. WEBSITE QUESTIONNAIRE

Lefevre, B., 1999. Personal communication. Provided USFS RASES notebooks and other information.

Nature Conservancy, Arizona Chapter. Personal communication with Nature Conservancy staff. Provided notes and maps for various areas; dates of observations not included.

Nature Conservancy, Arizona Chapter, 1997. Personal communication with Nature Conservancy staff. Provided notes and maps for various locations visited in 1997.

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Nodine, B., 1999. Personal communication. Provided verbal information.

Pima Association of Governments (PAG) field work, 1999. Observations from PAG staff from on-going stream monitoring projects. Information based on November 1999 observations.

Saguaro National Park, 1999. Personal communication with Saguaro National Park East staff, Don Swan and Natasha Kline.

Schorr, S., 1998. Personal communication. Provided notes for various locations visited in 1998 and prior to 1998.

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USFS RASES, 1998. U.S. Forest Service provided unpublished Riparian Area Survey and Evaluation System (RASES) notebook with field notes and photographs from 1998 of various survey locations in Santa Catalina and Nogales Ranger Districts.

USFS RASES, 1999. U.S. Forest Service provided unpublished Riparian Area Survey and Evaluation System (RASES) notebook with field notes and photographs from 1999 of various survey locations in Santa Catalina and Nogales Ranger Districts.

Personal Communication and Other Sources of Information

Bertelsen, D., 1999. Personal communication at Sonoran Desert Conservation Plan Steering Committee meeting. Also provided a map of Finger Rock Canyon.

Briggs, M., 1999. Personal communication with Sonoran Institute staff member. Provided notes and maps.

Buenos Aires National Wildlife Refuge, 1999. Personal communication with NWR personnel.

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Donkersley, N., 1999. Personal communication with manager of Catalina State Park. Provided verbal information.

Eastoe, C., 1999. Personal communication. Provided notes.

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Hopp, S., 1999. Personal communication. Provided location information and personal observations for various locations.

Karrer, C., 1999. Personal communication. Provided notes and verbal information for various locations visited in 1999 and prior to 1999.

Karrer, C. and S. Schorr, 1999. Personal communication. Provided notes and maps for various locations visited in 1999.

GIS Coverages

GIS Coverages provided by Pima County Technical Services (regional coverages): stock tanks; springs; and hydromeso coverages. Arivaca coverages include alluvium, Arivaca Lake, recharge areas, washes, well data, perennial flow, and riparian areas.

GIS Coverages provided by Organ Pipe National Monument: park boundary, topography for the park, roads, washes, well locations, results of well monitoring, locations of springs, and pond location.

GIS Coverages provided by BLM for Upper Cienega Creek: riparian areas, GAP vegetation coverage, range sites (including soils info and range condition).

GIS coverages provided by Arizona State Land Department for Arizona Land Resources Information System (ALRIS): streams, geology, hydrologic unit codes, and riparian base.

GIS coverages from Pima County Land Information System (PCLIS): street network, washes, parcels, county boundary, Tucson Water well locations, jurisdictional boundaries, topography, township/range, township/range/section, and ADWR well locations.

GIS coverages from U.S. Forest Service: streams within National Forest boundaries.

U.S. Geological Survey (USGS) National Hydrography dataset Arc/Info coverages (pre-release).

GWSI database with information for wells in Pima County with depth to water less than 75 feet provided by Arizona Department of Water Resources (ADWR) linked to Arizona Department of Environmental Quality (ADEQ) well location GIS coverage.

Downloaded USGS Digital Raster Graphic (DRG) file of topographic quads from the AZ Image Archive Site.

Aerial Imagery

City of Tucson-PAG Regional Orthophoto Datasets, April 1998.

Various USGS Digital Othrophoto Quadrangles (DOQ), including one color infrared DOQ of Arivaca completed in 1996, provided by Pima County Technical Services.

Various USGS Digital Orthophoto Quadrangles viewed off the TerraServer website.

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Maps

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Morse, Darwin III, 1979. Baseline Water Quality Analyses of Madera Creek, Madera Canyon. MS Thesis from School of Renewable and Natural Resources, University of Arizona.

Motschall, Robert, 1976. Water Quality Analyses of the Recreational Waters of Sabino and Bear Creeks. MS Thesis from School of Renewable and Natural Resources, University of Arizona.

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APPENDIX B
SONORAN DESERT CONSERVATION PLAN
STREAMS AND GROUNDWATER GIS COVERAGES
DATA SOURCES

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APPENDIX B. DATA SOURCES

7. Draft report and ArcView shape file distributed for review by ~~October 15~~ November 19

8. Public meeting held by ~~October 29~~ December 3

9. EPAC review on ~~November 5~~ December 3

10. Final report and maps completed by ~~November 19~~ December 24

5. Prepare draft ArcView shape file

   a. Digitize locations using ArcView GIS (base map will be created from coverages taken from the most recent release of the Pima County Land Information System CD-ROM)
   b. Include data source(s) in attribute table for each stream reach or shallow groundwater area digitized
   c. Prepare suitable layouts for various scales. Layout will include list of data sources and criteria
   d. Generate hardcopies from selected layouts

6. Prepare draft report to accompany maps and document methodology, findings, results

7. Distribute draft report and maps to review panel (ArcView shape file will be distributed electronically where possible)

8. Public meeting

9. EPAC review and comment

10. Prepare and distribute final report, final ArcView shape file on zip disk or CD ROM, and hardcopy plots of final maps

Schedule

Assuming a project start date of ~~August 1, 1999~~, September 8, 1999, tasks are anticipated to be completed by the following dates:

1. Data sources compiled by ~~August 13~~ September 17

2. Draft criteria completed by ~~August 20~~ September 24

3. Review panel selected by ~~August 13~~ September 17
   Draft criteria distributed by ~~August 20~~ September 24
   Meeting of review panel held by ~~August 30~~ October 4
   Comments on criteria incorporated by ~~September 6~~ October 11

4. Initial screening of areas completed by ~~September 20~~ October 25
   Final list of areas completed by ~~October 4~~ November 8

5. Draft ArcView shape file completed by ~~October 15~~ November 19

6. Draft report completed by ~~October 15~~ November 19

Description of Tasks

1. Compile data sources
    a. ADEQ surface water rules
    b. USGS 7.5 minute quadrangles
    c. Digital orthophoto coverage (DEMs, DTMs)
    d. Hardcopies of aerial photographs where digital coverage is lacking
    e. ADWR stream gaging and groundwater level data
    f. Tucson Water groundwater level data
    g. USGS stream gaging data and groundwater level data
    h. Satellite imagery
    i. Miscellaneous literature, including hydrogeologic literature

2. Identify criteria for including a location in the ArcView shape file
    a. Perennial and Intermittent streams
        i. Legal definitions and designations
        ii. Scientific definitions
        iii. Documentation by reliable sources
    b. Shallow groundwater
        i. Identify water level requirements of riparian vegetation from published literature
        ii. Solicit input from University of Arizona faculty

3. Convene panel to review methodology, data source list, and criteria
    a. Solicit volunteers to review criteria
    b. Distribute draft criteria
    c. Meet to review and solicit comments (including comments on what information should be included in the ArcView attribute tables)
    d. Incorporate comments

4. Identify areas meeting criteria
    a. Initial screening from gaging station data, ADEQ rules, USGS 7.5 minute quadrangles, and literature
    b. Identify locations clearly meeting criteria based on confirmation from multiple information sources
    c. Conduct additional research on sites with conflicting or limited information
    d. Delineate extent of areas meeting criteria on existing aerial photographs, digital images, and maps
    e. Conduct limited site visits as needed
    f. Prepare final list of areas meeting criteria, including definition of the lateral extent of each area

SONORAN DESERT CONSERVATION PLAN
PROPOSAL FOR DEVELOPING GIS COVERAGE OF PERENNIAL STREAMS, INTERMITTENT STREAMS, AND LOCATIONS OF SHALLOW GROUNDWATER

Pima Association of Governments
July 1999

Purpose

Pima County, in its work for the Sonoran Desert Conservation Plan (SDCP), has determined that preserving and restoring riparian and aquatic habitats will be very important to the SDCP. Pima County has reviewed existing data sources and has found that the present GIS coverage from Arizona Game and Fish Department does not correctly identify perennial streams. There is no GIS file that defines intermittent streams, nor one that defines areas of shallow groundwater. Intermittent streams and shallow groundwater areas are areas where different types of riparian vegetation could exist, even if the vegetation is not presently found there.

The purpose of this project will be to create a GIS coverage (i.e., an ArcView shape file) of intermittent streams, perennial streams, and shallow groundwater in Pima County.

Scope

The project results will rely heavily on a review of existing maps, photographs, literature, and other documentation. Limited site visits, to identify surface flows or evidence of near-surface flows, will be conducted only for sites for which documentation is inadequate or conflicting. Project results will be accompanied by extensive documentation of methodology and data sources, and they will undergo thorough technical and public review.

Although the ArcView shape file produced for this project will encompass all of Pima County, the focus of the project will be eastern Pima County. Research on areas west of the eastern boundary of the Tohono O'odham reservation will be limited to review of existing literature, regulatory standards, and satellite imagery.

Deliverables

1. ArcView shape file, including metadata in Pima County Land Information System format, of intermittent streams, perennial streams, and shallow groundwater in Pima County

2. Report , with hardcopy plots included, documenting methodology, data sources, and findings

3. Presentation-quality maps

APPENDIX A. PROJECT PROPOSAL

APPENDICES

APPENDIX E. PERENNIAL STREAMS

Perennial Stream Coverage

Perennial Stream Reach	Cadastral Location	USGS Topographic Map	Certainty
Apache Spring	18-18-27	Apache Peak, Ariz.	1
Arivaca Creek	21-10-20,27,28,29,34	Arivaca, Ariz.	3
Bingham Cienega	11-18-22	Redington, Ariz.	3
Buehman Canyon	12-18-4,5,6,7,8,18	Buehman Canyon, Ariz.	3
Buehman Canyon	12-18-4,5,6,7,8,18	Buehman Canyon, Ariz.	3
Buehman Canyon	12-17-13,14,24	Buehman Canyon, Ariz.	3
Bullock Canyon	12-17-24	Piety Hill, Ariz.; Buehman Canyon, Ariz.	2
Canada del Oro	11-15-15,22,27	Mt. Lemmon, Ariz.	2
Cienega Creek (lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek (lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek (lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek (lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek (lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek (lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek (upper)	19-17-3,10,14,15	Spring Water Canyon, Ariz.	3
Cienega Creek (upper)	18-17-12,13,14,23/18-18-6,7	Spring Water Canyon, Ariz,; The Narrows, Ariz.	3
Cienega Creek (upper)	18-17-12,13,14,23/18-18-6,7	Spring Water Canyon, Ariz,; The Narrows, Ariz.	3
Cinco Canyon	19-17-14	Spring Water Canyon, Ariz.	3
Davidson Canyon	17-17-6	Mount Fagen, Ariz.	3
Edgar Canyon	11-18-29,30	Buehman Canyon, Ariz.	3

Perennial Stream Reach	Cadastral Location	USGS Topographic Map	Certainty
Empire Gulch	19-17-17,18	Empire Ranch, Ariz.	3
Empire Gulch	19-17-3,10	Spring Water Canyon, Ariz.	3
Espiritu Canyon	13-18-11,14,15,22	Soza Canyon, Ariz.	2
Honey Bee Canyon	11-13-13,24	Oro Valley, Ariz.	3
Lemmon Creek	12-15-3,10,15	Mt. Lemmon, Ariz.	2
Little Nogales Spring	18-18-11	Mescal, Ariz.	3
Mattie Canyon	18-17-23,26	Spring Water Canyon, Ariz.	3
Montosa Canyon	18-18-24	Apache Peak, Ariz.	2
Nogales Spring	18-18-11	Mescal, Ariz.	3
Posta Quemada	16-17-8	Vail, Ariz.	3
Quitobaquito Pond	17-7w-18	Quitobaquito Springs, Ariz.	3
Quitobaquito Springs	17-7w-18	Quitobaquito Springs, Ariz.	3
Romero Canyon	12-14-1,2	Mt Lemmon, Ariz; Oro Valley, Ariz.	3
Ruelas Canyon	11-13-8	Ruelas Canyon, AZ	2
Sabino Creek (lower)	12-15-26,35/13-15-2,3,9,10	Sabino Canyon, AZ	3
Sabino Creek (mid)	12-15-1,11,12,14,15,22,23,26	Mt Lemmon, Ariz; Sabino Canyon, AZ	3
Sabino Creek (upper)	11-15-25/11-16-30,31/12-16-6	Mt Lemmon, Ariz.	3
San Pedro River	12-18-23	Redington, Ariz.	2
San Pedro River	11-18-10,15	Redington, Ariz.	2
Santa Cruz River	12-12-35/13-12-1,2/13-13-6,7,17,18,20,21	Jaynes, Ariz.	3
Scholefield Spring	18-16-16	Empire Ranch, Ariz.	1
Simpson Spring	19-18-12	Apache Peak, Ariz.	2

Perennial Stream Reach	Cadastral Location	USGS Topographic Map	Certainty
Tanque Verde (upper)	13-16-36	Agua Caliente Hill, Ariz.	2
Wakefield Canyon	18-18-11,12	Mescal, Ariz.	3
Wakefield Canyon	18-18-2	Mescal, Ariz.	3
Wakefield Canyon	17-18-35/18-18-2	Mescal, Ariz.	3
Wakefield Canyon	17-18-27	Mescal, Ariz.	3
Wild Burro Canyon	11-13-5,6	Tortolita Mountains, Arizona	2
Wild Burro Canyon	11-12-1,12	Ruelas Canyon, Ariz.	2
Wild Burro Canyon	11-13-5,6	Tortolita Mountains, Arizona	2
Wild Burro Canyon	11-13-5,6	Tortolita Mountains, Arizona	2
Wild Burro Canyon	11-12-1,12	Ruelas Canyon, Ariz.	2
Wild Cow Spring	19-18-12	Apache Peak, Ariz.	1
Youtcy Canyon	13-18-4	Piety Hill, Ariz.	2
Youtcy Canyon	13-18-5,6	Piety Hill, Ariz.	2

Perennial Stream Coverage

Perennial Stream Name	*Tree Species Identified*	*Environmental Features*
Apache Spring		
Arivaca Creek		
Bingham Cienega	velvet ash, goodding willow, mesquite	
Buehman Canyon	velvet mesquite, arizona ash, fremont cottonwood, goodding willow, juniper, arizona sycamore	longfin dace, leopard frogs, unique waters designation
Buehman Canyon	velvet mesquite, arizona ash, fremont cottonwood, goodding willow, juniper, arizona sycamore	longfin dace, leopard frogs, unique waters designation
Buehman Canyon		longfin dace, leopard frogs
Bullock Canyon		longfin dace, leopard frogs
Canada del Oro	ponderosa pine, gambel oak, gray oak, douglas fir, alder, white fir, arizona sycamore, fremont cottonwood, willow	
Cienega Creek (lower)	fremont cottonwood, goodding willow, mesquite	longfin dace, leopard frogs, migratory birds
Cienega Creek (lower)	fremont cottonwood, goodding willow, mesquite	longfin dace, leopard frogs, migratory birds
Cienega Creek (lower)	fremont cottonwood, goodding willow, mesquite	longfin dace, leopard frogs, migratory birds
Cienega Creek (lower)	fremont cottonwood, goodding willow, mesquite	longfin dace, leopard frogs, migratory birds
Cienega Creek (lower)	fremont cottonwood, goodding willow, mesquite	longfin dace, leopard frogs, migratory birds
Cienega Creek (lower)	fremont cottonwood, goodding willow, mesquite	longfin dace, leopard frogs, migratory birds

Perennial Stream Name	*Tree Species Identified*	*Environmental Features*
Cienega Creek (upper)	fremont cottonwood, goodding willow, mesquite arizona ash	gila topminnow, gila chub, longfin dace
Cienega Creek (upper)	goodding willow, fremont cottonwood, arizona ash, mesquite	gila topminnow, gila chub, longfin dace, leopard frogs
Cienega Creek (upper)	goodding willow, fremont cottonwood, arizona ash, mesquite	gila topminnow, gila chub, longfin dace, leopard frogs
Cinco Canyon		
Davidson Canyon	ash, goodding willow, hackberry, mesquite, seepwillow	2 species of fish, frogs
Edgar Canyon	ash, willow	leopard frogs, fish
Empire Gulch	fremont cottonwood, goodding willow, mesquite	
Empire Gulch	goodding willow, fremont cottonwood, mesquite	
Espiritu Canyon		
Honey Bee Canyon	goodding willow, seep willow, fremont cottonwood, hackberry, mesquite	red-spotted toad, black-necked garter snake, migratory birds
Lemmon Creek		non-native brown trout (stocked by AZ Game and Fish)
Little Nogales Spring		leopard frogs, tadpoles; possible topminnow reintroduction site
Mattie Canyon	fremont cottonwood, goodding willow	gila chub
Montosa Canyon		
Nogales Spring	oak, walnut, hackberry, sycamore	leopard frogs, turtles, coati; possible topminnow

Perennial Stream Name	*Tree Species Identified*	*Environmental Features*
Posta Quemada	cottonwood, willow, mesquite	
Quitobaquito Pond	fremont cottonwood, mesquite, goodding willow	quitobaquito pupfish
Quitobaquito Springs	fremont cottonwood, mesquite, goodding willow	quitobaquito pupfish
Romero Canyon	willow, arizona ash, arizona sycamore, white oa many-seeded juniper, mexican blue oak	green sunfish
Ruelas Canyon	cottonwood-willow series	
Sabino Creek (lower)	fremont cottonwood, velvet mesquite, mexican blue oak, arizona ash, arizona sycamore, arizo walnut, willow	gila chub
Sabino Creek (mid)	arizona ash, fremont cottonwood, arizona sycamore, emory oak, alligator juniper, silverlea oak	frogs, tadpoles, lizards; possible topminnow reintroduction site
Sabino Creek (upper)	multi-seeded juniper, white fir, arizona white oa douglas fir, mexican blue oak, silverleaf oak, gr oak, arizona ash, ponderosa pine, gambel oak, aspen	chub in Soldier Lake
San Pedro River		
San Pedro River		
Santa Cruz River		
Scholefield Spring		
Simpson Spring	juniper, oak	
Tanque Verde (upper)		fish, turtles
Wakefield Canyon	sycamore, willow, walnut, hackberry, mesquite, ash, cottonwood	leopard frogs

Perennial Stream Name	Tree Species Identified	Environmental Features
Wakefield Canyon	sycamore, willow, ash, cottonwood, walnut, hackberry, mesquite	leopard frogs
Wakefield Canyon	walnut, sycamore, cottonwood	
Wakefield Canyon	cottonwood, seepwillow, ash	longfin dace
Wild Burro Canyon	cottonwood-willow series	
Wild Burro Canyon	cottonwood-willow series	
Wild Burro Canyon	cottonwood-willow series	
Wild Burro Canyon	cottonwood-willow series	
Wild Burro Canyon	cottonwood-willow series	
Wild Cow Spring		leopard frogs
Youtcy Canyon		leopard frogs
Youtcy Canyon		

APPENDIX F. INTERMITTENT STREAMS

Intermittent Stream Coverage

Intermittent Stream Reach	Cadastral Location	USGS Topographic Map	Certainty
Agua Verde Creek	16-17-8,9,13,14,15,16/16-18-15,16,17,18,22	Rincon Peak; Galleta Flat West; Vail, Ariz.	2
Alder Canyon	11-16-13	Mount Bigelow, Ariz.	1
Arivaca Creek	21-10-34	Arivaca, Ariz.	3
Ash Creek	15-18-23,25,26,36	Galleta Flat West, Ariz.	2
Atchley Canyon	11-16-23,24	Mount Bigelow, Ariz.	2
Barrel Canyon	18-16-14,15	Empire Ranch, Ariz.	2
Bear Canyon (lower)	12-15-36/12-16-31/13-16-1,2,10,11,15	Sabino Canyon, AZ; Agua Caliente Hill, Ariz.	3
Bear Canyon (upper)	12-16-28,29,31,32	Agua Caliente Hill, Ariz.	2
Bear Creek	14-18-25	Happy Valley, Ariz.	2
Bootlegger Spring	17-18-31	The Narrows, Ariz.	2
Box Canyon (rincon)	14-16-34,35/15-16-3,4,9	Tanque Verde Peak, Ariz.	2
Brown Canyon	19-18-17,18,20,21	Baboquivari Peak, Ariz.	1
Buehman Canyon	12-17-24/12-18-18,19	Buehman Canyon, Ariz.	3
Buehman Canyon	12-17-14,15	Buehman Canyon, Ariz.	3
Bullock Canyon	12-17-24/12-18-19	Buehman Canyon, Ariz.	2
Bullock Canyon	12-17-34,35	Piety Hill, Ariz.	3
Bullock Canyon	12-17-24	Piety Hill, Ariz.	2
Canada Agua	11-13-15	Ruelas Canyon, Ariz.	2
Canada del Oro	11-15-2,11	Mt Lemmon, Ariz.	2
Cargodera Canyon	11-14-25,26,27/11-15-31,32	Oro Valley, Ariz.; Mt Lemmon, Ariz.	2
Chiminea Canyon	14-17-27,33/15-17-4,9,16	Mica Mountain, Ariz.	2

Intermittent Stream Reach	Cadastral Location	USGS Topographic Map	Certainty
Chimney Canyon	16-17-1,12/16-18-6	Rincon Peak, Ariz.	2
Cienega Creek (upper)	18-18-6	The Narrows, Ariz.	3
Cienega Creek (upper)	18-17-23,26,34,35/19-17-3	Spring Water Canyon, Ariz.	3
Cienega Creek(lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek(lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek(lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek(lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek(lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Cienega Creek(lower)	16-16-14,23,24/16-17-19,20,28,29,30,34,35	Vail; The Narrows; Rincon Peak, Ariz.	3
Davidson Canyon	17-16-31	Mount Fagan, Ariz.	2
Davidson Canyon	16-17-30	Vail, Ariz.	3
Davidson Canyon	17-17-6	Mount Fagan, Ariz.	2
Deer Creek	14-18-23	Happy Valley, Ariz.	1
Distillery Canyon	16-18-5,7,8	Rincon Peak, Ariz.	2
East Fork Sabino Canyon	12-15-25,26	Sabino Canyon, Ariz.	1
Espiritu Canyon	13-18-22,27	Soza Canyon, Ariz.	2
Finger Rock Canyon	12-14-34	Tucson North, Ariz.	3
Florida Canyon	19-15-19,30,31,32	Mt. Wrightson; Helvetia, Ariz.	3
Gardner Canyon	19-17-10,15	Spring Water Canyon, Ariz.	3
Geesaman Wash	11-16-15	Mount Bigelow, Ariz.	1
La Milagrosa Canyon	13-16-16	Agua Caliente Hill, Ariz.	1
Madera Canyon	19-14-35	Mt Hopkins, Ariz.	2

Intermittent Stream Reach	Cadastral Location	USGS Topographic Map	Certainty
Madrona Canyon	14-17-27,34/15-17-3,10,16	Mica Mountain, Ariz.	2
Mattie Canyon	18-17-26	Spring Water Canyon, Ariz.	3
Miller Creek	15-18-2,3,11/14-18-33,34	Happy Valley, Ariz.	3
Molino Canyon	13-16-3,9,16/12-16-26,34,35	Agua Caliente Hill, Ariz.	2
Mud Spring Canyon	19-18-21	Spring Water Canyon, Ariz.	2
Paige Creek	15-18-11,12	Happy Valley, Ariz.	3
Paige Creek	15-18-1	Happy Valley, Ariz.	2
Palisade Canyon Creek	12-15-24,25/12-16-8,18,19	Mount Bigelow; Mt Lemmon; Sabino Canyon, AZ	1
Peck Basin	11-16-35,36	Mount Bigelow, Ariz.	1
Pima Canyon	12-14-28,29	Tucson North, Ariz.	2
Rincon Creek	15-17-9,10,11,16,17,18/15-16-1,12,13	Mica Mountain;Vail, Ariz.;Tanque Verde Peak, Ariz.	3
Romero Canyon (lower)	12-14-2,4/11-14-33,34,35	Oro Valley, Ariz.	3
Romero Canyon (upper)	12-15-7/12-14-1	Mt. Lemmon, Ariz.	2
Rose Canyon Creek	12-16-15,16	Mount Bigelow, Ariz.	1
Sabino Canyon	13-15-16,21,22,28,33	Sabino Canyon, Ariz.	3
San Pedro River	12-18-2,3,11,12,13/11-18-23,26,27,34	Redington, Ariz.	2
San Pedro River	11-18-14,15,23	Redington, Ariz.	2
San Pedro River	11-18-3,10	Redington, Ariz.; Kielberg, Ariz.	2
Santa Cruz River	12-12-35 thru 11-10-14	Jaynes; Ruelas Canyon; Marana; West of Marana,Ariz	3
Smitty Spring	17-18-28	The Narrows, Ariz.	2
Soldier Canyon	13-16-5,7	Agua Caliente Hill, Ariz.	2
Sutherland Wash	11-14-12,13,14,23,26,27,34/12-14-3,4	Oro Valley, Ariz.; Mt. Lemmon, Ariz.	2

Intermittent Stream Reach	Cadastral Location	USGS Topographic Map	Certainty
Sycamore Canyon	12-16-30,31	Sabino Canyon, AZ; Agua Caliente, Ariz.	2
Tanque Verde Creek (lower)	13-15-30,31,32/13-14-25	Tucson North, Ariz.	2
Tanque Verde Creek (mid)	14-16-2,3,4	Tanque Verde Peak, Ariz.	3
Tanque Verde Creek (upper)	13-17-26,27,32,33,34	Piety Hill, Ariz.; Agua Caliente Hill, Ariz.	3
Tanque Verde Creek (upper)	13-17-31	Agua Caliente Hill, Ariz.	3
Tanque Verde Creek (upper)	13-16-36/14-16-1	Agua Caliente Hill, Ariz.	3
Thomas Canyon	19-7-24,25,36/19-8-30,31	Baboquivari Peak; Mildred Peak, Ariz.	1
Turkey Creek	15-18-1,2/14-18-34,35	Happy Valley, Ariz.	2
Unnamed Spring	17-18-33/18-18-4	The Narrows, Ariz.	2
Unnamed tributary to Ash Creek	15-18-25,26	Galleta Flat West, Ariz.	1
Ventana Canyon	12-14-24,25/12-15-30,31/13-15-6,7,8	Sabino Canyon, Ariz.	2
Ventana Canyon	13-15-17	Sabino Canyon, Ariz.	3
Ventana Canyon	13-15-17,20,29,30	Sabino Canyon, Ariz.	3
Wakefield Canyon	18-18-2	Mescal, Ariz.	3
West Fork Sabino Creek	12-15-8,16,22	Mt Lemmon, Ariz.	1
Youtcy Canyon	13-18-5	Piety Hill, Ariz.	2
Youtcy Canyon	13-18-4	Piety Hill, Ariz.	2

Intermittent Stream Coverage

Intermittent Stream Name	*Tree Species Identified*	*Environmental Features*
Agua Verde Creek	cottonwood, ash, mesquite, willow	fish upstream Posta Quemada Canyon confluence
Alder Canyon	alder, arizona sycamore, hackberry tree, arizona ash, gray oak, arizona walnut, alligator juniper	bewick's wren, canyon wren, gil woodpecker
Arivaca Creek	cottonwood, mesquite	
Ash Creek	arizona sycamore, fremont cottonwood, juniper, hackberry tree, mesquite	
Atchley Canyon	emory oak, arizona sycamore, alder, hackberry tree, juniper, arizona ash, arizona walnut	
Barrel Canyon	mesquite, juniper, oak, hackberry	
Bear Canyon (lower)	arizona sycamore, arizona ash, fremont cottonwood, willow	
Bear Canyon (upper)	sycamore, willow, cottonwood, ash, oak, juniper	
Bear Creek	velvet mesquite, arizona ash, hackberry tree, one-seed juniper, poplar	tadpoles, frogs, horned toad
Bootlegger Spring	willow, seep willow, cottonwood, ash, mesquite, oak, juniper	
Box Canyon (rincon)		leopard frogs in pools in upper reaches
Brown Canyon	sycamore, mesquite	
Buehman Canyon		
Buehman Canyon		
Bullock Canyon		
Bullock Canyon	arizona sycamore, mesquite, juniper, hackberry tree, arizona ash, arizona walnut	

Intermittent Stream Name	*Tree Species Identified*	*Environmental Features*
Bullock Canyon		
Canada Agua	mesquite, desert willow	
Canada del Oro	ponderosa pine, gambel oak, gray oak, douglas fir, ald white fir, arizona sycamore, fremont cottonwood, willow	
Cargodera Canyon	arizona ash, velvet mesquite, hackberry tree	frogs, mud turtle
Chiminea Canyon		leopard frogs in pools in upper reaches
Chimney Canyon	arizona ash, velvet mesquite, hackberry tree	
Cienega Creek (upper)	goodding willow, arizona ash, mesquite	
Cienega Creek (upper)	goodding willow, fremont cottonwood, mesquite	
Cienega Creek(lower)	fremont cottonwood, goodding willow, mesquite	
Cienega Creek(lower)	fremont cottonwood, goodding willow, mesquite	
Cienega Creek(lower)	fremont cottonwood, goodding willow, mesquite	
Cienega Creek(lower)	fremont cottonwood, goodding willow, mesquite	
Cienega Creek(lower)	fremont cottonwood, goodding willow, mesquite	
Cienega Creek(lower)	fremont cottonwood, goodding willow, mesquite	
Davidson Canyon	ash, goodding willow, seepwillow, mesquite, hackberry	
Davidson Canyon	cottonwood, willow, mesquite	fish
Davidson Canyon	ash, gooding willow, seepwillow, hackberry, mesquite	frogs
Deer Creek	velvet mesquite, arizona sycamore, arizona white oak. one-seeded juniper	frogs

Intermittent Stream Name	*Tree Species Identified*	*Environmental Features*
Distillery Canyon	arizona ash, willow, velvet mesquite, hackberry tree	
East Fork Sabino Canyon	oak, juniper, ash	
Espiritu Canyon		
Finger Rock Canyon	fremont cottonwood, seepwillow	many canyon tree frogs, whipsnake
Florida Canyon	arizona ash, arizona sycamore, hackberry tree, mesquite, mexican blue oak	
Gardner Canyon	fremont cottonwood, goodding willow, arizona ash	
Geesaman Wash	goodding willow, velvet mesquite, hackberry tree,mexican blue oak, juniper, fremont cottonwood	
La Milagrosa Canyon	fremont cottonwood	
Madera Canyon	alligator juniper, arizona sycamore, silverleaf oak, net leaf oak, black oak, arizona ash, willow, fremont cottonwood	
Madrona Canyon		leopard frogs in pools in upper reaches
Mattie Canyon	fremont cottonwood, goodding willow	gila chub
Miller Creek	arizona sycamore, fremont cottonwood, arizona ash, hackberry tree, emory oak, mesquite	
Molino Canyon	fremont cottonwood, arizona ash, goodding willow, arizona white oak, alligator juniper, emory oak	
Mud Spring Canyon	arizona ash, fremont cottonwood, juniper	
Paige Creek	arizona sycamore, fremont cottonwood, arizona ash, hackberry tree, emory oak, velvet mesquite	
Paige Creek	arizona sycamore, fremont cottonwood, arizona ash, juniper, arizona hackberry, emory oak	
Palisade Canyon Creek		
Peck Basin		

Intermittent Stream Name	*Tree Species Identified*	*Environmental Features*
Pima Canyon	fremont cottonwood, velvet mesquite, arizona ash, hackberry, alder	bewick's wren
Rincon Creek	arizona walnut, fremont cottonwood, gooding willow, mesquite	leopard frogs in pools in upper reaches; topminnow
Romero Canyon (lower)	ash, mesquite	
Romero Canyon (upper)		
Rose Canyon Creek		
Sabino Canyon	mesquite, mixed broadleaf deciduous woodland	
San Pedro River		
San Pedro River		
San Pedro River		
Santa Cruz River		
Smitty Spring	cottonwood, ash	
Soldier Canyon	fremont cottonwood, willow, mesquite	frogs, tadpoles
Sutherland Wash	fremont cottonwood, arizona ash, velvet mesquite, hackberry tree	
Sycamore Canyon	sycamore, ash, alder, willow, oak, juniper	
Tanque Verde Creek (lower)		
Tanque Verde Creek (mid)		
Tanque Verde Creek (upper)	juniper, arizona ash, goodding willow, arizona walnut, fremont cottonwood, velvet mesquite	
Tanque Verde Creek (upper)	fremont cottonwood, arizona ash, velvet mesquite	frogs, frog eggs

Intermittent Stream Name	*Tree Species Identified*	*Environmental Features*
Tanque Verde Creek (upper)		
Thomas Canyon		
Turkey Creek	arizona sycamore, hackberry tree, arizona ash	
Unnamed Spring	ash	
Unnamed tributary to Ash Creek	arizona sycamore, hackberry, mesquite	
Ventana Canyon	cottonwood, mesquite	frogs, tadpoles above resort
Ventana Canyon	willow, cottonwood, mesquite	
Ventana Canyon	mesquite	
Wakefield Canyon	willow	
West Fork Sabino Creek		
Youtcy Canyon		
Youtcy Canyon		

APPENDIX G. Basis for Streamflow Extent Delineations

APPENDIX G
SONORAN DESERT CONSERVATION PLAN
STREAMS AND GROUNDWATER GIS COVERAGES
BASIS FOR STREAM FLOW EXTENT DELINEATIONS

Agua Verde Creek

Agua Verde Creek was determined to have intermittent flow based on field observations by Cheryl Karrer and Staffan Schorr in November 1999. Beginning of flow was arbitrarily drawn at the headwaters. End of intermittent flow was drawn near the Posta Quemada Canyon confluence based on fish and flow observations in 1998 by Dave Bertelsen. A document by the Sonoran Institute (1999) listed the Agua Verde corridor as a perennial water source. Although several sources have observed flow in this creek, the locations for beginning and end of flow were less documented. This creek may have perennial water. Very little information was available for this creek and no long term monitoring documentation was available.

Alder Canyon

Alder Canyon was determined to have intermittent flow based on a USFS RASES survey conducted in August 1998. GPS and township/range/section location information was provided. The length of this intermittent reach was arbitrarily drawn as the length of the creek that crosses the Section where the USFS RASES survey was conducted (i.e., beginning of flow at the west edge and end of flow at east edge of Section 13). No other source of stream flow information was available for this creek.

Apache Spring

Apache Spring was determined to have perennial flow based on a document by the Sonoran Institute (1999). This document listed Apache Spring as a perennial water source. No additional documentation or descriptive information was available.

Arivaca Creek

Arivaca Creek was determined to have both perennial and intermittent flow based on personal communication with John Regan, a resident of Arivaca. Beginning and end of flow locations were drawn according to Regan's observations. ADWR's Arizona Water Resources Assessment (1994b) labeled Arivaca Creek as a perennial stream. A color infrared digital ortho quad (DOQ) shows evidence for perennial and intermittent water. An instream flow claim also exists along this creek (ADWR 1994c). No other documentation on stream flow was available.

Ash Creek

Ash Creek was determined to have intermittent flow based on field observations in October 1999 and previous years by Staffan Schorr. In October 1999, pools were present along the entire reach within Pima County and into Cochise County. A USFS RASES survey was conducted along the creek in Pima County, however no documentation of flow was included in the results. No other stream flow documentation was available.

Atchley Canyon

Atchley Canyon was determined to have intermittent flow based on a USFS RASES survey conducted in August 1998. Water was present at the time of the RASES survey. The length of this intermittent reach was arbitrarily drawn as the length of the creek that

crosses the Section where the USFS RASES survey was conducted (i.e., beginning of flow at the west edge and end of flow at north edge of Section 23). No other stream flow documentation was available.

Barrel Canyon

Barrel Canyon was determined to have intermittent flow based on field observations by Staffan Schorr in September and October 1999 and in previous years. Pools and flow were observed where Barrel Canyon crosses Hwy 83. Barrel Spring, located near the Davidson Canyon confluence, was listed as a perennial water source in a document by the Sonoran Institute (1999). A USFS RASES survey was conducted upstream of the flow observations in September 1999, however no flow or pools were observed. No other stream flow documentation was available.

Bear Canyon

Intermittent flow was well documented for lower Bear Canyon in the Sabino Canyon Recreation area by USFS RASES and Motschall (1976). Bob Magon and other Coronado National Forest staff confirmed that Bear Canyon flows for several months in most years in response to snowmelt. Magon reported that flow usually ends at the Wilderness Boundary. The upper portion of Bear Canyon was determined to have intermittent flow based on the description of flow by Coronado National Forest staff and by field observations at Sycamore Reservoir in spring and early summer 1998 and 1999 by Staffan Schorr. Beginning of flow was arbitrarily drawn near the headwaters. No other stream flow documentation was available for the upper portion of Bear Canyon.

Bear Creek

Bear Creek was determined to have intermittent flow based on a USFS RASES survey conducted in September 1998. Flow was not documented, however frogs and tadpoles were observed. The length of this intermittent reach was arbitrarily drawn as the length of the creek that crosses the Section where the USFS RASES survey was conducted (i.e., beginning of flow at the west edge and end of flow at east edge of Section 25). Bob Lefevre of the U.S. Forest Service suggested that if flow existed in a steep portion of a canyon, then flow would probably exist until the topography flattens out. The steep topography in Bear Creek, shown on the USGS topographic map, suggested that flow most likely would be present upstream of the reach where the RASES survey was conducted. Therefore, beginning of flow was extended upstream a small distance to a location where the canyon topography was no longer as steep. End of flow was drawn at the county line. Intermittent flow may exist in Bear Creek within Cochise County. Very little documentation was available for this creek.

Bingham Cienega

Bingham Cienega was determined to have perennial water based on observations by PAG staff and a report by Julia Fonseca (1998). PAG staff conducted quarterly water quality sampling at Bingham Cienega during 1999. Water was present throughout the year. The Nature Conservancy, Arizona Chapter confirmed this designation.

Bootlegger Spring

Bootlegger Spring was determined to have intermittent flow based on maps and personal field notes provided by Julia Fonseca. The observations were made in April 1994. The Sonoran Institute (1999) listed Bootlegger Spring as a perennial water source. No other stream flow documentation was available.

Box Canyon (Rincon Mtns)

Box Canyon was determined to have intermittent flow based on personal communication with Natasha Kline and Don Swan of Saguaro National Park East. Some portions of this canyon may have perennial water with leopard frogs. Beginning of flow was arbitrarily drawn based on the conversations with National Park staff. End of flow was drawn where the canyon opens up into the valley floor. No other stream flow documentation was available.

Brown Canyon

Brown Canyon was determined to have intermittent flow based on personal communications with Buenos Aires National Wildlife Refuge staff members. According to the Wildlife Biologist at the Refuge, Brown Canyon has flow that could be classified as intermittent and end of flow could be marked approximately three miles upstream of Hwy 286. No other stream flow documentation was available.

Buehman Canyon

Nature Conservancy staff have visited Buehman Canyon on several occasions. Beginning and end of intermittent and perennial flows were based on Nature Conservancy observations during various years and field observations by Cheryl Karrer in October 1999. No exact dates of observations by the Nature Conservancy were available. This canyon has been fairly well documented and monitored.

Bullock Canyon

Bullock Canyon was determined to have both perennial and intermittent flow based on field observations by staff of the Arizona Chapter of the Nature Conservancy in 1997 and 1998. Locations for beginning and end of perennial and intermittent flows were based on Nature Conservancy observations. A USFS RASES survey was conducted along Bullock Canyon, however no notes about the presence or absence of water were included. No other stream flow documentation was available.

Canada Agua

Canada Agua was determined to have intermittent flow based on observations made by Harris Environmental Group in June 1998 and observations made by Hector Conde. Harris Environmental Group (1998) described a "steady flow of water" from a pipe in a dam along this canyon. Descriptive text provided by Hector Conde describes Canada Agua as having hydroriparian vegetation along with perennial water. No dates of observations were included in Conde's text. This reach was categorized as intermittent due to the lack of documentation. However, perennial water may exist in Canada Agua. No other source of information on stream flow was available for this canyon.

Canada del Oro

Canada del Oro (CDO) was determined to have intermittent and perennial flows based on a USFS RASES surveys conducted June 1998 and GIS Streams coverage provided by the U.S. Forest Service. RASES surveys were conducted at two locations along the upper portions of CDO in Pima County and flow was designated to be intermittent at both locations. Originally, the length of intermittent flow in CDO was drawn to connect the two survey locations and end at the county line. However, the USFS GIS coverages for streams within the National Forest designated CDO as perennial. The USGS 7.5 Minute topographic map of the area also has CDO designated as perennial. The beginning and end of perennial flow locations were drawn according to the maps and GIS coverages available. Intermittent flow continues to the county line and possibly into

Pinal County (USFS RASES). No evidence of surface flow was available for the portion of CDO that re-enters Pima County and flows south.

Cargodera Canyon

A USFS RASES survey was conducted just inside the National Forest Boundary along Cargodera Canyon in September 1998. Flow and a large pool was observed at the survey location. Beginning of flow was determined to be just inside the National Forest boundary based on a schematic drawing included in the RASES notes. End of flow was extended a small arbitrary distance downstream of the Boundary with the assumption that flow would have continued beyond the survey location. No other source of stream flow information was available.

Chiminea Canyon

Chiminea Canyon was determined to have intermittent flow based on personal communication with Natasha Kline and Don Swan of Saguaro National Park East. Some portions of this canyon may have perennial pools with leopard frogs. Mr. Swan reported that the creek flows to Rincon Creek in most years in response to snowmelt. Beginning of flow was arbitrarily drawn according to information from conversations with National Park staff. No other stream flow documentation was available.

Chimney Canyon

Chimney Canyon was determined to have intermittent flow based on USFS RASES survey conducted in November 1998. Flow was observed at the time of the survey. Beginning of flow was based on locations of springs along the creek as shown on the Rincon Peak USGS 7.5.Minute topographic map. Originally, end of flow was drawn at the National Forest Boundary due to lack of documentation downstream of that location. However, additional information provided by various people who attended a meeting for the Sonoran Desert Conservation Plan Steering Committee gave evidence that intermittent flow would continue to Agua Verde Creek. No other stream flow documentation was available for this canyon.

Cienega Creek

Cienega Creek was determined to have perennial and intermittent flow in both its upper and lower portions based on stream monitoring by the Bureau of Land Management (BLM) and by PAG. The BLM manages the upper portion of Cienega Creek and has conducted riparian assessments along the creek and its tributaries in 1988, 1989, and 1993. The beginning and end of flow locations are based on maps and assessment sheets provided by Karen Simms of BLM. Additional sources provided stream flow information for the reach near the Narrows. The upper Cienega Creek was well documented with reliable sources.

The lower portion of Cienega Creek is managed by Pima County Parks and Recreation, but PAG has conducted monthly stream flow and well water level monitoring since the late 1980's. The beginning and end of flow locations are based on field observations by PAG staff in late June 1999. The lower Cienega Creek was well documented with reliable sources.

Cinco Canyon

Cinco Canyon was determined to have perennial water based on observations made BLM staff. BLM (1999) described this area as having seven natural ponds. Five of the seven ponds were documented to have perennial water. Mud turtles and leopard frogs were observed in these ponds. Julia Fonseca provided a description of this document

and the reference information. No other source of information was available for this reach.

Davidson Canyon

Davidson Canyon was determined to have both perennial and intermittent flow based on field observations by several sources. Field visits by Julia Fonseca, Mike Block, and Greg Hess in May 1996 and Greg Hess and Staffan Schorr in December 1999 documented a perennial reach upstream of the I-10 crossing. Two species of fish were observed in flowing water at a bedrock outcrop in May 1996. Descriptive text of Fonseca, Block, and Hess's field observations, including location information on beginning and end of flow, was provided. Hess and Schorr visited the site and observed flow and large pools with many fish (notes provided). PAG staff monitored flow extent at locations near the I-10 crossing from 1989 to 1994. Davidson Canyon does not have surface flow downstream of I-10 until intermittent flow surfaces near the Cienega Creek confluence. This reach of intermittent flow has been monitored by PAG since 1993. No documentation of flow was available for the upper portions of Davidson Canyon.

Deer Creek

Deer Creek was determined to have intermittent flow based on a USFS RASES survey conducted in September 1998. Flow was not documented, however frogs were observed. Initially, the length of this intermittent reach was arbitrarily drawn as the length of the creek that crosses the Section which the USFS RASES survey was conducted (i.e., beginning of flow at the west edge and end of flow at east edge of Section 23). However, Bob Lefevre of the U.S. Forest Service suggested that if flow existed in a steep portion of a canyon, then flow would probably exist until the topography flattens out. The USGS topographic map showed that the canyon's steep topography continued downstream to the county line. This suggested that flow would most likely continue to at least that location. Therefore, end of flow was extended to the location where topography flattened out. Very little documentation was available for this creek.

Distillery Canyon

Distillery Canyon was determined to have intermittent flow based on a USFS RASES survey conducted November 1998. Flow was observed at the time of the survey. Beginning of flow was based on locations of springs along the creek as shown on the Rincon Peak USGS 7.5 Minute topographic map. Originally, end of flow was drawn at the National Forest Boundary due to the lack of documentation downstream of that location. However, additional information provided by various people who attended a meeting for the Sonoran Desert Conservation Plan Steering Committee gave evidence that intermittent flow would continue to Agua Verde Creek. No other sources of stream flow information were available for this canyon.

East Fork Sabino Canyon

East fork Sabino Canyon was determined to have intermittent flow based on personal field notes provided by Staffan Schorr. Moist soil and pools were present in November 1999. No further documentation was available for this canyon.

Edgar Canyon

A portion of Edgar Canyon was determined to have perennial flow based on field observations by PAG staff. PAG staff conducted quarterly water quality sampling in this portion of Edgar Canyon in 1999. Personal field notes from October 1999 provided by Cheryl Karrer confirmed the beginning and end of perennial flow. This portion of Edgar

Canyon has been fairly well documented. No additional source of stream flow information was available for any other portion of the canyon.

Empire Gulch

Empire Gulch was determined to have perennial reaches based on surveys conducted in 1989 and 1993 by the Bureau of Land Management (BLM). Karen Simms of BLM's Tucson office provided riparian analysis data sheets for each reach of Empire Gulch along with a Spring Water Canyon USGS 7.5 Minute topographic map with perennial reach lengths and riparian areas marked on it. This area has been thoroughly documented and monitored since 1989, when the BLM assumed ownership of the Empire-Cienega area.

Espiritu Canyon

Espiritu Canyon was determined to have both perennial and intermittent flow based on field observations by the Arizona Chapter of the Nature Conservancy. Nature Conservancy staff provided a summary of their field observations and a map showing beginning and end of intermittent and perennial flow for Espiritu Canyon. The dates of the observations were not included. A USFS RASES survey was conducted upstream of the location marked to be beginning of intermittent flow by Nature Conservancy. The RASES survey notes did not include documentation on the presence or absence of water at the survey location, therefore intermittent flow was not extended to that location.

Finger Rock Canyon

Finger Rock Canyon was determined to have intermittent flow based on a USFS RASES survey conducted in September 1998. The RASES transect was described to be located within a "1.5 mile hike on the Finger Rock trail". One pool was observed in this reach of the canyon. Information provided by people attending a Sonoran Desert Conservation Plan Steering Committee meeting suggested that Finger Rock Spring might provide perennial water. Originally, intermittent flow was marked to begin just above Finger Rock Spring. However, Dave Bertelsen provided a map showing intermittent flow beginning at the headwaters. The location of beginning of flow was drawn according to Bertelsen's observations. End of flow was marked at the National Forest boundary due to lack of information otherwise and because the topography of the canyon flattens out at that point.

Florida Canyon

Florida Canyon was determined to have intermittent flow based on a USFS RASES survey conducted in July 1999 and personal communication with a resident of the canyon. The RASES survey location was near the Santa Rita Work Center. Charlie Plumb from the Santa Rita Experimental Range lives at the Work Center, which is located near the bottom of Florida Canyon. He reported that the creek flows due to snowmelt for several months each year, in most years. He recalled that flow usually ends where the canyon flattens out to the valley floor. End of flow was marked at the location where topography flattens out. Mr. Plumb also reported that there are perennial springs near the headwaters that are developed, but usually have some flow in the creek. Beginning of intermittent flow was marked at the headwaters. No perennial flow was represented in Florida Canyon for this project due to the lack of documentation.

Gardner Canyon

Gardner Canyon was determined to have intermittent flow near the confluence with Cienega Creek based on information provided by BLM staff. Beginning and end of flow locations were marked on maps and described in riparian assessment sheets provided

by Karen Simms of BLM. This reach of Gardner Canyon was assessed by the BLM in 1988-89 and 1993. No other stream flow documentation was found for portions of this canyon within Pima County.

Geesaman Wash

Geesaman Wash was determined to be intermittent based on a USFS RASES survey conducted in August 1998. Water was present at the time of the survey. The length of this intermittent reach was arbitrarily drawn as the length of the creek that crosses the Section where the USFS RASES survey was conducted (i.e., beginning of flow at the west edge and end of flow at east edge of Section 15). No other source of stream flow information was available.

Honey Bee Canyon

Honey Bee Canyon was determined to have perennial flow based on information provided by residents of Oro Valley and by the Honey Bee Canyon Master Plan. Beginning and end of flow locations were marked based on existing hydrologic conditions described in Chapter 2 of the Honey Bee Canyon Master Plan (CBD/Planning 1994). Exhibit 9 of the Master Plan showed vegetation assemblages along the canyon. The reach described as having perennial water was also shown to have aquatic vegetation and cottonwood trees. Field observations by Cheryl Karrer in November 1999 confirmed this information. Personal communication with Hector Conde of Oro Valley Neighborhood Coalition also suggested the presence of perennial water in the canyon. No additional sources of information on stream flow were available for Honey Bee Canyon.

La Milagrosa Canyon

La Milagrosa Canyon was determined to have intermittent flow based on field observations by Staffan Schorr in late spring 1998 and observations by Steven Hopp. This canyon was not well documented. Notes from field observations in April 1998 by Schorr stated that pools were present in the canyon. No other sources of stream flow information were available for this canyon.

Lemmon Creek

Lemmon Creek was determined to have perennial water based on information from a variety of sources. The USGS 7.5 Minute topographic map of the area and maps in ADWR's Water Resources Assessment (1994b) show Lemmon Creek as perennial. A long-time visitor of the creek submitted information for this creek via the electronic survey on PAG's website. This information agreed with the perennial designation. Beginning of flow was arbitrarily drawn according to observations made by local residents who frequently hike in this area. Several residents have also reported that Tucson's local newspapers have written articles related to trout fishing in Lemmon Creek. Arizona Game and Fish reportedly stocked this creek with trout until the mid-1980's. The hydrology and vegetation of this creek have not been well documented.

Little Nogales Spring

Little Nogales Spring was determined to have perennial flow based on information provided by the BLM and Julia Fonseca and a report by the Arizona Game and Fish Department (Weedman and Young 1997). All three sources agree that perennial flow exists at this spring, however the length of flow varied between the sources. Maps provided by Karen Simms of BLM's Tucson office showed the perennial reach as being much longer than the maps and field notes provided by Julia Fonseca (1997). Beginning of flow was marked at the location of the spring. End of flow was marked at an arbitrary

location in between the end of flow reported by the two sources. The Weedman and Young report listed Little Nogales Spring as a possible fish reintroduction site, but no information on stream flow or length of flow was included in the report. The only uncertainty about this perennial flow was the location of end of flow.

Madera Canyon

Madera Canyon was determined to have intermittent flow based on information from a variety of sources. The USGS 7.5 Minute topographic map of the area labeled the canyon as a perennial stream and ADEQ Water Quality Standards listed this canyon as a warmwater fishery. However, the following documents suggested that Madera Canyon had intermittent flow within Pima County: USFS RASES survey conducted May 1999, a M.S. Thesis by Darwin Morse (1979), and a U.S. Forest Service report (1974). The Technical Advisory Committee for this project agreed that Madera Canyon should be designated as an intermittent stream based on the information available. The location for beginning of flow was based on a sampling location for Morse 1979, which was just inside Pima County. The end of intermittent flow was marked at the USGS location for end of perennial flow. Although several studies and surveys have been conducted in Madera Canyon, it remains unclear whether perennial flow is present.

Madrona Canyon

Madrona Canyon was determined to have intermittent flow based on information provided by Saguaro National Park East staff and a scoping report for the National Park (Mott 1997). Figure 2 of the scoping report shows Madrona Canyon as having a riparian zone from roughly the 4000-foot contour line down to Rincon Creek. Don Swan and Natasha Kline from the Saguaro National Park East confirmed that this canyon flows to the Rincon Creek confluence for several months in most years. The location for beginning of flow was arbitrarily drawn according to the scoping report and descriptions by National Park staff. There may also be perennial pools with leopard frogs in the upper reaches of the drainage. No other source of information was available.

Mattie Canyon

Mattie Canyon was determined to have perennial and intermittent flow based on field observations by the BLM, a M.S. Thesis by R.E. Forrest (1992), and a report by the Sonoran Institute (1999). Karen Simms of BLM's Tucson office provided maps and results of riparian assessments conducted in the canyon. Locations of beginning and end of flows were based on these maps and assessments. The study by Forrest found Gila Topminnow in Mattie Canyon. Sonoran Institute's document listed Mattie Canyon as a source for perennial water. This canyon has been monitored by the BLM.

Miller Creek

Miller Creek was determined to have intermittent flow based on information from a USFS RASES survey conducted in August 1998 and field observations in October 1999 by Staffan Schorr. No exact location information was included in the RASES survey sheets for this creek, however watershed acreage was provided for each survey location. Flow and pools were observed at both survey locations. Field notes provided by Schorr documented considerable flow in Miller Creek near the confluence with Paige Creek, which was also flowing. A full man-made pond existed near this location. Miller Creek also has an instream flow claim along its reaches.

Molino Canyon

Molino Canyon was determined to have intermittent flow based on information from a USFS RASES survey conducted in October 1998 and field observations in spring 1998

and April 1999 by Staffan Schorr. Flow was documented adjacent to the Molino Basin campground by USFS RASES. Field notes provided by Schorr documented good flow and deep pools a few miles upstream of the campground on two occasions in spring 1998 and once in April 1999. Pools and flow were also documented at the Molino Basin Lookout area located downstream of the campground and fee station. Multispec ortho photographs taken April 1998 show Molino Canyon with a moist channel at the confluence with Agua Caliente Creek. No other source of information was available.

Montosa Canyon

Montosa Canyon was determined to have perennial flow based on field observations by Dale Turner in June 1998. Turner's field notes were provided. Beginning and end of flow locations were drawn according to Turner's description of the flow. No other stream flow documentation was available for this canyon.

Mud Spring Canyon

Mud Spring was determined to have intermittent flow based on information provided by BLM staff. Karen Simms of BLM's Tucson office provided results for riparian assessments conducted by BLM in this canyon. Mud Spring Canyon was in the datasheet as having a beginning and end of intermittent flow, but this reach was not included in the maps that Simms provided, which showed flow in nearby creeks. Beginning and end of flow was drawn according to the description in the database. A document by the Sonoran Institute (1999) listed Mud Spring as a perennial water source. No other source of information on stream flow was available.

Nogales Spring

Nogales Spring was determined to have perennial flow based on field observations by Julia Fonseca and a document by the Sonoran Institute (1999). Julia Fonseca visited this area in August 1997 and provided maps and field notes. Locations of beginning and end of flow were drawn according to these maps and notes. The Sonoran Institute (1999) document listed Nogales Spring as a perennial water source. No other source of information was available for this spring.

Paige Creek

Paige Creek was determined to have intermittent flow based on several sources of information. A Ph.D. Dissertation by R.L. Jemison (1989), a M.S. Thesis by K.A. Snyder (1995), personal field notes provided by Staffan Schorr, and field observations provided by Nature Conservancy staff have reported flow in Paige Creek. The report by Snyder mentioned that a perennial reach existed just downstream of the confluence with Miller Creek. However, only one other source had similar observations. According to Schorr's field notes, relatively swift, channelized flow was present in both Miller Creek and Paige Creek at the confluence during the time of the visit. Nature Conservancy staff observed intermittent flow along Paige Creek in 1998. No long-term monitoring has been conducted in this portion of Paige Creek.

Staffan Schorr and Nature Conservancy staff also reported intermittent flow at the confluence with Turkey Creek, which is downstream of the Miller Creek confluence. Schorr documented pools and trickle flow in October 1999 at this location. Nature Conservancy staff have also designated this portion of Paige Creek as intermittent according to observations made in 1998.

Palisade Canyon Creek

Palisade Canyon Creek was determined to have intermittent flow based on ADEQ's Water Quality Standards. ADEQ designated Palisade Canyon Creek as a coldwater fishery. Intermittent flow was drawn throughout the entire length of this canyon because no location information was available from the ADEQ designation. No other source of information on stream flow was available.

Peck Basin

Peck Basin was determined to have intermittent flow based on observations made by Steven Hopp and by spring locations on the USGS 7.5 Minute topographic map of the area. Locations of beginning and end of flow were drawn at the western and eastern extents of Peck Basin. No stream flow documentation was available for this area. Very little information was available for this basin.

Pima Canyon

Pima Canyon was determined to have intermittent flow based on a USFS RASES survey conducted July 1998. The survey location was approximately one and a half miles into the National Forest on Pima Canyon trail. Water was observed at the survey location, but it was unclear as to whether the canyon had flow or just pools. Beginning of intermittent flow was marked at the upper end of the survey location. End of flow was determined to be where the canyon flattens out to the valley floor, which corresponded with the National Forest boundary. No other source of information on stream flow was available for this canyon.

Posta Quemada

Posta Quemada was determined to have perennial flow based on observations by PAG staff. PAG has conducted quarterly water quality sampling along this creek in 1999. Flow was observed during each visit. A USFS RASES survey was conducted a considerable distance upstream of this perennial reach. No other source of information was available for this area.

Quitobaquito Springs

All sources of information available for the Quitobaquito area reported that the springs and pond were perennial water sources. This area was very well documented by the USGS, the University of Arizona, the Arizona Game and Fish Department, and the staff of Organ Pipe Cactus National Monument. A report by Weedman and Young (1997) listed Quitobaquito as a site where Quitobaquito Pupfish exist. ADWR's Water Resources Assessment document (1994b) showed Quitobaquito as having perennial water, as well.

Rincon Creek

Rincon Creek was determined to have intermittent flow based on a variety of sources. Mark Briggs from the Sonoran Institute provided information on the bottomland environments of lower Rincon Creek and a map showing his observations of the location of end of flow. End of flow was extended after viewing a multispec ortho photo of the area taken in April 1998. A report by Briggs, Schmid, and Halvorson (1997) confirmed the presence of intermittent flow, but it did not include any location information regarding end of flow. A scoping report for the Saguaro National Park (Mott 1997) was available and provided descriptions of the environment near Rincon Creek and its main tributaries, including stream flow observations. Don Swan from the Saguaro National Park East confirmed that Rincon Creek has intermittent flow from its upper reaches to the valley,

but he did not know exact locations for beginning or end of flow. The Weedman and Young report (1997) listed Rincon Creek as a site where Gila Topminnow were seen in 1987.

Romero Canyon

Romero Canyon was determined to have perennial and intermittent flow based on a USFS RASES survey conducted in November 1998, a report by Weedman and Young (1997), field observations by Greg Hess and Cheryl Karrer, and personal communication with Neal Donkersley of Catalina State Park. The area known as Romero Pools was drawn as perennial according to RASES survey observations and observations by people who regularly visit the pools. Since Romero Pools was designated as perennial, the source of water was believed to be from the upper portions of the canyon. However, no source of information gave evidence for perennial water in the upper portions. A location above Romero Pools was a site of a failed population of Gila Topminnow (Weedman and Young 1997). Therefore, the upper portion of Romero Canyon was designated as intermittent for this project. Beginning of flow was marked at the location listed in the Weedman and Young report. The portion of Romero Canyon below Romero Pools was determined to have intermittent flow based on observations by Donkersley and other Catalina State Park staff, as well as observations by Hess and Karrer.

Rose Canyon Creek

Rose Canyon was determined to have intermittent flow based on ADEQ's Water Quality Standards. ADEQ designated Rose Canyon Creek as a warmwater fishery. Intermittent flow was drawn throughout the length of the creek because no location information was available from the ADEQ designation. No other source of information on stream flow was available.

Ruelas Canyon

Ruelas Canyon was determined to have perennial reaches based on information from the Tortolita Mountain Park Master Plan provided by Steve Anderson of Pima County Parks and Recreation. The locations of Cottonwood-Willow series vegetation, shown in Figure 4-A of the Mountain Park report, overlapped the locations of springs, shown in Figure 6-F of the same report. Also, photographs of these areas were included in Chapter 6 of the report. The photographs showed water and lush riparian vegetation at these spring locations, therefore perennial flow was determined to be present in Ruelas Canyon at these locations. No other documentation of water in this canyon was available.

Sabino Creek

Sabino Canyon Creek was determined to have perennial flow for most of its length and intermittent flow near the confluence with Tanque Verde Creek. The upper portion of Sabino Creek was fairly well documented as being perennial by Haile 1987, USFS RASES 1998, ADWR 1994b, ADEQ 1993, Mt Lemmon USGS topographic map, and ADEQ water quality standards 1996.

Although USFS RASES surveys conducted along the mid portions of Sabino Canyon label the creek as intermittent, Motschall 1976, ADWR 1994b, ADWR 1994c, ADEQ 1993, Mt Lemmon and Sabino Canyon USGS topographic maps, the National Wetland Inventory by AZ Game & Fish 1980, Weedman and Young 1997, field observations in November 1999 by Staffan Schorr, field observations by the Arizona Chapter of the Nature Conservancy, and ADEQ water quality standards 1996 give evidence for perennial flow. Many large pools may exist in this portion of the creek, as suggested by

Weedman and Young 1997 and observed by Schorr 1999. The Weedman and Young report (1997) lists this reach as being a possible Gila Topminnow reintroduction site.

The lower portion of Sabino Creek, in the Sabino Canyon Recreation Area, may not have flow for its entire length, however a succession of large pools can be found all year throughout the reach. Sustaining populations of Gila Chub and Green Sunfish can be found in these pools (Dudley 1995). Nature Conservancy staff has documented perennial flow outside the National Forest boundary. Multispec ortho photographs taken of this area in April 1998 showed Sabino Creek having flow into Tanque Verde Creek.

San Pedro River

The San Pedro River was determined to have perennial and intermittent flow based on observations by staff of the Arizona Chapter of the Nature Conservancy and on observations made by PAG staff (PAG 1999). Nature Conservancy staff provided notes and maps compiled from field observations made by various staff members. The beginning and end of flow locations were drawn according to these maps and notes. No dates for the observations were included with the provided information. PAG staff conducted quarterly water quality sampling in the San Pedro River and its tributaries throughout 1999. Observations made by PAG staff at the sampling locations confirm the information provided by Nature Conservancy for those locations. A diversion dam is located a quarter-mile inside Cochise County with perennial waters upstream of that location. No other source of information was available for stream flow along the San Pedro River.

Santa Cruz River

The Santa Cruz River was determined to have perennial and intermittent flow based on several sources. Two USGS reports (Galyean 1996 and Schumann and Galyean 1991) and one Ph.D. Dissertation (Lacher 1996) stated that perennial flow existed in the Santa Cruz River beginning at the Roger Road Wastewater Treatment Facility (WWTF) and ending at the gaging station at Cortaro Road. Beginning of flow was marked at the Roger Road WWTF. End of perennial flow was drawn at the downstream side of the Cortaro Road bridge where the gaging station is located. The same documents also observed intermittent flow downstream of Cortaro Road. The study areas for these reports did not include the channel downstream of Trico Road, therefore intermittent flow was determined to end at Trico Road due to lack of information otherwise. Flow may continue past this location. Personal communication with Sal Shafiqullah of the Pima County Flood Control District confirmed the designations of the river. Stream flow in the Santa Cruz River was well documented.

Scholefield Spring

Scholefield Spring was determined to have perennial water based on a document by the Sonoran Institute (1999). The document listed Scholefield Spring as a perennial water source. No other documentation on flow was available.

Simpson Spring

Simpson Spring was determined to have perennial water based on personal field notes provided by Dale Turner. The observations were made in July 1998. No other source of flow information was available.

Smitty Spring

Smitty Spring was determined to have intermittent water based on maps and personal field notes provided by Julia Fonseca. The observations were made in April 1994. No other source of information on flow was available.

Soldier Canyon

Soldier Canyon was determined to have intermittent flow based on a USFS RASES survey conducted in October 1998 and field observations made by residents and local hikers. Pools, frogs, and tadpoles were observed at the survey location along the canyon at the time of the RASES survey, however no location information was included in the survey summary. Beginning of flow was marked at the Prison Camp Road area based on observations made in the springtime of various years by local hikers who have frequently visited the canyon. End of flow was drawn at the National Forest boundary because that would be the lowest point the RASES survey would have been conducted and because no information was available for the portion of the canyon below that location. The end of flow location was unclear. No other sources of stream flow information were available for this canyon.

Sutherland Wash

Sutherland Wash was determined to have intermittent flow based on personal communication with Catalina State Park staff and observations made by Greg Hess and Cheryl Karrer in various years. Neal Donkersley of the Catalina State Park provided information on flow in this wash. He has observed flow in Sutherland for several months in most years. The location of beginning of flow was arbitrarily drawn near the headwaters based on observations by Karrer and Donkersley. End of flow was drawn at the confluence with Canada del Oro based on information from Donkersley. No other source of information on stream flow was available for Sutherland Wash.

Sycamore Canyon

Sycamore Canyon was determined to have intermittent flow based on personal field notes provided by Staffan Schorr. The observations were made in April 1998 and November 1999. Flow was observed in April 1998 and pools and wet soil were present in November 1999. Sycamore Reservoir, which is located at the confluence of Bear and Sycamore Canyons, has been designated as a coldwater fishery by ADEQ. No other source of stream flow information was available.

Tanque Verde Creek

Tanque Verde Creek was determined to have intermittent flow and a small reach of perennial water based on USFS RASES survey information, personal communication with Chris Eastoe, and personal communication with Mark Briggs of the Sonoran Institute. The perennial water was located at Tanque Verde Falls (Eastoe and Briggs). USFS RASES surveys were conducted at four locations along Tanque Verde Creek in July 1998. Water was present at all locations during the time of the survey and frogs and frog eggs were present at one reach above Tanque Verde Falls. Since all three RASES survey locations suggested intermittent flow, the locations were connected to represent intermittent flow throughout the creek. Chris Eastoe, a local resident who has frequently visited the Tanque Verde Falls area, reported that turtles and frogs were present in perennial pools. Mark Briggs provided a map showing his observations of flow along this creek. Multispec ortho photographs taken of the area in April 1998 revealed flow in the creek bed until just upstream of Houghton Road. End of flow was

marked at this location. Beginning of flow was marked near the furthest upstream RASES survey location.

Thomas Canyon

Thomas Canyon was determined to have intermittent flow based on field notes provided by staff of the Arizona Chapter of the Nature Conservancy. The location of end of flow was drawn at the location where the canyon flattens out towards the valley floor, which was the description of end of flow provided by the Nature Conservancy. The beginning of flow was arbitrarily drawn at the headwaters. No other source of information on stream flow was available for Thomas Canyon.

Turkey Creek

Turkey Creek was determined to have intermittent flow based on a USFS RASES survey conducted August 1998 and field observations by Staffan Schorr. No exact location information was included in the RASES survey sheets for this creek, however watershed acreage was provided for each survey location. Although USFS staff did not find water at any of the three survey locations, riparian vegetation was present. Field notes from October 1999 provided by Staffan Schorr documented the presence of small bedrock pools and wet soil along two miles of the creek beginning near the Turkey Creek trailhead. Schorr's visit to the creek did not include any reach beyond the two miles, therefore beginning of intermittent flow was not marked beyond that location. Intermittent flow may exist upstream. Pools were also observed in Turkey Creek at the confluence with Paige Creek. No precipitation events had occurred in that area for several weeks prior to the field visit. Very little documentation was available for this creek.

Unnamed Spring near upper Cienega Creek

This unnamed spring was determined to have intermittent water based on maps and personal field notes provided by Julia Fonseca. The observations were made in April 1994. No other source of information on stream flow was available.

Unnamed tributary to Ash Creek

This large unnamed tributary to Ash Creek was determined to have intermittent flow based on personal field notes provided by Staffan Schorr. Bedrock pools and wet soils were present in the creek channel in October 1999. Beginning of flow was marked at the furthest upstream location where pools were observed. No other source of information on stream flow was available for this tributary.

Ventana Canyon

Ventana Canyon was determined to have intermittent flow based on USFS RASES survey information, personal field notes and maps provided by Julia Fonseca, personal communication with Eylon Shamir of Pima County Flood Control District, and multispec ortho photographs taken of the area in April 1998. The RASES survey was conducted a few miles within the National Forest boundary in October 1998. Pools, frogs, and tadpoles were present at the time of the survey. Beginning of flow was marked at the survey location. Julia Fonseca visited the portion of Ventana Canyon near the crossing of Sunrise Drive in June 1996. She observed riparian vegetation and moist soil. Eylon Shamir collected water quality samples at this location in November 1999 for Pima County Flood Control District. He observed flow beginning 30 feet upstream of the road bridge and ending 100 feet downstream. This reach of Ventana Canyon is located downstream from a golf course and resort. Desert scrub was present upstream and downstream of this reach near Sunrise Drive (Fonseca 1996 and Shamir 1999).

Multispec ortho photographs of the area revealed that Ventana Canyon had flow until just upstream of the confluence with Tanque Verde Creek. Because there was evidence for intermittent flow at three locations along the canyon, PAG staff considered it reasonable to connect the locations to represent intermittent flow throughout this reach.

Wakefield Canyon

Wakefield Canyon was determined to have perennial and intermittent flow based on personal field notes and maps provided by Julia Fonseca and on observations by BLM staff. Julia Fonseca's observations were made in April 1994 and August 1997. Beginning and end of flow locations were drawn according to this information. Fish and frogs were seen in reaches of Wakefield Canyon (Fonseca 1994 and 1997). Karen Simms of the BLM provided a map documenting perennial flow from Silver Spring. A Sonoran Institute document (1999) listed Wakefield Canyon as a perennial water source. This canyon was fairly well documented.

West Fork Sabino Creek

West Fork Sabino Canyon was determined to have intermittent flow based on USFS RASES site listings. This canyon was listed as a potential riparian area by the USFS. No RASES survey sheet was included in the notebooks provided by the Forest Service. Since perennial water was identified downstream in Sabino Canyon, PAG staff thought it reasonable to represent West Fork Sabino as having intermittent flow. Beginning and end of flow locations were arbitrarily drawn near the headwaters and at the confluence with Sabino Canyon, respectively. No other source of information was available for this canyon.

Wild Burro Canyon

Wild Burro Canyon was determined to have perennial reaches based on information from the Tortolita Mountain Park Master Plan provided by Steve Anderson of Pima County Parks and Recreation. The locations of Cottonwood-Willow series vegetation, shown in Figure 4-A of the Mountain Park report, overlapped the locations of springs, shown in Figure 6-F of the same report. Also, photographs of these areas were included in Chapter 6 of the report. The photographs showed water at these spring locations, therefore perennial flow was determined to be present in Wild Burro Canyon at these locations. No other documentation of water in this canyon was available.

Wild Cow Spring

Wild Cow Spring was determined to have perennial water based on a document by the Sonoran Institute (1999). The document listed this spring as a perennial water source. No other stream flow information was available for this spring.

Youtcy Canyon

Youtcy Canyon was determined to have perennial and intermittent flow based on field notes and maps provided by Nature Conservancy staff and on observations made by Steven Hopp. No dates of observations were included in the information provided by the Nature Conservancy. Beginning and end of flow locations were marked according to the Nature Conservancy's observations. Steven Hopp suggested that this canyon had potential for at least intermittent flow. No other sources of information on stream flow were available for this canyon.

APPENDIX H. Basis for Delineating Shallow Groundwater Areas

APPENDIX H
SONORAN DESERT CONSERVATION PLAN
STREAMS AND GROUNDWATER GIS COVERAGES
BASIS FOR SHALLOW GROUNDWATER AREA EXTENT DELINEATIONS

Agua Caliente Creek Area

The shallow groundwater area around Agua Caliente Creek was drawn using depth to water data from ADWR's Wells-55 Registry and GWSI databases, Tucson Water's 1997-1998 static water levels, and multispectral ortho photographs taken in 1998. Land surface elevation contour lines were followed and used in conjunction with well locations to draw the extent of shallow groundwater. The ortho photos of the area showed dense vegetation along the creek bed. The Agua Caliente Creek and the Tanque Verde Creek shallow groundwater areas may not be distinct from each other as the GIS coverage suggests. These areas were separated for descriptive purposes only. Many wells with depth to water less than 50 feet were located in the area.

Agua Verde Creek Area

The area of shallow groundwater under Agua Verde Creek was drawn using 1:400 scale blue line aerial photographs taken of the area in 1999 and ADWR Well 55-registry and GWSI databases. Dense vegetation shown along the creek channel was used as an indication of shallow groundwater. Contour lines were followed on USGS topographic maps and the PCLIS topo coverage to better define the flood plain. Water level data was available for only one well in this area.

Arivaca Area

The shallow groundwater area near Arivaca was drawn based on a color infrared digital ortho quad of the area, water level data from ADWR's Well-55 Registry and GWSI databases, and personal observations of vegetation from John Regan, a resident of Arivaca. There were many wells with water levels less than 50 feet in this area.

Cedar Canyon

The area of shallow groundwater in Cedar Canyon was drawn as a point due to the lack of information. This area was determined to potentially have shallow groundwater based on the vegetation identified during a USFS RASES survey. However, no other information was available to further extend the area of suspected shallow groundwater to areas outside the survey location. Therefore, a point was used to represent the area of shallow groundwater. It is possible that water levels in the area around this point were less than 50 feet, but no well data were available for the immediate area.

Cienega Creek

Cienega Creek was determined to have shallow groundwater areas based on water level data from ADWR databases, aerial imagery of the area, and PAG water level monitoring results from 1999. For the lower portion of Cienega Creek, 1:400 scale blue line aerial photographs taken in 1998 were used to trace the dense vegetation along the creek. Land surface elevation contour lines, which probably corresponded to the geologic floodplain, were followed. Where available, water level data from ADWR and PAG were used to better define the area of shallow groundwater. The area of shallow groundwater for the upper portion of Cienega Creek was identified using ADWR databases and USGS aerial imagery on TerraServer website. There were several wells with water levels less than 50 feet in both the upper and lower portions of Cienega Creek. Data

from the GWSI database for one well in the lower portion of Cienega Creek south of I-10 revealed water levels greater than 50 feet.

Cocio Wash

Cocio Wash was determined to have shallow groundwater based on ADWR well data and on information from Weedman and Young (1997) and Fonseca (1999). This area is adjacent to the Silver Bell Mine. An aerial photograph taken in the early 1970's showed riparian vegetation throughout Cocio Wash and its tributaries near the mine. Weedman and Young listed this wash as a site where topminnow existed. The fish population, as well as the presumed perennial water source, was buried by mining activities in the 1980's. This area was difficult to delineate due to the lack of information sources. The area represented in the GIS coverage was arbitrarily drawn around wells with known shallow water levels and avoided known areas of bedrock where possible. Recent aerial photographs of the area were not available for his project.

Davidson Canyon

Davidson Canyon was determined to have areas with shallow groundwater based on depth to water data for wells in ADWR databases, depth to water data from PAG (1998), 1:400 scale aerial photographs, and vegetation observations made by Fonseca, Block, and Hess (1996) and Hess and Schorr (1999). Dense vegetation was visible in the aerial photographs taken of the area in 1998 and was used as an indicator of shallow groundwater. The area with dense vegetation was drawn following land surface elevation contour lines. There were several wells with water levels less than 50 feet in Davidson Canyon.

Fraguita Wash

The area of shallow groundwater in Fraguita Wash was drawn as a point due to the lack of information. This area was determined to potentially have shallow groundwater based on the vegetation identified during a USFS RASES survey. However, no other information was available to further extend the area of suspected shallow groundwater to areas outside the survey location. Therefore, a point was used to represent the area of shallow groundwater. It is possible that water levels in the area around this point were less than 50 feet, but no well data were available in the immediate area.

Fresnal Wash

The area of shallow groundwater in Fresnal Wash was drawn as a point due to lack of information. This area was determined to potentially have shallow groundwater based on the vegetation identified during a USFS RASES survey. However, no other information was available to further extend the area of suspected shallow groundwater to areas outside the survey location. Therefore, a point was used to represent the area of shallow groundwater. It is possible that water levels in the area around this point were less than 50 feet, but no well data were available in the immediate area.

Gardner Canyon

The area of shallow groundwater in Gardner Canyon was drawn based on water levels from ADWR's Well-55 Registry and GWSI databases and water levels from a thesis by Huth (1997). No riparian vegetation was visible in aerial photographs taken of the area in 1994. Contour lines in the PCLIS topo coverage became very sparse in this location, but were followed as best as the coverage allowed.

Pantano Wash

The area of shallow groundwater in Pantano Wash was arbitrarily drawn around the gravel operation upstream of Houghton Road. No water level data were available for the immediate area. Multispectral digital photographs were used to identify the gravel operations facility and pools associated with them. Residents of the area reported this area as having pools with aquatic vegetation and other riparian vegetation. No other source of information was available for this area.

Posta Quemada Area

The area of shallow groundwater around Posta Quemada was drawn using 1:400 scale aerial photographs of the area taken in 1998 and water level data from ADWR Well 55-registry and GWSI databases. The dense vegetation shown in the aerial photographs indicated that shallow groundwater was present. Water level information was available for one well in the area.

Rillito Creek

The area of shallow groundwater at the confluence of Pantano Wash and Tanque Verde Creek was drawn according to depth to water data from Tucson Water's 1997-98 static water levels and ADWR 55-registry and GWSI databases. Several wells with water levels less than 50 feet below land surface were clustered at this location.

Rincon Creek

The area of shallow groundwater around Rincon Creek was drawn primarily according to multispectral ortho photography of the area. Few wells were included in ADWR databases for this area. The vegetation present in the area, as seen in the aerial photography, indicated the presence of shallow groundwater. The dense vegetation along the creek was traced from the aerial photographs to represent the area of shallow groundwater. However, aerial photographs of the upper reaches of Rincon Creek were not available at the time of this investigation and there were few wells in the ADWR databases located in that area. The upper reaches were not included in the shallow groundwater coverage due to lack of information. Data from the GWSI database for at least one well in the selected area revealed water levels greater than 50 feet. However, data from wells located adjacent to these wells showed water levels less than 50 feet.

Sabino Canyon

Depth to water data for wells in ADWR's 55-registry and GWSI databases, as well as Tucson Water's 1997-98 static water levels, were used to draw the area of shallow groundwater in the lower reaches of Sabino Canyon. The Nature Conservancy staff provided notes and maps documenting the vegetation along this portion of the canyon. The type of vegetation in this area was used as an indicator of shallow groundwater. Multispectral ortho photography of the area also showed dense vegetation along and adjacent to the creek channel. There were many wells with depths to water less than 50 feet in the area.

San Luis Wash

The area of shallow groundwater in San Luis Wash was drawn as a point due to lack of information. This area was determined to potentially have shallow groundwater based on the vegetation identified during a USFS RASES survey. The vegetation assemblage at the survey location indicated that shallow groundwater may exist at that location. However, no other information was available to further extend the area of suspected shallow groundwater to areas outside the survey location. Therefore, a point was used

to represent the area of shallow groundwater. It is possible that water levels in the area around this point were less than 50 feet.

San Pedro River

The shallow groundwater area around the San Pedro River included Bingham Cienega. The extent of the area was drawn based on water level data from ADWR's databases, water level data from Roeske and Werrell (1973), water level data from Fonseca (1998), and 1:400 scale aerial photographs taken of the area in 1998. Dense vegetation and water level information for wells in the area were used to determine the extent of the area with shallow groundwater.

Sopori Wash

The area of shallow groundwater around Sopori Wash was drawn using aerial imagery and depth to water data from ADWR databases. The extent of the area was drawn around dense vegetation shown on 1-foot resolution grayscale ortho photographs of the area. The area was extended to include nearby wells with shallow water levels, even if dense vegetation was not present at the well location. Data from the GWSI database for at least one well in the selected area revealed water levels greater than 50 feet. However, data from other wells located adjacent to these wells showed water levels less than 50 feet.

Sutherland Wash

Sutherland Wash was determined to have areas with shallow groundwater based on depth to water data from ADWR's 55-registry database and aerial imagery. Metropolitan Water District also provided depth to water data for wells near Catalina State Park. There were only two wells in the area that exhibited water levels less than 50 feet below land surface, according to the sources available. The USGS digital ortho quad for Oro Valley showed dense vegetation in two areas along Sutherland Wash. The location of these two areas coincided with the locations of the two wells with shallow water levels. The aerial imagery was quite limited in showing distinct areas with dense vegetation. High use may have impacted the vegetation in the area near the Canada del Oro confluence. The vegetation listed in USFS RASES survey results and field notes by Julia Fonseca were used as indicators of shallow groundwater.

Tanque Verde Creek

The area of shallow groundwater associated with Tanque Verde Creek was drawn using depth to water data from ADWR's 55-registry and GWSI databases, Tucson Water's 1997-98 static water level map, and multispectral ortho photographs taken in 1998. Land surface elevation contour lines were followed and used in conjunction with well locations to draw the extent of shallow groundwater. The ortho photos of the area showed dense vegetation along and adjacent to the creek bed. One resident provided depth to water data from his well, which is located very near the creek channel. The Tanque Verde Creek and the Agua Caliente Creek shallow groundwater areas may not be distinct from each other as the GIS coverage suggests. These areas were separated for descriptive purposes only. There were many wells with water levels less than 50 feet in the area.

APPENDIX I. Shallow Groundwater Areas

Shallow Groundwater Area Coverage

Shallow Groundwater Area	Cadastral Location	USGS Topographic Map	Certainty
Agua Caliente Canyon	13-16-16,17,19,20,29,30,31,32/13-15-25,36/14-15-1,2	Agua Caliente Hill, Ariz.; Sabin Creek, Ariz.	3
Agua Verde Creek	16-18-16,17,18,21,22/16-17-8,9,13,14,15,16	Rincon Peak, Ariz., Vail, Ariz.	2
Arivaca Area	21-10-19,20,22,27,28,29,33,34,35/22-10-1,2	Arivaca, Ariz.	3
Arrieta Wash	22-9-20	Cumero Mtn, Ariz.	2
Box Canyon	15-16-8,9	Vail, Ariz.	2
Cedar Canyon	21-11-25	Murphy Peak, Ariz.	2
Cienega Creek (lower)	17-17-1,12/17-18-7,8,17,20,29	The Narrows, Ariz.	3
Cienega Creek (lower)	16-17-19,28,29,30,33,34,35/17-17-1,2/16-16-14,23,24	The Narrows; Rincon Peak, Ariz	3
Cienega Creek (upper)	19-17-2,3,14,15,23/18-17-12,13,14,23,26,34,35/18-18-6,7	Spring Water Canyon; The Narrows, Ariz.	3
Cocio Wash	12-9-16,19,20,21	Silver Bell Peak, Ariz.	1
Davidson Canyon	16-17-30,31/17-17-6,7,18,19,30,31/17-16-31/18-16-1,11,	Vail; Mount Fagan; Empire Ranch, Ariz.	3
Davidson Canyon (upper)	18-16-23,24,25,26	Empire Ranch, Ariz.	3
East Fork Apache Canyon	22-11-2	Murphy Peak, Ariz.	2
Fraguita Wash	22-10-7	Arivaca, Ariz.	2
Fresnal Wash	22-9-26	Cumero Mtn, Ariz.	2
Gardner Canyon	19-17-31,32	Sonoita, Ariz.	3
Pantano Wash	15-16-6	Tucson East, Ariz.	1
Posta Quemada Canyon	16-17-8	Rincon Peak, Ariz.	2

Shallow Groundwater Area	Cadastral Location	USGS Topographic Map	Certainty
Rillito Creek	13-14-25,26	Tucson North, Ariz.; Sabino Canyon, Ariz.	3
Rincon Creek	15-16-14,15,16,17,22,23	Mica Mountain; Tanque Verde Peak; Vail, Ariz.	3
Sabino Canyon	13-15-15,16,21,22,27,28,32,33	Sabino Canyon, Ariz.	3
San Luis Wash	22-9-12	Wilbur Canyon, Ariz.	2
San Pedro River	11-18-2,3,10,11,14,15,22,23,26,27,34	Redington, Ariz.	3
Sopori Wash	19-12-33/20-11-11,12,14,15,21,22,28	Saucito Mtn, Ariz.	2
Sutherland Wash	11-14-14,23,26,27	Oro Valley, Ariz.	2
Sutherland Wash	11-14-33,34/12-14-3,4	Oro Valley, Ariz.	2
Tanque Verde Creek	13-16-31,32,33,35,36/14-16-1,2,3,4,5,6,9,10/14-15-1	Tucson East;Sabino Canyon; Tanque Verde Peak, Ariz	3
Tanque Verde Creek	13-15-29,30,31,32/13-14-25	Tucson North, Ariz.	3

APPENDIX J. List of Files Provided to Pima County

APPENDIX J
SONORAN DESERT CONSERVATION PLAN
List of Files Sent to Pima County

PStreams.dbf
PStreams.sbn
PStreams.sbx
PStreams.shp
PStreams.shx

IStreams.dbf
IStreams.sbn
IStreams.sbx
IStreams.shp
IStreams.shx

Shallgw.dbf
Shallgw.sbn
Shallgw.sbx
Shallgw.shp
Shallgw.shx

Othergw.dbf
Othergw.shp
Othergw.shx

Oth_well.dbf
Oth_well.shp
Oth_well.shx

Gwsi90.dbf
Gwsi90.sbn
Gwsi90.sbx
Gwsi90.shp
Gwsi90.shx

Gwsi85.dbf
Gwsi85.sbn
Gwsi85.sbx
Gwsi85.shp
Gwsi85.shx

Gwsi80.dbf
Gwsi80.sbn
Gwsi80.sbx
Gwsi80.shp
Gwsi80.shx

55reg95.dbf
55reg95.sbn
55reg95sbx
55reg95.shp
55reg95.shx

55reg90.dbf
55reg90.sbn
55reg90.sbx
55reg90.shp
55reg90.shx

55reg85.dbf
55reg85.sbn
55reg85.sbx
55reg85.shp
55reg85.shx

55reg80.dbf
55reg80.sbn
55reg80.sbx
55reg80.shp
55reg80.shx

Pstreamsmeta.txt
Istreamsmeta.txt
Shallgwmeta.txt
Othergwmeta.txt
Othwellmeta.txt
Gwsi90meta.txt
Gwsi85meta.txt
Gwsi80meta.txt
55reg95meta.txt
55reg90.meta.txt
55reg85meta.txt
55reg80meta.txt

aaREADME.txt