Water Quality in Pima County, Water Quality of Priority Streams in Pima County, Water Quality Requirements of Native Aquatic Species in Pima County

Sonoran Desert Conservation and
Comprehensive Plan
2002

Pima County, Arizona
Board of Supervisors
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County Administrator
Chuck Huckelberry

MEMORANDUM

Date: August 8, 2002

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

From: C.H. Huckelberry
County Administrator

Re: **Final Water Quality Studies for Sonoran Desert Conservation Plan Alternatives Analysis**

Background

Pima Association of Governments has worked with County staff for over two years on a series of riparian and water resource studies related to the Sonoran Desert Conservation and Comprehensive Land Use Plan. The three studies found within this document represent the final versions of (1) Water Quality in Pima County; (2) Water Quality of Priority Streams in Pima County; and (3) Water Quality Requirements of Native Aquatic Species in Pima County.

Water Quality in Pima County

This study summarizes water quality for groundwater and surface water in Pima County. It discusses groundwater contamination sites, stormwater quality, surface water monitoring, effluent quality, and the quality of CAP water. Conclusions are that with the exception of contamination sites, groundwater is of good quality, stormwater runoff meets federal standards as does treated wastewater, and in the streams with surface water, quality is adequate for the intended use.

Water Quality of Priority Streams in Pima County

A review of the quality of over twenty priority streams in Pima County led to conclusions that the over all quality is good. Seven streams were identified for further research and monitoring. Many of these streams are within protected lands, however the study recommends that where applicable, land use planning identify which future uses are appropriate to minimize impacts and maintain water quality.

Water Quality Requirements of Native Aquatic Species in Pima County

The water quality for priority vulnerable species was studied with emphasis on the requirements for two frog species and six fish. Findings include that native aquatic species have relatively high tolerance for ranges in temperature, pH levels, and salinity. Water quality was found to be generally within the required range to support native species populations. The greatest threats, the study concluded, are loss of habitat and water supply, and the introduction of non-native species.

Attachments

Water Quality in Pima County

Prepared for the Pima County Comprehensive Plan and Sonoran Desert Conservation Plan

March 2002

Prepared by

Pima Association of Governments

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Acknowledgments

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Pima County Comprehensive Plan and Sonoran Desert Conservation Plan

Water Quality in Pima County

Introduction

Background

Since 1998, Pima County has been working toward a comprehensive assessment of urban growth and the environment which has led to the creation of the Sonoran Desert Conservation Plan. Development of this plan has been prompted in part by the federal Endangered Species Act. In addition, the County is updating its Comprehensive Plan as required by the state's recently adopted Growing Smarter legislation. The two plans will contain a water quality element in order to meet the requirements of the Growing Smarter legislation, and to ensure the preservation of species dependent on surface water or shallow groundwater in Pima County.

Pima Association of Governments (PAG) is assisting with the preparation of the Water Quality Element at the County's request. This request was prompted in part by the fact that PAG is the state-designated Water Quality Planning Agency for Pima County under Section 208 of the Clean Water Act.

PAG's Section 208 Water Quality Management Plan consists of a document written in 1978 and all of the subsequent amendments and updates to that document. The 208 Plan addresses one of the major water quality concerns associated with growth, which is the disposition of waste. The original PAG 208 Plan and several amendments also identified various point- and non-point sources of pollutants. However, the 208 Plan has not had a recent comprehensive, countywide update and it does not include site-specific programs for unique aquatic habitats identified in the Sonoran Desert Conservation Plan. Therefore, reliance on the existing 208 Plan would probably not meet the County's needs, and development of additional planning materials is warranted.

Purpose

The purpose of this report is to provide, using existing literature to the extent possible, a brief, descriptive overview of the quality of various water sources found in Pima County. By identifying high-quality water sources as well as areas with potential water quality problems, it will be possible to prioritize regional water quality planning efforts. These plans could include additional monitoring, assigning appropriate uses for some water sources, improving the quality of some sources where necessary, and protecting the water quality of other sources. This report, along with a separate report summarizing existing regulations, plans and programs related to water quality management and protection, will provide a foundation on which the water quality element of the County plan can be developed.

Information and Data Sources

Much of the information in this report comes from previously published documents containing information about water quality in Pima County. In particular, this report relies heavily on the following: *Water Quality State of the Region Report* (PAG, 1994); *Tucson Active Management Area Third Management Plan* (ADWR, 1999); *The Status of Water Quality in Arizona - Clean Water Act Section 305b Report* (ADEQ, 2000); *Water Quality Assessment for the Tucson Active Management Area Northwest Replenishment Program Feasibility Study* (PAG, 1996); City of Tucson's *Municipal Stormwater Annual Report for Fiscal Year 1998-1999;* and *Pima County NPDES Stormwater Discharge Permit (No. AZS000002) Third Annual Report, September 2000.*

Scope and Limitations

This report is the first deliverable under PAG's contract with Pima County to provide assistance with developing the Water Quality Element of the *Sonoran Desert Conservation Plan* and the *Comprehensive Land Use Plan*. The study area is all of Pima County, excluding Indian reservations. However, the emphasis is on eastern Pima County.

This report, in accordance with the PAG-Pima County contract, relied primarily on data that were readily available in existing literature. No original data were collected for this project, and PAG did not attempt to verify the accuracy of the data contained in the sources used. In addition, the time and budget available for this project did not permit an exhaustive search for all literature that might be available on water quality in Pima County. Additional data, including monitoring results more current than the data used for this report, are probably available. However, it is assumed that the data used for this report are adequate to provide a general, descriptive overview of water quality in the county. PAG only used data from previously published, peer-reviewed literature, or data provided by organizations with an extensive history of water quality monitoring and data reporting, for this project.

This report should not be used for a detailed, quantitative comparison of the different water sources, or for concluding that one water source is "better" or "worse" than another. In order to conduct such an analysis, a consistent set of data, from samples collected at approximately the same time and by consistent methods and under the same QA/QC protocols, would be necessary. The data in this report represent sampling and analyses that were completed by various organizations at different times and for different purposes. PAG did not verify that consistent methods and QA/QC standards were followed. Therefore, variability in the data from one water source to the next could be due, at least in part, to differences in sampling programs. The sampling programs would not be expected to be the same for different water sources, because different water sources are used for different purposes, regulated under different programs, and monitored for different reasons, for different constituents and at different frequencies.

A more appropriate use of this report is to review the information for the individual water sources, and use the information as the basis for discussions of: (1) adequacy of the quality of each source for its current or intended use; (2) potential suitable uses for each water source in the future; (3) data gaps and regional priorities for additional monitoring; and (4) regional priorities for water quality protection and/or improvements. In this way, the report should be a useful starting point for an update to existing countywide water quality plans.

Study Area Description

Pima County is large and diverse. It is 9,240 square miles in area and within its boundaries are some of the most pristine, unfrequented landscapes in the United States, as well as one of the nation's fastest growing metropolitan areas. It includes the second largest Indian reservation in the country, irrigated farmlands, open pit copper mines, military facilities, National Parks and Monuments, National Forests, National Wildlife Refuges, County-managed natural preserves, major corporate and university research facilities, world-class tourist resorts, urban districts, suburbs, and commercial areas.

Based on 2000 Census data, the population of Pima County is approximately 840,000; the population of Tucson, the largest incorporated city, is approximately 490,000. The towns of Marana and Oro Valley were the fastest and second-fastest growing towns in Arizona in the 1990s.

Natural Setting

Pima County is in the Basin and Range physiographic province, which is characterized by northwest-trending mountain ranges separated by alluvial basins. Land surface elevations in Pima County range from less than 2,000 feet above sea level on the basin floors to more than 9,000 feet above sea level in the mountains. Most of the Tucson metropolitan area lies within the Tucson basin, a gently sloping plain between 2,000 and 3,000 feet in elevation, which is ringed by eight mountain ranges. The highest of these are the Santa Rita, Santa Catalina and Rincon ranges, all of which reach elevations above 8,000 feet.

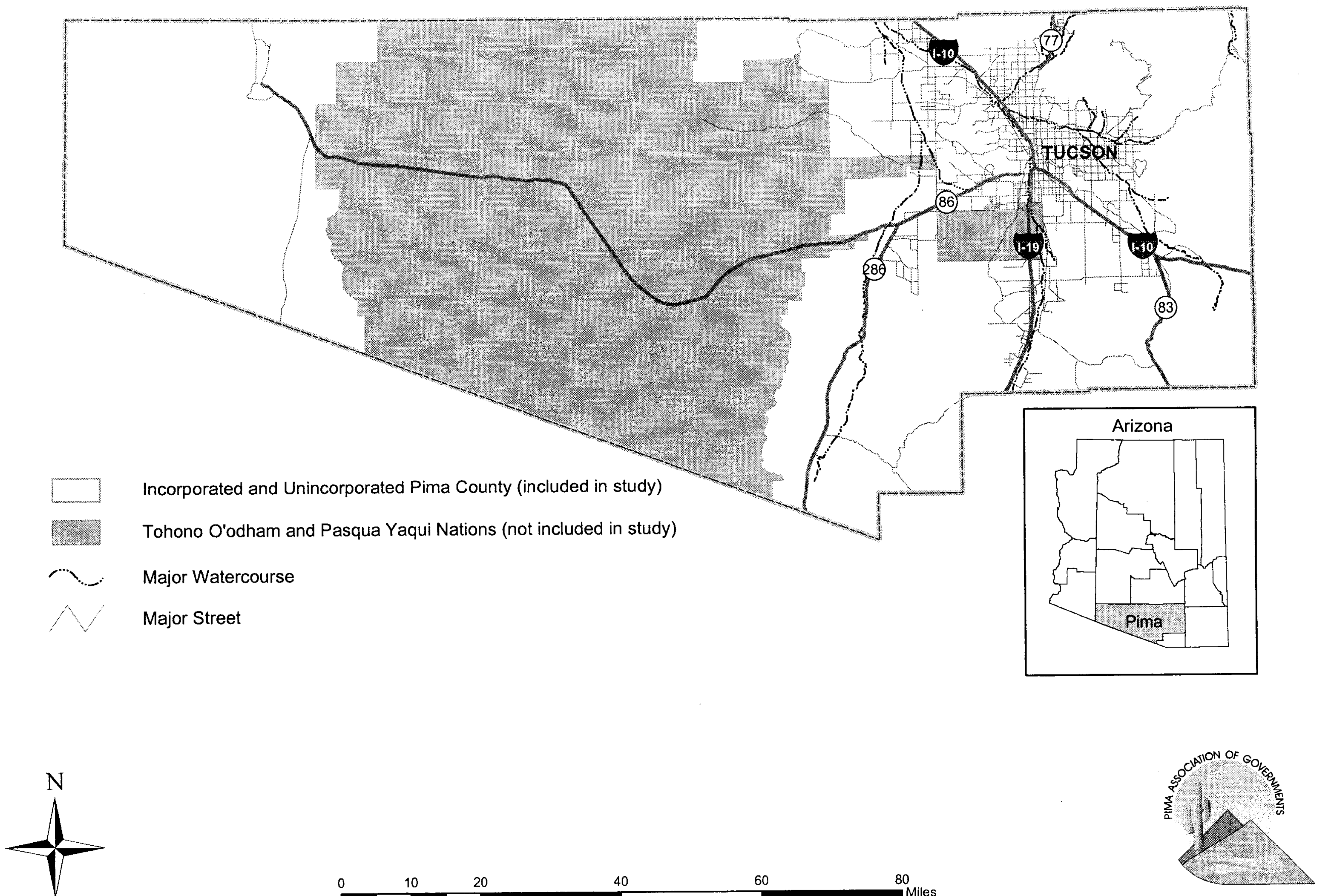
A large portion of eastern Pima County lies in two alluvial basins: Avra Valley in the west and the Tucson basin in the east. The basins are separated by the Tucson Mountains. Land use in Avra Valley consists mostly of open space and agriculture. Much of the Tucson basin is urbanized, but outside the Tucson metropolitan area, the predominant land uses are agriculture, mining, and open space.

The Santa Cruz River and its tributaries form eastern Pima County's regional drainage network. The Santa Cruz River is a tributary of the Gila River, which in turn flows into the Colorado River.

Climate

The climate is arid to semi-arid in the basins, with summertime temperatures often exceeding 100 degrees Fahrenheit. Precipitation in the Tucson basin averages 12 inches per year (NOAA, 1998). Most of the precipitation occurs in the form of intense, localized thunderstorms during the summer and gentle, regional rains during the winter. Natural vegetation in the basins is sparse, ranging from Lower Sonoran Desert shrubs and cacti to Upper Sonoran Desert grasslands. Lower temperatures and increased precipitation in the mountains support mid-elevation oak and juniper woodlands, and at the highest elevations, coniferous forests.

Figure 1. Study Area.



Principal Water Sources of Pima County

Five principal categories of water sources are present in Pima County:

- Groundwater pumped from wells;
- Naturally occurring perennial and intermittent surface waterbodies, such as streams, springs, and spring-fed ponds and pools;
- Stormwater runoff;
- Imported Central Arizona Project (CAP) water; and
- Treated wastewater.

These water sources are closely linked in many ways. Therefore, in many aspects of planning, they should not be treated entirely separately. For example, springs and many perennial and intermittent streams are directly fed by groundwater. Wastewater is also primarily derived from groundwater that is used for domestic, commercial and industrial purposes. Therefore, the quality of wastewater and many surface waters can be influenced by the quality of local groundwater. Also, stormwater, CAP water, and wastewater recharge groundwater in many locations of the County, either naturally or artificially. The quality of these sources can therefore affect the quality of local groundwater.

Each of these water source categories is described briefly below. A detailed report on water resources, entitled *Water Resources in Pima County*, July 2001, has been prepared by the Water Resources Research Center.

Groundwater

Historically, groundwater has been the most widely used water resource in Pima County. Throughout most of the County, groundwater is drawn from wells that tap deep aquifers found in the alluvial basins. These aquifers consist of unconsolidated to semi-consolidated silts, sands, gravels, and clays derived from the mountain ranges surrounding the basins. Elsewhere, groundwater is drawn from shallow wells tapping comparatively localized sources, such as fractured bedrock, flood plain aquifers, or perched aquifers.

Most of the groundwater development has occurred in eastern Pima County, in the Upper Santa Cruz Basin and Avra Valley. Groundwater in these areas is used for public drinking water supply, landscape and crop irrigation, and industry. Pumpage of groundwater for these uses totals more than 300,000 acre-feet per year in the Tucson Active Management Area, which includes most of eastern Pima County and part of Pinal County (ADWR, 1999). This greatly exceeds the volume of groundwater recharge, resulting in water-table declines of over 200 feet (Tucson Water, 1998). Depths to groundwater in eastern Pima County currently range from less than 50 feet to greater than 700 feet below land surface (Tucson Water, 2000a). In general, water level declines can lead to lower well productivity, increased pumping costs, declining water quality, and land subsidence (Water Resources Research Center, 1999). For these and other reasons, there is widespread interest in developing and using other water sources instead of relying entirely on groundwater pumpage.

Surface Waterbodies

According to the Arizona Department of Water Resources, in its Third Management Plan for the Tucson Active Management Area (TAMA), the main surface water drainage in the TAMA is the Santa Cruz River. The river, which is about 60 miles long within the AMA, flows north through the Upper Santa Cruz Valley Subbasin and then northwest into the Avra Valley Subbasin. From the Roger Road wastewater treatment plant an approximately nine mile reach of the Santa Cruz has perennial flow due to treated effluent discharged into the channel at Roger Road and Ina Road. The remainder of the Santa Cruz within the TAMA is ephemeral (ADWR, 1999).

Major tributaries of the Santa Cruz River in the Upper Santa Cruz Valley Subbasin include the Canada del Oro, which drains the northern part of the Upper Santa Cruz Valley Subbasin, and Rillito Creek and its tributaries, which drain the area north and east of Tucson. Tributaries to Rillito Creek include Pantano Wash and Tanque Verde Creek. Pantano Wash receives flow from Rincon Creek and Cienega Creek. Tanque Verde Creek receives flow from Sabino Creek. In the Avra Valley Subbasin, Altar Wash originates in the southern part of the valley and flows north to become Brawley Wash. Brawley Wash flows to the north and northwest through Avra Valley to its confluence with the Santa Cruz River southwest of Red Rock.

The San Pedro River is a tributary of the Gila River and drains 4485 square miles of Arizona and Mexico. The San Pedro River enters the northeastern corner of Pima County in what is considered the Lower San Pedro Basin. The river is fed by flow from the northeast side of the Santa Catalina Mountains and by two significant drainages from the Galiuro Mountains. Most of the stream reaches on the San Pedro are intermittent, but in the area around Bingham Cienega there is both perennial and intermittent flow (Royayne, M.J. and T. Maddock III, 1996).

The vast majority of the watercourses in Pima County are ephemeral, and do not represent a significant water source, except for stormwater runoff. In contrast, the number of perennial and intermittent watercourses is relatively small, but the surface water in these waterbodies is very important habitat for terrestrial and aquatic species.

Prior to the initiation of research for the Sonoran Desert Conservation Plan (SDCP), a comprehensive assessment of perennial and intermittent streams in Pima County was not available. In January 2000, however, a countywide assessment of these watercourses was completed, and a GIS coverage showing the locations of perennial and intermittent streams was created for the SDCP. Fifty-five perennial stream reaches and eighty-two intermittent stream reaches from a total of seventy-four different streams were identified (PAG, 2000a).

The identified perennial and intermittent streams of Pima County are in a variety of locations and environments, and most are located in eastern Pima County. This is likely due to the presence of higher land elevations and greater precipitation. Thirty-eight streams that had perennial or intermittent reaches had flows that originated in the Santa Catalina, Rincon or Santa Rita Mountains (PAG, 2000a).

The identified natural perennial and intermittent streams flowing in eastern Pima County are shown on the following tables. Some of the streams are listed on both tables because they contain both perennial and intermittent reaches.

Table 1. Perennial Streams in Pima County (PAG, 2000a).

Apache Spring 0.03 miles	Montosa Creek 0.2 miles
Arivaca Creek * 2.7 miles	Nogales Spring 0.3 miles
Bingham Cienega	Posta Quemada 0.3 miles
Buehman Canyon (three reaches) * 5.1 miles	Quitobaquito (Pond and Spring)
Bullock Canyon 0.7 miles	Romero Canyon 0.4 miles
Canada Del Oro 4.2 miles	Ruelas Canyon 0.1 miles
Cienega Creek (nine reaches) * 10.5 miles	Sabino Creek (3 reaches) * 15 miles
Cinco Canyon 0.2 miles	San Pedro River (2 reaches) * 1.2 miles
Davidson Canyon 0.7 miles	Santa Cruz River (effluent dependent) * 6.8 miles
Edgar Canyon * 0.7 miles	Scholefield Spring 0.04 miles
Empire Gulch (two reaches) 1.4 miles	Simpson Spring 0.4 miles
Espiritu Canyon 2.2 miles	Tanque Verde 0.5 miles
Honey Bee Canyon 0.2 miles	Wakefield Canyon (3 reaches) 1.2 miles
Lemmon Creek 2.7 miles	Wild Burro Canyon (5 reaches) 0.6 miles
Little Nogales Spring 0.2 miles	Wild Cow Spring 0.05 miles
Mattie Canyon 1.3 miles	Youtcy Canyon (2 reaches) 1.3 miles

*- Indicates water quality data are available on these streams and are included in this report.

Table 2. Intermittent Streams in Pima County (PAG, 2000a)

Agua Verde Creek 15.0 miles	Madrona Canyon 3.4 miles
Alder Canyon 1.2 miles	Mattie Canyon 0.4 miles
Arivaca Creek* 0.7 miles	Miller Creek 4.1 miles
Ash Creek 3.1 miles	Molino Canyon 5.2 miles
Atchley Canyon 1.8 miles	Mud Spring Canyon 2.6 miles
Barrel Canyon 1.3 miles	Paige Creek (2 reaches) 3.0 miles
Bear Canyon (2 reaches) 9 miles	Palisade Canyon Creek (2 reaches) 4.5 miles
Bear Creek 3.2 miles	Peck Basin 1.2 miles
Bootlegger Spring 0.1 miles	Pima Canyon 1.8 miles
Box Canyon 4.1 miles	Rincon Creek 11.3 miles
Brown Canyon 3.4 miles	Romero Canyon (2 reaches) 4.8 miles
Buehman Canyon (2 reaches)* 2.5 miles	Rose Canyon Creek 0.4 miles
Bullock Canyon (3 reaches) 3.1 miles	Sabino Canyon 3.4 miles
Canada Agua 0.01 miles	San Pedro River (3 reaches) 10.6 miles
Canada del Oro 1.2 miles	Santa Cruz River (2 reaches) 20.4 miles
Cargodera Canyon 0.2 miles	Smitty Spring 0.1 miles
Chiminea Creek 4.1 miles	Soldier Creek 2.9 miles
Chimney Canyon 3.3 miles	Sutherland Wash 6.5 miles
Cienega Creek (8 reaches)* 9.4 miles	Sycamore Canyon 1.1 miles
Davidson Canyon (3 reaches) 1.2 miles	Tanque Verde Creek (5 reaches) 17.1 miles
Deer Creek 2.5 miles	Thomas Canyon 3.0 miles
Distillery Canyon 3.3 miles	Turkey Creek 3.2 miles
East Fork Sabino Canyon 1.3 miles	Unnamed tributary to Ash Creek 1.2 miles
Espiritu Canyon 6.9 miles	Unnamed Spring 0.2 miles
Finger Rock Canyon 2.8 miles	Unnamed Spring 0.9 miles
Florida Canyon 3.4 miles	Ventana Canyon (3 reaches) 9.2 miles
Gardner Canyon 0.5 miles	Wakefield Canyon 0.8 miles
Geesaman Wash 1.1 miles	West Fork Sabino Creek 2.4 miles
La Milagrosa Canyon 0.9 miles	Youtcy Canyon (2 reaches) 1.6 miles
Madera Canyon * 1.5 miles	

*- Indicates water quality data are available on these streams and are included in this report.

Many of the streams in Pima County are located, totally or partially, in areas protected by the National Park Service, National Forest Service or Pima County Parks and Recreation. However, a number of important stream reaches are 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.

One of the perennial streams, Cienega Creek, is an important water, recreation and wildlife resource located southeast of Tucson in the Santa Cruz watershed. It is one of the few low-elevation streams in Pima County that exhibits significant perennial flow. The section of Cienega Creek that flows from Interstate 10 to the Del Lago dam has been designated by the Arizona Department of Environmental Quality (ADEQ) as a "Unique Water", which means it has been classified as an "outstanding state resource water". Buehman Canyon, another perennial stream in Pima County, has also been designated a "Unique Water" by the State.

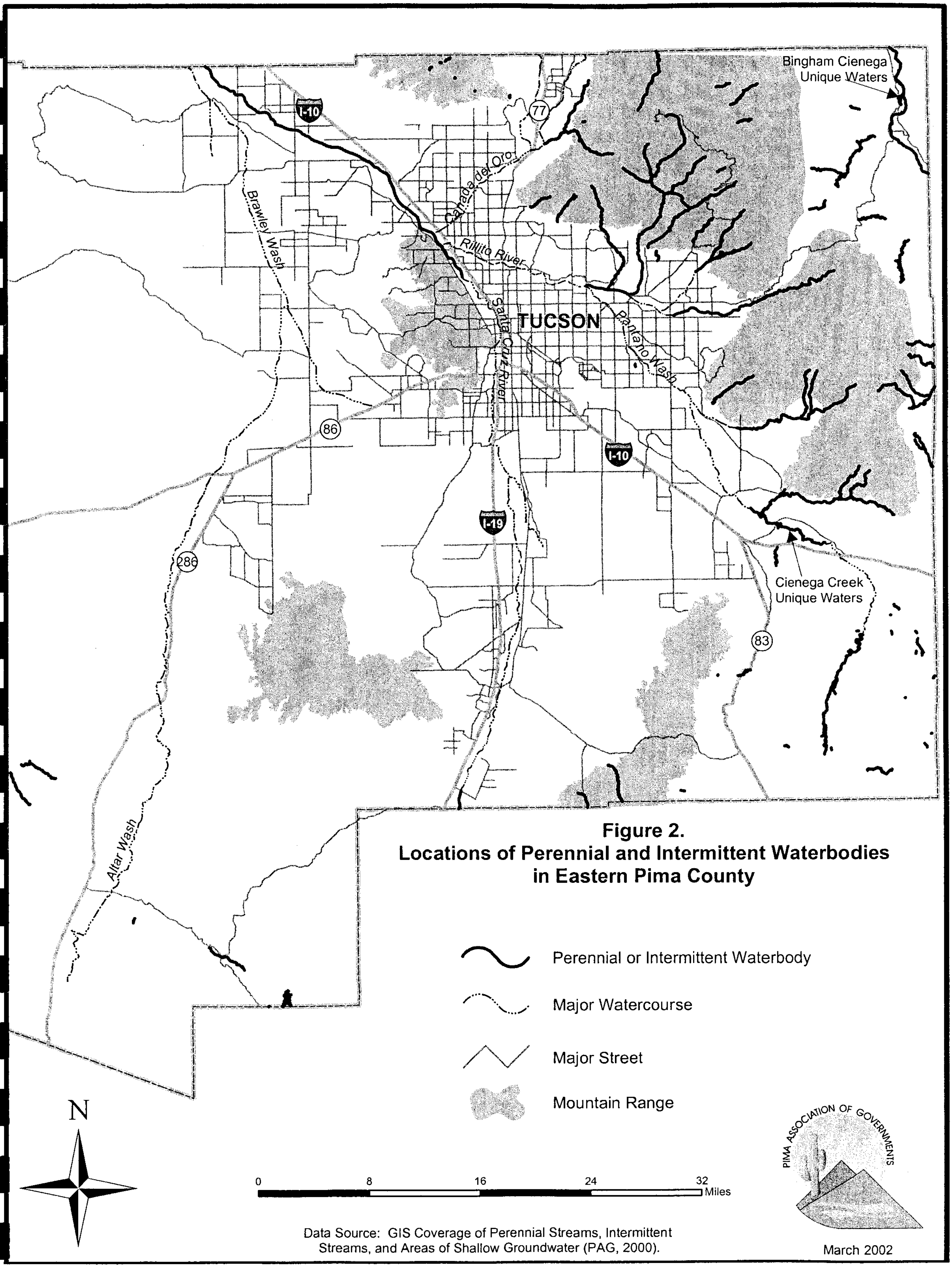


Figure 2.
Locations of Perennial and Intermittent Waterbodies in Eastern Pima County

Data Source: GIS Coverage of Perennial Streams, Intermittent Streams, and Areas of Shallow Groundwater (PAG, 2000).

March 2002

Stormwater Runoff

Because stormwater runoff is typically short-term and occurs in response to precipitation events, the direct use of this surface water has been limited. However, surface water flow is an important source of recharge to the aquifer in the Tucson AMA. Groundwater conditions can be greatly affected by occasionally large surface water flows in the Santa Cruz River and its tributaries. Surface water flows recharge the groundwater system in the vicinity of the stream as water infiltrates through the stream channel sediments to the underlying aquifer. Stream channel recharge in the Upper Santa Cruz Valley Subbasin is estimated at 30,960 acre-feet per year and in the Avra Valley Subbasin at around 6695 acre-feet per year (ADWR, 1999).

Stormwater runoff in major urbanized areas is regulated by the USEPA's National Pollutant Discharge Elimination System program (NPDES), and these urban areas are required to obtain stormwater permits. The intent of the permit program is to improve the quality of the stormwater runoff and its subsequent impact, if any, on surface water. Regulated municipalities must develop a plan with mechanisms designed to locate and eliminate discharge into storm sewers from sources other than stormwater. They must also have a mechanism for erosion and sediment control for preventing and reducing other pollutants associated with construction activity. In addition, they must also inspect industrial facilities to ensure that measures are in place to prevent stormwater contamination. Finally, they must have an operation and maintenance program to prevent or reduce pollutant runoff from all municipal operations (City of Tucson, 1999). Stormwater NPDES permits have been issued to Pima County and the City of Tucson. Both entities conduct stormwater monitoring and implement programs to reduce pollutant runoff.

Although the use of stormwater is currently very limited, it is an important resource that should be considered in water-related planning efforts. Stormwater runoff supports riparian vegetation along washes, and it can create aquatic habitats at retention basins. For example, the Ajo Detention Basin has recently been constructed and designed to utilize stormwater. In addition, stormwater has been considered as a potential source water for artificial groundwater recharge projects in Pima County. In particular, Rillito Creek has been proposed as a site for artificial recharge of stormwater (Pima County Department of Transportation and Flood Control District, 1986). However, CH2M Hill and others (1988) reported in a recharge feasibility assessment for the Tucson area that the potential for artificial recharge using stormwater is limited to 17,000 acre-feet annually. The variability of flows complicates recharge and the design of any in-stream recharge system must take into account the heavy sediment loads associated with stormwater. A major problem with recharging stormwater is the clogging caused by the settling of suspended sediment (CH2M Hill, 1988).

CAP Water

To address groundwater depletion throughout the state, the Central Arizona Project (CAP) aqueduct was constructed. The CAP aqueduct is 326 miles long and transports water from the Colorado River to southern Arizona. The CAP aqueduct delivers Colorado River Water from Lake Havasu to cities, towns, and agricultural areas in central and southern Arizona. Some of the water is stored along the way in Lake Pleasant, which is impounded by the New Waddell

Dam on the Agua Fria River northwest of Phoenix. Releases of stored water from Lake Pleasant contribute to variations in the chemistry of the water delivered to Tucson.

Tucson Water has the largest allocation of CAP water in the area with approximately 138,920 acre-feet per year. Other jurisdictions, water companies, and public and private entities also have CAP water allocations. These include: Metropolitan Domestic Water Improvement District (8858 acre-feet), Spanish Trail Water Company (3037 acre-feet), Community Water Company of Green Valley (1337 acre-feet), Green Valley Water Company (1900 acre-feet), the Town of Oro Valley (1500 acre-feet) and others (ADWR, 1999).

Tucson Water began direct delivery of CAP water in November of 1992, but ended it in October of 1994, due to persistent problems of corrosion in the public and private water lines. In April of 1996 Tucson Water began a recharge and recovery pilot project in Avra Valley called the Central Avra Valley Storage and Recovery Project (CAVSARP). Recharge operations began in the summer of 1996. In June of 1999, Tucson Water began delivering a blend of recovered CAP water and groundwater to the first of four neighborhoods in its service area as a demonstration that the blended water would be acceptable to area residences and that it would not cause the same corrosion problems as before (PAG, 1999a). The demonstration projects were successful and Tucson Water began system-wide delivery of the blended groundwater/recovered CAP water in May of 2001.

Permits from the Arizona Department of Water Resources (ADWR) are required whenever water is intentionally added to an aquifer. As of 2001 there were four Underground Storage Facilities (USF) for CAP water in the TAMA. They include: CAVSARP, Pima Mine Road Recharge Project (PMRRP), Avra Valley Recharge Project, and the Lower Santa Cruz Recharge Project (ADWR, 1999; CAP, 2001).

Tucson Water's Clearwater Renewable Resource Facility is a water supply project in Avra Valley designed to recharge Colorado River water to blend with native groundwater in the aquifer. The blend is then piped to the greater Tucson area and distributed to Tucson Water's customers. CAVSARP is the primary structural element of the larger Clearwater Facility. It provides the means to take water from the CAP canal, recharge the water in basins in Avra Valley, and then recover and pump the water as far as the Hayden-Udall Water Treatment Plant. The Clearwater Project also includes blending of the recovered water with waters from other wellfields, delivery of the blended water to water customers, and ultimately the shut-down of many wells in the central wellfield (Tucson Water, 2000b). As of December 31, 2000 the total net recharge volume for the Clearwater Renewable Resources Facility was 43,290 acre-feet.

The Pima Mine Road Recharge Project is a constructed facility located approximately 15 miles south of Tucson which is jointly owned by the Central Arizona Water Conservation District and Tucson Water. The pilot testing was conducted from March 1997- March 1999. A full-scale underground storage facility permit, allowing up to 30,000 acre-feet of CAP water to be recharged per year, was issued in September of 2000. As of December 31, 2000, the total net recharge volume for the project was 25,185.29 acre-feet. (CAWCD, 2001).

The Avra Valley Recharge Project is operated by the Central Arizona Project, using CAP water purchased by Metropolitan Domestic Water Improvement District and the Arizona Water Bank (PAG, 1999). It consists of four off-channel constructed shallow spreading basins which have a combined area of about 11.4 acres (PAG, 1999a). The facility is located northeast of the Avra

Valley airport. The permit for the pilot project allowed for 8,300 acre-feet maximum volume and the full-scale facility permit allows for 11,000 acre-feet annually (ADWR, 1999).

The Lower Santa Cruz Recharge Project was dedicated in November 2000. This project is a joint effort by CAP, Town of Marana, Pima County Flood Control District and BKW Farms. Approximately 30,000 acre-feet of Colorado River water will be recharged each year at this facility (CAP, 2001).

Additional uses for CAP water include agriculture and industry. Many potential agricultural users in the Tucson AMA declined their CAP water allocations mainly due to the high cost of the water and infrastructure. In 1997 agriculture use of CAP was approximately 25,000 acre-feet. The City of Tucson also has groundwater savings facilities involving several irrigation districts, where CAP water is utilized for irrigation in lieu of groundwater. ADWR (1999) has indicated that industrial uses of CAP water are limited due to costs and water quality concerns. The mines are the largest volume industrial water users in the TAMA. The lack of delivery infrastructure, costs associated with CAP water quality as it affects operations, and the cost of the water may preclude direct CAP use (ADWR, 1999).

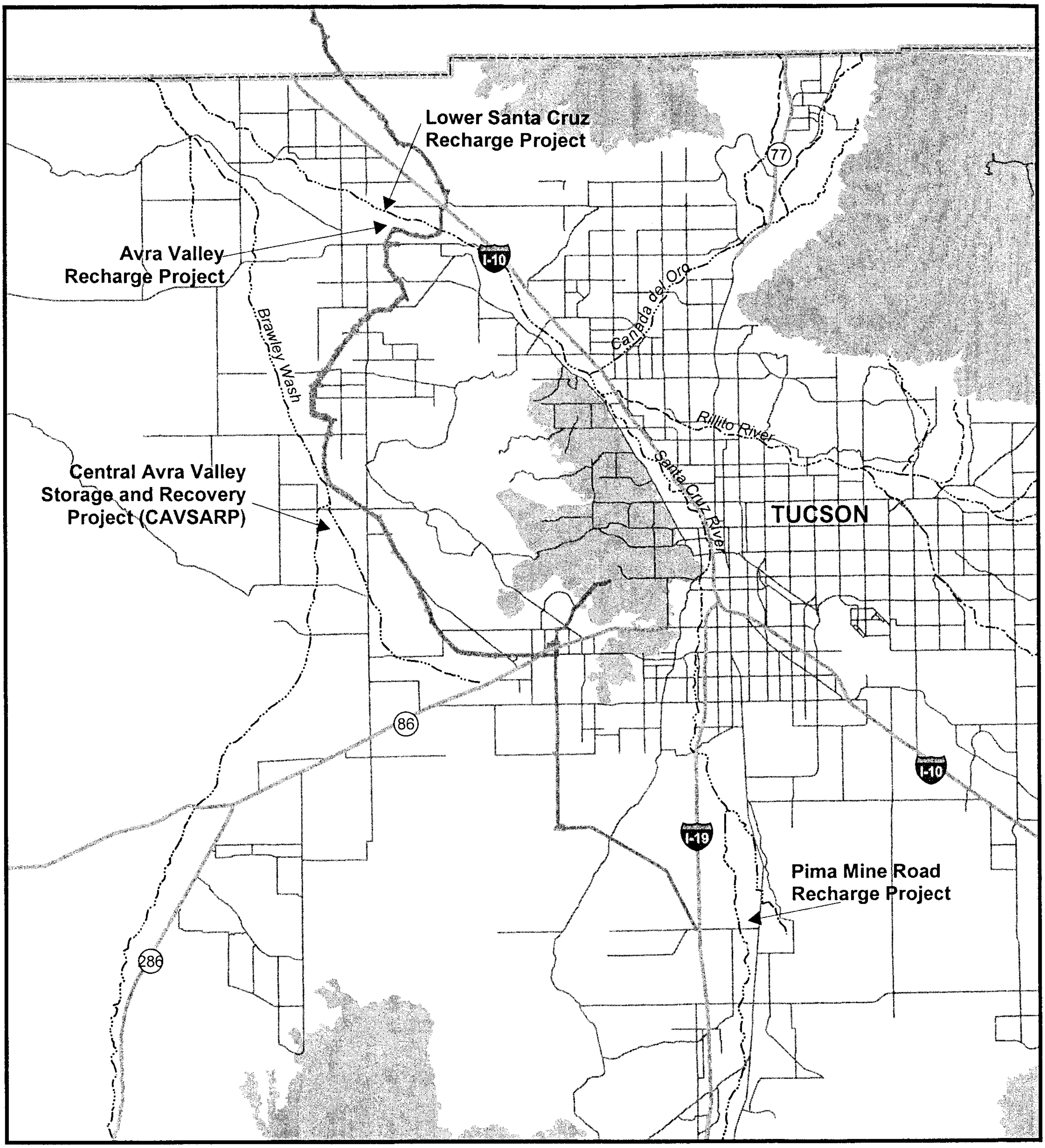
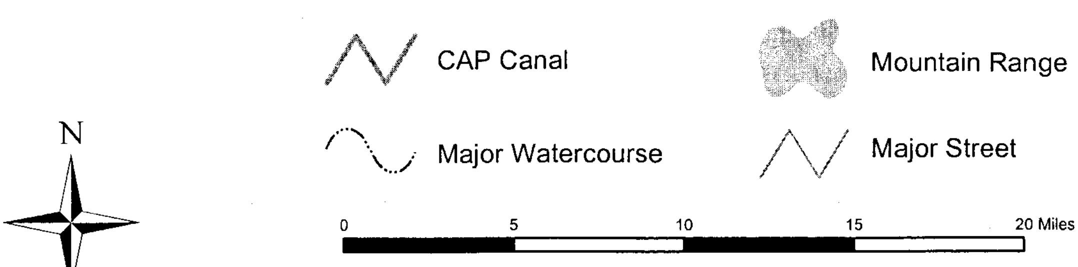


Figure 3. Locations of Central Arizona Project (CAP) Canal and Underground Storage Facilities in Pima County



Data Source: Location of CAP canal provided by Pima County Land Information System (PCLIS) CD-ROM.
Names and locations of recharge facilities from ADWR (1998) and CAP (2001).

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Treated Wastewater

For purposes of this report, treated wastewater is defined as water that has been used for domestic, commercial or industrial purposes, conveyed via sewer lines to either the Ina Road or Roger Road wastewater treatment facility, and either reused directly, discharged to the Santa Cruz River, or further treated and distributed through the City's reclaimed water system. Additional wastewater treatment facilities are located throughout Pima County. Effluent from these plants is not addressed in this report, because the vast amount of effluent generated for reuse comes from the two above- referenced facilities. The capacities of the Ina Road and Roger Road treatment facilities are 25 mgd and 41 mgd, respectively (PAG, 1999a). These two plants treated approximately 68,664 acre-feet of wastewater during fiscal year 1999-2000 (PCWMD, 2001). The discharges support an effluent dependent stream and a diverse riparian habitat, subject to flood events, along a river channel that would otherwise be ephemeral. Pima County also supplies approximately 500 acre-feet per year of treated effluent to the Arthur Pack Golf Course for irrigation. The effluent discharges also recharge the regional aquifer for many miles along the Santa Cruz River.

The reclaimed water treatment process begins at Pima County's Roger Road Treatment Facility. The County treats the wastewater to secondary standards required by state and federal agencies. A portion of this treated wastewater is piped into Tucson Water's reclaimed water filtration plant. The water is filtered through pressure filters containing anthracite coal and sand, and disinfected. The treated reclaimed water is gravity-fed to a 3-million-gallon reservoir on-site, ready for distribution to customers (Malcolm Pirnie, 1999). The delivery system includes more than 85 miles of separate piping and five separate reservoirs with a combined storage capacity of 15 million gallons (Tucson Water 2001a).

According to Tucson Water (2001a), more than 3 billion gallons of reclaimed water were delivered to customers in 1999. Currently, over eight percent of Tucson Water's total demand for water is met with reclaimed water. There are over 250 reclaimed water customers including 14 golf courses, 34 schools, and 30 parks. It is anticipated that in the future 15 percent of total water demand will be met by the use of reclaimed water.

Some of the water treated at the Roger Road Facility is piped to Tucson Water's Sweetwater Recharge Facilities where it is naturally filtered through the earth and stored underground for future use. The filtered water is recovered through wells and piped to the chlorine contact chamber where it is chlorinated and mixed with the filtered water produced at the plant (Tucson Water, 2001a).

Tucson Water operates the Sweetwater Wetlands on the east side of the Santa Cruz River. The constructed wetlands occupy 17 acres and consist of two settling ponds and two polishing ponds. The backwash water from the filtration plant is piped to the Sweetwater Wetlands where it is naturally treated before it is released into the recharge basin (Tucson Water, 2001; PAG, 1999a).

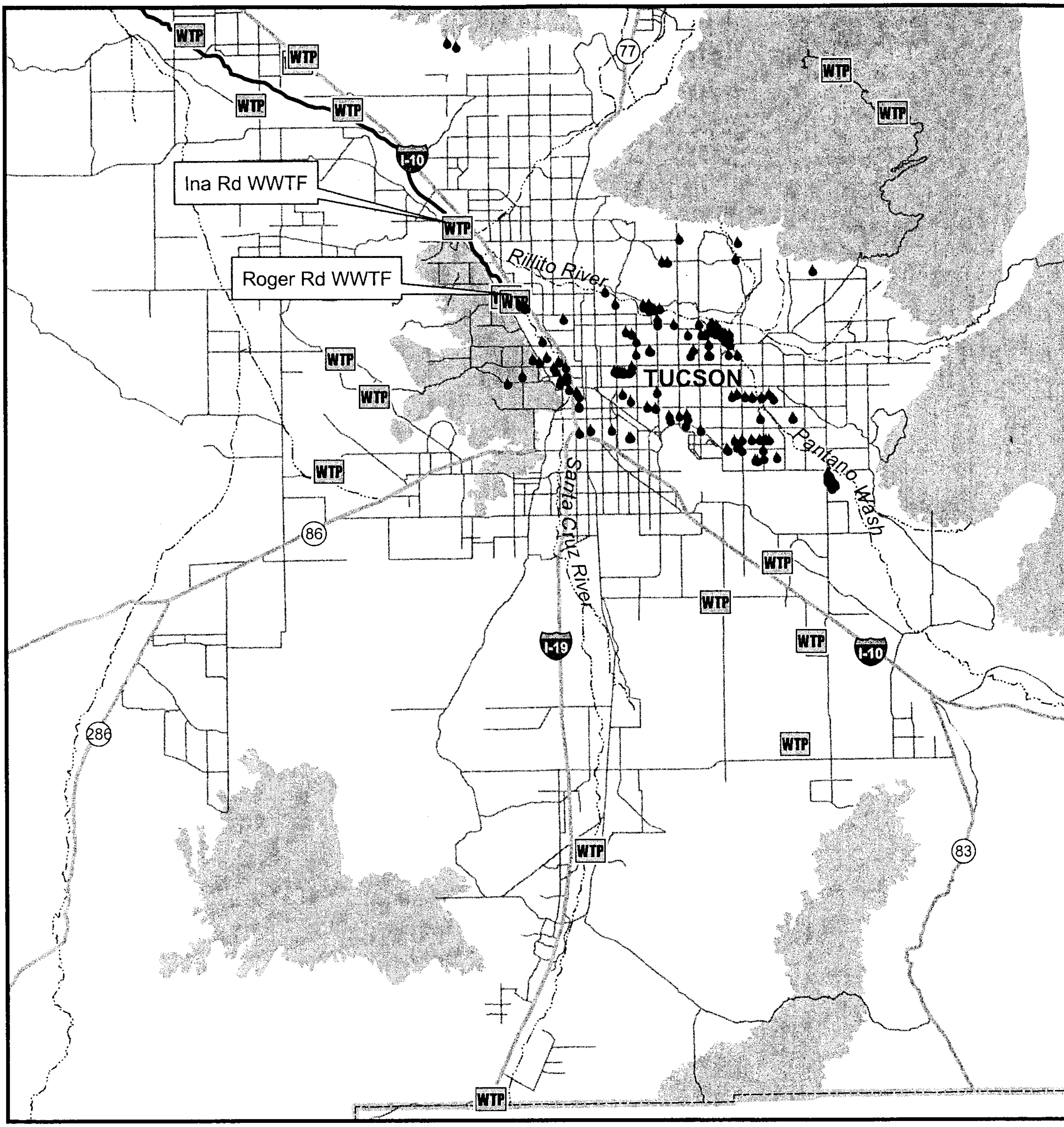

Figure 4. Wastewater Treatment Facilities (WWTF) and Effluent Use in Eastern Pima County

Effluent User

WTP Existing Wastewater Treatment Facility

Effluent Dominated Water (EDW)

Major Watercourse

Major Street

Mountain Range

N

0 7.5 15 22.5 30 Miles

Data Source: Locations of effluent users provided by Tucson Water. Locations of wastewater treatment facilities based on PAG WWTF inventory (1999c).

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Water Quality in Pima County

Groundwater Quality

Natural factors and human activities affect groundwater quality. Natural factors that have the most effect in the basins of south-central Arizona are depth in the aquifer and distance from major faults. Groundwater temperatures and pH significantly increase with well depth. In a United States Geological Survey (USGS) study, concentrations of dissolved solids, alkalinity, calcium, potassium, chloride and sulfate were significantly higher in samples collected from wells less than 2 kilometers from major fault lines. The groundwater quality in basins that do not have significant urban or agricultural development is primarily a factor of natural processes such as interaction with sediments and rock. Natural sources of dissolved solids and nitrate can impact water quality in these basins. However, areas with urban or agricultural development can also impact nitrate concentrations (USGS, 1999; USGS, 2000). The mineralogy of the aquifer material also influences water quality.

Most existing groundwater quality data for Pima County is representative of eastern Pima County, because more groundwater development has occurred there. Monitoring data in this area are abundant, due to a variety of regulatory requirements. In general, groundwater in the Tucson AMA is of acceptable quality for most uses. Most of the groundwater resources meet federal and state drinking water standards, though contaminant levels exceed primary safe drinking water standards in a few areas. Groundwater withdrawals from wells within these identified areas have been discontinued or are in the process of remediation. Other areas of known contamination not currently under remediation are monitored to ensure that contaminants do not spread (ADWR, 1999). In addition, the concentration of arsenic in groundwater would likely be of concern in several areas if an arsenic standard of 10 ppb is enacted.

Groundwater is the main drinking water source for Pima County. For this report general water quality data from various drinking water providers in the County were reviewed. Drinking water providers are required to sample the water that is delivered to their customers and report those constituents that were detected during the required monitoring. A detected result means a concentration that is above the minimum value that can be measured by a laboratory. In most cases, the minimum detectable level of a constituent is well below the USEPA's regulatory limit for that constituent (Tucson Water, 2000). A review of water quality data from Pima County drinking water providers for the 1998-2000 sampling years indicated the most common regulated constituents detected were nitrate, fluoride, arsenic, and chromium. Though these constituents were detected in the drinking water supplies, none were seen at levels that exceeded the established drinking water maximum contaminant levels (MCLs).

Concentrations of selected constituents in eastern Pima County groundwater are shown on Table 3. The data are from Tucson Water's wellfields, which encompass large areas of the Tucson basin and Avra Valley in eastern Pima County. The wells vary in depths, are regularly monitored, and for the purpose of this report are considered to be fairly representative of the area. Table 4 shows groundwater quality data from western Pima County.

Table 3. Concentrations of Selected Constituents In Tucson-Area Groundwater, 2000-2001 (Tucson Water web site 2001).

Parameter	Tucson Water Supply Source				
	Clearwater	Avra Valley Wells	Santa Cruz Wells	Central Wells	South Side / TARP
Fluoride, mg/L F	0.51	0.46	0.85	0.37	0.72
Hardness, mg/L CaCO3	83	79	178	106	226
Nitrate as Nitrogen, mg/L N	1.36	2.04	4.53	2.04	1.94
Sodium, mg/L Na	44	37	38	39	66
TDS, mg/L	227	In Progress	In Progress	258	In Progress
pH, Std. Units	8.04	8.13	7.66	7.85	7.96

"In Progress" indicates that the data is under development and will be included in the table as the data becomes available.

Arsenic in groundwater in the Tucson Water well fields was measured during 2000. Four of the 161 points of entry (POE) tested had maximum arsenic concentrations greater than 9.0 µg/l, with the highest maximum value of 10 µg/l found at one site. 56 of the POEs had maximum arsenic values of < 2 µg/l (Tucson Water, 2001b).

Table 4. Detected Inorganic Water Quality Constituents, Arizona Water Company, Ajo, Arizona, 2000 Annual Report. (Arizona Water Co., 2001)

Parameter	Units	MCLG	MCL	Highest Level detected	Sample Year
Arsenic	ppb	0	50	22	2000
Chromium	ppb	100	100	20	2000
Fluoride	ppm	4	4	1.7	2000
Nitrate	ppm	10	10	3	2000
Sodium	ppm			190	1998
Sulfate	ppm			160	1998

In the 1970's and 1980's some additional groundwater studies were conducted in western Pima County by the USGS. Samples from three groundwater sources Bonita Well, Pozo Salado Well, and Quitobaquito Spring, all located within the Organ Pipe Cactus National Monument, indicate that the major-ion chemistry is similar to chemistry of groundwater in other alluvial basins in southern Arizona. The upgradient well, Bonita Well had dissolved solids measures at 338 mg/l and 0.4 mg/l of fluoride. This is similar to analyses of groundwater sampled from recharge areas in other alluvial basins in southern Arizona (Robertson, 1991). Readings for pH ranged from 7.4 in the upgradient well to 8.4 in the downgradient well. Dissolved solids and fluoride also increased from the upgradient well to the downgradient site and ranged from 338mg/l to 1500mg/l and 0.4 mg/l to 5.4 mg/l respectively (Carruth, 1996)

Land uses that have reportedly led to historic groundwater contamination in eastern Pima County include: landfills and disturbed areas, wells no longer in service that have not been capped properly, irrigated agriculture, animal impoundments, underground storage tanks, surface impoundments, wastewater treatment facilities, mines, and industry and commerce (PAG, 1994). Common groundwater contaminants in the Tucson area groundwater include volatile organic compounds (VOC), nitrates, petroleum hydrocarbons, and heavy metals.

Areas of contamination in eastern Pima County include: Broadway- Pantano WQARF Site, Davis Monthan Air Force Base, Downtown Tucson, El Camino Del Cerro WQARF Site, Tucson Airport Area Remediation Project (TARP), Air Force Plant 44, Los Reales WQARF Site, Price Service Center, Silverbell Jail Annex Landfill/Miracle Mile WQARF Site and Shannon Road-Rillito Creek WQARF Site. The groundwater is usually considered contaminated if the most recent well sample data available indicated an MCL exceedance (PAG, 1994).

Broadway-Pantano WQARF Site

The Broadway landfill was closed in 1971 and since that time a groundwater contaminant plume has developed beneath the site. Four public drinking water wells have been removed from service due to the PCE contamination at this site. Contaminant levels near the edge of the plume are 5ppb. The highest concentration measured was 100 ppb directly adjacent to the landfill. An activated carbon adsorption system has been selected to treat the contaminated groundwater. Treatment will focus on pumping the aquifer and re-injecting the water to achieve hydraulic containment (PAG, 2000b).

Davis Monthan Air Force Base

In 1985 groundwater contaminated with jet fuel was found on the base in the area of the air strip called the J-3 pump house. A soil vapor extraction system was used to remove jet fuel from the soil and reduce the groundwater contamination. This system has been in operation since the early 1990's and the contamination remains localized on the Air Force Base. (PAG, 1994).

Downtown Tucson

Groundwater in the vicinity of downtown Tucson contains petroleum products and VOCs at various locations. Diesel fuel is the most widespread contaminant. Chlorinated VOCs such as TCE and PCE are present in more localized areas, including the Mission Linen site, where PCE concentrations have been reported at levels as high as 11,000 µg/l (ADWR, 1999). The 7th Street and Arizona Avenue and Park-Euclid WQARF sites are located within the downtown Tucson area (ADEQ, 2001).

El Camino del Cerro WQARF Site

The El Camino del Cerro WQARF site is located in northwest Tucson. The primary contaminants of concern include PCE, TCE, vinyl chloride, and benzene (ADEQ web site, 2001). Nitrate contamination is also present (PAG, 1994). Groundwater monitoring and field investigations are underway. Pima County is operating a landfill gas extraction system at the closed El Camino del Cerro landfill. VOCs have been removed at a rate of 30 to 40 pounds per week (PAG, 2000b).

Tucson Airport Area Remediation Project (TARP)

This is a federal Superfund site. Groundwater in the area is contaminated with TCE, and a pump and treat remediation system has been in operation since 1994. Contaminants are being removed using three air stripping towers. The design rate was 5,800 gpm and the average expected TCE concentration of the influent was approximately 15-35 μg/l. By the end of 1999 the system had treated approximately 13.4 billion gallons of water and had removed 1,400 pounds of TCE. This plant supplies almost 9% of Tucson's total drinking water supply (PAG, 2000b).

Air Force Plant 44

This location is part of the Tucson Area Superfund Site plume, south of Los Reales Road in the Tucson metropolitan area. The groundwater contamination plume beneath the site contains chromium and TCE. Remediation at this site began in 1987 and uses air strippers with carbon adsorption and a re-injection system (PAG, 1994).

Los Reales WQARF Site

Groundwater downstream of the Los Reales Landfill is contaminated with TCE and PCE in a plume that measured approximately ½ mile wide by ½ mile long. No public water supply wells have been impacted by this contamination, which is trapped in the upper aquifer. An air stripper remediation system was installed to contain the groundwater plumes. The average concentration of TCE in the groundwater entering the treatment system is approximately 7 ppb (PAG, 1994; PAG 2000a).

Price Service Center

Petroleum contaminated groundwater is present in the area of the City of Tucson's Price Service Center. This contamination resulted from leaks and damage to several underground storage tanks. The shallow groundwater has had benzene detected at concentrations as high as 30,000 ppb. No public water wells have been impacted by this contamination (PAG, 1994).

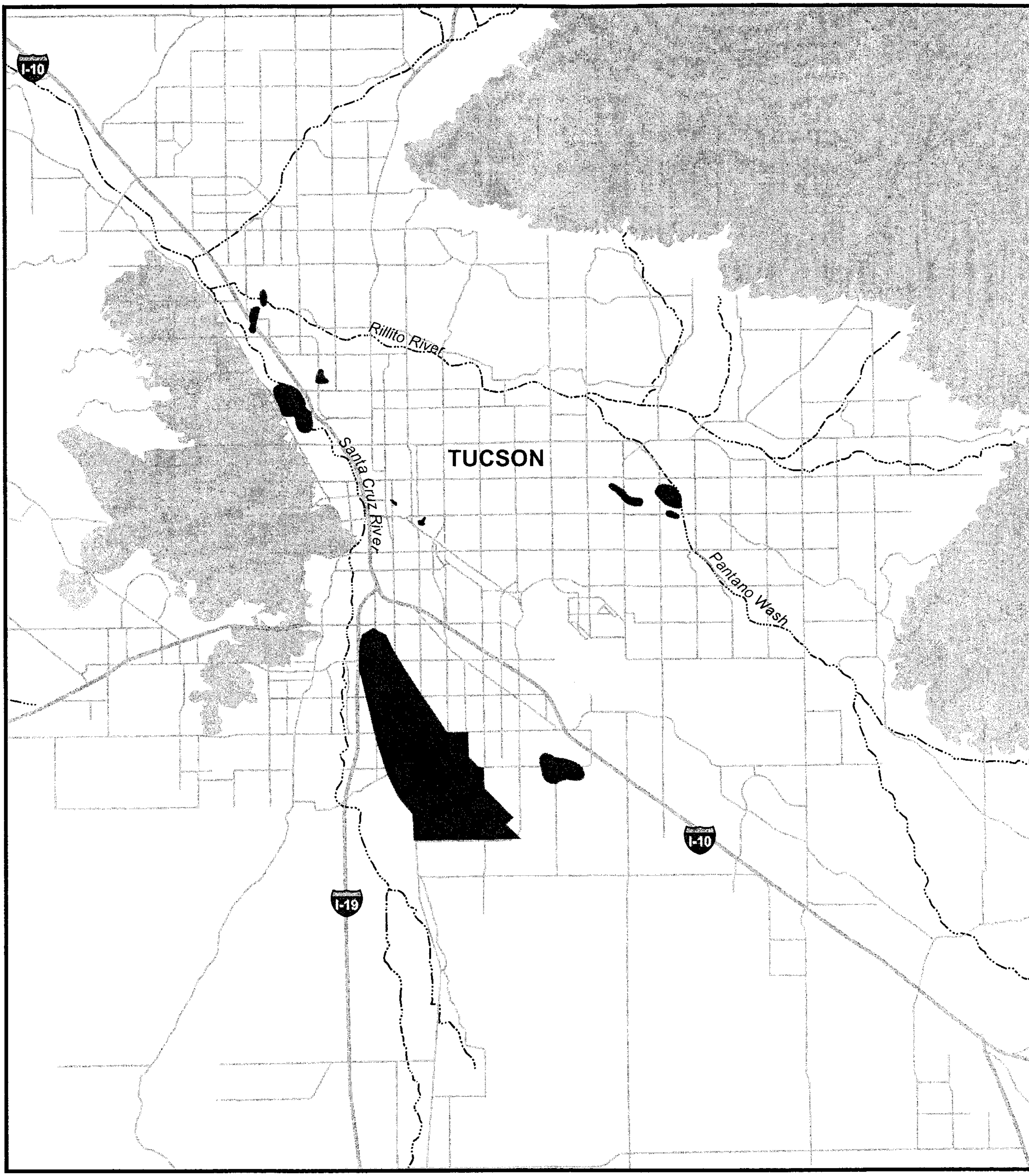

Figure 5. Locations of State (WQARF) and Federal Superfund Sites in Pima County

WQARF or Superfund Site
Major Watercourse
Major Street
Mountain Range

0 4 8 12 16 Miles

Data Source: Locations of WQARF and Superfund Sites provided electronically by Arizona Department of Environmental Quality (ADEQ).

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Silverbell Jail Annex/Miracle Mile WQARF Site

TCE and PCE have been found at concentrations of 13.5 ppb and 154 ppb respectively. In addition, the inorganic groundwater quality of the area is naturally poor with high TDS, sulfate, and chloride concentrations. High nitrate concentrations have also been present since the 1950's. This contamination has impacted two public-supply wells serving mobile home parks in the area. (PAG, 1994). A pilot remediation project using a re-circulation well system at Silverbell Landfill has been in use for several years (PAG, 2000b).

Shannon Road-Rillito Creek WQARF Site

PCE was detected in the groundwater at this site in 1993. Metro Water installed a well head treatment system on the South Shannon well. Two public supply wells have been impacted. One owned by the City of Tucson has been shut down and the other, owned by a mobile home park, has been equipped with a carbon treatment system since July 1997 (PAG, 2000b).

Other Sites

In addition to the above listed sites, there are a number of former landfill sites and underground storage tank sites that may have impacted the local groundwater. Also, an area encompassing 42 square miles in the south Santa Cruz area, which extends from two miles south of the Tucson City limit to just north of Green Valley, contains seven public supply wells that have exceeded the MCL for nitrate. Historical data indicate the high nitrate concentrations in this area developed between the late 1940's and the mid-1960s. The nitrate contamination in this area appears to be a result of a combination of irrigated agriculture, sewage effluent, septic tanks and animal feed lots (PAG, 1992).

Surface Waterbodies Water Quality

Stream water quality in the higher elevations of Pima County is primarily determined by natural factors. Processes such as chemical weathering of bedrock and soils, biological activity in soils, groundwater discharge to streams, and runoff determine the water quality of these streams. Locally, stream water quality may be affected by agriculture, mining and urban land use. Nutrient and dissolved-solids concentrations fluctuate seasonally in these streams. The patterns of rainfall and snowmelt account for the seasonal fluctuations in concentrations of nutrients. Concentrations increase in streams during times of rainfall and snowmelt runoff because the runoff carries nutrients washed off the land surface into the streams. Seasonal patterns of dissolved solids are opposite to those of nutrients. During periods of runoff, flow in streams is diluted and the dissolved-solids concentrations are lower. Streams affected by human activities may have elevated concentrations of dissolved solids from a variety of activities including urban and agricultural runoff. Man made compounds such as pesticides and volatile organic compounds (VOC) in streams are a direct result of human activities (USGS, 2000).

ADEQ Monitoring

Arizona Department of Environmental Quality (ADEQ) assessed 281 miles of streams and six lakes in the Santa Cruz-Rio Magdalena-Rio Sonoyta Watershed, which includes Santa Cruz County and a large portion of eastern Pima County. This watershed is 11,096 square miles and makes up about 10% of the state's land. The watershed is a composite of two surface water basins: the Santa Cruz which flows north to the Gila River, and the Rio Magdalena and Rio Sonoyta drainages which flow south into Mexico. In its report, *The Status of Water Quality in Arizona, Clean Water Act Section 305(b) Report 2000,* ADEQ tabulated the results of the stream assessments. The data for streams and lakes in Pima County are included in Appendix A.

ADEQ performs two types of assessments: "monitored" and "evaluated." Monitored assessments are based on current data that are less than five years old and normally there are at least four monitoring events within a year. Evaluated assessments are based on less data and information. Assessment reliability generally increases with increased quantity and diversity of data.

Three lakes, Arivaca Lake, Kennedy Lake, and Lakeside Lake, in Pima County were assessed by ADEQ. Though none were found to be in full support of their designated uses, ADEQ recognized that smaller lakes were more likely to be in the partial support or non-support category. Through its monitored assessment ADEQ found Arivaca Lake to be non-supporting of its designated use due to high pH, low dissolved oxygen and mercury.

The following area streams were monitored or evaluated by ADEQ and determined to be in full support of their designated uses: Arivaca Creek (headwaters to Altar Wash), Canada del Oro (headwaters to Big Wash), Cienega Creek (headwaters to Del Ago Dam), Sabino Canyon Creek (headwaters to the Tanque Verde Creek), Tanque Verde Creek, and Madera Canyon Creek (headwaters to the Santa Cruz River). Only the Santa Cruz River (Canada del Oro to Guild Wash) was found to be non-supporting due to some of the samples indicating low dissolved oxygen, but this reach is in full support with regard to turbidity.

The State is required to develop water quality improvement plans for any streams and lakes that have been identified as impaired. The TMDL Program (Total Maximum Daily Load) is a separate but closely related effort to the Water Quality Assessment Program. The purpose of the program is to identify the sources and quantities of pollutants being delivered to a waterbody and to identify the maximum quantities of the pollutant that the waterbody can assimilate and still meet water quality standards. The goal is to develop a plan which identifies how all the various contributors of pollutants can work together to reduce pollutant loading and help get the water body back into compliance with the water quality standard. Waterbodies that are scheduled for development of TMDLs are identified on the state's "water quality limited waters" list, which is commonly referred to as the "303(d) list"(ADEQ, 2000).

Only one water in Pima County was on the state's 1998 303(d) list. Arivaca Lake was listed with mercury as the primary stressor, along with a fish consumption advisory. Arivaca Creek was de-listed in 1998 for dissolved oxygen, which was determined to be a natural condition.

ADEQ has additional water quality monitoring data for area streams. The following table includes selected data from ADEQ's surface water quality database.

Table 5. Selected Stream Water Quality Data, 1989-2000, From ADEQ Database

Site	Ca Total (mg/l)	Mg Total (mg/l)	Na Total (mg/l)	K Total (mg/l)	Bicarbonate Total (mg/l)	SO4 Total (mg/l)	Cl Total (mg/l)	F Total (mg/l)	Arsenic Total (mg/l)	TDS (mg/l)
Arivaca Creek at Ruby Rd 3/23/93	70.7	9.9	16.2	1.88	265	ND	9.8	0.23	ND	287
Madera at Whitehouse, 12/19/90	71.3	12.6	17.7	1.1	141	100	6.9	0.36	<.005	320
Tanque Verde Creek 8/1/89	11.2	1.8	6.6	2.1	32	13	3.7	0.12	<.005	90
Sabino Creek 5/13/91	11.0	1.8	2.3	0.5	31*	5.55*	2.1	0.13	<.005	60
San Pedro River 8/31/91	57.4	12.9	46.0	4.4	183	87	15	0.82	<0.005	340
Buehman Canyon 5/18/00	71	8.2	20	2.5	260	21	8	0.68	ND	295

Notes: Sabino Creek below Summerhaven; Buehman Canyon 2 miles below confluence with Bullock Canyon; Tanque Verde at Sabino Canyon Road and San Pedro at Redington. ND= not detected, *- average of two sample results, mg/l= milligrams per liter.

Sonoran Desert Conservation Plan Studies

In addition to ADEQ's monitoring, several waterbodies that are potentially very important aquatic habitat in Pima County have been sampled for studies conducted by PAG and Pima County Flood Control District as part of the Sonoran Desert Conservation Plan. These include Cienega Creek, Bingham Cienega, and the San Pedro River.

A portion of Cienega Creek has been designated by the state as a "unique water", which means it qualifies for site-specific water quality standards established to maintain and protect the existing water quality. The water quality of Cienega Creek was described in the Unique Waters Final Nomination Report submitted to the state. This report concluded that the water quality of base flows in the reach nominated for Unique Water status met standards designed for designated uses, including aquatic and wildlife (warm-water). The lowermost reaches of Cienega Creek were sampled more recently (in the late 1990s) as part of a two-year study by PAG and Pima County Flood Control District to determine the source of the water. The results are summarized on Table 6.

Bingham Cienega is a rare, perennial wetland located approximately 2000 feet west of the lower San Pedro River, and ¼ mile north of the settlement of Redington. PAG and the Pima County Flood Control District sampled Bingham Cienega, the San Pedro River, and Edgar Canyon (a tributary to the San Pedro) in the late 1990s, in order to identify the water source of the cienega. The results are summarized on Table 6.

Table 6. Average Values, Water Quality Data for Selected Streams in Pima County September 1998-June 2000 ***(PAG, 2001; PAG 2000).***

Site	Ca dissolved (mg/l)	Mg dissolved (mg/l)	Na dissolved (mg/l)	K dissolved (mg/l)	Alkalinity CaCO3 (mg/l)	SO4 dissolved (mg/l)	Cl dissolved (mg/l)	F dissolved (mg/l)	Arsenic dissolved (mg/l)	TDS (mg/l)
Cienega Creek	109	32	61	5.9	252	257	14	0.57	0.0006	737
Bingham Cienega	64	12	40	1.7	219	55.8	11	1.14	.0043	280
San Pedro River	64	16	55	2	222	90.2	18	0.92	0.0022	344
Edgar Canyon	64	15	24	1.1	238	18.6	6.9	0.39	0	287

Notes: 0 = constituent was not detected at the Practical Quantitation Limit (PQL).
mg/l= milligrams per liter

Most of the natural surface water sources are located in eastern Pima County. An exception is the Quitobaquito Spring and pond, which are located in Organ Pipe National Monument near Lukeville Arizona and the Mexican border. Water quality data collected from several aquatic studies are shown below.

Table 7. Chemical Constituents in Water at Quitobaquito, Arizona. From: Description and Conservation Status of *Cyprinodan macularius eremus*. A New Subspecies of Pupfish from Organ Pipe Cactus National Monument, Arizona. (Miller and Fuiman, 1987).

*Parameter	Quitobaquito Pond, 1982,	Quitobaquito Pond, 1963, 1964	Quitobaquito Spring, 1982	Quitobaquito Spring, 1963-64
TDS	820		670	
TSS	<10		<10	
pH	9.22		8.07	
HCO3	220	411	300	316-402
F	4.9	5.3	4.1	4.3
Cl	190	383	150	148-318
PO4	<0.50		<0.50	
NO3	<0.50		9.9	
SO4	110	100	95	71-91
Na	230	350	188	191-284
K	3.1	7.0	2.7	4.5-6.0

* No units were included in the journal article for this data, convention is mg/l for these parameters except pH, which is in standard units

PAG is unaware of any extensive water quality monitoring data for most of the streams in Pima County with one or more reaches of perennial and/or intermittent flow. Although it is likely that additional studies and monitoring data are available for some streams, it appears that the vast majority of the aquatic habitats in Pima County have not been adequately monitored for water quality.

Stormwater Runoff Water Quality

For the purpose of this report PAG reviewed historical stormwater quality data from the 1996 *Water Quality Assessment for the Tucson Active Management Area Northwest Replenishment Program Feasibility Study,* and NPDES stormwater monitoring reports submitted by the City of Tucson and Pima County to the EPA.

Historical Data

The Lower Santa Cruz River

For the Lower Santa Cruz River, PAG (1991) reported water quality data for a sample collected by ADEQ on October 6, 1989, from the Santa Cruz River and Congress Street Bridge. Concentrations of the major constituents are shown on the following table.

Table 8. Stormwater Quality Data for the Santa Cruz River at Congress Street Bridge Collected by ADEQ October 6, 1989 (PAG, 1991).

Parameter	Concentration (mg/l) milligrams per liter
Calcium	17.6
Magnesium	2.32
Sodium	9.1
Potassium	9.3
Bicarbonate	75
Chloride	1.1
Sulfate	10
NO2+NO3	0.61
TDS (total dissolved solids)	90
TSS (total suspended solids)	10,600

In addition Harding Lawson Associates (1987) reported water quality data for a Santa Cruz River sample collected upstream of the Roger Road treatment plant in 1985. The results were as follows: Bicarbonate 104 mg/l, TDS 230 mg/l, and TSS 11,724 mg/l. No other data for this sample were reported.

The Rillito Creek Basin

Water Quality data (PAG, 1996) for the Rillito Creek basin included concentrations of major ions, nutrients, trace metals, suspended sediments and organics reported by the USGS for the years 1986-1993. Slightly less than two thirds of the samples were collected automatically. Automatic samplers were programmed to activate when the flow stage exceeded a threshold value of 0.2 feet in 2 minutes. A sample was collected every 5 minutes during a rising stage, and every 10 minutes during a falling stage. The samples were composited. Samples were not collected on a regular basis (e.g. once a month), or at a consistent time of day, presumably because the frequency of runoff events in the Tucson area is highly irregular. However, the data represented nearly equal numbers of winter and summer storms (PAG, 1996). The data are shown on Tables 9 and 10.

Table 9. 1986-1993 Stormwater Quality Data for Tanque Verde Creek at Sabino Canyon Road (USGS, 1995; USGS, 1994)

Constituent	Average (mg/l)*	Minimum (mg/l)	Maximum (mg/l)
Calcium	10.4	4.3	25
Magnesium	1.6	0.98	4.6
Sodium	6.0	4.1	10
Potassium	2.2	0.7	6.5
Aluminum (total)	117	0.47	410
Bicarbonate	34	14	68
Chloride	4.0	2.1	7.2
Sulfate	9.9	4.5	16
Nitrate	0.3	0.07	0.81
TDS	93	41	205
TOC	84	8.8	240
TSS	2891	22	10300

*mg/l= milligrams per liter.

Table 10. 1986-1993 Stormwater Quality Data for Rillito Creek at Dodge Boulevard (USGS, 1995;USGS 1994).

Constituent	Average (mg/l)*	Minimum (mg/l)	Maximum (mg/l)
Calcium	15	8.2	46
Magnesium	1.9	0.8	5.9
Sodium	6.6	1.9	15
Potassium	2.5	0.8	5.1
Aluminum (total)	195	44	550
Bicarbonate	53	28	121
Chloride	3.8	1.5	12
Sulfate	13	4.6	52
Nitrate	0.5	0.18	1.3
TDS	100	19	243
TOC	117	19	210
TSS	12089	21	36700

*mg/l= milligrams per liter

Brown and Caldwell (1984) and CH2M Hill and others (1988) have reported that stormwater runoff can contain elevated levels of trace metals. Some of the undissolved metals in the stormwater samples (particularly aluminum, which is abundant in clays) may be naturally occurring in sediments that are eroded during storm events. These sediments are carried downstream in suspension, and metals contained in (or sorbed onto) these sediments are included in the analysis of total metals (PAG, 1996).

Municipal NPDES Monitoring Data

The City of Tucson's Municipal Stormwater Permit stipulates that the City will implement the stormwater monitoring program as described in the City's October 1996 permit application. EPA amended the monitoring program slightly by adding the chemical DDE to the list of pollutants for which sampling and analysis was to be conducted. The purpose of the monitoring program was to develop a substantial local database of land-use-specific stormwater quality data, and to develop a focused management program (City of Tucson, 1999).

Analysis of 15 constituents is required under the monitoring program approved for the City's NPDES Municipal Stormwater permit (permit # AZS000001) and includes the following constituents: Arsenic (As), copper (Cu), lead (Pb), zinc (Zn), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrogen as nitrite, nitrogen as nitrate, total dissolved solids (TDS), total suspended solids (TSS), total kjeldahl nitrogen (TKN), DDE, oil and grease, total phenols and total phosphorous. Under the approved monitoring program each sampling site was automated in 1999 to allow better response to storm events with the goal of sampling each site once during the winter rainy season and once during the summer rainy season. Because the automated units were not yet operating according to EPA protocol manual, samples were manually collected for the 1998-99 reporting period (City of Tucson, 1999).

Stormwater was monitored at five locations representing different land uses typical to Tucson. They include: single family residential site, multi-family residential site, commercial site, industrial site, and a mixed-use site. Table 11 summarizes the analyses results for the events sampled during the 1998-99 fiscal year.

Table 11. Fiscal Year 1998-99 Monitoring Results for City of Tucson Stormwater. Municipal Stormwater Annual Report, City of Tucson (City of Tucson, 1999).

DATE	7/22/98	7/31/98	4/01/99	8/05/98	9/16/98	10/21/98	MAX	MIN
Facility	Mfr	Sfr	Sfr	Mxu	Ind	Com		
Rainfall (in)	0.55	0.50	1.20	0.15	0.10	0.10	1.20	0.10
Duration (hours)	3 hours	2 hours 20 min	16 hours	3 hours	2 hours	1 hour 20 min.	16 hour	1 hour 20 min
Last Rain (days)	4	9	115	3	12	47	115	3
Temperature	25.9	27.1	N/T	N/T	27.5	18.2	27.5	18.2
pH	7.1	7.4	7.2	6.7	6.7	6.5	7.4	6.5
Total Flow (gal)	151,814	92,111	356,823	269,451	148,672	21,790	356,823	21,790
As (mg/l)	<0.005	<0.005	<0.003	<0.005	0.006	<0.005	0.006	ND
Cu (mg/l)	<0.015	0.026	0.056	<0.016	0.063	<0.005	0.063	ND
Pb (mg/l)	<0.005	0.026	0.036	0.043	0.022	0.010	0.043	ND
Zn (mg/l)	0.07	0.16	0.32	0.44	0.34	0.35	0.44	0.07
BOD (mg/l)	10	20	N/A	35	48	98	98	10
COD (mg/l)	89	209	334	285	371	582	582	89
Nitrate+nitrite (mg/l)	0.5	1.0	1.5	1.7	2.2	1.3	2.2	0.5
Total Phosphorus (mg/l)	0.89	4.3	0.83	2.55	6.96	1.60	6.96	0.83
TDS (mg/l)	53	116	236	118	233	383	383	53
TSS (mg/l)	71	160	136	186	16	29	186	16
TKN (mg/l)	0.50	1.70	5.92	1.70	1.10	2.30	5.92	0.50
DDE (μg/l)	<1.0	<1.0	<0.02	<1.0	N/A	N/A	ND	ND
Oil & Grease (mg/l)	<5.0	<5.0	N/A	<5.0	<5.0	<5.0	ND	ND
Phenols (μg/l)	<5.0	<5.0	N/A	<5.0	<10	<5.0	ND	ND

Sfr= Single family residential-Grant Road and Wilson Ave
Mfr = Mutli-family residential-Greenlee Rd.
Com = Commercial El Con Mall- Randolf Way
Mxu = Mixed use-First Ave at Limberlost
Ind = Industrial 17th Street
N/T = Not Taken- Due to Equipment Failure
N/A = Lab Quality Control Failure, No data available
ND = Non-detected

The 1998-99 sampling results, similar to the results submitted in the previous annual report, indicated that Tucson stormwater was essentially free of the man-made contaminants included in the monitoring program. The results were variable, with no definite trends identified.

Similar to the City of Tucson, Pima County has an NPDES stormwater permit, no. AZS000002. The permit stipulates that a summary of the required monitoring data, accumulated throughout the reporting period, be submitted to the USEPA in the form of an annual report. Wet weather monitoring is conducted in accordance to permit requirements with samples collected biannually at five monitoring stations, once during the winter rainy season and once during the summer rainy season. Those results are shown on Table 12.

Table 12. Monitoring Results for Pima County Stormwater, Second Reporting Period, September 2000. From the Third Annual Report, Pima County NPDES Stormwater Discharge Permit (Pima County, 2000).

Facility	Site 1	Site 1	Site 1	Site2A	Site 3	Site 3	Site 3	Site 4	Site 4	Site 4	Site 5	Site 5
Date	7/14/99	3/6/00	6/22/00	7/6/99	7/14/99	3/6/00	6/22/00	7/14/99	3/6/00	6/22/00	7/5/99	6/19/00
H2O Temperature on arrival °C	29.3	9.6	23.0	24.0	31.3	10.5	24.5	30.0	10.4	26.4	27.2	22.2
H2O Temperature + 1 hour °C	-	9.0	-	23.9	-	10.1	27.1	-	11.1	25.7	27.8	25.1
H2O Temperature +2 hours °C	-	-	-	-	-	9.7	-	-	11.5	25.8	27.9	29.8
H2O Temperature + 3 hours °C	30.7	9.2	23.3	24.6	29.6	9.7	25.6	28.4	11.6	25.6	-	30.7
pH at arrival s.u.	9.07	6.97	8.03	7.94	6.58	7.43	7.79	7.32	7.39	7.76	8.03	8.65
pH + 1 hour s.u.	-	7.45	-	7.91	-	7.55	7.05	-	7.44	7.67	7.84	8.06
pH+ 2 hours s.u.	-	-	-	-	-	7.51	-	-	7.54	7.81	7.94	7.90
pH + 3 hours s.u.	8.16	7.5	7.42	7.25	7.72	7.45	7.15	8.24	7.46	7.95	-	7.90
Fecal coliform on arrival Mpn/100ml	3000	500	3000	160000	3000	11000	900	9000	17000	50000	5000	900
Fecal coliform +1 hour Mpn/100ml	-	-	-	-	-	-	-	-	-	-	-	-
Fecal coliform + 2 hours Mpn/100ml	-	-	-	-	-	-	-	-	-	-	-	-
Fecal coliform + 3 hours MPn/100ml	220	1300	2400	30000	1700	30000	1600	2400	1700	900	300	16000
Cu (µg/l)(total)	183	13.6	21.6	21.5	27.9	18.4	31.9	34.0	29.8	50.0	81.2	107
Pb (µg/l)(total)	210	ND	17.4	T	ND	ND	T	T	T	T	93.3	136
Zn (µ/l)(total)	476	36.2	48.9	78.6	161	129	183	46.5	165	155	214	305
Hardness (calculated) mg/l	876	46.1	57.5	41.1	32.2	27.7	54.3	88	36.0	58.0	285	272
TSS mg/l	5631	49	273	125	55	29	32	120	65	52	712	596
4,4-DDE (µg/l)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

s.u.-standard units, °C- degrees Celsius, Mpn/100mg/l- most probable number per 100mg/l, mg/l- milligrams per liter, µg/l-micrograms per liter, --- no measurement taken or no sample collected, ND- not detected at or above the laboratory detection limit. T-trace

Site 1-Residential, low density

Site 2A- Residential, medium density

Site 3- Residential, high density

Site 4- Commercial

Site 5- Industrial

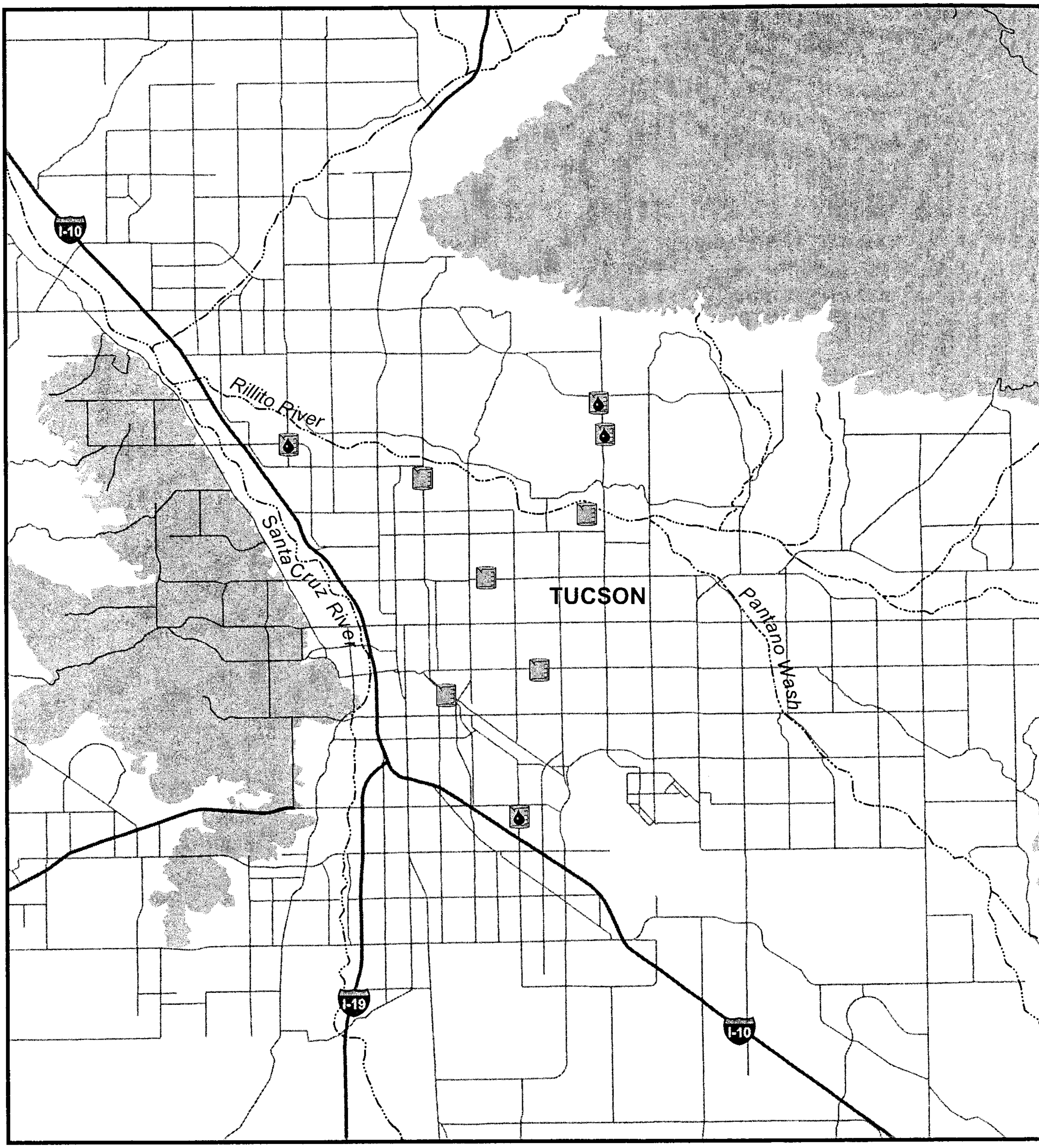
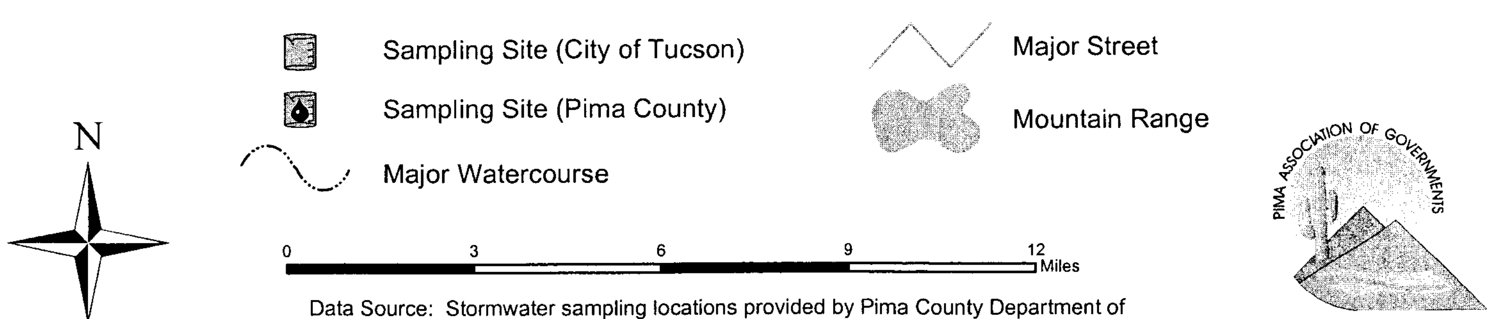


Figure 6. Stormwater Sampling Locations in Eastern Pima County



Data Source: Stormwater sampling locations provided by Pima County Department of Environmental Quality and City of Tucson DOT Stormwater Managment Division.

March 2002

CAP Water Quality

The CAP water delivered to the Tucson area is a mixture of Colorado River Water, Bill Williams River water, and Agua Fria River water. However, the Colorado River water is the most significant source. The CAP water delivered to the Tucson area is a sodium-sulfate water type and with the exception of turbidity and total coliform bacteria, which is expected in surface water, meets all primary drinking water standards established by the USEPA and ADEQ (Tucson Water, 2000b).

Total dissolved solids (TDS) concentrations in Colorado River water between 1972 and 1999 ranged between 535 and 747 and averaged 644 mg/l. Review of the data indicates the TDS concentration in Colorado River water is generally lower during periods of abundant precipitation within the Colorado River watershed (Tucson Water, 2000b).

Analytical results for common constituents for all CAP water samples collected at the pump station at the CAP aqueduct (Tucson Water sample point 713) between October 1997 and April 2000 are summarized on Table13. The data were collected by Tucson Water, which conducts extensive monitoring of CAP water delivered to the Clearwater Renewable Resource Facility.

CAP water quality was also monitored at the Pima Mine Road Recharge Project during the year 2000. Analytical results of the source water samples did not indicate the presence of any analyte at concentrations exceeding the Arizona Aquifer Water Quality Standards (AWQS). No pesticides or herbicides were detected above the laboratory reporting limits. Results of the general minerals, and physical parameters (except temperature) were remarkably consistent among the three sampling periods conducted in 2000 (CAWCD, 2001). Results of the source water samples for mineral and physical parameters are shown on Table14.

Table 13. Summary of Water Quality for Untreated CAP Water at the Clearwater Site, October 1997-April 2000 (Tucson Water, 2000b).

Constituent (mg/l)	Mean	Std. Dev.	Min.	Max.	MCL	No.of samples
Cations (mg/l)						
Calcium	66	4.53	56	75	-	14
Magnesium	28	3.05	26	38	-	14
Potassium	5.0	0.76	4.5	7.5	-	14
Sodium	92	12.8	85	135	-	14
Anions (mg/l)						
Bicarbonate*	133	24.4	70	156	-	18
Bromide	@0.015	0.041	<0.1	0.14	-	13
Chloride	82	13.2	72	123	-	13
Sulfate	248	30.5	227	348	-	13
Nitrate (as Nitrogen)	@0.0077	0.0277	<0.025	0.1	10	13
Fluoride	0.313	0.051	0.24	0.44	4	13
Orthophosphate (as phosphorus)	<0.3	0	<0.3	<0.3	-	11
Bicarbonate alkalinity as mg/l	109	20	57	128	-	18
Total Alkalinity	129	16.6	84	148	-	11
TDS	603	48	566	712	-	14
Hardness calculated as CaCO3	280	12.6	261	303	-	13
Field Parameters						
pH	8.34	0.43	7.70	9.37	-	16
Electrical Conductivity	949	58.6	880	1010	-	4
Temperature (Celsius)	22.6	5.1	10.6	32.1	-	16
Dissolved Metals (mg/l)						
Aluminum	<0.1	0	<0.1	<0.1	-	5
Arsenic	@0.0023	0.0015	<0.002	0.0057	0.05	14
Barium	0.105	0.0102	0.095	0.13	2	14
Boron	0.131	0.0213	0.12	0.2	-	14
Iron	@0.072	0.120	<0.02	0.38	-	9
Lead	@0.0051	0.017	<0.002	0.064	0.015	14
Selenium	<0.005	0	<0.005	<0.005	0.05	12
Silicon	3.9	0.71	2.5	5.2	-	13
Zinc	@0.052	0.093	<0.02	0.31	-	10
Total Trihalomethane (µg/l)	<0.5	0	<0.5	<0.5	100	17
Haloacetic acids (µg/l)	<3	0	<3	<3	-	5
Total Coliform MPN-CFU/100ml	@60	101	<2	300	-	8
TOC	3.3	0.32	2.7	3.81	-	18
Radon (pCi/l)	<22	-	<22	<22	-	1
Perchlorate	@0.0066	0.005	<0.004	0.014	-	6

Source: Sample point 713 (CAP Aqueduct M.P. 308.175)
Mg/l- milligram per liter
*Bicarbonate concentration- 1.22 times the results of bicarbonate alkalinity reported above.
µmho/cm- micromohos per centimeter
MPN/100 ml- most probable method; results given in colony forming units (CFU) per 100 milliliters
< less than; constituent not detected above the laboratory reporting limit
@- Constituent was not detected above the laboratory reporting limit in some or all of the samples included in calculation

Table 14. Water Quality Monitoring Results, Source Water, Pima Mine Road Recharge Project Mineral and Physical Parameters (CAWCD, 2001).

Parameter	Units	AWQS limit	Sample date 01/06/2000 Results	Sample Date 03/03/2000 Results	Sample Date 10/19/2000 Results
Alkalinity, total	mg/l		109	110	104
Alkalinity, bicarbonate	mg/l		133	133	126
Alkalinity, Carbonate	mg/l		0.864	1.72	1.30
Chloride	mg/l		76.3	72.2	88.7
Fluoride	mg/l	4	0.32	0.31	0.36
Nitrate (as N)	mg/l	10	ND	ND	ND
pH	Std unit		8.0	8.3	8.2
Specific Conductance	Us/cm		915	855	905
Sulfate	mg/l		253	236	267
Total Dissolved Solids	mg/l		530	530	650
Temp (field)	°F		65.5	74.1	nm
Aluminum, dissolved	mg/l		ND	ND	ND
Antimony, dissolved	mg/l	0.006	ND	ND	ND
Arsenic, dissolved	mg/l	0.05	0.0045	0.0025	0.004
Barium, dissolved	mg/l	2	0.066	0.091	0.105
Beryllium, dissolved	mg/l	0.004	ND	ND	ND
Cadmium, dissolved	mg/l	0.005	ND	ND	ND
Calcium	mg/l		120*	68	62
Chromium, dissolved	mg/l	0.1	ND	0.0041	ND
Copper, dissolved	mg/l		ND	0.0037	0.021
Iron, dissolved	mg/l		ND	ND	ND
Lead, dissolved	mg/l	0.05	0.019	ND	0.66
Magnesium	mg/l		18.1*	29	31
Mercury, dissolved	mg/l	0.002	ND	ND	ND
Nickel, dissolved	mg/l	0.01	ND	0.005	ND
Potassium	mg/l		3.5*	4.1	5.5
Selenium, dissolved	mg/l	0.05	ND	ND	ND
Silver, dissolved	mg/l		ND	ND	ND
Sodium, dissolved	mg/l		51.5*	84	100
Thallium, dissolved	mg/l	0.002	ND	ND	ND
Zinc, dissolved	mg/l		0.14	0.015	0.088
TOC	mg/l		0.9	2.8	3
nm=not measured		Nd= Not detected above		Laboratory reporting limit	

* results are questionable for these analytes, laboratory results appear to have been switched with another sample but could not be confirmed by the laboratory.

Treated Wastewater Water Quality

Roger and Ina Road Effluent

The Roger Road Wastewater Treatment Facility (WWTF) and the Ina Road Water Pollution Control Facility (WPCF) are required to monitor for a number of parameters to comply with NPDES (1999) and Aquifer Protection Permits (2001). These monitoring requirements, provided by Pima County Wastewater Management Department, are shown on Tables 15 and 16.

Table 15. Roger Road WWTF Monitoring Requirements

Daily	Monthly	Bi-monthly	Quarterly
BOD	Enteric Virus	As, Cd, Cu, Cr	1,1,1-TCA
TSS	Acute Toxicity	Cyanide	
Fecal Coliform	Chronic Toxicity	Pb, Hg, Se, Ag, Zn	
Settleable Solids	Alkalinity	phenols	
Residual Chlorine		phthalates	
pH		methylene chloride	
		chloroform	
		PCE, PCA	

Table 16. Ina Road WPCF Monitoring Requirements

Daily	Monthly	Bi-monthly
BOD	Enteric Virus	As, Cd, Cu, Cr
TSS	Acute Toxicity	Cyanide
Fecal Coliform	Chronic Toxicity	Pb, Hg, Se, Ag, Zn
Settleable Solids	Alkalinity	phenols
Residual Chlorine		PCE
pH		Total Ammonia
		Temperature
		Dissolved Oxygen

The data collected from the County's monitoring have been summarized in several previous studies, including those by PAG (1994b, 1996) and Malcolm Pirnie (1994). In addition, more recent monitoring data were provided by Pima County Wastewater Management Department for this report; these data included information summarized from year 2000 discharge monitoring reports. The recent data, shown on Table 17 and 18, indicate that the effluent water quality is well within the NPDES and APP permit limits.

Table 17. Roger Road Wastewater Treatment Facility Discharge Monitoring Report Summarized Information Year 2000 (PCWMD, 2001a).

Constituent (Units)*	Permit Limit	1st Quarter Averages Jan- Mar	2nd Quarter Averages Apr-June	3rd Quarter Averages July-Sept	4th Quarter Averages Oct-Dec
Flow (MGD)	Up to 41	26.3	23.2	28.0	29.2
Suspended Solids (Kg/day)	4,654	2,217	2,090	1,470	2,247
Suspended Solids (mg/l)	45	25	30	16	23.5
Fecal Coliform (#/100ml)	200	4	16	35	12
pH	6.5 - 9.0	7.6	7.6	7.6	7.6
Disinfectant Residual (mg/l)	0.5	0.22	0.07	0.15	0.09

*MGD- Million gallons per day, Kg/day- Kilograms per day, mg/l- Milligrams per liter #/100 ml- counts per 100 milliliters.

Table 18. Ina Road Water Pollution Control Facility Discharge Monitoring Report Summarized Information Year 2000 (PCWMD, 2001a).

Constituents (Units)*	Permit Limits	1st Quarter Averages Jan - Mar	2nd Quarter Averages Apr - Jun	3rd Quarter Averages Jul - Sept	4th Quarter Averages Oct-Dec
Flow (MGD)	Up to 25	22.5	23.1	22.1	24.3
Suspended Solids (Kg/day)	2,839	1,516	1,398	1,151	2,103
Suspended Solids (mg/l)	45	19	18	16	31
Fecal Coliform (#/100ml)	200	5	14	31	28
pH	6.5 - 9.0	7.1	7.1	7.2	7.2
Disinfectant Residual (mg/l)	0.5	0.30	0.44	0.15	0.35

*MGD- Million gallons per day, Kg/day- Kilograms per day, mg/l- Milligrams per liter #/100 ml- counts per 100 milliliters.

Appendix B includes priority pollutant quarterly sampling results for the Roger Road and Ina Road facilities. Most of the parameters that the county tests for are not detected in the effluent water samples. When a parameter is detected the result is compared to the water quality standard. Tables 19 and 20 lists those compounds that were detected in the quarterly monitoring during 2000.

Table 19. Quarterly Priority Pollutant Organic Compounds Detected in Effluent from Ina Road WPCF, 2000 (PCWMD, 2001a).

Parameter	Ina Road number of samples detected	Ina Road Results mean – max. µg/l	Water Quality Standard	Were Standards exceeded
Chloroform	4 of 4	1.6- 2.0	1400	No
1,4-Dichlorobenzene	4 of 4	4.0-6.4	1880	No
Methylene Chloride	4 of 4	<1.0-1.02	8400	No
Tetrachloroethene	1 of 4	<0.5	1400	No
Toluene	2 of 4	<0.32-<0.5	8700	No
Diethyl phthalate	1 of 4	<5	26000	No
Bis(2-ethylhexyl)phthalate	4 of 4	14.7-34.8	400	No

Table 20. Quarterly Priority Pollutant Organic Compounds Detected in Effluent from Roger Road WWTF, 2000 (PCWMD, 2001a).

Parameter	Roger Road number of samples detected	Roger Road Results mean-max. µg/l	Water Quality Standard	Were Standards exceeded
Chloroform	4 of 4	<0.81-1.32	1400	No
1,4-Dichlorobenzene	2 of 4	<1.25-<5	1880	No
Methylene Chloride	4 of 4	<1.41-1.63	8400	No
G-BHC(gamma)	1 of 4	0.38	7.6	No
Toluene	3 of 4	<0.41-<0.5	8700	No
Bis(2-ethylhexyl)phthalate	2 of 4	<7.1-16.3	400	No
Pentachlorophenol	1 of 4	<10.0	17	No

Additional sampling data are available in ADEQ's Year 2000 305(b) report and 1998 Water Quality Limited Waters 303(d) List, and the United States Geological Survey's 2000 report *Water Quality in the Central Arizona Basins, 1995 - 98.* These data are for the effluent dependent reach of the Santa Cruz River downstream from the treatment facilities. Stressors of concern noted in this literature included turbidity and dissolved oxygen, with the standard for dissolved oxygen being exceeded in 6 of 12 samples collected by the USGS and the standard for turbidity being exceeded in only 1 of 12 samples. In its 1998 303(d) report, ADEQ de-listed this reach of the Santa Cruz, noting that only one sample had exceeded the turbidity standard.

Although the USGS (2000) suggested that the quality of effluent-dependent streams, including low dissolved oxygen, limits restoration of in stream communities and presents a challenge for fish survival, they also noted that these streams provide a variety of benefits, including riparian communities with a high level of terrestrial plant and animal diversity. This observation is supported by literature available from Pima County's Water Quality Research Project, which seeks to identify appropriate water quality standards for ephemeral and effluent-dependent streams in the arid western United States (PCWMD, 2001).

Additional data for surface water samples collected from 10 locations in the Santa Cruz River downstream from the two wastewater treatment facilities during the year 2001, indicate acceptable levels of dissolved oxygen. The results are shown on Table 21.

Also, extensive monitoring at three locations in the effluent dependent Santa Cruz River was conducted over a 32 month period between 1992 and 1994. The results indicated acceptable dissolved oxygen levels. The samples were collected at the Ina Road outfall, the Cortaro Road Bridge, and the Avra Valley Road Bridge. Out of the 228 DO samples collected, only two samples showed a concentration of DO less than 3.0 mg/l. Those results were 2.9 mg/l and 2.8 mg/l. (PCWMD, 2000).

Table 21. Summary of Dissolved Oxygen Field Measurements in the Santa Cruz River (PCWMD, 2001a).

Sample Location	Sample Date	# of Miles downstream from Roger Rd WWTP	# of Miles downstream from Ina Road WPCF	Dissolved Oxygen (mg/l)
SC-01	1/24/01	0.60	--	5.36
	8/13/01			5.47
SC-02	2/28/01	2.93	--	8.43
	8/13/01			4.83
SC-03	1/24/01	5.93	0.08	7.49
	2/28/01			10.13
	8/13/01			5.18
SC-04	8/13/01	7.70	1.85	3.28
SC-05	1/24/01	8.94	3.09	5.36
	8/14/01			4.83
SC-06	8/14/01	10.02	4.17	5.05
SC-07	1/24/01	12.11	6.26	6.81
	8/17/01			4.56
SC-08	2/13/01	13.23	7.38	6.58
	5/10/01			7.08
	8/16/01			4.31
SC-09	2/13/01	16.65	10.80	6.73
	5/10/01			8.99
	8/16/01			8.51
SC-10	2/13/01	17.93	12.08	7.92
	5/10/01			8.97
	8/16/01			7.88

Note: Samples are collected as a grab sample from a free flow portion of the stream. Each sample location is adjacent to groundwater monitor well locations.

Table 22 shows results from the year 2000 effluent sampling for metals at the Roger Road and Ina Road wastewater treatment facilities.

Table 22. Priority Pollutant- Metals, Quarterly Sampling for 2000 (PCWMD, 2001a).

Parameter	Ina Road WPCF 12 month mean mg/l	Ina Road WPCF 12 month max. mg/l	Roger Road WWTP 12 month mean mg/l	Roger Road WWTP 12 month max mg/l
Antimony	<0.0021	<0.0037	<0.0021	<0.0037
Arsenic	<0.0039	<0.0080	<0.0081	<0.0100
Beryllium	<0.0009	<0.0013	<0.0007	<0.0013
Cadmium	<0.0006	<0.0008	<0.0018	<0.0050
Chromium	<0.0054	0.0134	<0.0065	0.0188
Copper	0.0256	0.0270	0.018	0.025
Cyanide	<0.008	<0.015	<0.005	<0.005
Lead	<0.0019	<0.0050	<0.0019	<0.0050
Mercury	<0.000026	<0.000026	<0.000026	<0.000026
Molybdenum	<0.0066	<0.0079	0.0207	0.0251
Nickel	<0.0029	<0.0050	0.0050	0.0058
Selenium	<0.0022	<0.0038	<0.0022	<0.0038
Silver	<0.0015	<0.0019	<0.0036	<0.0050
Thallium	<0.0017	<0.0047	<0.0017	<0.0047
Zinc	0.0377	0.0434	0.0346	0.0394

"<" indicates the value was below the detection limit.

Reclaimed Water

Reclaimed water is ideally suited for turf irrigation and other commercial and industrial uses (Tucson Water, 2001; PAG, 1994a). Under a state wastewater reuse permit the reclaimed water is monitored for flow, turbidity, fecal coliform, pH, enteric virus, and *Ascaris lumbricoides* (Dotson, 2001). Water is sampled at a point that is representative of the quality of water received by the reclaimed water customers. The reclaimed water has a higher TDS concentration than secondary effluent. This is due in part to mixing with groundwater at the facility, where background TDS levels are higher than most Tucson Water wellfields (PAG, 1994a). Tables 23 and 24 present data provided by Tucson Water for this sample point. All of the data are within permitted limits.

Table 23. Average Values, Water Quality Data, Tucson Water Reclaim System, January--July 2001. Data from Tucson Water.

Constituent	Average	No. of Samples
Total Dissolved Solids	657 mg/l	6
Total Kjeldahl Nitrogen	10.09 mg/l	6
Total Organic Carbon	7.75 mg/l	6
Total Suspended Solids	1.6 mg/l*	7
Turbidity	3.28 NTU	6
Ammonia as N	6.29 mg/l	6
Nitrate as N	3.87 mg/l	7
Chloride	107.43 mg/l	7
pH	7.7 su	6
Conductivity	1012.66 umhos/cm	6
Fluoride	0.9	7
Potassium	8.2 mg/l	2
Phosphate as P	1.52 mg/l	6
Sulfate	120.8	7
Calcium	59.5	2
Total Alkalinity	247	3
Sodium	130 mg/l	2

*- This value calculated using a value of zero for one sample with a result of <1.

Samples collected on January 4, 2001, and April 12, 2001, were also analyzed for VOCs and metals. In general these constituents were only detected at levels less than the lowest standard or quantification limit of the method. Aluminum, Arsenic, Barium, Boron, Copper, Iron, Magnesium, Nickel and Zinc were all present at detectable levels, but below permit limits. The results of the two samples are listed on Table 24.

Table 24. Analytical Results for Reclaimed Water, Sample Dates January 4, 2001 and April 12, 2001. Data provided by Tucson Water.

Constituent (mg/l)	Sample Date 1/4/01	Sample Date 4/12/01
Aluminum, Total	<.1	.12
Arsenic, Total	0.0038	0.0055
Barium, Total	0.033	0.031
Boron, Total	0.3	0.29
Copper, Total	0.015	<0.01
Iron, Total	0.11	0.084
Magnesium, Total	10	9.9
Nickel, Total	0.013	<0.01
Zinc, Total	0.026	0.039

mg/l= milligrams per liter.

Summary and Conclusions

Summary

This report summarizes general findings about water sources and their quality in Pima County. Water sources in Pima County include groundwater, CAP water, treated wastewater, stormwater runoff, and perennial and intermittent surface waterbodies.

General water quality in Pima County is summarized on the following table. Mean values are presented for each constituent. Reclaimed water has the highest TDS of the water sources, with a mean value of 657 mg/l. Water from stormwater has the lowest TDS, with a mean value of 93 mg/l. Mean hardness values for the CAP water are higher than well water with CAP water at 280 mg/l as CaCO3 and well water having a mean value of 119 mg/l as CaCO3 (PAG, 1994).

Table 25. Average Water Quality Data (mg/l) for Selected Tucson Area Water Sources

Constituent	Tucson Water 2001 Systemwide average*	Combined Effluent**	Reclaimed Water (avg.)***	CAP Water ‡ (avg.)	Stream Water (avg.)+	Stormwater (avg.)†
TDS	322	509	657	603	232	93
Hardness as CaCO3	115	139	-	280	56.2	-
Sodium	40.0	109	130	92	18.1	6.0
Chloride	16.6	83.2	107.4	82	7.6	4.0
Calcium	38	46.6	59.5	66	48.8	10.4
Magnesium	4.7	6.25	10	28	7.9	1.6
Sulfate	44	85	120.8	248	37.76	9.9
Alkalinity	130	224	247	129	-	-

* Average drinking water quality for Tucson Water main system, 2001 data supplied by Tucson Water. Hardness is Total, mg/l, TDS Calculated
** Combined effluent is flow-weighted average secondary effluent quality for Ina and Roger Road Wastewater Treatment Plants. Data from PCWMD.
***- Reclaimed Water, average values from January 2001- July 2001. Data from Tucson Water.
‡ Data from CAP water at the Clearwater Site October 1997-April 2000. Tucson Water
+ Average stream water quality for 6 streams in Pima County, data from ADEQ
† Average Stormwater quality data from USGS measurements at Tanque Verde Creek at the Sabino Canyon confluence.

Conclusions

Groundwater

Groundwater is the most widely used water resource in Pima County. Water quality data for this source are abundant, due to its extensive use and regulatory monitoring requirements. It is generally of very good quality and suitable for its intended uses, which include drinking water, irrigation and industry. Groundwater contamination has occurred in several locations. Nitrates and VOCs are the predominant contaminants. Other contaminants, such as metals and pesticides, are insignificant compared to VOCs. Contaminated groundwater is generally not used for potable purposes, with the exception of locations where it is either treated or blended to meet drinking water standards. Contaminated groundwater in Pima County is intensively monitored, and in most cases is either under remediation or further investigation.

CAP Water

CAP water is being used in increasing quantities in Pima County. Current uses include potable supply, artificial groundwater recharge and crop irrigation. The quality of this water is extensively monitored, and its quality is sufficient for its intended uses, which include drinking water, aquifer recharge, irrigation and industry.

Treated Wastewater

Treated wastewater is also being used in increasing quantities. It is extensively monitored, and its quality meets standards for its intended uses, which include reuse for turf irrigation, agriculture and discharge to an effluent dependent stream. The effluent discharges currently support valuable riparian habitat subject to major stormwater events.

Stormwater Runoff

This water is not widely used as a resource. However, it is extensively monitored under existing regulations. The water quality meets NPDES permit requirements.

Surface Waterbodies

Although it is relatively scarce, naturally occurring surface water in perennial and intermittent streams provides very important habitat in Pima County. Most of the streams that have been monitored are of a quality sufficient for their intended use or habitat. However, monitoring is very limited compared to the other water sources. The vast majority of perennial and intermittent streams in Pima County are not regularly monitored for water quality.

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Appendix A

Arizona Department of Environmental Quality
Santa Cruz-Rio Magdalena-Rio Sonoyta
Watershed Stream Assessments and Stream Monitoring Data

Appendix A: Santa Cruz-Rio Magdalena-Rio Sonoyta Watershed Streams Assessments and Streams Monitoring Data (ADEQ).

SANTA CRUZ - RIO MAGDALENA - RIO SONOYTA WATERSHED STREAMS ASSESSMENTS					
WATERBODY NAME SEGMENT WATERBODY SIZE WATERBODY ID	TYPE OF ASSESSMENT BIOASSESSMENT* YEAR ADDED TO 303(d) LIST	DESIGNATED USE SUPPORT	STRESSORS	POTENTIAL SOURCES	ASSESSMENT COMMENTS
Alamo Wash headwaters-Rillito Creek 9 miles AZ15050302-002	Monitored -- --	Partial	Copper	Urban runoff	USGS study of water and sediment from stormwater discharges in Alamo Wash in 1993, 5 samples: copper exceeded standard once (Tadayon, 1995).
Arivaca Creek headwaters-Puertocito/Altar Wash 15 miles AZ15050304-008	Evaluated -- --	Fully			ADEQ 3 stations 1991-93 with a total of 39 samples: full support. Low dissolved oxygen due to spring sources and low flows (all natural).
Canada del Oro headwaters-Big Wash 31miles AZ15050301-017	Evaluated -- --	Fully			ADEQ bioassessment site (phys/chem monitoring) 1992-94, 3 samples: full support. Biassessment not appropriate, because Index of Biological Integrity developed for perennial waters cannot be applied to intermittent waters.
Cienega Creek Interstate 10 to Del Lago Dam 11 miles AZ15050302-006B	Monitored Exceptional community --	Fully			ADEQ monitoring at 6 sites 1991-1998, 26 samples: full support.
Cienega Creek headwaters-Interstate 10 38 miles AZ15050302-006A	Evaluated -- --	Fully			ADEQ monitoring 1992-1998, 5 sites, 8 samples: full support.
Madera Canyon Creek headwaters-Santa Cruz 13 miles AZ15050301-322	Evaluated -- --	Fully			ADEQ 2 stations in 1991 (Roundup and Whitehorse) 2 samples: full support. ADEQ Biocriteria Development Reference Site (phys/chem monitoring) 1992-94, 3 samples: full support.

SANTA CRUZ - RIO MAGDALENA - RIO SONOYTA WATERSHED STREAMS ASSESSMENTS

WATERBODY NAME SEGMENT WATERBODY SIZE WATERBODY ID	TYPE OF ASSESSMENT BIOASSESSMENT* YEAR ADDED TO 303(d) LIST	DESIGNATED USE SUPPORT	STRESSORS	POTENTIAL SOURCES	ASSESSMENT COMMENTS
Arivaca Lake 119 acres AZL15050304-0080	Monitored Hypereutrophic 1996	Not supporting	Mercury, low dissolved oxygen, high pH	Resource extraction, lake design and maintenance, natural, unknown, atmospheric deposition	Fish advisory due to mercury in fish tissue 1995 (AGFD and ADEQ samples). ADEQ and EPA water samples collected in 1997-1998, total of 52 samples: high pH and low dissolved oxygen. TMDL completed in 1999 for mercury.
Kennedy Lake 10 acres AZL15050301-0720	Monitored Eutrophic --	Not supporting	High pH	Point source, lake design and maintenance, natural	AGFD routine monitoring 1994-1997, 3 sampling events: high pH. AGFD urban lakes project, 11 field measurements, 4 lab samples: high pH (some low dissolved oxygen).
Lakeside Lake 15 acres AZL15050302-0760	Monitored Hypereutrophic --	Partial	High pH, low dissolved oxygen	Point source, lake design and maintenance, natural	AGFD routine monitoring 1994-1997, 4 sampling events: low dissolved oxygen. AGFD urban lakes project monitoring 1998, 11 field measurements, 4 lab chemistries: partial support due to low DO and high pH.

From: Arizona Department of Environmental Quality, *The Status of Water Quality in Arizona, Clean Water Act Section 305(b) Report 2000.*

Appendix A: Santa Cruz-Rio Madalena-Rio Sonoyta Watershed Streams Assessments and Streams Monitoring Data (ADEQ).

SANTA CRUZ-RIO MAGDALENA-RIO SONOYTA WATERSHED -- STREAMS MONITORING DATA								
STREAM NAME SEGMENT WATERBODY ID DESIGNATED USES	AGENCY PROGRAM SITE DESCRIPTION SITE ID	SAMPLES	PARAMETER UNITS	STANDARD	RANGE OF RESULTS (MEDIAN)	FREQUENCY EXCEEDED STANDARDS	USE SUPPORT*	COMMENTS
Agua Caliente headwaters-Coronado Forest AZ15050302-348A A&Ww, FC, FBC, AgL	ADEQ Biocriteria Program Above Coronado Natl Forest Boundary SCACW004.93	1995 - 1 water, bugs	Ok					Need more information to assess.
Alamo Wash headwaters-Rillito Creek AZ15050302-002 A&We, PBC	USGS #09485570 USGS report 95-4062 At Fort Lowell Road SCAAW001.27	1991-1994 - 9 water	Copper (dissolved)µg/l	varies (12)	<10-80	1 of 6	Partial A&We	Stormwater only.
Arivaca Creek headwaters-Puertocito/Alta AZ15050304-008 A&Ww, FC, FBC, AgL	ADEQ Fixed Station Network At Figueroa Spring SCARI008.19	1991 - 6 water 1992 - 6 water 1993 - 4 water	Dissolved oxygen mg/l	6.0 (90% saturation)	5.3-10.1 (68.5-128.6%)	1 of 10	Full	Naturally low dissolved oxygen during low flows.
	ADEQ Fixed Station Network At Ruby Road SCARI010.54	1991 - 8 water 1992 - 6 water 1993 - 4 water	Dissolved oxygen mg/l	6.0 (90% saturation)	1.1-12.0 (14.2-119%)	8 of 18	Full	Naturally low dissolved oxygen during low flow.
	ADEQ Fixed Station Network Near headwater spring SCARI010.86	1991 - 4 water 1992 - 1 water 1993 - 1 water	Dissolved oxygen mg/l	6.0 (90% saturation)	5.2-6.91 (60.6-77.1%)	3 of 6	Full	Naturally low Dissolved oxygen at springs.
Cave Creek headwaters-Cienega Creek AZ15050302-185 A&Ww, FC, FBC, AgL	ADEQ Biocriteria Program Near Mount Wrightson Wilderness SCCAV002.95	1992 - 1 water, bugs	Ok					Need more information to assess.

SANTA CRUZ-RIO MAGDALENA-RIO SONOYTA WATERSHED -- STREAMS MONITORING DATA (ADEQ)

STREAM NAME SEGMENT WATERBODY ID DESIGNATED USES	AGENCY PROGRAM SITE DESCRIPTION SITE ID	SAMPLES	PARAMETER UNITS	STANDARD	RANGE OF RESULTS (MEDIAN)	FREQUENCY EXCEEDED STANDARDS	USE SUPPORT*	COMMENTS
Cienega Creek Headwaters-Interstate 10 AZ15050302-006A A&Ww, FC, FBC, AgL	BLM Routine Monitoring At Narrows SCCIE010.99	1993 - 1 water (2 sites)	Ok				Full	
	ADEQ Stream Ecosystem Monitoring Below Stevenson Canyon SCCIE011.8	1998 - 1 water, bugs, physical	Ok				Full	
	ADEQ Stream Ecosystem Monitoring Below narrows SCCIE012.4	1998 - 1 water, bugs, physical	Ok				Full	
	ADEQ Biocriteria Program Above the Narrows SCCIE012.55	1992 - 1 water, bugs 1993 - 1 water, bugs 1994 - 1 water, bugs 1996 - 1 water, bugs	Ok				Full	
	ADEQ Fixed Station Network Below E.C. Conserv. SCCIE013.61	1992 - 1 water 1993 - 1 water	Ok				Full	
Gardner Canyon Creek headwaters-Cienega Creek AZ15050302-195 A&Ww, FC, FBC	ADEQ Biocriteria Program Near Mount Wrightson Wilderness SCGDN010.49	1992 - 1 water, bugs	Ok					Need more information to assess.

Santa Cruz River Airport Wash-Rillito Creek AZ15050301-003 A&We, PBC, AgL	ADEQ Fixed Station Network At Congress Street SCSCR038.95	1991 - 1 water	Ok					Need more information to assess.
Santa Cruz River Canada del Oro-Guild Wash AZ15050301-001 A&Wedw, PBC	USGS NAWQA Site #09486500 At Cortaro, AZ SCSCR029.16	1996 - 8 water 1997 - 4 water	Dissolved oxygen mg/l	3.0 (3 hours after sunrise to sunset)	2.0-3.7	6 of 12	Non A&Wedw	
	ADEQ Fixed Station Network At Cortaro Road bridge SCSCR029.18	1991 - 8 water 1992 - 6 water 1993 - 6 water	Turbidity NTU	50	10.3-8970	1 of 12	Full	
Tanque Verde Creek Wentworth Road-Rillito Creek AZ15050302-009B A&We, PBC, AgL	USGS #09484500 USGS report 95-4062 At Sabino Canyon Road SCTAN001.29	1991-1994 - 9 water	Ok				Full	Stormwater only.

From: Arizona Department of Environmental Quality, *The Status of Water Quality in Arizona, Clean Water Act Section 305 (b) Report 2000.*

Appendix B

Priority Pollutant Quarterly Sampling 2000
For Ina Road WPCF and Roger Road WWTP

TABLE I.A.4 PRIORITY POLLUTANT QUARTERLY SAMPLING 2000 - ROGER ROAD WWTP

APPENDIX B

Reporting Units, Influent and Effluent: Organics = μg/L; Metals = mg/L

Reporting Units, Biosolids: Organics = mg/kg; Metals = mg/kg

All data from composite samples.

PARAMETER	INFLUENT			EFFLUENT			BIOSOLIDS		
	12 Month Mean	12 Month Maximum**	Data Compilation Codes*	12 Month Mean	12 Month Maximum**	Data Compilation Codes*	12 Month Maximum**	MDL ***	Data Compilation Codes*
1,1,1-Trichloroethane	< 0.13	< 0.13	4 / 0 / 4	< 0.13	< 0.13	4 / 0 / 4			4 / 0 / [illegible]
1,1,2,2-Tetrachloroethane	< 0.15	< 0.15	4 / 0 / 4	< 0.15	< 0.15	4 / 0 / 4			4 / 0 / [illegible]
1,1,2-Trichloroethane	< 0.08	< 0.08	4 / 0 / 4	< 0.08	< 0.08	4 / 0 / 4			4 / 0 / 4
1,1-Dichloroethane	< 0.1	< 0.1	4 / 0 / 4	< 0.1	< 0.1	4 / 0 / 4			4 / 0 / 4
1,1-Dichloroethene	< 0.11	< 0.11	4 / 0 / 4	< 0.11	< 0.11	4 / 0 / 4			4 / 0 / 4
1,2-Dichlorobenzene	< 0.75	< 2.72	4 / 0 / 4	< 0.84	< 1.97	4 / 0 / 4			4 / 0 / 4
1,2-Dichloroethane	< 0.12	< 0.12	4 / 0 / 4	< 0.12	< 0.12	4 / 0 / 4			4 / 0 / 4
1,2-Dichloropropane	< 0.2	< 0.5	4 / 1 / 3	< 0.12	< 0.12	4 / 0 / 4			4 / 0 / 4
1,3-Dichlorobenzene	< 0.69	< 2.76	4 / 0 / 4	< 0.78	< 1.52	4 / 0 / 4			4 / 0 / 4
1,4-Dichlorobenzene	< 9.95	22.7	4 / 4 / 0	< 1	< 5	4 / 2 / 2			4 / 0 / 4
4,4-DDD(p,p TDE)	< 0.07	< 0.22	4 / 0 / 4	< 0.03	< 0.09	4 / 0 / 4			4 / 4 / 0
4,4-DDE(p,p DDX)	< 0.08	< 0.19	4 / 0 / 4	< 0.03	< 0.07	4 / 0 / 4			4 / 0 / 4
4,4-DDT	< 0.08	< 0.26	4 / 0 / 4	< 0.03	< 0.1	4 / 0 / 4			4 / 0 / 4
A-BHC(alpha)	< 0.14	< 0.14	4 / 0 / 4	< 0.02	< 0.06	4 / 0 / 4			4 / 0 / 4
Aldrin	< 0.10	< 0.25	4 / 0 / 4	< 0.04	< 0.1	4 / 0 / 4			4 / 0 / 4
B-BHC(beta)	< 0.09	< 0.24	4 / 0 / 4	< 0.07	< 0.24	4 / 0 / 4			4 / 0 / 4
Benzene	< 0.35	1.08	4 / 1 / 3	< 0.11	< 0.11	4 / 0 / 4			4 / 0 / 4
Bromodichloromethane	< 0.11	< 0.11	4 / 0 / 4	< 0.11	< 0.11	4 / 0 / 4			4 / 0 / 4
Bromoform	< 0.11	< 0.11	4 / 0 / 4	< 0.11	< 0.11	4 / 0 / 4			4 / 0 / 4
Bromomethane	< 0.15	< 0.15	4 / 0 / 4	< 0.15	< 0.15	4 / 0 / 4			4 / 0 / 4
Carbon tetrachloride	< 0.09	< 0.09	4 / 0 / 4	< 0.09	< 0.09	4 / 0 / 4			4 / 0 / 4
Chlordane	< 0.7	< 1.6	4 / 0 / 4	< 0.29	< 0.64	4 / 0 / 4			4 / 0 / 4
Chlorobenzene	< 0.16	< 0.16	4 / 0 / 4	< 0.16	< 0.16	4 / 0 / 4			4 / 0 / 4
Chloroethane	< 0.22	< 0.22	4 / 0 / 4	< 0.22	< 0.22	4 / 0 / 4			4 / 0 / 4
Chloroform	3.22	3.83	4 / 4 / 0	< 0.81	1.32	4 / 4 / 0			4 / 0 / 4
Chloromethane	< 0.09	< 0.09	4 / 0 / 4	< 0.09	< 0.09	4 / 0 / 4			4 / 0 / 4
Cis-1,3-Dichloropropene	< 0.11	< 0.11	4 / 0 / 4	< 0.11	< 0.11	4 / 0 / 4			4 / 0 / 4
D-BHC(delta)	< 0.07	< 0.22	4 / 0 / 4	< 0.03	< 0.09	4 / 0 / 4			4 / 0 / 4
Dibromochloromethane	< 0.17	< 0.17	4 / 0 / 4	< 0.17	< 0.17	4 / 0 / 4			4 / 0 / 4
Dieldrin	< 0.10	< 0.23	4 / 0 / 4	< 0.04	< 0.09	4 / 0 / 4			4 / 0 / 4
Endosulfan I	< 0.10	< 0.17	4 / 0 / 4	< 0.04	< 0.05	4 / 0 / 4			4 / 0 / 4
Endosulfan II	< 0.14	< 0.36	4 / 0 / 4	< 0.06	< 0.15	4 / 0 / 4			4 / 0 / 4
Endosulfan sulfate	< 0.11	< 0.34	4 / 0 / 4	< 0.05	< 0.13	4 / 0 / 4			4 / 0 / 4
Endrin	< 0.12	< 0.32	4 / 0 / 4	< 0.05	< 0.13	4 / 0 / 4			4 / 0 / 4
Endrin aldehyde	< 0.07	< 0.13	4 / 0 / 4	< 0.03	< 0.04	4 / 0 / 4			4 / 0 / 4
Ethyl benzene	< 0.75	1.38	4 / 4 / 0	< 0.2	< 0.5	4 / 0 / 4			4 / 0 / 4
G-BHC(gamma)	< 0.07	< 0.14	4 / 1 / 3	< 0.12	0.38	4 / 1 / 3	0.1	0.0165	4 / 1 / 3
Heptachlor	< 0.06	< 0.16	4 / 0 / 4	< 0.03	< 0.06	4 / 0 / 4			4 / 0 / 4
Heptachlor epoxide	< 0.05	< 0.12	4 / 0 / 4	< 0.02	< 0.05	4 / 0 / 4			4 / 0 / 4
Methylene chloride	30.0	50.4	4 / 4 / 0	< 1.41	1.63	4 / 4 / 0			4 / 0 / 4
PCB-1016	< 0.50	< 0.72	4 / 0 / 4	< 0.2	< 0.4	4 / 0 / 4	0.23	0.142	4 / 4 / 0
PCB-1221	< 0.90	< 1.48	4 / 0 / 4	< 0.38	< 0.59	4 / 0 / 4			4 / 0 / 4
PCB-1232	< 0.67	< 1.01	4 / 0 / 4	< 0.34	< 0.43	4 / 0 / 4			4 / 0 / 4
PCB-1242	< 0.5	< 0.9	4 / 0 / 4	< 0.22	< 0.36	4 / 0 / 4			4 / 0 / 4
PCB-1248	< 0.62	< 0.97	4 / 0 / 4	< 0.28	< 0.39	4 / 0 / 4			4 / 0 / 4
PCB-1254	< 0.57	< 0.97	4 / 0 / 4	< 0.23	< 0.39	4 / 0 / 4			4 / 0 / 4
PCB-1260	< 0.43	< 0.64	4 / 0 / 4	< 0.20	< 0.29	4 / 0 / 4			4 / 0 / 4
Tetrachloroethene	< 0.47	0.76	4 / 3 / 1	< 0.12	< 0.12	4 / 0 / 4			4 / 0 / 4
Toluene	3.15	8.12	4 / 4 / 0	< 0.4	< 0.5	4 / 3 / 1			4 / 0 / 4
Toxaphene	< 4.14	< 15.4	4 / 0 / 4	< 1.68	< 6.16	4 / 0 / 4	< 0.11	0.091	4 / 4 / 0
Trans-1,3-Dichloropropene	< 0.09	< 0.09	4 / 0 / 4	< 0.09	< 0.09	4 / 0 / 4			4 / 0 / 4
Trichloroethene	< 0.3	< 0.5	4 / 2 / 2	< 0.09	< 0.09	4 / 0 / 4			4 / 0 / 4
Trichlorofluoromethane	< 0.08	< 0.08	4 / 0 / 4	< 0.08	< 0.08	4 / 0 / 4			4 / 0 / 4
Vinyl chloride	< 0.12	< 0.12	4 / 0 / 4	< 0.12	< 0.12	4 / 0 / 4			4 / 0 / 4

All NOTES will be found on the last page of this table.

Data From Pima County Wastewater Management Department

TABLE I.A.4 PRIORITY POLLUTANT QUARTERLY SAMPLING 2000 - ROGER ROAD WWTP

(CONTINUED)

PARAMETER	INFLUENT 12 Month Mean	INFLUENT 12 Month Maximum**	INFLUENT Data Compilation Codes*	EFFLUENT 12 Month Mean	EFFLUENT 12 Month Maximum**	EFFLUENT Data Compilation Codes*	BIOSOLIDS 12 Month Maximum**	BIOSOLIDS MDL ***	BIOSOLIDS Data Compilation Codes*
1,2,4-Trichlorobenzene	< 1.13	< 2.72	4 / 2 / 2	< 1.57	< 2.19	4 / 0 / 4			4 / 0 / [illegible]
2,4,6-Trichlorophenol	< 3.40	< 6.08	4 / 0 / 4	< 2.64	< 3.04	4 / 0 / 4			4 / 0 / [illegible]
2,4-Dichlorophenol	< 1.0	< 1.5	4 / 0 / 4	< 0.79	< 0.92	4 / 0 / 4			4 / 0 / [illegible]
2,4-Dimethylphenol	< 1.41	< 1.59	4 / 0 / 4	< 0.99	< 1.21	4 / 0 / 4			4 / 0 / 4
2,4-Dinitrophenol	< 6.2	< 10.4	4 / 0 / 4	< 4.87	< 5.21	4 / 0 / 4			4 / 0 / 4
2,4-Dinitrotoluene	< 1.32	< 1.78	4 / 0 / 4	< 4.87	< 5.21	4 / 0 / 4			4 / 0 / 4
2,6-Dinitrotoluene	< 1.90	< 4.22	4 / 0 / 4	< 1.53	< 2.11	4 / 0 / 4			4 / 0 / 4
2-Chloronaphthalene	< 4.14	< 6.54	4 / 0 / 4	< 3.32	< 3.47	4 / 0 / 4			4 / 0 / 4
2-Chlorophenol	< 1.1	< 1.7	4 / 0 / 4	< 1.0	< 1.7	4 / 0 / 4			4 / 0 / 4
2-Nitrophenol	< 1.46	< 2.22	4 / 0 / 4	< 1.18	< 1.39	4 / 0 / 4			4 / 0 / 4
3,3-Dichlorobenzidine	< 1.38	< 2.26	4 / 0 / 4	< 1.10	< 1.13	4 / 0 / 4			4 / 0 / 4
4,6-Dinitro-2-methylphenol	< 7.9	< 13.3	4 / 0 / 4	< 6.21	< 6.66	4 / 0 / 4			4 / 0 / 4
4-Bromophenylphenyl ether	< 10.01	< 4.18	4 / 0 / 4	< 1.99	< 2.09	4 / 0 / 4			4 / 0 / 4
4-Chloro-3-methylphenol	< 2.9	< 6.1	4 / 0 / 4	< 2.6	< 6.1	4 / 0 / 4			4 / 0 / 4
4-Chlorophenylphenyl ether	< 3.3	< 5.6	4 / 0 / 4	< 2.6	< 2.8	4 / 0 / 4			4 / 0 / [illegible]
4-Nitrophenol	< 7.9	< 11.1	4 / 0 / 4	< 6.57	< 9.55	4 / 0 / 4			4 / 0 / [illegible]
Acenaphthene	< 2.4	< 4.3	4 / 0 / 4	< 2.00	< 2.15	4 / 0 / 4			4 / 0 / 4
Acenaphthylene	< 2.11	< 3.44	4 / 0 / 4	< 1.68	< 1.72	4 / 0 / 4			4 / 0 / [illegible]
Acrolein	< 0.53	< 0.53	1 / 0 / 1	< 0.53	< 0.53	1 / 0 / 1			1 / 0 / [illegible]
Acrylonitrile	< 0.38	< 0.38	1 / 0 / 1	< 0.38	< 0.38	1 / 0 / 1			1 / 0 / [illegible]
Anthracene	< 5.14	< 9.74	4 / 0 / 4	< 3.92	< 4.87	4 / 0 / 4			4 / 0 / 4
Benzo(a)anthracene	< 0.92	< 1.56	4 / 0 / 4	< 0.73	< 0.78	4 / 0 / 4			4 / 0 / [illegible]
Benzo(a)pyrene	< 1.2	< 2.1	4 / 0 / 4	< 0.92	< 1.05	4 / 0 / 4			4 / 0 / [illegible]
Benzo(b)fluoranthene	< 1.43	< 2.14	4 / 0 / 4	< 1.17	< 1.45	4 / 0 / 4			4 / 0 / 4
Benzo(g,h,i)perylene	< 3.52	< 8.62	4 / 0 / 4	< 3.18	< 8.62	4 / 0 / 4			4 / 0 / 4
Benzo(k)fluoranthene	< 2.5	< 3.8	4 / 0 / 4	< 2.1	< 3.8	4 / 0 / 4			4 / 0 / [illegible]
Bis(2-chloroethoxy)methane	< 1.89	< 2.92	4 / 0 / 4	< 1.53	< 1.73	4 / 0 / 4			4 / 0 / [illegible]
Bis(2-chloroethyl)ether	< 1.71	< 2.68	4 / 0 / 4	< 1.38	< 1.48	4 / 0 / 4			4 / 0 / 4
Bis(2-chloroisopropyl)ether	< 2.30	< 3.66	4 / 0 / 4	< 1.84	< 1.88	4 / 0 / 4			4 / 0 / [illegible]
Bis(2-ethylhexyl)phthalate	16.29	21.1	4 / 4 / 0	< 7.1	16.3	4 / 2 / 2	65.1	9.63	4 / 4 / [illegible]
Butylbenzyl phthalate	< 1.65	< 2.22	4 / 1 / 3	< 1.01	< 1.11	4 / 0 / 4			4 / 0 / 4
Chrysene	< 4.83	< 7.44	4 / 0 / 4	< 3.90	< 4.43	4 / 0 / 4			4 / 0 / 4
Dibenzo(a,h)anthracene	< 5.10	< 7.86	4 / 0 / 4	< 4.31	< 7.86	4 / 0 / 4			4 / 0 / 4
Diethyl phthalate	< 4.62	5.63	4 / 3 / 1	< 1.38	< 1.42	4 / 0 / 4			4 / 0 / 4
Dimethyl phthalate	< 15.87	< 31.2	4 / 0 / 4	< 12.0	< 15.6	4 / 0 / 4			4 / 0 / 4
Di-N-butyl phthalate	< 4.3	< 6.7	4 / 1 / 3	< 3.04	< 3.35	4 / 0 / 4			4 / 0 / 4
Di-N-octyl phthalate	< 2.32	< 4.34	4 / 0 / 4	< 1.77	< 2.17	4 / 0 / 4			4 / 0 / 4
Dioxin	< 0.03	< 0.03	1 / 0 / 1	< 0.03	< 0.03	1 / 0 / 1	< 0.03	0.03 (	1 / 0 / 1
Fluoranthene	< 1.44	< 2.46	4 / 0 / 4	< 1.13	< 1.23	4 / 0 / 4			4 / 0 / 4
Fluorene	< 1.75	< 2.92	4 / 0 / 4	< 1.39	< 1.46	4 / 0 / 4			4 / 0 / 4
Hexachlorobenzene	< 0.78	< 1.05	4 / 0 / 4	< 0.65	< 1.05	4 / 0 / 4			4 / 0 / 4
Hexachlorobutadiene	< 2.27	< 7.84	4 / 0 / 4	< 3.32	< 3.92	4 / 0 / 4			4 / 0 / 4
Hexachlorocyclopentadiene	< 2.43	< 3.89	4 / 0 / 4	< 2.07	< 3.89	4 / 0 / 4			4 / 0 / 4
Hexachloroethane	< 3.18	< 5.18	4 / 0 / 4	< 2.53	< 2.59	4 / 0 / 4			4 / 0 / 4
Indeno(1,2,3-cd)pyrene	< 1.45	< 2.52	4 / 0 / 4	< 1.13	< 1.26	4 / 0 / 4			4 / 0 / 4
Isophorone	< 2.19	< 3.54	4 / 0 / 4	< 1.72	< 1.87	4 / 0 / 4			4 / 0 / 4
Naphthalene	< 1.41	< 3.66	4 / 2 / 2	< 1.82	< 1.83	4 / 0 / 4	< 3.47	0.04	4 / 2 / 2
Nitrobenzene	< 1.98	< 2.84	4 / 0 / 4	< 1.63	< 2.25	4 / 0 / 4			4 / 0 / 4
N-Nitrosodimethylamine	< 3.42	< 5.84	4 / 0 / 4	< 2.69	< 2.92	4 / 0 / 4			4 / 0 / 4
N-Nitrosodi-N-propylamine	< 2.35	< 3.54	4 / 0 / 4	< 1.9	< 2.3	4 / 0 / 4			4 / 0 / 4
N-Nitrosodiphenylamine	< 2.60	< 3.56	4 / 0 / 4	< 2.17	< 3.56	4 / 0 / 4			4 / 0 / 4
Pentachlorophenol	< 9.5	< 17.6	4 / 0 / 4	< 7.86	< 8.81	4 / 1 / 3			4 / 0 / 4
Phenanthrene	< 1.22	< 2.02	4 / 0 / 4	< 0.97	< 1.01	4 / 0 / 4			4 / 0 / 4
Phenol	< 22.96	70.74	4 / 3 / 1	< 0.81	< 0.82	4 / 0 / 4			4 / 0 / 4
Pyrene	< 1.32	< 2.06	4 / 0 / 4	< 1.06	< 1.14	4 / 0 / 4			4 / 0 / 4

All NOTES will be found on the last page of this table.

APPENDIX B

Data From Pima County Wastewater Management Department

TABLE I.A.4 PRIORITY POLLUTANT QUARTERLY SAMPLING 2000 - ROGER ROAD WWTP (CONTINUED)

PARAMETER	INFLUENT			EFFLUENT			BIOSOLIDS		
	12 Month Mean	12 Month Maximum**	Data Compilation Codes*	12 Month Mean	12 Month Maximum**	Data Compilation Codes*	12 Month Mean	12 Month Maximum**	Data Compilation Codes*
Antimony (T)	< 0.0021	< 0.0037	4 / 0 / 4	< 0.0021	< 0.0037	4 / 0 / 4	< 3.68	6.74	4 / 3 / 1
Arsenic (T)	< 0.0070	< 0.0080	4 / 3 / 1	< 0.0081	< 0.0100	4 / 4 / 0	12.43	14.4	4 / 4 / 0
Beryllium (T)	< 0.00093	< 0.0013	3 / 0 / 3	< 0.0007	< 0.0013	4 / 0 / 4			
Cadmium (T)	< 0.0006	< 0.0008	4 / 0 / 4	< 0.0018	< 0.0050	4 / 1 / 3	4.14	4.6	4 / 4 / 0
Chromium (T)	0.0103	0.0217	4 / 4 / 0	< 0.0065	0.0188	4 / 3 / 1	52.83	61.7	4 / 4 / 0
Copper (T)	0.0813	0.0896	4 / 4 / 0	0.018	0.025	4 / 4 / 0	#####	608	4 / 4 / 0
Cyanide (T)	< 0.008	< 0.015	4 / 1 / 3	< 0.005	< 0.005	4 / 0 / 4	2.04	4.314	4 / 4 / 0
Lead (T)	< 0.0059	0.0068	4 / 3 / 1	< 0.0019	< 0.0050	4 / 2 / 2	46.10	55.4	4 / 4 / 0
Mercury (T)	< 0.000026	< 0.000026	4 / 0 / 4	< 0.000026	< 0.000026	4 / 0 / 4	2.21	2.68	4 / 4 / 0
Molybdenum (T)	0.0252	0.0330	4 / 4 / 0	0.0207	0.0251	3 / 3 / 0	29.08	43.5	4 / 4 / 0
Nickel (T)	< 0.0060	0.0079	4 / 4 / 0	0.0050	0.0058	4 / 4 / 0	34.70	38.1	4 / 4 / 0
Selenium (T)	< 0.0033	< 0.0050	4 / 2 / 2	< 0.0022	< 0.0038	4 / 0 / 4	< 3.27	4.6	4 / 2 / 2
Silver (T)	0.0075	0.0093	4 / 4 / 0	< 0.0036	< 0.0050	4 / 3 / 1	42.38	45.7	4 / 4 / 0
Thallium (T)	< 0.0010	< 0.0017	4 / 0 / 4	< 0.0017	< 0.0047	4 / 0 / 4	< 3.01	< 4.52	4 / 1 / 3
Zinc (T)	0.156	0.190	4 / 4 / 0	0.0346	0.0394	4 / 4 / 0	1015	1120	4 / 4 / 0

NOTES:

* The data compilation codes represent: Number of samples / number of values above detection limit / number of values below detection limit. Samples for which pollutant levels were below detection limits were used as the detection level in calculations. Mean values are then reported as "less than" the computed value (<). An analysis value that is "Trace" is counted as detect.

** Detection and quantitation levels varied during the year. If no value is given or if a "<" value is given, the value was below the detection limit.

*** The MDL level reflects the lowest method detection limit or practical quantitation level obtained during the year.

(1) The detection limit for Dioxin is the PQL of method TSS 8.7, determined as reliable by the TSS laboratory.

APPENDIX B — Data From Pima County Wastewater Management Department

TABLE I.A.3 PRIORITY POLLUTANT QUARTERLY SAMPLING 2000 - INA ROAD WPCF

Reporting Units, Influent and Effluent: Organics = μg/L; Metals = mg/L

Reporting Units, Biosolids: Organics = mg/kg; Metals = mg/kg

All data from composite samples.

PARAMETER	INFLUENT			EFFLUENT			BIOSOLIDS		
	12 Month Mean	12 Month Maximum**	Data Compilation Codes*	12 Month Mean	12 Month Maximum**	Data Compilation Codes*	12 Month Maximum**	MDL ***	Data Compilation Codes*
1,1,1-Trichloroethane	< 0.13	< 0.13	4 / 0 / 4	< 0.13	< 0.13	4 / 0 / 4			4 / 0 / 4
1,1,2,2-Tetrachloroethane	< 0.15	< 0.15	4 / 0 / 4	< 0.15	< 0.15	4 / 0 / 4			4 / 0 / 4
1,1,2-Trichloroethane	< 0.08	< 0.08	4 / 0 / 4	< 0.08	< 0.08	4 / 0 / 4			4 / 0 / 4
1,1-Dichloroethane	< 0.1	< 0.1	4 / 0 / 4	< 0.10	< 0.11	4 / 0 / 4			4 / 0 / 4
1,1-Dichloroethene	< 0.11	< 0.11	4 / 0 / 4	< 0.10	< 0.11	4 / 0 / 4			4 / 0 / 4
1,2-Dichlorobenzene	< 0.72	< 2.72	4 / 0 / 4	< 0.84	< 1.97	4 / 0 / 4			4 / 0 / 4
1,2-Dichloroethane	< 0.12	< 0.12	4 / 0 / 4	< 0.12	< 0.12	4 / 0 / 4			4 / 0 / 4
1,2-Dichloropropane	< 0.12	< 0.12	4 / 0 / 4	< 0.12	< 0.12	4 / 0 / 4			4 / 0 / 4
1,3-Dichlorobenzene	< 0.69	< 2.76	4 / 0 / 4	< 0.78	< 1.52	4 / 0 / 4			4 / 0 / 4
1,4-Dichlorobenzene	< 9	14	4 / 4 / 0	< 3.99	6.35	4 / 4 / 0	< 5.81	0.23	4 / 4 / 0
4,4-DDD	< 0.07	< 0.22	4 / 0 / 4	< 0.03	< 0.09	4 / 0 / 4			4 / 0 / 4
4,4-DDE	< 0.08	< 0.19	4 / 0 / 4	< 0.03	< 0.07	4 / 0 / 4			4 / 0 / 4
4,4-DDT	< 0.08	< 0.26	4 / 0 / 4	< 0.03	< 0.1	4 / 0 / 4			4 / 0 / 4
A-BHC(alpha)	< 0.05	< 0.14	4 / 0 / 4	< 0.02	< 0.06	4 / 0 / 4			4 / 0 / 4
Aldrin	< 0.10	< 0.25	4 / 0 / 4	< 0.04	< 0.1	4 / 0 / 4			4 / 0 / 4
B-BHC(beta)	< 0.09	< 0.24	4 / 0 / 4	< 0.04	< 0.1	4 / 0 / 4			4 / 0 / 4
Benzene	< 0.11	< 0.11	4 / 0 / 4	< 0.11	< 0.11	4 / 0 / 4			4 / 0 / 4
Bromodichloromethane	< 0.16	< 0.5	4 / 1 / 3	< 0.11	< 0.11	4 / 0 / 4			4 / 0 / 4
Bromoform	< 0.11	< 0.11	4 / 0 / 4	< 0.11	< 0.11	4 / 0 / 4			4 / 0 / 4
Bromomethane	< 0.15	< 0.15	4 / 0 / 4	< 0.15	< 0.15	4 / 0 / 4			4 / 0 / 4
Carbon tetrachloride	< 0.09	< 0.09	4 / 0 / 4	< 0.09	< 0.09	4 / 0 / 4			4 / 0 / 4
Chlordane	< 0.7	< 1.6	4 / 0 / 4	< 0.29	< 0.64	4 / 0 / 4			4 / 0 / 4
Chlorobenzene	< 0.16	< 0.16	4 / 0 / 4	< 0.16	< 0.16	4 / 0 / 4			4 / 0 / 4
Chloroethane	< 0.21	< 0.22	4 / 0 / 4	< 0.22	< 0.22	4 / 0 / 4			4 / 0 / 4
Chloroform	1.79	1.98	4 / 4 / 0	1.63	2.02	4 / 4 / 0			4 / 0 / 4
Chloromethane	< 0.09	< 0.09	4 / 0 / 4	< 0.09	< 0.09	4 / 0 / 4			4 / 0 / 4
Cis-1,3-Dichloropropene	< 0.11	< 0.11	4 / 0 / 4	< 0.11	< 0.11	4 / 0 / 4			4 / 0 / 4
D-BHC(delta)	< 0.07	< 0.22	4 / 0 / 4	< 0.03	< 0.09	4 / 0 / 4			4 / 0 / 4
Dibromochloromethane	< 0.17	< 0.17	4 / 0 / 4	< 0.17	< 0.17	4 / 0 / 4			4 / 0 / 4
Dieldrin	< 0.10	< 0.23	4 / 0 / 4	< 0.04	< 0.09	4 / 0 / 4			4 / 0 / 4
Endosulfan I	< 0.16	< 0.36	4 / 0 / 4	< 0.04	< 0.05	4 / 0 / 4			4 / 0 / 4
Endosulfan II	< 0.15	< 0.36	4 / 0 / 4	< 0.06	< 0.15	4 / 0 / 4			4 / 0 / 4
Endosulfan sulfate	< 0.11	< 0.34	4 / 0 / 4	< 0.05	< 0.13	4 / 0 / 4			4 / 0 / 4
Endrin	< 0.12	< 0.32	4 / 0 / 4	< 0.05	< 0.13	4 / 0 / 4			4 / 0 / 4
Endrin aldehyde	< 0.06	< 0.13	4 / 0 / 4	< 0.03	< 0.04	4 / 0 / 4			4 / 0 / 4
Ethyl benzene	< 0.16	< 0.16	4 / 0 / 4	< 0.16	< 0.16	4 / 0 / 4			4 / 0 / 4
G-BHC(gamma)	< 0.09	< 0.14	4 / 0 / 4	< 0.03	< 0.06	4 / 0 / 4			4 / 0 / 4
Heptachlor	< 0.06	< 0.16	4 / 0 / 4	< 0.03	< 0.08	4 / 0 / 4			4 / 0 / 4
Heptachlor epoxide	< 0.05	< 0.12	4 / 0 / 4	< 0.02	< 0.05	4 / 0 / 4			4 / 0 / 4
Methylene chloride	< 1	< 1	4 / 4 / 0	< 1.01	1.02	4 / 4 / 0	0.29	0.23	4 / 4 / 0
PCB-1016	< 0.50	< 0.72	4 / 0 / 4	< 0.24	< 0.4	4 / 0 / 4			4 / 0 / 4
PCB-1221	< 0.90	< 1.48	4 / 0 / 4	< 0.38	< 0.59	4 / 0 / 4			4 / 0 / 4
PCB-1232	< 0.67	< 1.01	4 / 0 / 4	< 0.34	< 0.43	4 / 0 / 4			4 / 0 / 4
PCB-1242	< 0.5	< 0.9	4 / 0 / 4	< 0.22	< 0.36	4 / 0 / 4			4 / 0 / 4
PCB-1248	< 0.62	< 0.97	4 / 0 / 4	< 0.23	< 0.39	4 / 0 / 4			4 / 0 / 4
PCB-1254	< 0.57	< 0.97	4 / 0 / 4	< 0.23	< 0.39	4 / 0 / 4			4 / 0 / 4
PCB-1260	< 0.43	< 0.64	4 / 0 / 4	< 0.20	< 0.29	4 / 0 / 4			4 / 0 / 4
Tetrachloroethene	< 0.4	< 0.5	4 / 3 / 1	< 0.2	< 0.5	4 / 1 / 3			4 / 0 / 4
Toluene	< 1.03	1.84	4 / 4 / 0	< 0.33	< 0.5	4 / 2 / 2	0.63	0.13	4 / 4 / 0
Toxaphene	< 4.14	< 15.4	4 / 0 / 4	< 1.62	< 6.16	4 / 0 / 4			4 / 0 / 4
Trans-1,3-Dichloropropene	< 0.09	< 0.09	4 / 0 / 4	< 0.09	< 0.09	4 / 0 / 4			4 / 0 / 4
Trichloroethene	< 0.30	< 0.5	4 / 2 / 2	< 0.09	< 0.09	4 / 0 / 4			4 / 0 / 4
Trichlorofluoromethane	< 0.08	< 0.08	4 / 0 / 4	< 0.08	< 0.08	4 / 0 / 4			4 / 0 / 4
Vinyl chloride	< 0.12	< 0.12	4 / 0 / 4	< 0.12	< 0.12	4 / 0 / 4			4 / 0 / 4

All NOTES will be found on the last page of this table.

APPENDIX B

Data From Pima County Wastewater Management Department

TABLE I.A.3 PRIORITY POLLUTANT QUARTERLY SAMPLING 2000 - INA ROAD WPCF

(CONTINUED)

PARAMETER	INFLUENT 12 Month Mean	INFLUENT 12 Month Maximum**	INFLUENT Data Compilation Codes*	EFFLUENT 12 Month Mean	EFFLUENT 12 Month Maximum**	EFFLUENT Data Compilation Codes*	BIOSOLIDS 12 Month Maximum**	BIOSOLIDS MDL ***	BIOSOLIDS Data Compilation Codes*
1,2,4-Trichlorobenzene	< 1.10	< 2.72	4 / 1 / 3	< 1.57	< 2.19	4 / 0 / 4			4 / 0 / 4
2,4,6-Trichlorophenol	< 3.40	< 6.08	4 / 0 / 4	< 2.64	< 3.04	4 / 0 / 4			4 / 0 / 4
2,4-Dichlorophenol	< 0.98	< 1.50	4 / 0 / 4	< 0.79	< 0.92	4 / 0 / 4	< 2.03	0.88	4 / 1 / 3
2,4-Dimethylphenol	< 1.49	< 0.00	4 / 0 / 4	< 0.99	< 1.21	4 / 0 / 4			4 / 0 / 4
2,4-Dinitrophenol	< 6.16	< 10.40	4 / 0 / 4	< 4.87	< 5.21	4 / 0 / 4			4 / 0 / 4
2,4-Dinitrotoluene	< 0.00	< 0.00	4 / 0 / 4	< 1.09	< 1.7	4 / 0 / 4			4 / 0 / 4
2,6-Dinitrotoluene	< 1.90	< 4.22	4 / 0 / 4	< 1.53	< 2.11	4 / 0 / 4			4 / 0 / 4
2-Chloronaphthalene	< 4.14	< 6.54	4 / 0 / 4	< 3.32	< 3.47	4 / 0 / 4			4 / 0 / 4
2-Chlorophenol	< 1.13	< 1.70	4 / 0 / 4	< 1.0	< 1.7	4 / 0 / 4			4 / 0 / 4
2-Nitrophenol	< 1.46	< 2.22	4 / 0 / 4	< 1.18	< 1.39	4 / 0 / 4			4 / 0 / 4
3,3-Dichlorobenzidine	< 1.38	< 2.26	4 / 0 / 4	< 1.10	< 1.13	4 / 0 / 4			4 / 0 / 4
4,6-Dinitro-2-methylphenol	< 7.87	< 13.30	4 / 0 / 4	< 6.21	< 6.66	4 / 0 / 4			4 / 0 / 4
4-Bromophenylphenyl ether	< 2.51	< 4.18	4 / 0 / 4	< 1.99	< 2.09	4 / 0 / 4			4 / 0 / 4
4-Chloro-3-methylphenol	< 2.93	< 6.10	4 / 0 / 4	< 2.58	< 6.10	4 / 0 / 4			4 / 0 / 4
4-Chlorophenylphenyl ether	< 3.26	< 5.60	4 / 0 / 4	< 2.6	< 2.8	4 / 0 / 4			4 / 0 / 4
4-Nitrophenol	< 7.95	< 11.10	4 / 0 / 4	< 6.57	< 9.55	4 / 0 / 4			4 / 0 / 4
Acenaphthene	< 2.43	< 4.30	4 / 0 / 4	< 2.00	< 2.15	4 / 0 / 4			4 / 0 / 4
Acenaphthylene	< 2.11	< 3.44	4 / 0 / 4	< 1.68	< 1.72	4 / 0 / 4			4 / 0 / 4
Acrolein	< 0.53	< 0.53	1 / 0 / 1	< 0.53	< 0.53	1 / 0 / 1			1 / 0 / 1
Acrylonitrile	< 0.38	< 0.38	1 / 0 / 1	< 0.38	< 0.38	1 / 0 / 1			1 / 0 / 1
Anthracene	< 5.14	< 9.74	4 / 0 / 4	< 4.05	< 4.87	4 / 0 / 4			4 / 0 / 4
Benzo(a)anthracene	< 0.92	< 1.56	4 / 0 / 4	< 0.73	< 0.78	4 / 0 / 4			4 / 0 / 4
Benzo(a)pyrene	< 1.18	< 2.10	4 / 0 / 4	< 0.92	< 1.05	4 / 0 / 4			4 / 0 / 4
Benzo(b)fluoranthene	< 1.43	< 2.14	4 / 0 / 4	< 1.17	< 1.45	4 / 0 / 4			4 / 0 / 4
Benzo(g,h,i)perylene	< 3.52	< 8.62	4 / 0 / 4	< 3.18	< 8.62	4 / 0 / 4			4 / 0 / 4
Benzo(k)fluoranthene	< 2.51	< 3.80	4 / 0 / 4	< 2.1	< 3.8	4 / 0 / 4			4 / 0 / 4
Bis(2-chloroethoxy)methane	< 1.89	< 2.92	4 / 0 / 4	< 1.53	< 1.73	4 / 0 / 4			4 / 0 / 4
Bis(2-chloroethyl)ether	1.71	2.68	4 / 0 / 4	< 1.38	< 1.48	4 / 0 / 4			4 / 0 / 4
Bis(2-chloroisopropyl)ether	< 2.30	< 3.66	4 / 0 / 4	< 1.84	< 1.88	4 / 0 / 4			4 / 0 / 4
Bis(2-ethylhexyl)phthalate	52.53	139.00	4 / 4 / 0	< 14.7	34.8	4 / 4 / 0	86	8.47	4 / 4 / 0
Butylbenzyl phthalate	< 3.92	< 5.00	4 / 3 / 1	< 1.01	< 1.11	4 / 0 / 4			4 / 0 / 4
Chrysene	< 4.83	< 7.44	4 / 0 / 4	< 3.90	< 4.43	4 / 0 / 4			4 / 0 / 4
Dibenzo(a,h)anthracene	< 5.10	< 7.86	4 / 0 / 4	< 4.31	< 7.86	4 / 0 / 4			4 / 0 / 4
Diethyl phthalate	< 3.57	< 6.00	4 / 2 / 2	< 2.3	< 5.0	4 / 1 / 3	< 5	1.65	4 / 1 / 3
Dimethyl phthalate	< 15.87	< 31.20	4 / 0 / 4	< 11.97	< 15.6	4 / 0 / 4			4 / 0 / 4
Di-N-butyl phthalate	< 6.39	< 13.40	4 / 1 / 3	< 3.04	< 3.35	4 / 0 / 4	< 9.07	3.89	4 / 1 / 3
Di-N-octyl phthalate	< 2.32	< 4.34	4 / 0 / 4	< 1.77	< 2.17	4 / 0 / 4			4 / 0 / 4
Dioxin	< 0.03	< 0.03	1 / 0 / 1	< 0.03	< 0.03	1 / 0 / 1	< 0.03	0.03 (1)	1 / 0 / 1
Fluoranthene	< 1.44	< 2.46	4 / 0 / 4	< 1.13	< 1.23	4 / 0 / 4			4 / 0 / 4
Fluorene	< 0.00	< 0.00	4 / 0 / 4	< 1.39	< 1.46	4 / 0 / 4			4 / 0 / 4
Hexachlorobenzene	< 0.78	< 1.05	4 / 0 / 4	< 0.65	< 1.05	4 / 0 / 4			4 / 0 / 4
Hexachlorobutadiene	< 2.31	< 7.84	4 / 1 / 3	< 3.32	< 3.92	4 / 0 / 4			4 / 0 / 4
Hexachlorocyclopentadiene	< 2.43	< 3.89	4 / 0 / 4	< 2.07	< 3.89	4 / 0 / 4			4 / 0 / 4
Hexachloroethane	< 0.00	< 0.00	4 / 0 / 4	< 2.53	< 2.59	4 / 0 / 4			4 / 0 / 4
Indeno(1,2,3-cd)pyrene	< 1.45	< 2.52	4 / 0 / 4	< 1.13	< 1.26	4 / 0 / 4			4 / 0 / 4
Isophorone	< 2.19	< 3.54	4 / 0 / 4	< 1.72	< 1.87	4 / 0 / 4			4 / 0 / 4
Naphthalene	< 1.28	< 3.66	4 / 1 / 3	< 1.82	< 1.83	4 / 0 / 4	< 4.96	0.0467	4 / 1 / 3
Nitrobenzene	< 1.98	< 2.84	4 / 0 / 4	< 1.63	< 2.25	4 / 0 / 4			4 / 0 / 4
N-Nitrosodimethylamine	< 3.42	< 5.84	4 / 0 / 4	< 3.08	< 3.56	4 / 0 / 4			4 / 0 / 4
N-Nitrosodi-N-propylamine	< 2.35	< 3.54	4 / 0 / 4	< 1.90	< 2.30	4 / 0 / 4			4 / 0 / 4
N-Nitrosodiphenylamine	< 2.60	< 3.56	4 / 0 / 4	< 1.73	< 1.79	4 / 0 / 4			4 / 0 / 4
Pentachlorophenol	< 9.46	< 17.60	4 / 0 / 4	< 7.26	< 8.81	4 / 0 / 4			4 / 0 / 4
Phenanthrene	< 1.22	< 2.02	4 / 0 / 4	< 0.97	< 1.01	4 / 0 / 4			4 / 0 / 4
Phenol	< 5.78	10.85	4 / 2 / 2	< 0.81	< 0.82	4 / 0 / 4	< 2.17	0.93	4 / 1 / 3
Pyrene	< 1.32	< 2.06	4 / 0 / 4	< 1.06	< 1.14	4 / 0 / 4			4 / 0 / 4

All NOTES will be found on the last page of this table.

APPENDIX B

Data From Pima County Wastewater Management Department

TABLE I.A.3 PRIORITY POLLUTANT QUARTERLY SAMPLING 2000 - INA ROAD WPCF

(CONTINUED)

PARAMETER	INFLUENT			EFFLUENT			BIOSOLIDS		
	12 Month Mean	12 Month Maximum**	Data Compilation Codes*	12 Month Mean	12 Month Maximum**	Data Compilation Codes*	12 Month Mean	12 Month Maximum**	Data Compilation Codes*
Antimony (T)	< 0.0021	< 0.0037	4 / 0 / 4	< 0.0021	< 0.0037	4 / 0 / 4	< 1.96	4.37	4 / 3 / 1
Arsenic (T)	< 0.0045	< 0.0080	4 / 3 / 1	< 0.0039	< 0.0080	4 / 1 / 3	6.21	7.93	4 / 4 / 0
Beryllium (T)	< 0.0028	< 0.0080	3 / 1 / 2	< 0.0009	< 0.0013	3 / 0 / 3	< 0.53	< 1.17	4 / 2 / 2
Cadmium (T)	< 0.0018	< 0.0050	4 / 1 / 3	< 0.0006	< 0.0008	4 / 0 / 4	2.72	3.37	4 / 4 / 0
Chromium (T)	< 0.0080	0.0216	4 / 4 / 0	< 0.0054	0.0134	4 / 2 / 2	25.4	31.5	4 / 4 / 0
Copper (T)	0.0894	0.104	4 / 4 / 0	0.0256	0.0270	4 / 4 / 0	597	712	4 / 4 / 0
Cyanide (T)	< 0.0098	< 0.024	4 / 1 / 3	< 0.008	< 0.015	4 / 1 / 3	1.93	2.21	4 / 4 / 0
Lead (T)	< 0.0035	< 0.0050	4 / 3 / 1	< 0.0019	< 0.0050	4 / 1 / 3	20.8	23.7	4 / 4 / 0
Mercury (T)	< 0.000026	< 0.000026	4 / 0 / 4	< 0.000026	< 0.000026	4 / 0 / 4	1.8	2.5	4 / 4 / 0
Molybdenum (T)	< 0.0070	0.0089	3 / 3 / 0	< 0.0066	0.0079	3 / 3 / 0	6.81	8.27	4 / 4 / 0
Nickel (T)	< 0.0037	0.0047	4 / 3 / 1	< 0.0029	< 0.0050	4 / 3 / 1	13.8	15.4	4 / 4 / 0
Selenium (T)	< 0.0023	< 0.0038	4 / 1 / 3	< 0.0022	< 0.0038	4 / 0 / 4	< 3.24	3.99	4 / 3 / 1
Silver (T)	< 0.0042	0.0058	4 / 4 / 0	< 0.0015	< 0.0019	4 / 0 / 4	21.6	29.7	4 / 4 / 0
Thallium (T)	< 0.0018	< 0.0047	4 / 1 / 3	< 0.0017	< 0.0047	4 / 0 / 4	< 2.13	< 4.29	4 / 1 / 3
Zinc (T)	0.111	0.1190	4 / 4 / 0	0.0377	0.0434	4 / 4 / 0	715	808	4 / 4 / 0

NOTES:

* The data compilation codes represent: Number of samples / number of values above detection limit / number of values below detection limit. Samples for which pollutant levels were below detection limits were u as the detection level in calculations. Mean values are then reported as "less than" the computed value (<).

** Detection limits varied during the year. If no value is given or a "<" value is given, the value was below the detection limit.

*** The MDL level reflects the lowest method detection limit or practical quantitation level obtained during the year.

(1) The detection limit for Dioxin is the PQL of method TSS 8.7, determined as reliable by the TSS laboratory.

TABLE I.A.5 QUARTERLY PRIORITY POLLUTANT ORGANIC COMPOUNDS DETECTED IN EFFLUENT - 2000

Compound	DETECTED ONCE		DETECTED MORE THAN ONCE			AZ WQS	Did Effluent Exceed AZ WQS
	Detection (Samples)	Result (μg/L)	Detection (Samples)	Result (μg/L) Mean	Maximum	PBC or A & W edw/Acute (μg/L)	
INA ROAD WPCF							
Chloroform			4 of 4	1.6	2.0	1400	No
1,4-Dichlorobenzene			4 of 4	4.0	6.4	1880	No
Methylene chloride			4 of 4	<1.0	1.02	8400	No
Tetrachloroethene	1 of 4	<0.5				1400	No
Toluene			2 of 4	<0.32	<0.5	8700	No
Diethyl phthalate	1 of 4	<5				26000	No
Bis(2-ethylhexyl)phthalate			4 of 4	14.7	34.8	400	No
ROGER ROAD WWTP							
Chloroform			4 of 4	< 0.81	1.32	1400	No
1,4 -Dichlorobenzene			2 of 4	< 1.25	<5	1880	No
Methylene chloride			4 of 4	< 1.41	1.63	8400	No
G-BHC(gamma)	1 of 4	0.38				7.6	No
Toluene			3 of 4	< 0.41	< 0.5	8700	No
Bis(2-ethylhexyl)phthalate			2 of 4	< 7.1	16.3	400	No
Pentachlorophenol	1 of 4	<10.0				17	No

A "Non-Detect" analysis result is substituted by the MDL value in calculating the mean value of the results.
Analysis value that is "Trace" is counted as "Detect."
A "Trace" analysis result is substituted by the PQL value in calculating the mean value of the results.
A maximum "Detect" value that is "Trace" has a leading "<" operator .
Arizona Water Quality Standards PBC or Aquatic and Wildlife Effluent Dependent Water Acute is the minimum of either criteria.

The Water Quality of
Priority Streams in Pima County

Prepared for the Pima County Comprehensive Plan and
Sonoran Desert Conservation Plan

April 2002

Prepared By

Pima Association of Governments

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The Water Quality Of
Priority Streams in Pima County

Introduction

Background

Pima County is updating the Pima County Comprehensive Land Use Plan as required by the State's Growing Smarter Legislation. Pima County is also developing the Sonoran Desert Conservation Plan. These plans will contain a water quality element to meet the legislated requirement and to ensure the preservation of aquatic species. Pima Association of Governments (PAG) is the state designated Water Quality Planning Agency for Pima County under Section 208 of the Clean Water Act, and at the County's request is assisting in the preparation of the water quality portion of the plans.

As part of developing the water quality element, PAG prepared two reports for the County. One report summarized water quality data available for the principal types of water sources in Pima County: groundwater, CAP water, treated wastewater, stormwater runoff, and surface waterbodies such as streams. The other report summarized the water quality requirements of the native aquatic species in Pima County. As an additional part of the water quality element for the Pima County Comprehensive Plan and the Sonoran Desert Conservation Plan, a list of the highest priority streams was identified for water quality and quantity monitoring, management and restoration. This report compiles the existing water quality data and other pertinent information for the streams that have been identified as priorities.

Purpose

The purpose of this report is to compile existing water quality data, identify any water quality impairments, identify any gaps in the available data, and assess land uses through existing literature and aerial photography for the recently identified priority streams in Pima County. In addition, possible protective measures to ensure the water quality of some streams and a water quality monitoring plan are presented.

Limitations

The information provided in this report is limited to the data readily available to PAG staff from published literature and various agencies' monitoring programs. PAG did not conduct any original research for this project. Information compiled from a previous PAG study and report, *GIS Coverage of Perennial Steams and Intermittent Streams and Shallow Groundwater, January 2000,* was used. Also, PAG's literature and data search were significantly constrained by time and budget limitations. The data used in this study were primarily from Arizona Department of Environmental Quality (ADEQ), United

States Geological Survey (USGS), and Pima County Wastewater Management Department. In addition the U.S. Forest Service (USFS), Bureau of Land Management (BLM) and National Park Service were contacted. Other data sets are probably available, but not included in this report.

Priority Streams in Pima County

As part of the water quality element for the Pima County Comprehensive Plan and the Sonoran Desert Conservation Plan (SDCP), PAG and Pima County staff created a list of the highest priority streams for water quality and quantity monitoring, management and restoration. Stream selection was based primarily on the presence of perennial or intermittent stream flow, the area of riparian habitat, the presence of historic or existing populations of native fish and frog species, and location with respect to other surface water sources and possible wildlife corridors. The potential threat to any individual stream or the fact that an individual stream might already be monitored or protected was not considered when developing the list. Some streams did not have as high habitat value as others but were included because they were considered to be a priority by BLM, USFS, PAG, Arizona Game and Fish Department (AGFD), or County personnel. The SDCP Riparian Element report, especially Appendix A1 – Table 1 and the historic occurrence of native fish were used to determine the resources present in and around each stream. Maps showing the stream locations and the adjacent land ownership are included in Appendix A of this report.

The following streams are considered high priority:

- Agua Caliente Canyon
- Agua Verde Creek
- Arivaca Creek
- Bingham Cienega
- Buehman Canyon
- Canada del Oro
- Cienega Creek (upper and lower)
- Davidson Canyon
- Empire Gulch
- Espiritu Canyon
- Florida Canyon
- Mattie Canyon
- Quitobaquito Spring
- Rincon Creek
- Sabino Canyon (upper and lower)
- San Pedro River
- Santa Cruz River (mid/lower)
- Tanque Verde Creek (upper)
- Wakefield Canyon/Nogales Spring

Priority Stream Water Quality Monitoring History

PAG compiled existing water quality data for the selected highest priority streams in Pima County. ADEQ, USGS, PAG, the BLM, and others provided the data. Table 1 lists the highest priority streams, the types of monitoring, the sampling frequency, and the agency that collected the data over the past ten years. Given the time and budget constraints of this project, only data that were readily available and easy to locate were compiled. The listed data are not conclusive and data collected for some of the streams prior to the 1990's were not reviewed in cases where more recent data were available. There may be other data sources for these streams that we did not have the resources to locate.

Table 1. Sampling History for the Highest Priority Streams in Pima County

Priority Stream	Data Source(s)	Major Ions	Trace Metals	Nutrients	Field Parameters
Agua Caliente Canyon	ADEQ	4/95	4/95	4/95	4/95
Agua Verde Creek	None	--	--	--	--
Arivaca Creek At Figueroa Creek	ADEQ	12 times between 1990 and 1993	12 times between 1990-1993	12 times between 1990-1993	12 times between 1990-1993
Arivaca Creek at Headwater Spring	ADEQ	12 times between 1989-1992	12 times between 1989-1992	12 times between 1989-1992	12 times between 1989-1992
Arivaca Creek at Ruby Road	ADEQ	24 times 1989-1993	24 times 1989-1993	24 times 1989-1993	24 times 1989-1993
Bingham Cienega	PAG	7 times between 1998-2000	7 times between 1998-2000 Al, As, Mn	7 times between 1998-2000	7 times between 1998-2000 for EC, pH, temp.
Buehman Canyon below confluence with Bullock Canyon	ADEQ	4/96 5/00	4/96 5/00	4/96 5/00	4/96 5/00
Buehman Canyon near Redington	ADEQ	9 times between 11/95-7/97	9 times between 11/95-7/97	9 times between 11/95-7/97	9 times between 11/95-7/97
Canada del Oro	ADEQ	Once each year, 1992-1994.	Once each year, 1992-1994	Once each year 1992-1994	Once each year 1992-1994
Cienega Creek (Lower) (seven locations)	Pima County	18 times between 5/87-7/90 at three locations			
	ADEQ	60 times between 5/87-9/98 at six locations; 4 times at two locations from 12/00-12/01	60 times between 5/87-9/98 at six locations; 4 times at two locations from 12/00-12/01	60 times between 5/87-9/98 at six locations; 4 times at two locations from 12/00-12/01	62 times between 5/87-9/98 at six different locations; 5 times at two locations from 12/00-12/01
	PAG	7 times between 1998-2000	7 times between 1998-2000	7 times between 1998-2000	7 times between 1998-2000 for EC, pH, Temp.
Cienega Creek (Upper) below Stevenson Canyon (two locations)	ADEQ	9/98 4 times at two locations 12/00-12/01	9/98 4 times at two locations 12/00-12/01	9/98 4 times at two locations 12/00-12/01	9/98 5 times at two locations 12/00-12/01
Davidson Canyon	None	--	--	--	--
Empire Gulch	BLM	--	--	--	EC, pH, and temperature
Espiritu Canyon	None	--	--	--	--
Florida Canyon	None	--	--	--	--
Mattie Canyon	None	--	--	--	--
Quitobaqutio Spring	National Park Service	--	--	--	8 times at five locations 2/98-9/99

Priority Stream	Data Source(s)	Major Ions	Trace Metals	Nutrients	Field Parameters
Rincon Creek	None	--	--	--	--
Sabino Canyon below Summerhaven	ADEQ	9 times 11/90-3/92	9 times 11/90-3/92	9 times 11/90-3/92	9 times 11/90-3/92
Sabino Canyon at SCSAB004.39	ADEQ	4/01	4/01	4/01	4/01
San Pedro River Near Bingham Cienega	PAG	7 times 1998-00	7 times 1998-00	7 times 1998-00	7 times 1998-00 pH, EC, Temp
Sab Pedro River Near Redington	ADEQ	Aug 1991	Aug 1991	Aug 1991	Aug 1991
Santa Cruz River at Cortaro Rd.	ADEQ	50 times between 1986-93	50 times between 1986-1993	50 times between 1986-93	53 times between 1986-93
	USGS	12 times between 1/96-1/97		12 times 1/96-1/97	12 times 1/96-1/97
Santa Cruz at WWTP outfall	Pima County	per NPDES	per NPDES		per NPDES
Tanque Verde Creek (upper)	ADEQ	8/89	8/89	8/89	8/89
	USGS	25 times between 1987-1994	24 times between 1987-1994	16 times between 1987-1994	32 times between 1987-1994
Wakefield Canyon	None	--	--	--	--

Field parameters are generally measured on-site and include pH, dissolved oxygen, electrical conductivity, temperature, and alkalinity. Major ions include the following: sodium, calcium, magnesium, chloride, sulfate, bicarbonate and silica (Hounslow, 1995). Nutrients include the various forms of nitrogen and phosphorous.

Surface Water Quality Standards in Arizona

The Clean Water Act requires Arizona to establish surface water quality standards. These water quality standards define the water quality goals for all surface waters in the state. The standards designate the uses to be protected and prescribe the criteria that Arizona Department of Environmental Quality (ADEQ) determines are necessary to maintain and protect the water quality for its designated use. These standards also provide the regulatory basis for establishing water quality-based discharge limits and controls in NPDES permits (ADEQ, 2000).

The A.A.C. Title 18, Chapter 11, Water Quality Standards, apply to all surface water in the state. Arizona sets both numerical and narrative water quality standards for each waterbody based on the use of the waterbody. The "designated uses" are specified in the standards or based on the tributary rule. There are seven designated uses:

1) Aquatic and Wildlife. All waterbodies have one of four Aquatic and Wildlife categories and have either Full Body or Partial Body Contact designated use. The Aquatic and Wildlife categories are: warm water aquatic community (A&Ww), cold water aquatic community (A&Wc), effluent dependent water (A&Wedw), and ephemeral flow (A&We).
2) Full Body Contact (FBC)
3) Partial Body Contact (PBC)
4) Fish Consumption (FC)
5) Domestic Water Source (DWS)
6) Agriculture Irrigation (AgI)
7) Agriculture Livestock Watering (AgL)

Surface waterbodies are assessed annually and reported semi-annually to determine if their water quality is sufficient to meet the designated uses. Surface waterbody assessments are primarily made based on chemical water quality data, but other types of data and information are also considered. The following reaches of the priority streams have been assessed by ADEQ and are listed in Appendix B of A.A.C. Title 18, Chapter 11, List of Surface Waters and Designated Uses[1]:

- Agua Caliente Wash, headwaters to the national forest boundary, A&Ww
- Arivaca Creek, tributary to Altar Wash, A&Ww
- Buehman Canyon, headwaters to confluence with unnamed tributary, A&Ww
- Buehman Canyon, below confluence with unnamed tributary, A&Ww
- Canada del Oro, headwaters to Highway 89, A&Ww
- Cienega Creek, headwaters to Interstate 10, Interstate 10 to Del Lago Dam, and below Del Lago Dam, A&Ww
- Davidson Canyon, unnamed spring to confluence with unnamed tributary, A&Ww
- Empire Gulch, below Empire Ranch, A&Ww
- Espiritu Canyon Creek, tributary to Soza Wash, A&Ww
- Mattie Canyon, tributary to Cienega Creek, A&Ww

- Sabino Canyon Creek, headwaters to confluence with unnamed tributary, A&Wc
- Sabino Canyon Creek, below unnamed tributary, A&Ww
- San Pedro River, Redington to the Gila River, A&Ww
- Santa Cruz River, Roger Road WWTP to Baumgartner Road, A&Wedw

[1]The designated uses are currently under revision as part of the triennial review by ADEQ.

Assessments are primarily based on monitoring data but also include other information such as bioassessments, evidence of toxic impacts on fish, fish advisories, and swimming closures. The process involves collecting all available water quality data and information on a waterbody and comparing them to standards or EPA criteria. "Use Support" is based on frequency of exceedances or other information concerning water quality. However, each use and CWA goal has a separate set of standards and criteria to meet.

There are two categories of assessed waters: "monitored" and "evaluated". Monitored assessments are based on current monitoring, within the past five years, with chemical and physical monitoring occurring at least once per quarter for perennial streams, or at least four times in two years for non-perennial streams. Evaluated assessments are based on less data and information. Assessment reliability generally increases with increased quantity and diversity of data; having biological, physical and chemical data is also preferred to chemical data alone (ADEQ, 2000).

There are both numeric and narrative standards based on the water's use by people or animals. Arizona's numeric surface water quality standards, from Appendix B of ADEQ's *The Status of Water Quality in Arizona 305 (b) Report 2000*, are included in Appendix B of this report. Narrative water quality standards supplement the numeric standards and describe the conditions that are needed to maintain and protect aesthetic qualities of water (ADEQ, 2001). Being qualitative, the narrative standards provide blanket protection for all waterbodies regardless of whether or not a particular water quality standard applies to that waterbody (ADEQ, 1996).

Narrative nutrient standards serve to protect waters by limiting pollutants that might be discharged at concentrations that might cause highly productive growth of nuisance plants. To a great extent the presence of bioavailable nitrogen determines the rate of growth. Therefore, attention must be paid to the determination of natural inputs of nitrogen. Nitrate and ammonia occur in precipitation, and nitrate can be found in elevated quantities in spring water and in upwelling areas due to natural nitrification. Indicators of a possible narrative nutrient standard violation are low DO and high pH. Other indications include excessive algae growth, and a biological community with greater numbers of blackflies, snails, leeches and bloodworms, although in effluent dependent waters this condition may be normal (ADEQ, 1996).

The purpose of the narrative toxicity standard is to ensure that a surface water is free from pollutants in amounts or combinations that are toxic to animals, people and other organisms. According to ADEQ's draft guidelines a violation of the standard does not necessarily equal an impairment of uses or warrant addition to the State's 303(d) list of impaired waters. The draft guidelines indicate that ambient biomonitoring is one of the methods used to determine a waterbody's compliance with the standard. Ambient biomonitoring will be applied to waters that have the following designations: A&Ww, A&Wc, A&Wedw, FC, Domestic water source (DWS) and ephemeral waters, depending on the uses and the species the water quality standards are intended to protect. In addition, whole effluent biomonitoring (WEB, is also known as whole effluent toxicity testing, WET) is used to measure the toxicity of pollutants in effluent discharged to surface water (ADEQ, 2001).

The surface water quality standard rule includes a narrative standard intended to prevent harmful effects of bottom deposits on aquatic life and impairment of recreational uses. Bottom deposits are settleable solids. The narrative standard directly links the bottom deposits to aquatic life impairment. To determine compliance with the standard two basic elements are used: 1) bioassessment procedures for determining whether there is an impairment of aquatic life and 2) diagnostic procedures for determining that the cause of impairment of aquatic life is due to excessive sedimentation or siltation (ADEQ, 2001a).

Another important part of the Arizona Water Quality Standard Rule is the unique water designation. A unique water is one that ADEQ has determined to be an outstanding state resource water. Pima County is fortunate to have reaches in two streams designated as unique: Cienega Creek and Buehman Canyon Creek. Unique waters are given stringent surface water quality protections under the State's antidegradation rule, which states: "Existing water quality shall be maintained and protected in a surface water that is classified as a unique water ..."(A.A.C., 1996). Once a surface water is classified as a unique water, land use activities in the watershed have to be conducted in a way that prevents the degradation of existing water quality.

History of Surface Water Quality in Pima County

Historical water quality data can provide a baseline for interpreting current data and establishing seasonal trends. According to ADEQ, primary sources of historical data include: ADEQ fixed station records, USGS water quality database, Federal water quality database, complaint investigation files, ADEQ groundwater database, and published reports (ADEQ, 1992).

In addition to water quality data, historical water quality assessment reports can be used to track stream conditions. These reports indicate condition but do not provide specific water quality details. A review of the Pima County waterbodies listed in the Arizona Water Quality Assessment 305 (b) Reports for 1990-1996, on file at PAG, are summarized below. For regulatory purposes, the most recent (i.e., 2000) 305(b) report gives the most current assessment of the stream condition.

1996

Buehman Canyon from the headwaters to the San Pedro River was sampled between 1991-1993 and was determined to be in full support of its designated use.

The San Pedro River from Hot Springs to Redfield (sampled at the Redington ADEQ fixed station in 1991) was determined to be in full support of its designated use.

In the Santa Cruz-Rio Magdalena-Rio Sonoyta Watershed, the Santa Cruz River from Canada del Oro to Guild Wash was determined to be threatened. This was based on one out of 12 turbidity samples exceeding the standard.

The Canada del Oro from its headwaters to Big Wash was found to be in full support of its designated use based on ADEQ's biocriteria program.

Tanque Verde Creek was determined to be in full support of its designated use based on three sampling events in 1991.

Agua Caliente Wash was determined to be in full support of its designated use based on ADEQ's 1995 biocriteria monitoring program.

Sabino Canyon Creek, from just below Summerhaven to the lower Sabino Canyon was also in full support of its designated use. Samples were collected in 1991 and biocriteria monitoring was done in 1992, 1993, and 1994.

Arivaca Creek was deemed to be in partial support of its designated use based on sampling done between 1991-1993, where it was found that 8 out of 18 samples for DO collected at the Ruby Road fixed station were lower than the standard. At the Headwater Spring sampling location one out of ten of the DO samples were below the standard but the reach was determined to be in full support.

1994

The reach of the Santa Cruz River from Rillito Creek to Canada del Oro was in partial support due to fecal coliform. The section from Canada del Oro to Guild was in partial support due to turbidity.

Canada del Oro, from the headwaters to Big Wash, was considered to be threatened due to phosphate and fecal coliform. Tanque Verde and Cienega Creek were considered to be in full support.

Sabino Canyon Creek was in partial support due to turbidity. ADEQ collected 9 samples between 1990-92; USFS collected 1 sample at two locations in 1991. ADEQ collected 8 samples for a bacteria study only in 1992-93—there were no exceedances.

Arivaca Wash was in partial support due to low DO and fecal coliform. ADEQ collected 56 samples at 3 sampling locations between 1990-93.

1992

Two reaches of the Santa Cruz River, from Rillito to Canada del Oro and from Canada del Oro to Guild, were reported as having a use status of "threat". The threat for the reach from Rillito to Canada del Oro was due to fecal coliform. The threat for the reach from Canada del Oro to Guild was for mercury.

Canada del Oro (from headwaters to Big Wash) was listed as partial use support status. The partial support was due to nutrients and metals.

Cienega Creek from the headwaters to the Pantano was deemed to be in full support.

Tanque Verde Creek from the headwaters to the Rillito Creek was also in full support. USFS monitored in 1991 and ADEQ sampled in 1988-89.

Sabino Canyon Creek from the headwaters to Tanque Verde was also in full support. ADEQ had 10 samples from 1990-91 and 8 samples from 1989-90. USFS had 1 sample, 2 locations in 1991.

Arivaca Wash from the headwaters to Puertocito/Altar was classified as "non-support". This was due to DO at the headwater spring. The creek near Ruby Road was in partial support and in full support near the Figueroa Spring sample location.

The San Pedro River near Redington was sampled one time in 1991, had no exceedances and was determined to be in full support.

1991

The general description of the Santa Cruz River Basin explained that low dissolved oxygen was reported in samples collected along Cienega and Arivaca Creeks. The low DO was believed to be due to the samples collected near the spring sources where water is naturally lower in DO.

The Santa Cruz River had samples collected during a flood event that were found to be high in arsenic, cadmium, mercury and lead. It is believed these contaminants were transferred downstream from historic mining sites. This demonstration of periodic contamination resulted in the partial support designation.

1990

Mercury exceedances were found in the Santa Cruz as it flowed through Tucson, and therefore, this segment did not meet effluent dominated water quality standards.

Ammonia exceedances were reported along Cienega Creek so that aquatic and wildlife uses were impaired. These exceedances appeared to be related to rangeland management practices and recreation.

The San Pedro River from Redington to the Gila River was classified as partial or non-support due to turbidity, ammonia, mercury, arsenic, boron, copper, manganese, and lead. These were attributed to mining, rangeland, irrigation, and land disposal.

Potential Sources of Water Quality Stressors

According to ADEQ's year 2000 305(b) report, which assesses the status of water quality statewide, the most common "stressors", or pollutants, in Arizona streams are turbidity, metals, pH, pathogens, pesticides, other inorganics, nutrients, low dissolved oxygen and radiochemicals. The 305(b) report identifies turbidity as currently the single most common stressor in Arizona's streams. The turbidity standards were developed to protect against aquatic habitat degradation due to excessive sedimentation and algal blooms. Associated with algal blooms are high nutrient concentrations, low dissolved oxygen, and high pH. In the right combination and conditions these can lead to stress in aquatic organisms and can contribute to fish kills.

The major sources of the most common stressors identified by ADEQ are, in order of impact: natural sources, agriculture, mining, land development, urban runoff, point sources, septic systems, bank modification and recreation (ADEQ, 2000).

Natural conditions are considered a source of stressors because many of Arizona's soils are highly erodible or have naturally high levels of metals. If a stressor is entirely caused by natural conditions it is not a violation of the water quality standard. Along with natural conditions, mining is a source of metals and low pH.

Both grazing and crop production are probable sources of stressors such as turbidity, boron, selenium, nutrients, fecal coliform and pesticides. Grazing is the predominant land use in Arizona and is the probable source of significant sediment loading. Grazing can cause progressive physical and biological degradation of watershed conditions. The vegetation destruction caused by grazing can lead to heavier runoff, increased erosion, arroyo cutting and reduced groundwater infiltration and storage (State of AZ, 1995).

The State of Arizona, in its *Arizona Comparative Environmental Risk Project (ACERP)* report, included air pollution as a water quality stressor. The main sources of air pollution were listed as: mining and metal extraction, localized industry, coal-fired generating stations, and internal combustion engines. Airborne particles deposited through precipitation or biologically accumulated through absorption in a watershed can eventually enter streams. Levels would typically be low, but accumulation during prolonged drought may result in high concentrations in runoff from a precipitation event. Emissions from a copper smelter in Mexico contribute to acid rain in the San Bernadino Nation Wildlife Refuge, and acid precipitation may be a contributing factor in the extirpation of the Tarahumara frog (State of AZ, 1995).

Urban development also provides stressors to the stream environment. During the urbanization process, lands that were previously vegetated and open are converted to uses that usually increase the amount of impervious surface. This results in increased runoff volume and pollutant loading. Urbanization, in general, typically results in changes to the physical, chemical and biological characteristics of the watershed (EPA, 1999).

Urban development can cause an increase in pollutants that can have a direct impact on water quality. The major pollutants that have been found in runoff from some urban areas include sediment, nutrients, oxygen-demanding substances, heavy metals, petroleum hydrocarbons, pathogenic bacteria, and viruses. To help protect streams from potential water quality degradation from urban non-point source pollution, runoff management goals need to be developed and pursued. These should include maintaining predevelopment hydrologic conditions, minimizing soil erosion and sedimentation, runoff control and maintaining riparian resources (EPA, 1999).

Although turbidity was identified as the most common stressor in Arizona's streams in the 2000 305(b) report, this could be somewhat misleading. ADEQ (2001b) has indicated that turbidity data can be unreliable, and that turbidity is merely a surrogate measurement for estimating the amount of suspended solids in water. For these and other reasons, ADEQ has proposed to repeal the current numeric turbidity criteria.

In place of the turbidity criteria, ADEQ is proposing to adopt a new numeric criterion for suspended sediment concentration, which would apply at or near base flow, and not when there is elevated flow in response to a precipitation event (ADEQ, 2001b). Sediment is recognized as a significant water pollutant. ADEQ noted in its proposed rulemaking that EPA has identified sediment as the single most widespread cause of impairment of the nation's rivers and streams. Similarly, Lawson (2002) believes that sediment is the most serious pollutant to Arizona streams. Deposited on the bottoms of streams, it can impact fish spawning, reduce habitat complexity in streams and fill in rearing pools. Heavy sediment loads tend to destabilize the stream system, causing structural changes such as channel widening, bank erosion and riparian habitat decline. Sediment can also cause physical harm to aquatic organisms by causing clogged gills in fish (EPA,1999a; Lawson, 2002; Okay, 1998).

Priority Stream Water Quality and Potential Stressors

Readily available water quality data for each of the designated high priority streams were compiled and reviewed. Some streams had no known water quality data while others have been monitored extensively. In addition to reviewing the water quality data, PAG also looked at land uses and possible threats to the streams. Land ownership is shown on maps in Appendix A. The stream delineations are based on information from the PAG *GIS Coverage of Perennial Streams, Intermittent Streams, and Areas of Shallow Groundwater, Final Project Report*, from January 2000. Water quality data for the streams that have been monitored are included in Appendix C.

Agua Caliente Canyon

Agua Caliente Canyon Wash has intermittent flow and is located in an area with over 1000 acres of hydro-mesoriparian habitat, a deciduous riparian forest, a mesquite bosque, and shallow groundwater. This is an historic leopard frog location. This reach of the stream is located partly within the national forest boundary and is therefore relatively protected. A review of 1992 aerial photography of the area shows no built structures near the stream but there is evidence of hiking or livestock trails. This stream is located close to the urban area and might be impacted by recreational uses. Agua Caliente Spring, a rare perennial spring in the Tucson Basin, has perennial flow and possible potential for restoration projects for both aquatic flora and fauna, but was not included on the SDCP Riparian Element table. Water quality data for the spring are not available at this time. Water quality data are available for Agua Caliente Canyon from the ADEQ database and are included in Appendix C.

Agua Verde Creek

Agua Verde Creek has intermittent stream flow for over 15 miles and is associated with approximately 300 acres of Class A riparian habitat, a mesquite bosque, and shallow groundwater. Leopard frogs and fish exist in this creek

The creek is located in the corridor between the Rincon Mountains and the Santa Rita Mountains. Agua Verde Creek is a tributary of Cienega Creek downstream of the Marsh Station Bridge. Though Agua Verde Creek is not listed in R18-11, Appendix B, it is a tributary to a listed waterbody; therefore water quality standards under R18-11-105 apply. In this case the aquatic and wildlife (warm water) full body contact, and fish consumption standards apply.

In addition, the lower portion of Cienega Creek has been designated as a unique waterbody by the state. Once a surface water is classified as a unique water, land use activity in the watershed (which includes Agua Verde Creek) must be conducted in such a way that prevents the degradation of existing water quality. Land uses that cause nonpoint source pollution, including cattle grazing, mining, and agriculture, are not exempt from the antidegradation policy.

This reach of Agua Verde Creek is just south of the Coronado National Forest Boundary and traverses private, state, and county land in rural Pima County. A number of unimproved roads cross the streambed in this area. Aerial photography from 1992 and topographic maps from 1994 show unimproved roadways and some man-made structures along this reach. Most prominent are stock tanks, water wells, and ranch structures, surrounded by areas showing signs of pedestrian, livestock or off-road vehicle traffic. Land uses that might impact this stream would be ranching and grazing, pumping of the shallow groundwater and water diversion, septic systems and off-road vehicle uses that could result in possible habitat destruction or water degradation.

No known water quality data are available for Agua Verde Creek.

Arivaca Creek

Arivaca Creek has perennial and intermittent stream flow for over three miles through more than 1000 acres of hydro-mesoriparian habitat, including a deciduous riparian forest; it is associated with shallow groundwater. This is an historic leopard frog location with native fish establishment potential. Arivaca Creek is one of few perennial water sources in the area and is one of the major tributaries to Brawley Wash, which eventually flows into the Santa Cruz River north of the Pima/Pinal County line. The perennial flow is located near the community of Arivaca and includes the Arivaca Cienega within the Buenos Aires National Wildlife Refuge. There are no records of natural populations of native fish in Arivaca Creek, but in the 1930's there was an attempt to establish Gila topminnow (Pima County, 2000).

This creek flows through the community of Arivaca, is bordered by a main roadway, and is therefore easily accessible. Land uses that might impact the water quality would include accidental or deliberate dumping of hazardous substances, agriculture, grazing or livestock impacts, recreational impacts, water diversion, development (urbanization) and septic systems.

ADEQ has monitoring data for several reaches of Arivaca Creek. ADEQ's stream assessment indicated that the stream was in full support of its use designation and that it had low dissolved oxygen due to the spring source and low flows. Water quality data for Arivaca Creek are included in Appendix C.

Bingham Cienega

The Bingham Cienega has perennial surface water and is a unique wetland environment. The Bingham Cienega supports longfin dace and lowland leopard frogs, a variety of birds, and has native fish establishment potential (PAG, 2001). The area has historically been used for farming and ranching. In 1989, Pima County Flood Control District purchased the 28 acre Bingham Cienega and the surrounding 285 acres for the purpose of restoring natural ecological processes and preventing floodplain development. The area is managed by the Nature Conservancy (PAG, 2001). Because of its protected status, water quality threats are probably minimal. Water quality data for Bingham Cienega are included in Appendix C.

Buehman Canyon

Buehman Canyon has both perennial and intermittent stream flow over more than 7.5 miles, through more than 200 acres of Class A riparian habitat. The reach from the headwaters to an unnamed tributary is currently classified as a "Unique Water" by the State.

Longfin dace and lowland leopard frogs have been recorded in this stream reach. Transplanted stocks of desert pupfish were in the stream in 1989, but currently their status is unknown (Marsh and Sada, 1993). The area has additional native fish establishment potential.

Most of the perennial and intermittent flow is on private land, owned by The Nature Conservancy, with a small portion on state trust land. Aerial photography from 1992 shows many unimproved roads and trails in and around the perennial and intermittent reaches of this stream. Topographic maps from 1981 show mineshafts and prospecting areas along the stream. The area has been used for recreational purposes such as off-road vehicle riding and hiking. Potential impacts on the stream would be from human disturbance and erosion. Because of its protected status, and its isolated location, water quality threats from future land uses are probably minimal. Water quality data are included in Appendix C.

Canada del Oro

The Canada del Oro has perennial and intermittent stream flow for more than five miles through 300 acres of hydro-mesoriparian habitat and a mesquite bosque. Two native fish species are found here, and it is an historic leopard frog location. Aerial photography from 1995 shows unimproved roads and jeep tracks in the area of this stream. The perennial and intermittent portions of the stream are entirely within national forest land and therefore subject to minimal impacts, which could include recreational impacts from people and possibly livestock impacts.

ADEQ has evaluated this stream and determined it is in full support of its designated use. Data for Canada del Oro are included in Appendix C.

Cienega Creek (lower)

Lower Cienega Creek has perennial and intermittent stream flow (7.5 miles) through more than 550 acres of hydro-mesoriparian habitat, 55 acres of Class A riparian habitat, a deciduous riparian forest, and a mesquite bosque; it is also associated with shallow groundwater. One native fish species and leopard frogs are in the area. Establishment of additional native fish species may be possible. This portion of Cienega Creek has been designated as a "Unique Water" by the state. Pima County Parks and Recreation manage the lower portion of the creek, and PAG has conducted monthly stream flow and well water level monitoring since the late 1980's.

Land in the Cienega Creek basin (both upper and lower Cienega Creek) includes BLM, state, county, and private holdings. Uses include grazing, recreation, transportation corridors, mining, agriculture, and private residences. Much of the basin is part of an open-space network that includes the Cienega Creek Natural Preserve, the Las Cienegas National Conservation Area, Saguaro National Park and the Coronado National Forest (PAG, 1998).

Various existing and future land uses could adversely affect the quality and quantity of surface water, groundwater, and riparian habitat. Urbanization in the area could lead to increased groundwater withdrawals that might lower the groundwater table in the basin. This could result in diminished perennial stream flow and a loss of riparian vegetation. In addition, a proliferation of on-site residential waste treatment systems, particularly if they are not properly installed or maintained, could lead to a nutrient problem.

Other potential land use impacts include the threat of water degradation from spills or accidental releases of hazardous substances transported through the area on the railroad and Interstate 10. These reaches are easily accessible by road, which increases the likelihood of impact from deliberate dumping of debris or harmful substances. In addition, mining activities could result in stream degradation by increasing turbidity and contributing runoff potentially containing heavy metals. Agriculture uses can lead to the introduction of nitrates and pesticides into the waterway (PAG, 1998). According to Dr. Lin Lawson of ADEQ the biggest threat to Cienega Creek at the present time is the large volume of sediment that is introduced into the creek from its tributaries (Lawson, 2002).

This is one of the most extensively monitored streams in Pima County. ADEQ monitored Cienega Creek from Interstate 10 to the Del Lago dam and found it to be in full support of its designated use. Water quality data for Cienega Creek (lower) are included in Appendix C.

Cienega Creek (upper)

The upper Cienega Creek has perennial and intermittent stream flow for more than 12 miles through 900 acres of hydro-mesoriparian habitat and a mesquite bosque. The creek is also associated with areas of shallow groundwater. Three native fish species and leopard frogs exist in this reach. The upper portions of the basin are included in the Las Cienegas National Conservation Area and are maintained by the BLM.

Uses in the upper portion of the creek include: grazing, which can de-stabilize the banks resulting in sedimentation; recreation; and off-road vehicle use, which if not properly managed, could lead to degradation of the stream. As with the lower portion of Cienega Creek, the upper section is also easily accessible by road, increasing the likelihood of illegal dumping of debris and harmful substances into the creek.

ADEQ has evaluated the upper portion of Cienega Creek, from the headwaters to Interstate 10, and found that it is in full support of its designated use. Water quality data for Cienega Creek (upper) are included in Appendix C.

Davidson Canyon

Davidson Canyon has been determined to have both perennial and intermittent stream flows (two miles). The area has Class A riparian vegetation, shallow groundwater, one known native fish species (longfin dace) and leopard frogs. Additional native fish establishment may be possible (Pima County, 2000a). The stream is located in the corridor between the Santa Rita Mountains/Sonoita Valley and the Rincon Mountains (Pima County, 2000).

The perennial and intermittent reaches of this stream flow through private and state lands before joining with Cienega Creek. This stream is listed in the Water Quality Standards' Appendix B with an A&Ww use designation. Aerial photography from 1992 shows ranches and unimproved roadways in the area of the stream. Also, topographic maps show a pipeline, a power line, and unimproved roads crossing the streambed. Farther upstream there are mine shafts and areas where mineral prospecting has occurred. These reaches might be vulnerable to degradation from groundwater pumping and habitat loss, future upstream mining, and grazing and livestock uses, which can lead to sedimentation. (Pima County, 2000).

No known water quality data are available for Davidson Canyon.

Empire Gulch

Empire Gulch has perennial and intermittent stream flow for about one and one half miles. Leopard frogs are known to be in the area. Empire Gulch is also the only location in Pima County where the Huachuca water umbel is currently found. In the fall of 2001, the stream was stocked with longfin dace and Gila topminnow. Empire Gulch is listed in the Water Quality Standards as having an A&Ww use designation. This stream is a priority for the BLM. The BLM assumed ownership of the area in 1989 and cattle have been restricted from Empire Gulch since 1992 in order to allow restoration. This area has been thoroughly documented and monitored since that time. However, water quality has not been measured on a regular basis. Conductivity has been measured at 550 µmhos/cm, pH at 7.4, and temperature from 15-17 ° C at the source (Simms, 2001).

No additional water quality data are available for Empire Gulch.

Espiritu Canyon

Espiritu Canyon is in the northeast corner of Pima County and flows from the national forest boundary, through state land, and into City of Tucson land. This stream has documented perennial and intermittent stream flow for over four and one half miles and has leopard frog habitat. Information on shallow groundwater is not available. There is a potential for native fish establishment in this waterbody. Aerial photography from 1992 and the 1994 topographic map show several unimproved roads in and around this stream. The area could be impacted by grazing, off-road vehicle use, and other recreational uses.

No known water quality data are available for Espiritu Canyon.

Florida Canyon

Florida Canyon is an intermittent stream that flows for over three miles. PAG found no information on riparian vegetation or native fish species, but leopard frogs are known to be in the area. This is a priority stream for USFS. This reach is entirely on federal land (national forest) and might be impacted by grazing or recreational uses.

No known water quality data are available for Florida Canyon.

Mattie Canyon

Mattie Canyon has perennial and intermittent stream flow for over one and a half miles. There is no riparian vegetation information available for this stream. Gila topminnow (PAG, 2000a) and Gila chub are present in this stream and it has historically been a leopard frog location. This stream is located on BLM land and is a tributary to Cienega Creek. It is not listed in the state's Water Quality Standards. However, since it is a tributary to the upper Cienega Creek it is covered by R18-11-105 and therefore has a use designation of A&Ww. Aerial photography from 1992 and the 1994 topographic map show numerous unimproved roads and trails in and around the perennial and intermittent portions of this stream. The water quality could be impacted by recreational uses and grazing, which could lead to sediment problems.

No known water quality data are available for Mattie Canyon. However, ADEQ (Lawson, 2002) has indicated that the biggest problem here is sediment due to a headcut moving upstream.

Quitobaquito Spring

Quitobaquito Spring and pool make up a unique aquatic and riparian habitat in western Pima County, where there are few perennial water sources. The spring is located on the south side of the Quitobaquito Hills, just north of the international boundary. The water from Quitobaquito Spring is a sodium bicarbonate chloride type with dissolved solids concentrations that range from 662-783 mg/l. A pH of 8.1 and a fluoride concentration of 4.4 mg/l have also been measured (Carruth, 1996). A sample collected by Arizona Department of Water Resources in 1988 had a total dissolved solids (TDS) concentration of 671 mg/l, and average flow from the spring outlets in 1988 was 30 gallons per minute. (ADWR, 2001). The Quitobaquito pupfish, *C. macularius eremus,* is endemic to this area.

The spring and pond are located in the Organ Pipe National Monument and are very near a major road in Mexico and easily accessible. In fact, Quitobaquito Springs is a bus rest stop on Mexico Highway 2, for the route between Caborca and San Luis Rio Colorado, Mexico. Possible impacts to the waterbody would be degradation from dumping or spills of harmful substances. Another threat to the spring comes from agricultural spraying and groundwater pumping in Mexico. Aerial photography from 1995 shows a series of unimproved roads around the pond area.

Water quality data for Quitobaquito Spring and Pond are included in Appendix C.

Rincon Creek

Rincon Creek has intermittent stream flow for more than 11 miles through over 500 acres of hydro-mesoriparian habitat, a deciduous riparian forest, and a mesquite bosque; it is associated with shallow groundwater. Leopard frogs and one native fish species exist in the headwaters of the creek.

This stream begins on federal land and then travels through numerous private holdings that are slated for development. Possible impacts on the stream are from urbanization, septic tanks, recreation, and its accessibility to transportation corridors. Groundwater pumping for development might deplete the local aquifer, which would impact stream flow and local riparian communities.

No known water quality data are available for Rincon Creek.

Sabino Canyon (upper)

Sabino Canyon is a tributary of Tanque Verde Wash in the Santa Cruz River drainage. The creek was determined to have perennial flow for most of the upper portion (PAG, 2000a). The stream flows through more than 800 acres of hydro-mesoriparian habitat, a deciduous riparian forest, and a mesquite bosque; it is associated with shallow groundwater. Historically, three native fish species and leopard frogs have been found here. This stream may be a possible Gila topminnow reintroduction site.

Potential impacts to water quality could come from heavy recreational uses and the introduction of exotic aquatic species.

ADEQ sampled the water in Sabino Creek below Summerhaven for general water chemistry parameters. Recent monitoring of the reach above the east fork of the Sabino Canyon documented that a few isolated ponds had naturally occurring low dissolved oxygen. The reach from the headwaters to the Tanque Verde Creek was assessed by ADEQ and found to be in full support of its designated use. The results from samples collected by ADEQ are included in Appendix C.

Sabino Canyon (lower)

Lower Sabino Canyon, in the Sabino Canyon Recreation Area, has intermittent stream flow to near the confluence with Tanque Verde Creek (PAG, 2000a). A succession of large pools, which sustain populations of Gila chub, can be found year round in this reach.

This reach is accessible through the recreation area and is used heavily for recreation. Use impacts to this stream could be recreation, erosion and sedimentation, and the possibility of the release of harmful substances into the water. Another problem for lower Sabino Canyon is the presence of nonnative aquatic species that have a negative impact on the native aquatic species (AGFD, 1999). ADEQ has sampled this reach of Sabino Canyon, and the results are included in Appendix C.

San Pedro River

The San Pedro River in Pima County has perennial and intermittent stream flow (12 miles), through more than 2300 acres of hydro-mesoriparian habitat, a deciduous riparian forest, a mesquite bosque, and an area of shallow groundwater. Historically, 10 native fish species (one native fish species extant), leopard frogs, and pygmy owls have been found here.

The San Pedro River begins in the desert grasslands near Cananea in northern Sonora, Mexico. It then flows through Cochise, Pima and Pinal counties in Arizona and joins the Gila River. Water quality impacts from sewage discharges in Mexico can extend across the U.S. border during times of high flow (Lawson, 2002). Land ownership within one mile along the San Pedro River from the Arizona-Mexico border north to Redington, Arizona, is 41% private, 34% BLM, 24% State, and less than 1% United States Army. Since 1988, the BLM lands along the river from the international border to just below St. David, Arizona, have been designated as a Riparian National Conservation Area (Weedman, 1996).

Land uses in the watershed include mining, agriculture, grazing, logging, industry, residential and recreational. Some of the known uses that have the potential to impact water quality include groundwater withdrawals for agriculture, municipal uses and sewage effluent (Weedman, 1996). Also much of the river is accessible from transportation corridors, and accidental spills or dumping of hazardous substances could affect water quality.

The reach of the San Pedro River in Pima County flows through Redington and is easily reached from Redington Road. This reach is mostly on private land. The area is used for

ranching and recreation. Potential threats to the water quality include sediment, grazing, agricultural runoff, off-road vehicle use, septic systems, and the possibility of accidental or illegal dumping due to the close proximity of the road. Aerial photos from 1992 and topographic maps from 1994 show that many unimproved roads, trails, and an underground pipeline traverse the river.

Water quality data for the San Pedro River are included in Appendix C.

Santa Cruz River (mid/lower)

The Santa Cruz River has perennial and intermittent stream flow for more than 22 miles through 3500 acres of hydro-mesoriparian habitat, a deciduous riparian forest, and a mesquite bosque. This portion of the river is effluent dominated, receiving discharges from both the Roger Road WWTP and the Ina Road WPCF. As an effluent dependant reach, different state water quality standards apply than for the other priority streams in Pima County.

The Santa Cruz River flows through private, state, and federal lands. It is heavily developed and channelized through Nogales, Sonora, and Nogales, Arizona, and Tucson, Arizona. Sewage effluent enters the river from treatment facilities in Nogales and Tucson. The river is associated with a wide variety of land uses which include grazing, mining, urbanization, and groundwater pumping (Weedman, 1996). Native fish species, including Gila chub, desert sucker, Gila topminnow, desert pupfish, Sonoran sucker, and longfin dace were recorded in the Santa Cruz River near Tucson in the past. The last known records of fish in this part of the river were in 1943. Historically, leopard frogs have also been found here.

The effluent dependent reach of the Santa Cruz River downstream from the Nogales International Wastewater Treatment Plant supports native fish populations (longfin dace, desert sucker, Sonoran sucker, and Gila topminnow). Currently there are no native fish documented in the effluent dependent reach of the Santa Cruz River north of the two wastewater treatment plant outfalls in Pima County.

Land uses around the Santa Cruz River from Avra Valley Road to Trico Road include a major transportation corridor, Interstate 10 and the railroad, an active and a closed landfill, industrial area and agriculture. In addition, a number of facilities, both upstream and downstream from Tucson, have NPDES permits allowing discharges into the Santa Cruz River. Much of the river is also channelized and bank protected, and is crossed by numerous bridges. Future plans for this resource should take into consideration that other demands for this water, such as increased reuse, may decrease the amount available for additional proposed uses.

Water quality data are available for the effluent dependent reach of the Santa Cruz River below the Roger and Ina Road wastewater treatment plants. ADEQ, USGS, Pima County Wastewater Management Department, and others have monitored this river.

Many different studies have been done on the effluent dependent Santa Cruz River. Concentrations of periphytic chlorophyll- *a* were studied in the Santa Cruz River by the USGS. The results showed that chlorophyll-*a* concentrations from the effluent dependent waters were one to two orders of magnitude greater than at the non-effluent dependent comparison sites. These finding were consistent with other studies and demonstrate the water quality differences of the effluent-dependent waters as compared with water quality at control sites. The effluent dominated reaches showed fewer numbers of aquatic invertebrate species than the comparison sites. The species that were found were those that were more tolerant of waters with organic loading (Gebler, 1998). It is important to note that the comparison reported by Gebler (1998) was between streams that had entirely different sets of standards. The Santa Cruz is an effluent-dependent water, with its own set of standards, whereas the control site was a perennial warm water stream with stricter standards. The most recent data indicate that all of the Santa Cruz River standards are being met.

Water quality data for the Santa Cruz River are included in Appendix C.

Tanque Verde Creek (upper)

Tanque Verde Creek has greater than 17 miles of perennial and intermittent stream flow through more than 1000 acres of hydro-mesoriparian habitat, a deciduous riparian forest, and a mesquite bosque; it is associated with shallow groundwater. One native fish species and leopard frogs are known to be in this stream. The perennial reach of this stream, located at the Tanque Verde Falls and within the Coronado National Forest, is considered to be a priority for the USFS. This stream is easily accessible from the road that goes through Redington Pass and is a popular recreation area for off-road vehicle use, swimming, and hiking. Aerial photos show numerous trails and unimproved roads on both sides of the streambed. Potential impacts to this stream would be from recreational uses, dumping of hazardous substances and debris and sedimentation. ADEQ evaluated a reach of Tanque Verde Creek from Wentworth Road to Rillito Creek and found it to be in full compliance with its designated use.

PAG was not able to locate any water quality data specific to the upper Tanque Verde Creek. Water quality data from Tanque Verde Creek at Sabino Canyon Road are included in Appendix C.

Wakefield Canyon/ Nogales Spring

This stream has perennial and intermittent stream flow for nearly two miles and over 35 acres of Class A riparian habitat. The reach includes a series of springs, but no shallow groundwater information is available. This area contains leopard frogs and has potential for native fish establishment (Pima County, 2000a). The reaches are located in a corridor between the Whetstone Mountains and the Rincon Mountains. The perennial and intermittent portions of this stream are located on BLM and state owned land adjacent to national forest land. Review of a 1992 aerial photo showed unimproved roads and a stock tank in the vicinity of the perennial portion of Wakefield Canyon. Land uses that could impact this waterbody include grazing, off-road vehicles and recreation uses.

No known water quality data are available for Wakefield Canyon.

Priority Streams Water Quality Protection and Monitoring

The most effective water quality control plan starts with a watershed protection plan, and the primary purpose of the plan should be to prevent water quality degradation. In fact, state rules (R18-11-107) require that the level of water quality necessary to protect existing uses be maintained and protected. Furthermore, where the existing water quality of a surface water surpasses the applicable standard, the existing quality must be maintained and protected. Only under specific circumstances, and following specific procedures, will the state allow water quality degradation. Given this requirement, it is the responsibility of the government and all property owners involved to ensure the water quality is not compromised.

A comprehensive effort to ensure that the water quality of priority streams in Pima County is not degraded will likely involve three components: (1) land use planning to identify which future land uses (including potential pollutant dischargers) are appropriate near the streams; (2) minimization of impacts from existing and future land uses; and (3) regularly-scheduled monitoring to ensure that the quality of the streams is not degraded. Implementation of these components would involve landowners, land management agencies, regulatory agencies, and planners. Cooperation among different jurisdictions, private and public interests, and various stakeholders would be necessary.

Land Use Planning

The focus of land use planning for maintaining priority streams' water quality should be future point-source and nonpoint-source discharges of pollutants, which include sediment and erosion. Planning should encompass the entire watershed and look at current and potential future practices, with the goal of reducing sediment input and physical stream destruction. (Land use planning is also relevant with regard to protection of the *quantity* of flows in streams, but water resources issues are not addressed in this report.) Table 2 is a list of land uses that might be associated with potential point-source or nonpoint-source discharges of pollutants. Careful consideration should be given to land use plans involving one or more of these land uses being sited near a priority stream.

Table 2. Land Uses Affecting Surface Water. From: ADEQ Source Water Assessment Plan and EPA Management Measures for Urban Areas.

Land Use	Type of Contaminant
Landfills	biological, nitrite, nitrate
Septic Systems	biological, nitrite, nitrate, chemical
Wastewater Treatment Plants	biological, nitrite, nitrate
Reuse Irrigation	biological, nitrite, nitrate
Urban Runoff	biological, chemical, sediment
Construction Site Runoff	paints, metals, debris, soil erosion
Transportation corridors (roads)	oil, grease, runoff and dumping
Utility Roads	sediment
Railroads	chemical spills
Golf Courses	SOC
Industry (retail gasoline, dry cleaners)	VOC (via subsurface), spills
Mining Activities	sediment, metals
Agriculture	nitrite, nitrate, SOC, sediment
Grazing/feedlots	biological, nitrite, nitrate, soil erosion, sediment

Planning for future point-source discharges to streams is accomplished through the Pima Association of Governments Clean Water Act Section 208 Areawide Water Quality Management Plan. Under the Clean Water Act, the discharge of pollutants to surface waters is prohibited without a National Pollutant Discharge Elimination System (NPDES) permit, and a NPDES permit will not be issued for a point source that conflicts with the 208 Plan. Currently, the Santa Cruz River is the only priority stream to which point-source discharges are authorized by NPDES permits. No point-source discharges to priority streams other than the Santa Cruz River are included in the 208 Plan. Through the 208 Planning process, local governments can decide which, if any, point source discharges to priority streams should be allowed in the future.

Land use planning and zoning can provide additional tools to limit point-source discharges to priority streams. For example, an area zoned for industry would presumably be more likely to include point-source discharging facilities. By not planning industrial zones near priority streams, the County could limit the likelihood of future NPDES discharges to these streams without relying entirely on the 208 Planning process.

Planning for land uses that might contribute nonpoint source discharges to priority streams can be accomplished through the County's Comprehensive Land Use Plan and Sonoran Desert Conservation Plan, local cities' and towns' General Plans, and the planning efforts of land owners and land management agencies such as the National Forest Service, Bureau of Land Management, State Land Department, and National Park Service. The County should encourage the responsible entities, when developing long range plans, to consider limiting certain land uses and activities near priority streams if they are more likely to contribute to nonpoint source pollution, including excessive sediment inputs. In unincorporated areas available for urban and residential development, the County should determine what type of development is appropriate near priority streams. The effects of infrastructure development (or lack thereof) should also be considered. For example, developments with public sewers, paved roads, and water lines would not have certain impacts that would be associated with residential areas containing a proliferation of septic tanks and private wells. On the other hand, extensive, high-density development that could be spurred by public infrastructure construction could lead to other water quality concerns, such as increased recreational pressures on nearby streams, runoff from parking lots and streets, and increased pollutant loads from home and lawn chemicals.

Impact Minimization

Where potentially-polluting land uses exist, or are planned, in close proximity to priority streams, the impacts of these land uses on the streams' water quality should be minimized. This responsibility falls to regulatory agencies, land management agencies, property owners, permit holders, and lease holders. For discharges that are covered by individual water quality permits, regulatory agencies are responsible for ensuring that the permit holders meet the conditions of the permits, and that permit requirements are sufficient to ensure that water quality is protected. Although this responsibility primarily rests with ADEQ, Pima County has an opportunity to participate through the public review process when notified of ADEQ's intent to issue a permit. In addition, the County has specific authorities that the state has delegated, such as the issuance of permits for on-site waste disposal systems.

Discharges that are not covered by individual permits include discharges from many nonpoint sources. ADEQ has a nonpoint source discharge program whose mission, as stated on the ADEQ web site, is:

> "to preserve, protect, and enhance water quality and public health for the citizens of Arizona by minimizing the impact of pollution discharged to surface water and ground waters from nonpoint sources. The program addresses water pollution from irrigated agriculture, concentrated animal feeding operations, rangelands, agriculture, urban runoff, construction, mining (sand and gravel), and recreation activities. The nonpoint source program depends upon a combination of regulatory controls and cooperatively-based implementation, including use of extensive public outreach and education as well as community-based watershed advisory groups."

The County should have an opportunity to participate in many of this program's activities, including community-based watershed advisory groups addressing priority streams. In addition, the County can implement best manage practices to limit nonpoint source discharges from any lands or facilities it owns.

In developing plans to minimize impacts from land uses near priority streams, the County and the land management agencies it works with should pay particular attention to the quality of aquatic habitat and the potential problem of sediment. Although this report has focused to some extent on water quality data for constituents and parameters with existing numeric standards, such as dissolved oxygen, turbidity, and metals, sediment has been identified as a serious problem in Arizona (Lawson, 2002). In addition, ADEQ (2001b) has stated that the USEPA identifies sediment as the "single most widespread cause of impairment of the nation's rivers and streams, lakes, reservoirs, ponds and estuaries." ADEQ (2001b) notes numerous problems associated with sedimentation, including the filling of interstitial spaces in riffles and filling of rearing pools. Sediment transport in streams is influenced by many factors, and the processes leading to sediment problems are complex. Research on this topic is continuing, and the County should continue to support these efforts.

Monitoring

Any comprehensive effort to protect the water quality of priority streams in Pima County should include a water quality monitoring program for these streams. The monitoring plan should address: (1) where to sample; (2) when to sample; (3) what to sample for; (4) how to implement the program; and (5) data quality objectives (QA/QC). Ideally, given unlimited resources, all of the perennial and intermittent stream reaches in Pima County would be monitored on a seasonal basis every year, for all parameters for which standards have been set for the streams' designated uses. However, because resources for surface water quality monitoring are significantly limited, it is necessary to prioritize.

Because of the lack of water quality data and their priority status, PAG recommends that the following streams receive first priority for further investigation and water quality monitoring:

- Agua Verde Creek
- Davidson Canyon
- Empire Gulch
- Espiritu Canyon
- Florida Canyon
- Mattie Canyon
- Rincon Creek
- Wakefield Canyon

The remaining streams on the list of twenty priority streams should be next in importance, followed by the other perennial and intermittent streams in the County. Ephemeral streams would generally be the lowest priority, because of limited potential to support aquatic species.

At a minimum, each of the twenty priority streams should be sampled and evaluated at least once to determine if they have the water quality and habitat potential to support native aquatic species. It is unlikely that resources will be available to monitor all twenty streams seasonally every year. However, it might be possible to monitor the streams frequently enough to meet ADEQ's definition of "monitored" assessments, which according to the 305(b) Water Quality Assessment report (ADEQ, 2000) are based on data less than five years old, and at least four monitoring events within a year.

Little is known about the water quality requirements of specific native aquatic species (PAG, 2001), therefore the monitoring at each stream should include all of the parameters and constituents for which a surface water quality standard applies to that stream, as well as physical parameters, sediment loading and habitat evaluation. If this is not possible, we recommend that, at a minimum, the following field parameters, in addition to aquatic habitat evaluations, be included in the monitoring program for all streams:

- temperature
- pH
- dissolved oxygen
- electrical conductivity

Where warranted by land uses in the watershed, monitoring for sediment, nutrients, trace metals and pesticides would also be a priority, because these are among the most common stressors in Arizona lakes and streams. Bioassessments could supplement or replace the monitoring of field parameters and chemical constituents in some cases. In order to implement the monitoring program, we recommend the following steps:

- Work with ADEQ to identify which priority streams could be included in its ongoing surface water quality monitoring program.

- Work with other entities, including Arizona Game and Fish, the University of Arizona, U. S. Forest Service, National Park Service, Bureau of Land Management, and the U. S. Geological Survey, to discuss any plans they might have for research or monitoring projects that might include priority streams; identify possible cooperative research projects that could involve water quality monitoring at these streams.

- Determine which priority streams are accessible, as far as terrain, vehicular access, and landowner permission to sample.

- Identify and pursue potential funding sources for water quality and stream ecosystem monitoring.

- Continue to support monitoring of priority streams within County-owned lands.

- If necessary, expand the existing County-supported monitoring program to include any priority streams that will not be monitored by other entities.

Summary and Conclusions

Available water quality data for the high priority streams in Pima County indicate that the overall water quality is good. Of the twenty high priority streams identified in Pima County, twelve are included in the ADEQ 305 (b) Report 2000. Out of these twelve, eleven are in full support of their designated uses. The Santa Cruz River from Canada del Oro to Guild Wash was listed as not in full support of its designated use due to past low dissolved oxygen (DO) readings. However, recent DO data from Pima County Wastewater Management Department indicate that DO levels are currently at levels that would warrant a full support designation. The State will reassess the use support designation in its next 305(b) report.

ADEQ indicates in the 305(b) report that more assessment information is needed for Agua Caliente. In addition, no water quality data are currently available for the following streams: Agua Verde Creek, Davidson Canyon, Rincon Creek, Empire Gulch, Espiritu Canyon, Florida Canyon, Mattie Canyon, the upper Tanque Verde, and Wakefield Canyon. PAG recommends that the following waterbodies receive first priority for further investigation and monitoring:

- Agua Verde Creek
- Davidson Canyon
- Empire Gulch
- Florida Canyon
- Mattie Canyon
- Rincon Creek
- Wakefield Canyon

Most of the priority waterbodies are located at least partly within protected lands, such as National Forests, National Parks, or County preserves, and are therefore fairly unlikely to experience significant degradation. However, Agua Verde Creek, Rincon Creek, the San Pedro River, and Davidson Canyon could be somewhat more prone to degradation than the other priority waterbodies in the future, due to current land uses or land uses likely to occur in the future. In addition, most (if not all) of the waterbodies are located in areas with one or more land uses that present some degree of risk to water quality, including dirt roads, off road vehicle use, other recreational activities, and grazing. These and other land uses can contribute to adverse sediment effects and other water quality problems in streams.

A comprehensive effort to ensure that the water quality of priority streams in Pima County is not degraded will likely involve three components: (1) land use planning to identify which future land uses (including potential pollutant dischargers) are appropriate near the streams; (2) minimization of impacts from existing and future land uses; and (3) regularly-scheduled monitoring to ensure that the water quality and habitat of the streams is not degraded. Implementation of these components would involve landowners, land management agencies, regulatory agencies, and planners. Cooperation among different jurisdictions, private and public interests, and various stakeholders would be necessary.

The County also might want to pursue nominating additional perennial streams for Unique Water status. This status provides stringent protection against water quality degradation. The State can classify a surface water as unique if it finds the nominated body is an outstanding state resource water, based on the following criteria:

- perennial water;
- free-flowing condition;
- good water quality;
- meets one or both of the following conditions: is of exceptional recreational or ecological significance, or threatened or endangered species are known to be associated with the surface water and the existing water quality is necessary to maintain the species.

Many of the priority streams appear to meet these criteria.

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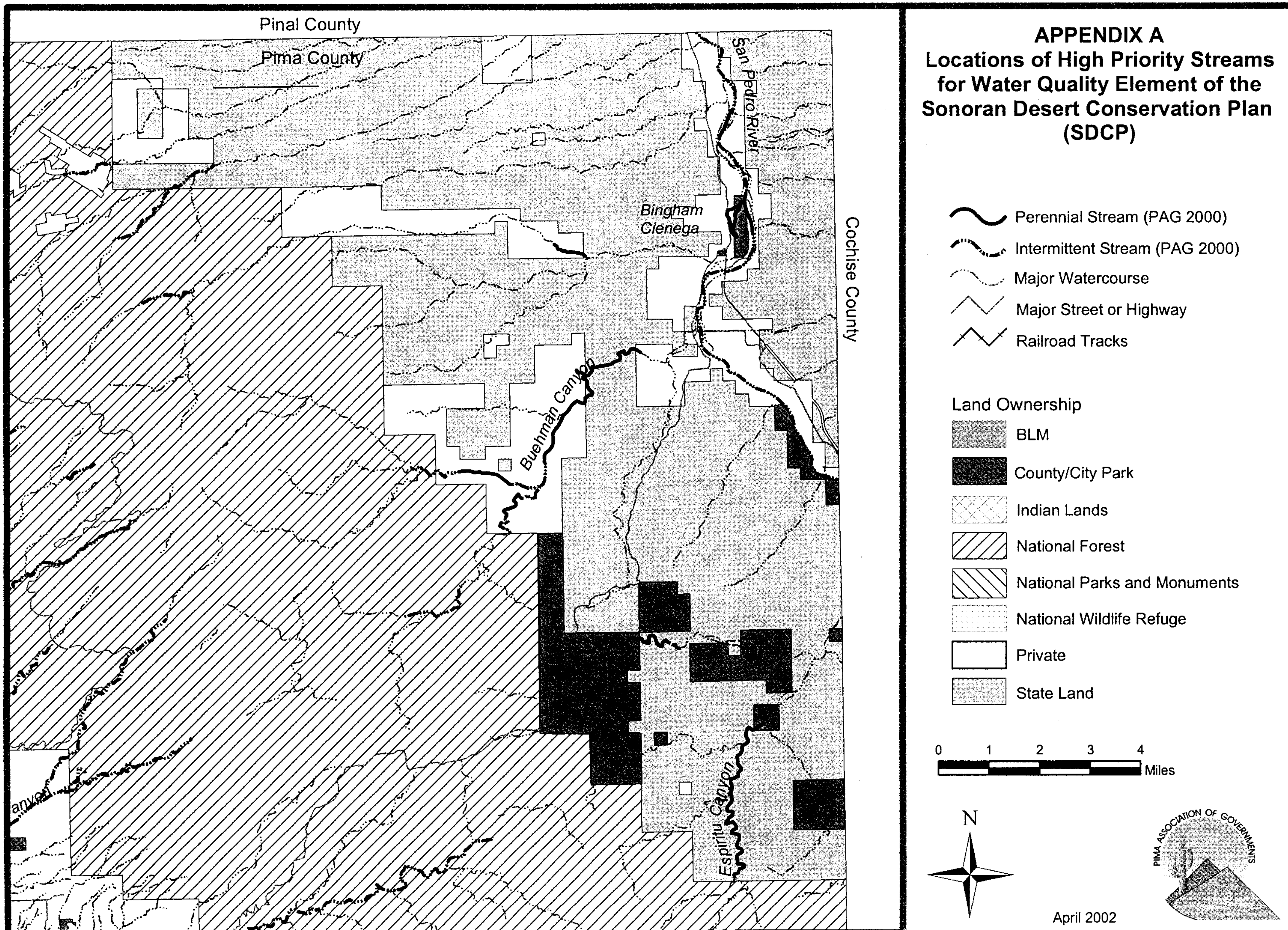
Appendix A

Priority Streams Land Ownership

APPENDIX A
Locations of High Priority Streams for Water Quality Element of the Sonoran Desert Conservation Plan (SDCP)



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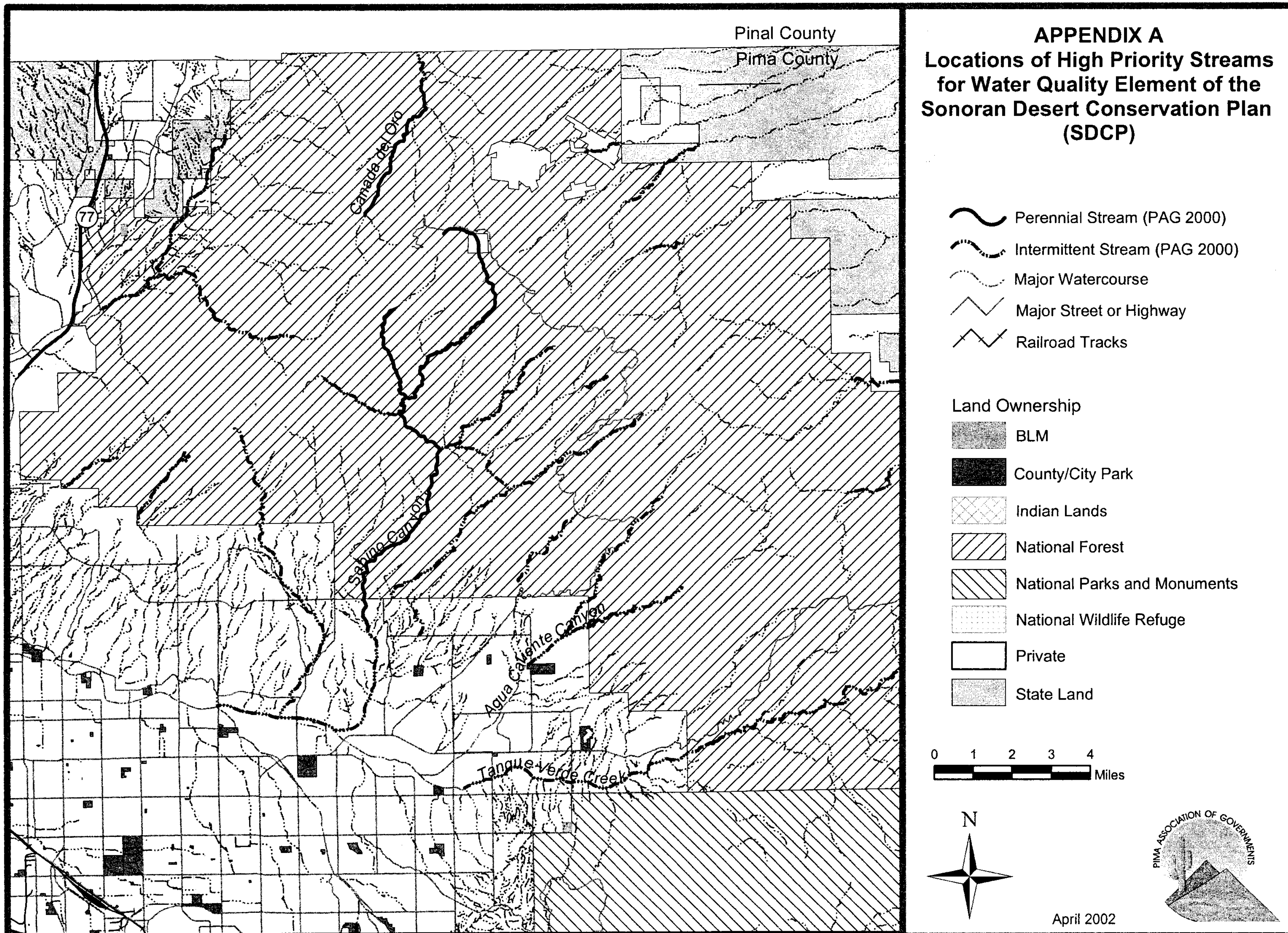

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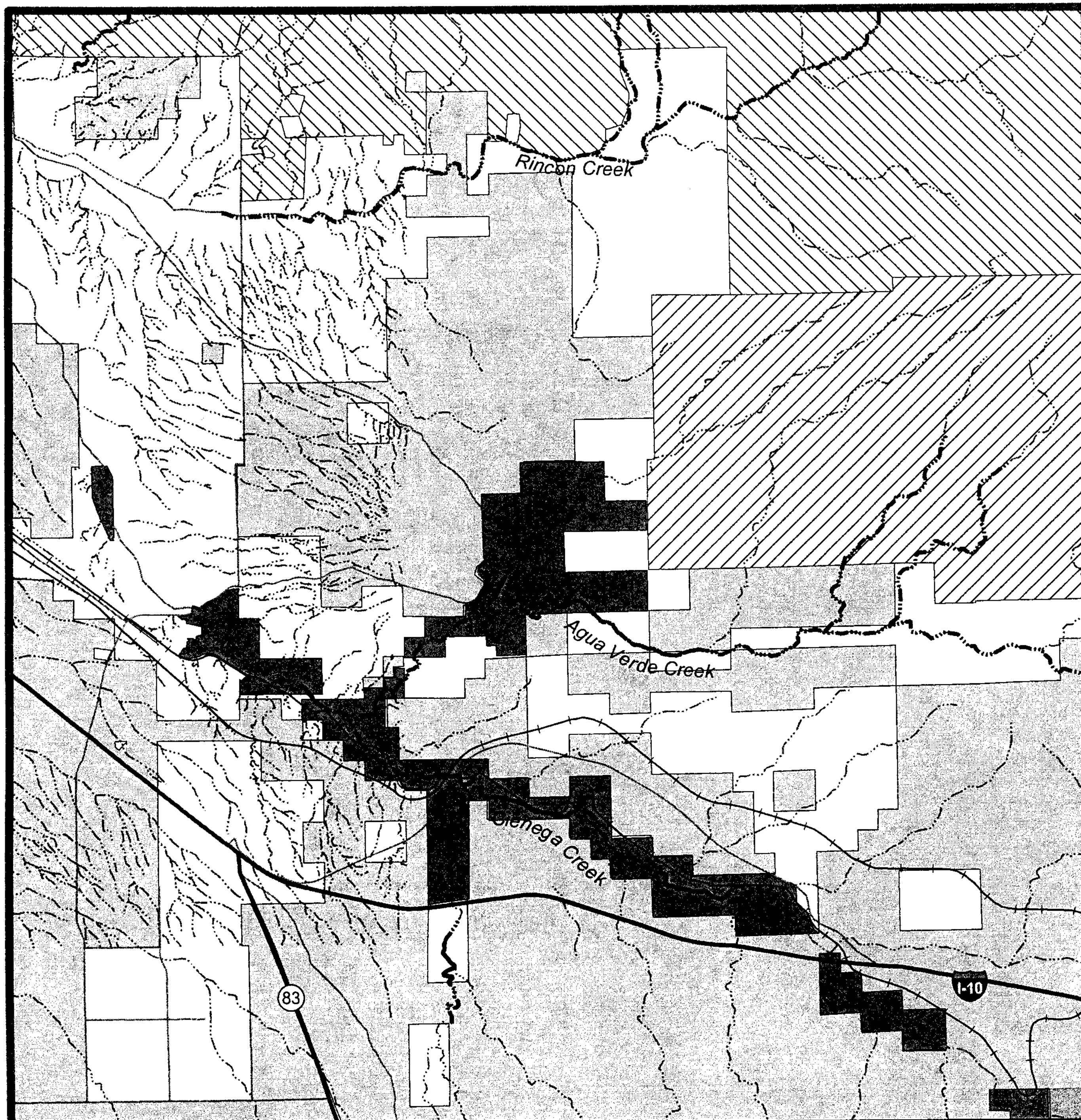

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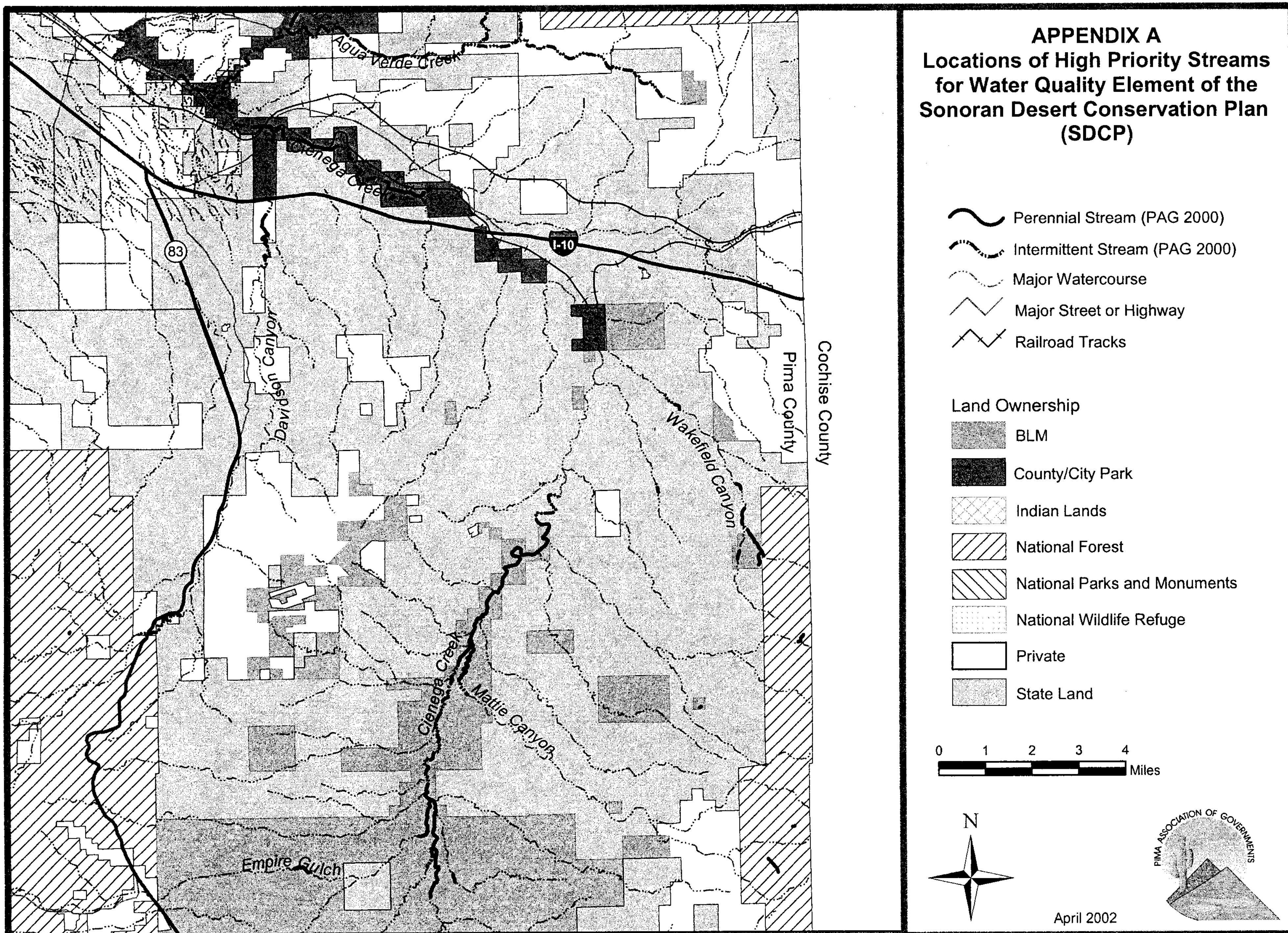

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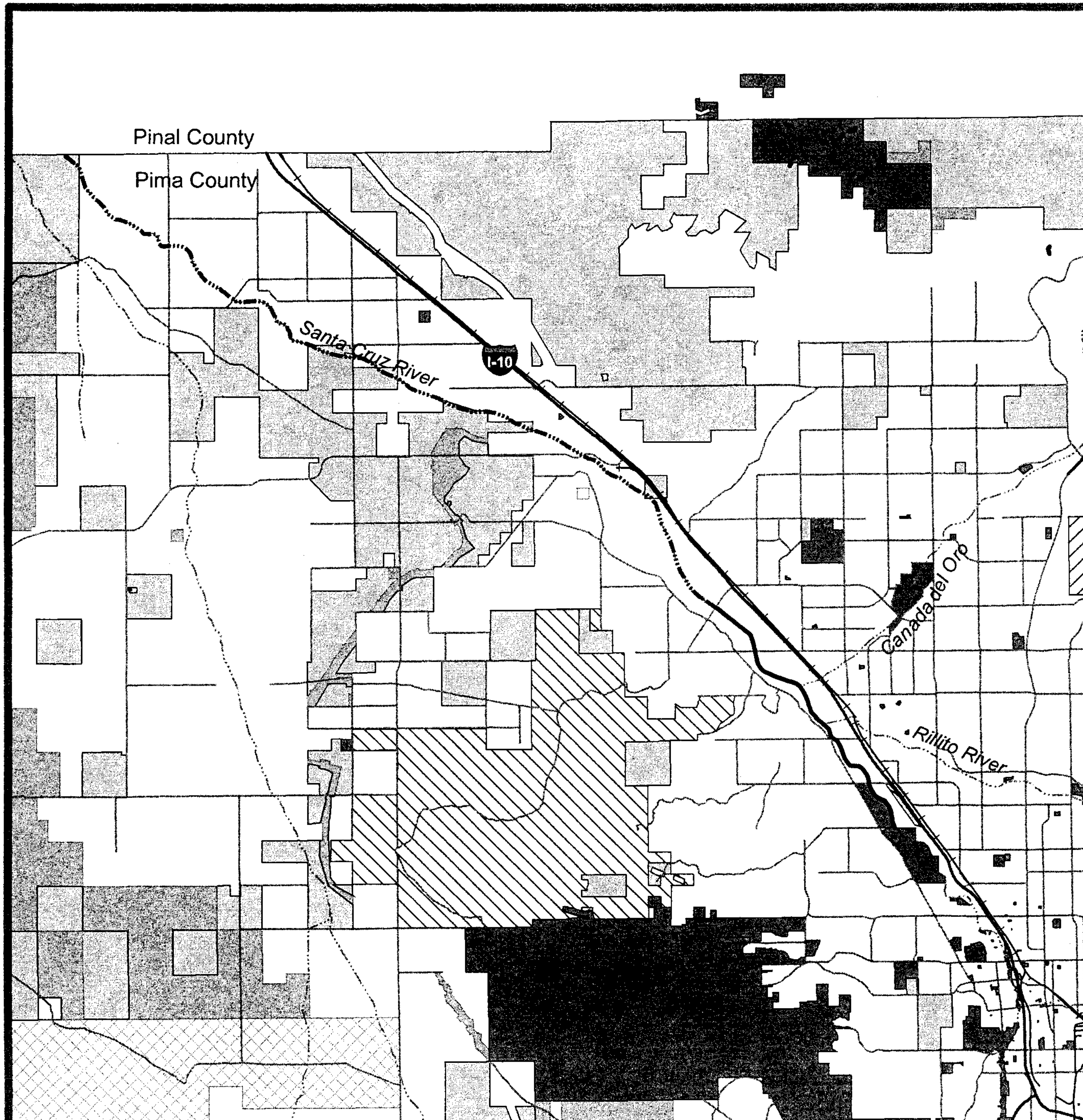

Perennial Stream (PAG 2000)
Intermittent Stream (PAG 2000)
Major Watercourse
Major Street or Highway
Railroad Tracks

Land Ownership
BLM
County/City Park
American Indian Nation
National Forest
National Parks and Monuments
National Wildlife Refuge
Private
State Land

0 1 2 3 4 Miles

N

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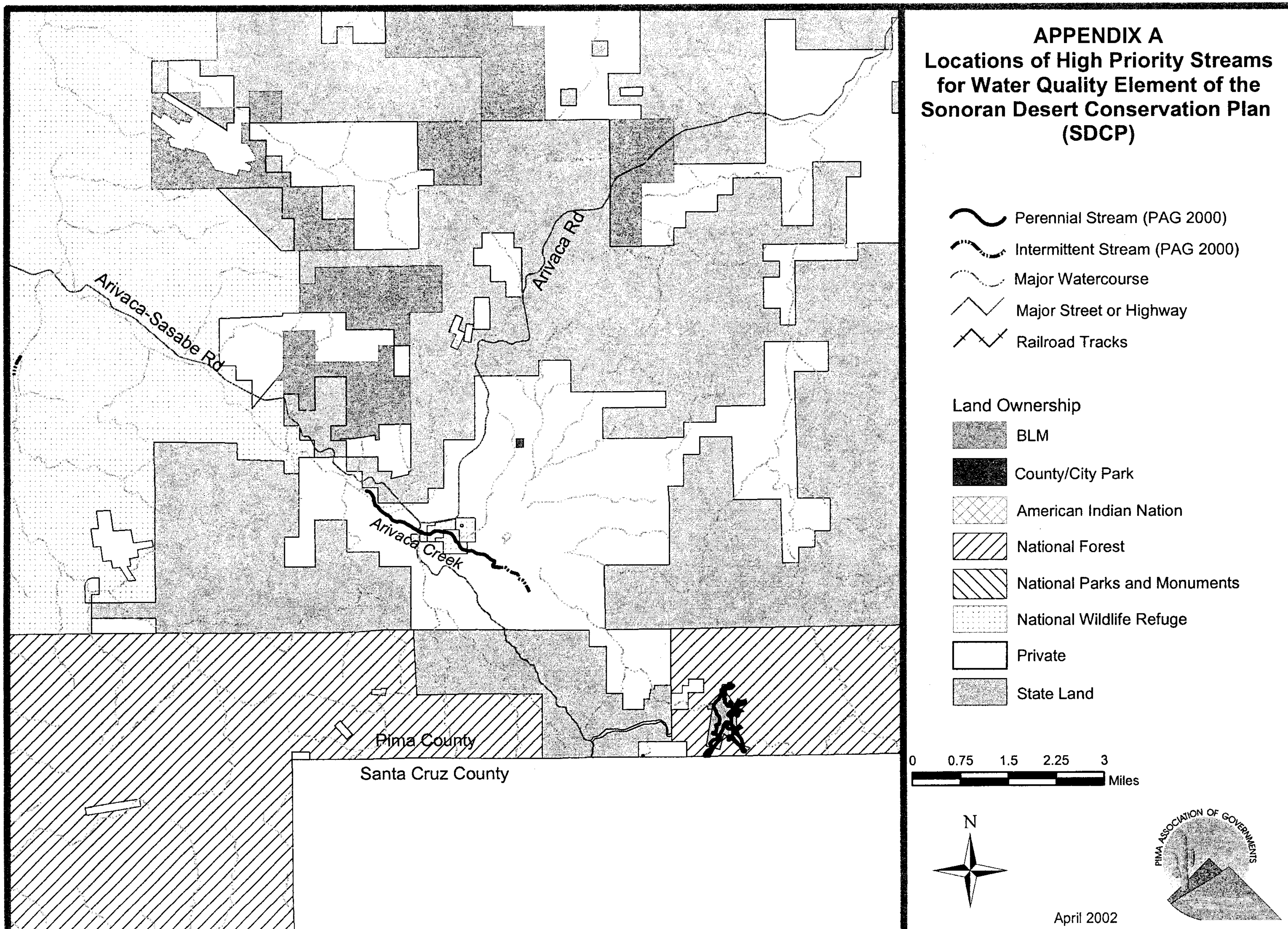

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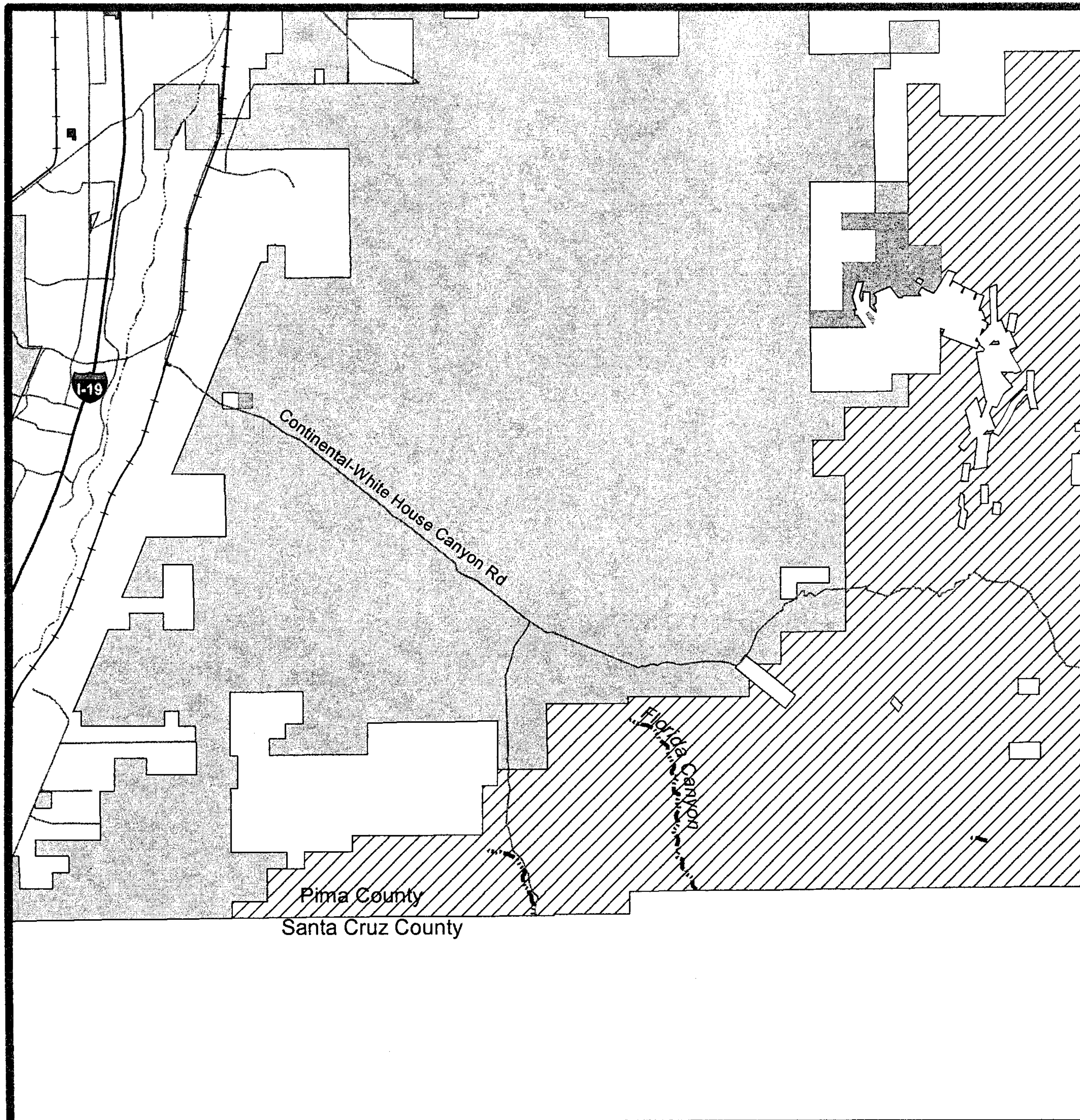

Perennial Stream (PAG 2000)
Intermittent Stream (PAG 2000)
Major Watercourse
Major Street or Highway
Railroad Tracks

Land Ownership
BLM
County/City Park
American Indian Nation
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National Parks and Monuments
National Wildlife Refuge
Private
State Land

0 1 2 3 4 Miles

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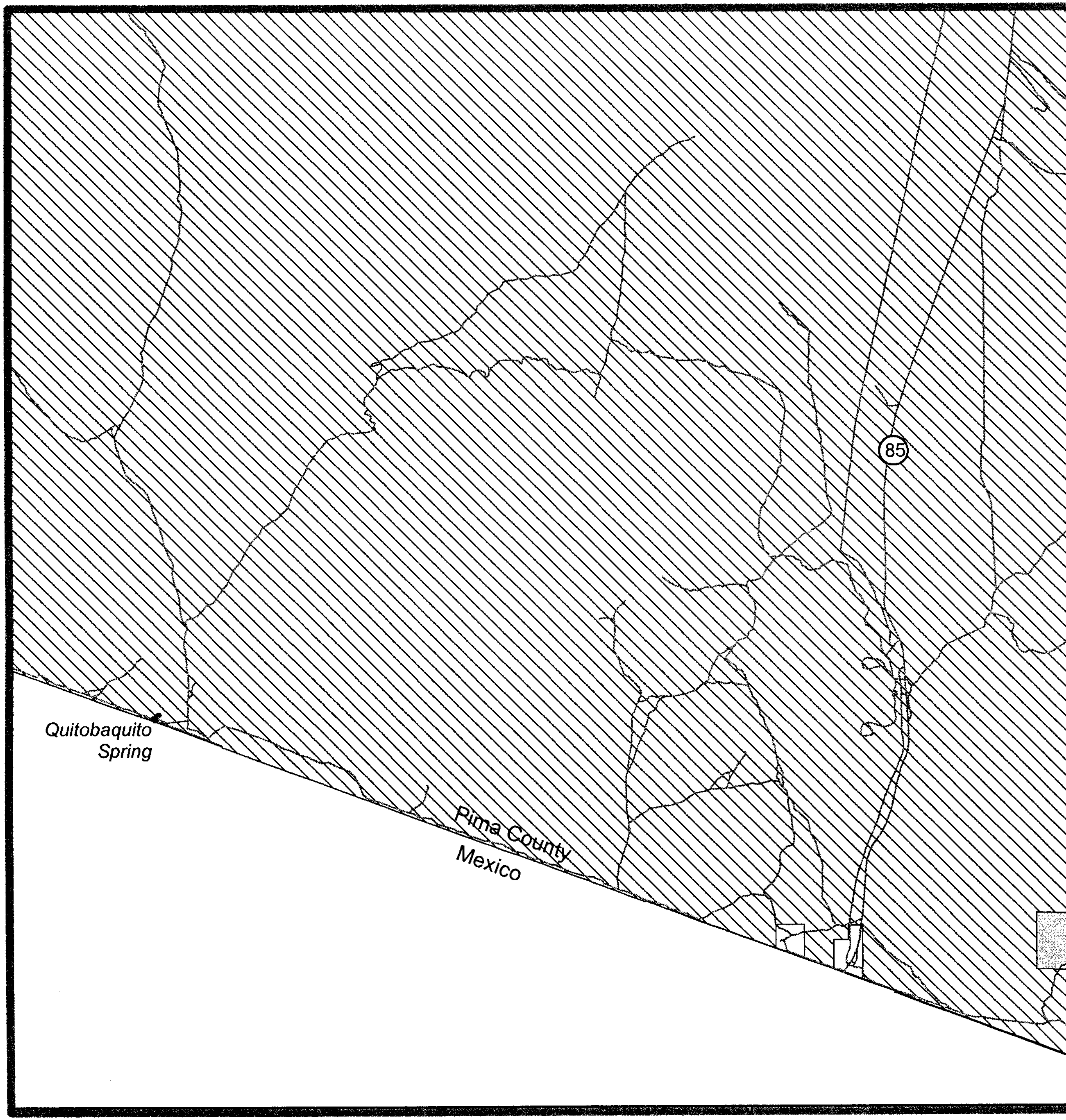

Perennial Stream (PAG 2000)
Intermittent Stream (PAG 2000)
Major Watercourse
Major Street or Highway
Railroad Tracks

Land Ownership
BLM
County/City Park
American Indian Nation
National Forest
National Parks and Monuments
National Wildlife Refuge
Private
State Land

0 1 2 3 4 Miles

N

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Appendix B

Numeric Water Quality Standards
From ADEQ
The Status of Water Quality in Arizona
Clean Water Act Section 305 (b)
Report 2000

APPENDIX B. NUMERIC STANDARDS AND OTHER CRITERIA

Arizona Surface Water Numeric Standards and Other Criteria

PARAMETER	DESIGNATED USE(S)	STANDARD OR ASSESSMENT CRITERIA	CHRONIC STANDARDS
Aluminum (Al)	DWS (SMCL)	50-200 µg/l	
Ammonia (NH3)	A&Wc/A&Ww	Standard varies by temperature and pH., see equations in standards.	
Antimony (dissolved) (Sb)	A&Wc/A&Ww A&Wedw	88 µg/l 1,000 µg/l	30 µg/l 600 µg/l
Antimony (total) (Sb)	DWS FBC/PBC FC	6 µg/l 56 µg/l 140 µg/l	NA
Arsenic (dissolved) (As)	A&Wc/A&Ww/A&Wedw A&We	360 µg/l 440 µg/l	190 µg/l 230 µg/l
Arsenic (total) (As)	DWS/FBC/PBC AGL FC AGI Peeple's Canyon Creek (Unique Waters)	50 µg/l 200 µg/l 1450 µg/l 2,000 µg/l 20 µg/l	NA
Barium (dissolved) (Ba)	FBC/PBC	9,800 µg/l	NA
Barium (total) (Ba)	DWS	2,000 µg/l	
Beryllium (dissolved) (Be)	A&Wc/A&Ww/A&Wedw	65 µg/l	5.3 µg/l
Beryllium (total) (Be)	FC DWS/ FBC PBC	0.21 µg/l 4 µg/l 700 µg/l	NA NA NA
Boron (total) (B)	DWS AGI FBC/PBC	630 µg/l 1,000 µg/l 12,600 µg/l	NA
Cadmium (total) (Cd)	DWS FC AgI/AgL FBC/PBC	5 µg/l 41 µg/l 50 µg/l 70 µg/l	NA
Cadmium (dissolved) (Cd)	A&W	Standard varies by water hardness*, see published standards.	
Chloride (Cl)	DWS	250 mg/l (SMCL)	NA
Chlorine (total residual) (Cl)	A&Wc/A&Ww/A&Wedw FBC/PBC	11 mg/l 14mg/l	5 mg/l
Chromium (total) (Cr)	DWS AgI/AgL	100 µg/l 1,000 µg/l	NA

From: The Status of Water Quality in Arizona Clean Water Act Section 305 (b) Report 2000

Arizona Surface Water Numeric Standards and Other Criteria

PARAMETER	DESIGNATED USE(S)	STANDARD OR ASSESSMENT CRITERIA	CHRONIC STANDARDS
Chromium III (total) (Cr III)	FC FBC/PBC	67,000 µg/l 140,000 µg/l	NA
Chromium (dissolved) (Cr)	Unique Waters standards for: West Fork Little Colorado River, above Government Springs Oak Creek and West Fork Oak Creek	10 µg/l 5 µg/l	
Chromium III (dissolved) (Cr)	A&Ww/A&Wc/A&We/A&Wedw	Standard varies by water hardness*, see published standards.	
Chromium VI (total) (Cr VI)	FBC/PBC FC	700 µg/l 3,400 µg/l	NA
Chromium VI (dissolved) (Cr VI)	A&Wc/A&Ww/A&Wedw/ A&We	16 µg/l 34 µg/l	11 µg/l 23 µg/l
Copper (dissolved) (Cu)	A&Ww/A&Wc/A&We/A&Wedw	Standard varies by water hardness, see published standards.	
	DWS PBC/FBC	1,000 µg/l 5,200 µg/l	NA
Copper (total) (Cu)	AgL AgI	500 µg/l 5,000 µg/l	NA
Cyanide (total) (Cn)	A&Wc A&Ww/A&Wedw A&We AgL, DWS FBC/PBC FC	22 µg/l 41 µg/l 84 µg/l 200 µg/l 2,800 µg/l 210,000 µg/l	5.2 µg/l 9.7 µg/l 19 µg/l
Dissolved Oxygen (DO)	A&Ww A&Wc A&Wedw	>6.0 mg/l >7.0 mg/l >3.0 mg/l Applies to 3 hours after sunrise to sunset >1.0 mg/l Applies to 3 hours after sunrise	
	West Fork Little Colorado (Unique Waters) Peoples Canyon Creek (Unique Waters) Cienega Creek (Unique Waters) Bonita Creek (Unique Waters)	no decrease due to discharge	
Escherichia coli	FBC	30-day geometric mean (5 sample minimum) single sample maximum	130 CFU/100ml 580 CFU/100ml
Fecal Coliform	A&Wedw	30-day geometric mean (5 sample minimum) 10% samples for a 30-day period single sample maximum	200 CFU/100 ml 400 CFU/100 ml 800 CFU/100 ml

From: The Status of Water Quality in Arizona Clean Water Act Section 305 (b) Report 2000

Arizona Surface Water Numeric Standards and Other Criteria

PARAMETER	DESIGNATED USE(S)	STANDARD OR ASSESSMENT CRITERIA	CHRONIC STANDARDS
	A&Ww/A&Wc/A&We/A&Wedw/DWS/PBC/AgI/AgL	30-day geometric mean (5 sample minimum) 10% samples for a 30-day period single sample maximum	1,000 CFU/100 ml 2,000 CFU/100 ml 4,000 CFU/100 ml
Fluoride (F)	DWS DWS (SMCL) FBC/PBC	4 mg/l 2 mg/l 8.4 mg/l	NA
Lead (dissolved) (Pb)	A&Ww/A&Wc/A&We/A&Wedw	Standard varies by water hardness, see published standards*.	
Lead (total) (Pb)	DWS AgL AgI	50 µg/l 100 µg/l 10,000 µg/l	NA
Manganese (total) (Mn)	DWS AgI FBC/PBC Unique Waters standards for: People's Canyon Creek, Burro Creek, and Francis Creek	4,900 µg/l 10,000 µg/l 19,600 µg/l 500 µg/l	NA
Mercury (dissolved) (Hg)	A&Wc/A&Ww A&Wedw A&We	2.4 µg/l 2.6 µg/l 5.0 µg/l	0.01 µg/l 0.2 µg/l 2.7 µg/l
Mercury (total) (Hg)	FC DWS AgL FBC/PBC	0.6 µg/l 2 µg/l 10 µg/l 42 µg/l	NA
Nickel (dissolved) (Ni)	A&W	Standard varies by water hardness, see published standards*.	
Nickel (total) (Ni)	DWS FC FBC/PBC	100 µg/l 730 µg/l 2,800 µg/l	140 µg/l 400 µg/l
Nitrate (as N) (NO3)	DWS mean value San Pedro (Curtiss-Benson) FBC/PBC	10 mg/l 10 mg/l 224 mg/l	NA
Nitrite (as N) (NO2)	DWS FBC/PBC	1 mg/l 14 mg/l	NA
Nitrogen (total) (N)	See nutrient chart below		
Nitrate/Nitrite (as Total Nitrogen)	DWS	10 mg/l	

From: The Status of Water Quality in Arizona Clean Water Act Section 305 (b) Report 2000

Arizona Surface Water Numeric Standards and Other Criteria

PARAMETER	DESIGNATED USE(S)	STANDARD OR ASSESSMENT CRITERIA	CHRONIC STANDARDS
pH	A&W/FBC/PBC DWS AgI Unique Water standards for: Bonita Creek, Cienega Creek, West Fork Little Colorado, Oak Creek, and West Fork Oak Creek	6.5 - 9.0 OR Maximum change due to discharge 0.5 5.0 - 9.0 4.5 - 9.0 no change due to discharge	
Phosphorus (total) (P)	See nutrient chart below		
Selenium (total) (Se)	A&Ww/A&Wc/AgI A&We A&Wedw/AgL/DWS FBC/PBC FC	20 µg/l 33 µg/l 50 µg/l 700 µg/l 9,000 µg/l	2 µg/l NA 2 µg/l 2 µg/l NA
Silver (total) (Ag)	DWS (SMCL)	100 µg/l	NA
Silver (dissolved) (Ag)	A&Ww/A&Wc/A&We/A&Wedw	Standard varies by water hardness, see published standards*.	
Sulfides (S2)	A&W	0.1 mg/l	NA
Sulfate (SO4)	DWS	250 mg/l (SMCL)	NA
Temperature (maximum increase due to discharge)	A&Wc A&Ww/A&Wedw Unique Water standards for: Bonita Creek, Cienega Creek, West Fork Little Colorado, and People's Canyon	1.0 ° C 3.0 ° C no increase due to discharge	NA
Thallium (total) (Tl)	DWS FBC/PBC FC	2 µg/l 41 µg/l 12 µg/l	NA
Thallium (dissolved) (Tl)	A&Wc/A&Ww/A&Wedw	700 µg/l	150 µg/l
Total Dissolved Solids (TDS)	DWS mg/l (SMCL) AgI (EPA criteria -- more sensative crops) AgI (EPA criteria -- less sensative crops)	500 mg/l 1000 mg/l 2000 mg/l	NA
	Unique Water standards for: West Fork Little Colorado River, Bonita Creek, & Cienega Creek	no increase due to discharge	NA
	Colorado River: below Hoover Dam below Parker Dam at Imperial Dam	NA	(flow-weighted average annual) 723 mg/l 747 mg/l 879 mg/l

From: The Status of Water Quality in Arizona Clean Water Act Section 305 (b) Report 2000

Arizona Surface Water Numeric Standards and Other Criteria

PARAMETER	DESIGNATED USE(S)	STANDARD OR ASSESSMENT CRITERIA	CHRONIC STANDARDS
Turbidity (NTU)	A&Wc (streams & lakes) A&Wedw, A&Ww (lakes only) A&Ww, A&Wedw (streams only) Oak Creek (Unique Waters) Peoples Canyon Creek (Unique Waters) Cienega Creek (Unique Waters) Bonita Creek (Unique Waters)	10 NTU 25 NTU 50 NTU 3 NTU change due to discharge 5 NTU change due to discharge 10 NTU 15 NTU	NA
Uranium (dissolved) (Ur)	DWS	35 µg/l	NA
Zinc (total) (Zn)	DWS AgI FC AgL FBC/PBC	2,100 µg/l 10,000 µg/l 22,000 µg/l 25,000 µg/l 42,000 µg/l	NA
Zinc (dissolved) (Zn)	A&Ww/A&Wc/A&We/A&Wedw	Standard varies by water hardness*, see published standards.	

*Standard is calculated using equations published with the surface water standards (e.g., copper A&Wc acute standard: $e^{(0.9422\,[\ln(\text{hardness})]-1.464)}$. In these equations, hardness (expressed as $CaCO_3$) does not exceed 400 mg/L.

RADIOCHEMICAL STANDARDS		
Radiochemical	Designated Use	Standard (mean value)
Gross Alpha (excluding radon and uranium)	DWS	15 pCi/l
Radium-226 + Radium-228	DWS	5 pCi/l
Strontium 90	DWS	8 pCi/l
Tritium	DWS	20,000 pCi/l

NUTRIENT STANDARDS			
WATERSHED OR SITE SPECIFIC LOCATION	Annual Mean	90th Percentile	Single Sample Max
Verde River and tributaries -- above Bartlett Lake	P 0.10 mg/l N 1.00 mg/l	P 0.30 mg/l N 1.50 mg/l	P 1.00 mg/l N 3.00 mg/l

Appendix C

Water Quality Data

Appendix C

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Appendix C. Water Quality Data

Agua Caliente Water Quality Data, sample collected above the National Forest Service Boundary. From ADEQ.

PARAMETER	SAMPLE DATE	RESULT	UNITS	DATA CODE	REPORTING LIMIT
Temperature, Water	4/13/95	14.9	° C		
Specific Conductance, Field	4/13/95	136	umhos/cm		
Specific Conductance	4/13/95	140	umhos/cm		
Oxygen, Dissolved	4/13/95	9.3	mg/l		
Oxygen Dissolved	4/13/95	92	Percent		
pH, Field	4/13/95	7.28	SU		
Alkalinity, Total (mg/l as CaCO3)	4/13/95	36	mg/l		
Alkalinity, Phenolphthalein	4/13/95		mg/l	ND	2.0
Bicarbonate Ion (mg/l as HCO3)	4/13/95	44	mg/l		
Carbonate Ion (mg/l AS CO3)	4/13/95		mg/l	ND	2.0
Residue, Total, Nonfiltrable	4/13/95		mg/l	ND	4.0
Nitrogen, Ammonia, Total (mg/l as N)	4/13/95	0.09	mg/l		
Nitrogen, Kjeldahl, Total (mg/l as N)	4/13/95	0.49	mg/l		
Nitrite + Nitrate, Total (mg/l as N)	4/13/95		mg/l	ND	0.01
Phosphorous, Total (mg/l as P)	4/13/95	0.046	mg/l		
Calcium, Total (mg/l as CA)	4/13/95	10.2	mg/l		
Magnesium, Total (mg/l as MG)	4/13/95	2.9	mg/l		
Sodium, Total (mg/l as NA)	4/13/95	13.7	mg/l		
Potassium, Total (mg/l as K)	4/13/95	1.26	mg/l		
Chloride, Total in Water	4/13/95	5.3	mg/l		
Sulfate, Total (mg/l as SO4)	4/13/95	20.2	mg/l		
Arsenic, Dissolved (ug/l as AS)	4/13/95		ug/l	ND	10
Copper, Dissolved (ug/l as CU)	4/13/95		ug/l	ND	10
Iron, Dissolved (ug/l as FE)	4/13/95		mg/l	ND	0.1
Solids, Total Dissolved	4/13/95	87	mg/l		
Residue, Total, Filtrable (Dried at180C)	4/13/95	108	mg/l		
Mercury, Dissolved (ug/l as HG)	4/13/95		ug/l	ND	.5
Turbidity, Field	4/13/95	1.8	NTU		

ND= not detected

Arivaca Creek at Headwater Spring. Data from ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS
Boron (Boron And Borates Only)	Total	11/5/92	--	19	ug/l
Lead And Compounds (Inorganic)	Total	11/5/92	--	29	ug/l
Specific Conductivity	Standard	11/5/92	--	372	umhos/cm
Specific Conductivity	Standard	11/5/92	--	375	umhos/cm
Total Dissolved Solids	Dissolved	11/5/92	--	238	mg/l
Total Suspended Solids	Suspended	11/5/92	K	4.0	mg/l
Dissolved Oxygen	Standard	11/5/92	--	60.6	percent
Beryllium And Compounds	Total	11/5/92	K	0.1	ug/l
Dissolved Oxygen	Dissolved	11/5/92	--	5.20	mg/l
Fecal Streptococci	Total	11/5/92	--	240	cfu/100
Selenium And Compounds	Total	11/5/92	K	5	ug/l
Barium And Compounds	Total	11/5/92	--	27	ug/l
Ammonia As Nitrogen	Total	11/5/92	K	0.2	mg/l
Nitrate + Nitrite	Total	11/5/92	--	1.26	mg/l
Kjeldahl Nitrogen	Total	11/5/92	--	0.2	mg/l
Mercury, Elemental	Total	11/5/92	K	0.2	ug/l
Calcium Carbonate	Total	11/5/92	--	173	mg/l
Temperature	Air	11/5/92	--	15.5	° C
Arsenic, Inorganic	Total	11/5/92	K	5	ug/l
Fecal Coliform	Total	11/5/92	--	6	cfu/100
Temperature	Water	11/5/92	--	16.5	° C
Phosphorus	Total	11/5/92	--	0.056	mg/l
Bicarbonate	Total	11/5/92	--	207	mg/l
Potassium	Total	11/5/92	--	2.09	mg/l
Magnesium	Total	11/5/92	--	6.72	mg/l
Fluoride	Total	11/5/92	--	0.20	mg/l
Turbidity	Total	11/5/92	--	0.60	NTU
Turbidity	Total	11/5/92	--	1.15	NTU
Chloride	Total	11/5/92	--	6.86	mg/l
Strontium	Total	11/5/92	--	203	ug/l
Nitrate	Total	11/5/92	--	1.26	mg/l
Hydroxide	Total	11/5/92	K	4.0	mg/l
Manganese	Total	11/5/92	--	10	ug/l
Sulfate	Total	11/5/92	--	14.0	mg/l
Calcium	Total	11/5/92	--	58.1	mg/l
Sodium	Total	11/5/92	--	13.1	mg/l
Cadmium	Total	11/5/92	K	0.7	ug/l
Carbonate	Total	11/5/92	K	4	mg/l
Antimony	Total	11/5/92	K	60	ug/l
Thallium	Total	11/5/92	K	60	ug/l
Chromium	Total	11/5/92	K	3	ug/l
Flow	Total	11/5/92	--	0.5	CFS
Silver	Total	11/5/92	K	1	ug/l
Copper	Total	11/5/92	K	4	ug/l
Nickel	Total	11/5/92	K	4	ug/l
Zinc	Total	11/5/92	--	14	ug/l

Arivaca Creek at Headwater Spring. Data from ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS
Iron	Total	11/5/92	--	40	ug/l
pH	Total	11/5/92	--	7.04	SU
pH	Total	11/5/92	--	7.1	SU

K= Actual value is known to be less than the value given, method detection limit listed in result column.

Arivaca Creek at Figueroa Spring. Data from ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS
Lead And Compounds (Inorganic)	Dissolved	5/10/93	U	10	ug/l
Boron (Boron And Borates Only)	Total	5/10/93	U	100	ug/l
Lead And Compounds (Inorganic)	Total	5/10/93	U	10	ug/l
Specific Conductivity	Standard	5/10/93	--	365	umhos/cm
Specific Conductivity	Standard	5/10/93	--	384	umhos/cm
Beryllium And Compounds	Dissolved	5/10/93	U	0.5	ug/l
Total Dissolved Solids	Dissolved	5/10/93	--	240	mg/l
Alkalinity, Phenolphthalein	Total	5/10/93	U	2	mg/l
Total Suspended Solids	Suspended	5/10/93	--	7	mg/l
Dissolved Oxygen	Standard	5/10/93	--	109.0	percent
Barium And Compounds	Dissolved	5/10/93	--	120	ug/l
Selenium And Compounds	Dissolved	5/10/93	U	5	ug/l
Beryllium And Compounds	Total	5/10/93	U	0.5	ug/l
Mercury, Elemental	Dissolved	5/10/93	U	0.5	ug/l
Dissolved Oxygen	Dissolved	5/10/93	--	9.45	mg/l
Arsenic, Inorganic	Dissolved	5/10/93	U	10	ug/l
Barium And Compounds	Total	5/10/93	--	120	ug/l
Selenium And Compounds	Total	5/10/93	U	5	ug/l
Ammonia As Nitrogen	Total	5/10/93	U	0.1	mg/l
Mercury, Elemental	Total	5/10/93	U	0.5	ug/l
Calcium Carbonate	Total	5/10/93	--	170	mg/l
Kjeldahl Nitrogen	Total	5/10/93	U	0.1	mg/l
Nitrate + Nitrite	Total	5/10/93	U	0.1	mg/l
Arsenic, Inorganic	Total	5/10/93	U	10	ug/l
Temperature	Air	5/10/93	--	28.0	° C
Stream Width	Standard	5/10/93	--	8.9	FT
Temperature	Water	5/10/93	--	16.0	° C
Strontium	Dissolved	5/10/93	--	270	ug/l
Stream Depth	Total	5/10/93	--	0.55	FT
Manganese	Dissolved	5/10/93	U	50	ug/l
Bicarbonate	Total	5/10/93	--	207	mg/l
Potassium	Total	5/10/93	--	2.76	mg/l
Chromium	Dissolved	5/10/93	U	10	ug/l
Phosphorus	Total	5/10/93	U	0.1	mg/l

Arivaca Creek at Figueroa Spring. Data from ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS
Fluoride	Total	5/10/93	--	0.21	mg/l
Turbidity	Total	5/10/93	--	0.29	NTU
Turbidity	Total	5/10/93	--	0.42	NTU
Antimony	Dissolved	5/10/93	U	5	ug/l
Thallium	Dissolved	5/10/93	U	5	ug/l
Magnesium	Total	5/10/93	--	8.4	mg/l
Chloride	Total	5/10/93	--	12.9	mg/l
Nickel	Dissolved	5/10/93	U	100	ug/l
Strontium	Total	5/10/93	--	270	ug/l
Cadmium	Dissolved	5/10/93	U	1	ug/l
Copper	Dissolved	5/10/93	U	10	ug/l
Sulfate	Total	5/10/93	--	16.1	mg/l
Calcium	Total	5/10/93	--	50.7	mg/l
Flow		5/10/93	--	0.37	FT/SEC
Silver	Dissolved	5/10/93	U	1	ug/l
Flow		5/10/93	--	1.52	CFS
Sodium	Total	5/10/93	--	17.1	mg/l
Manganese	Total	5/10/93	U	50	ug/l
Iron	Dissolved	5/10/93	U	100	ug/l
Nitrate	Total	5/10/93	U	0.1	mg/l
Carbonate	Total	5/10/93	U	2	mg/l
Chromium	Total	5/10/93	U	10	ug/l
Zinc	Dissolved	5/10/93	U	50	ug/l
Antimony	Total	5/10/93	U	5	ug/l
Thallium	Total	5/10/93	U	5	ug/l
Nickel	Total	5/10/93	U	100	ug/l
Cadmium	Total	5/10/93	U	1	ug/l
Copper	Total	5/10/93	U	10	ug/l
Silver	Total	5/10/93	U	1	ug/l
Iron	Total	5/10/93	U	100	ug/l
Zinc	Total	5/10/93	U	50	ug/l
pH	Total	5/10/93	--	8.15	SU
pH	Total	5/10/93	--	8.25	SU

U= Material analyzed for but not detected, and method detection limit is listed in the result column.

Arivaca Creek at Ruby Road. Data from ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS
Boron (Boron and Borates)	Total	7/28/93		110	ug/l
Lead And Compounds (Inorganic)	Total	7/28/93		ND	ug/l
Specific Conductivity	Standard	7/28/93		336	umhos/cm
Specific Conductivity	Standard	7/28/93		390	umhos/cm
Total Dissolved Solids	Dissolved	7/28/93		267	mg/l
Total Suspended Solids	Suspended	7/28/93		ND	mg/l
Dissolved Oxygen	Standard	7/28/93		52.9	percent
Beryllium And Compounds	Total	7/28/93		ND	ug/l
Barium And Compounds	Total	7/28/93		ND	ug/l
Selenium And Compounds	Total	7/28/93		ND	ug/l
Ammonia As Nitrogen	Total	7/28/93		ND	mg/l
Mercury, Elemental	Total	7/28/93		ND	ug/l
Calcium Carbonate	Total	7/28/93		205	mg/l
Kjeldahl Nitrogen	Total	7/28/93		0.18	mg/l
Nitrate + Nitrite	Total	7/28/93		ND	mg/l
Arsenic, Inorganic	Total	7/28/93		ND	ug/l
Temperature	Air	7/28/93		29.5	° C
Temperature	Water	7/28/93		18.0	° C
Bicarbonate	Total	7/28/93		250	mg/l
Potassium	Total	7/28/93		0.88	mg/l
Phosphorus	Total	7/28/93		ND	mg/l
Fluoride	Total	7/28/93		0.24	mg/l
Turbidity	Total	7/28/93		0.55	NTU
Turbidity	Total	7/28/93		0.76	NTU
Magnesium	Total	7/28/93		9.5	mg/l
Chloride	Total	7/28/93		7.6	mg/l
Strontium	Total	7/28/93		290	ug/l
Sulfate	Total	7/28/93		10	mg/l
Calcium	Total	7/28/93		59.1	mg/l
Flow		7/28/93		0.14	CFS
Sodium	Total	7/28/93		15.9	mg/l
Manganese	Total	7/28/93		ND	ug/l
Carbonate	Total	7/28/93		ND	mg/l
Chromium	Total	7/28/93		ND	ug/l
Antimony	Total	7/28/93		ND	ug/l
Thallium	Total	7/28/93		ND	ug/l
Nickel	Total	7/28/93		ND	ug/l
Cadmium	Total	7/28/93		ND	ug/l
Copper	Total	7/28/93		ND	ug/l
Silver	Total	7/28/93		ND	ug/l
Iron	Total	7/28/93		ND	ug/l
Zinc	Total	7/28/93		ND	ug/l
pH	Total	7/28/93		7.33	SU
pH	Total	7/28/93		7.94	SU

ND=not detected

Bingham Cienega Source Water Study.
Water Chemistry Summary November 1998- June 2000. From: PAG Bingham Cienega Source Water Study.

Bingham Cienega	11/23/1998	03/19/1999	06/15/1999	09/10/1999	11/20/1999	03/30/2000	06/09/2000
Silicon, dissolved (Si)	15	14	12	14	13	16	17
Aluminum, dissolved	0	0	0	0	0	--	--
Calcium, dissolved	67	67	55	60	63	62	73
Magnesium, dissolved	13	13	10	12	12	12	14
Manganese, dissolved	0.11	0.05	0	0.16	0.19	0.035	0
Potassium, dissolved	0	4.4	0	3.6	3.9	0	0
Sodium, dissolved	45	45	32	42	42	39	38
Arsenic, dissolved	0.0063	0.008	0	0.006	0	0	0.01
Chloride, dissolved	11.3	--	10.2	11	11	10	11
Sulfate, dissolved	69.8	63.7	48.4	53	56	50	50
Fluoride, dissolved	1.1	--	--	1.2	1.3	1	1.1
Alk. as CaCO3	234	238	204	200	220	210	230
Lab TDS	250	320	310	230	250	200	400
Lab Conductivity	580	570	520	590	560	560	600
Lab pH	7.4	7.7	6.9	6.8	7.1	7.3	7.6

Units are in mg/l except for pH (su) and conductivity (mmhos).

Buehman Canyon, above forest service roads 801 & 654 near Redington. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Specific Conductivity	Standard	7/15/97	--	380	umhos/cm	--
Specific Conductivity	Standard	7/15/97	--	399	umhos/cm	--
Total Dissolved Solids	Dissolved	7/15/97	--	270	mg/l	--
Beryllium And Compounds	Total	7/15/97	--	1.6	ug/l	--
Dissolved Oxygen	Standard	7/15/97	--	69.5	percent	--
Dissolved Oxygen	Dissolved	7/15/97	--	5.7	mg/l	--
Nitrate + Nitrite	Total	7/15/97	--	0.34	mg/l	--
Kjeldahl Nitrogen	Total	7/15/97	--	0.74	mg/l	--
Calcium Carbonate	Total	7/15/97	--	170	mg/l	--
Temperature	Air	7/15/97	--	31.5	° C	--
Temperature	Water	7/15/97	--	19.6	° C	--
Bicarbonate	Total	7/15/97	--	210	mg/l	--
Turbidity	Total	7/15/97	--	1.92	NTU	--
Potassium	Total	7/15/97	--	2.3	mg/l	--
Magnesium	Total	7/15/97	--	8.8	mg/l	--
Fluoride	Total	7/15/97	--	2.6	mg/l	--
Calcium	Total	7/15/97	--	52.0	mg/l	--
Chloride	Total	7/15/97	--	10	mg/l	--
Sulfate	Total	7/15/97	--	25	mg/l	--
Copper	Total	7/15/97	--	15	ug/l	--
Sodium	Total	7/15/97	--	22	mg/l	--
pH	Total	7/15/97	--	7.32	SU	--
Alkalinity, Phenolphthalein	Total	7/15/97	--	ND	mg/l	2

Buehman Canyon, above forest service roads 801 & 654 near Redington. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Total Suspended Solids	Suspended	7/15/97	--	ND	mg/l	4
Ammonia As Nitrogen	Total	7/15/97	--	ND	mg/l	0.1
Phosphorus	Total	7/15/97	--	ND	mg/l	0.1
Carbonate	Total	7/15/97	--	ND	mg/l	2
Boron (Boron And Borates)	Dissolved	7/15/97	--	ND	ug/l	100
Lead And Compounds (Inorganic)	Dissolved	7/15/97	--	ND	ug/l	5
Boron (Boron And Borates Only)	Total	7/15/97	--	ND	ug/l	100
Lead And Compounds (Inorganic)	Total	7/15/97	--	ND	ug/l	5
Beryllium And Compounds	Dissolved	7/15/97	--	ND	ug/l	0.5
Barium And Compounds	Dissolved	7/15/97	--	ND	ug/l	100
Selenium And Compounds	Dissolved	7/15/97	--	ND	ug/l	5
Mercury, Elemental	Dissolved	7/15/97	--	ND	ug/l	0.5
Arsenic, Inorganic	Dissolved	7/15/97	--	ND	ug/l	10
Barium And Compounds	Total	7/15/97	--	ND	ug/l	100
Selenium And Compounds	Total	7/15/97	--	ND	ug/l	5
Mercury, Elemental	Total	7/15/97	--	ND	ug/l	0.5
Arsenic, Inorganic	Total	7/15/97	--	ND	ug/l	10
Manganese	Dissolved	7/15/97	--	ND	ug/l	50
Chromium	Dissolved	7/15/97	--	ND	ug/l	10
Antimony	Dissolved	7/15/97	--	ND	ug/l	5
Thallium	Dissolved	7/15/97	--	ND	ug/l	5
Nickel	Dissolved	7/15/97	--	ND	ug/l	100
Cadmium	Dissolved	7/15/97	--	ND	ug/l	1
Copper	Dissolved	7/15/97	--	ND	ug/l	10
Manganese	Total	7/15/97	--	ND	ug/l	50
Silver	Dissolved	7/15/97	--	ND	ug/l	1
Iron	Dissolved	7/15/97	--	ND	ug/l	100
Zinc	Dissolved	7/15/97	--	ND	ug/l	50
Chromium	Total	7/15/97	--	ND	ug/l	10
Antimony	Total	7/15/97	--	ND	ug/l	5
Thallium	Total	7/15/97	--	ND	ug/l	5
Nickel	Total	7/15/97	--	ND	ug/l	100
Cadmium	Total	7/15/97	--	ND	ug/l	1
Silver	Total	7/15/97	--	ND	ug/l	1
Iron	Total	7/15/97	--	ND	ug/l	100
Zinc	Total	7/15/97	--	ND	ug/l	50

ND= not detected

Buehman Canyon, two miles below the confluence with Bullock Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Flow		5/18/00	--	0.06	CFS	--
Temperature	Air	5/18/00	--	21	° C	--
Temperature	Water	5/18/00	--	21.61	° C	--
Stream Depth	Standard	5/18/00	--	0.3	FT	--
Stream Width	Standard	5/18/00	--	7.5	FT	--
Flow		5/18/00	--	0.03	FT/SEC	--
Lead And Compounds (Inorganic)	Dissolved	5/18/00	--	ND	mg/l	0.0050
Lead And Compounds (Inorganic)	Total	5/18/00	--	ND	mg/l	0.005
Total Dissolved Solids	Dissolved	5/18/00	--	295	mg/l	--
Beryllium And Compounds	Dissolved	5/18/00	--	ND	mg/l	0.0005
Boron (Boron And Borates)	Total	5/18/00	--	ND	mg/l	0.1
Hardness (Caco3 + Mgco3)	Total	5/18/00	--	210	mg/l	--
Selenium And Compounds	Dissolved	5/18/00	--	ND	mg/l	0.005
Alkalinity, Phenolphthalein	Total	5/18/00	--	ND	mg/l	2.0
Beryllium And Compounds	Total	5/18/00	--	ND	mg/l	0.0005
Kjeldahl Nitrogen	Total	5/18/00	--	0.087	mg/l	0.05
Dissolved Oxygen	Dissolved	5/18/00	--	4.44	mg/l	--
Barium And Compounds	Dissolved	5/18/00	--	ND	mg/l	0.10
Mercury, Elemental	Dissolved	5/18/00	--	ND	mg/l	0.0005
Nitrate + Nitrite	Total	5/18/00	--	0.22	mg/l	0.02
Calcium Carbonate	Standard	5/18/00	--	210	mg/l	10
Arsenic, Inorganic	Dissolved	5/18/00	--	ND	mg/l	0.010
Selenium And Compounds	Total	5/18/00	--	ND	mg/l	0.005
Total Suspended Solids	Suspended	5/18/00	--	ND	mg/l	4
Calcium Carbonate	Total	5/18/00	--	210	mg/l	2.0
Mercury, Elemental	Total	5/18/00	--	ND	mg/l	0.0005
Barium and Compounds	Total	5/18/00	--	ND	mg/l	0.1
Ammonia As Nitrogen	Total	5/18/00	--	ND	mg/l	0.02
Arsenic, Inorganic	Total	5/18/00	--	ND	ug/l	0.01
Phosphorus	Total	5/18/00	--	0.029	mg/l	0.02
Bicarbonate	Total	5/18/00	--	260	mg/l	2.0
Fluoride	Total	5/18/00	--	0.68	mg/l	0.20
Potassium	Total	5/18/00	--	2.5	mg/l	0.50
Antimony	Dissolved	5/18/00	--	ND	mg/l	0.0050
Magnesium	Total	5/18/00	--	8.2	mg/l	1.0
Cadmium	Dissolved	5/18/00	--	ND	mg/l	0.0010
Chromium	Dissolved	5/18/00	--	ND	mg/l	0.010
Thallium	Dissolved	5/18/00	--	ND	mg/l	0.002
Chloride	Total	5/18/00	--	8.0	mg/l	1.0
Sulfate	Total	5/18/00	--	21	mg/l	10.0
Copper	Dissolved	5/18/00	--	ND	mg/l	0.010
Silver	Dissolved	5/18/00	--	ND	mg/l	0.001
Calcium	Total	5/18/00	--	71	mg/l	5.0
Nickel	Dissolved	5/18/00	--	ND	mg/l	0.10
Sodium	Total	5/18/00	--	20	mg/l	5.0

Buehman Canyon, two miles below the confluence with Bullock Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Antimony	Total	5/18/00	--	ND	mg/l	0.005
Manganese	Total	5/18/00	--	ND	mg/l	0.05
Zinc	Dissolved	5/18/00	--	ND	mg/l	0.050
Thallium	Total	5/18/00	--	ND	mg/l	0.002
Cadmium	Total	5/18/00	--	ND	mg/l	0.001
Carbonate	Total	5/18/00	--	ND	mg/l	2.0
Chromium	Total	5/18/00	--	ND	mg/l	0.01
Silver	Total	5/18/00	--	ND	mg/l	0.001
Copper	Total	5/18/00	--	ND	mg/l	0.01
Nickel	Total	5/18/00	--	ND	mg/l	0.1
Zinc	Total	5/18/00	--	ND	mg/l	0.05
Iron	Total	5/18/00	--	ND	mg/l	0.1
Turbidity	Total	5/18/00	--	0.54	NTU	--
Dissolved Oxygen	Standard	5/18/00	--	56.5	percent	--
pH	Total	5/18/00	--	6.93	SU	--
Specific Conductivity	Standard	5/18/00	--	460	umhos/cm	--
Specific Conductivity	Standard	5/18/00	--	461	umhos/cm	--

ND= not detected

Water Quality Data for Canada del Oro, South of the Pinal/Pima County Line. From ADEQ.

PARAMETER	DATE	RESULT	UNITS	DATA CODE	REPORTING LIMIT
Temperature, Water	4/7/94	13	° C		
Temperature, Air	4/7/94	20.3	° C		
Specific Conductance, Field	4/7/94	102	umhos/cm		
Oxygen, Dissolved	4/7/94	9.6	mg/l		
Oxygen, Dissolved	4/14/93	85.6	%		
pH, Field	4/7/94	8.01	SU		
Alkalinity, Total (mg/l as CaCo3)	4/7/94	41	mg/l		
Alkalinity, Phenolphthalein	4/7/94		Mg/l	ND	2.0
Bicarbonate Ion	4/7/94	50	mg/l		
Carbonate Ion	4/7/94		Mg/l	ND	2.0
Nitrogen, Ammonia, Total	4/7/94	0.31	mg/l		
Nitrogen, Kjeldahl	4/7/94	0.54	mg/l		
Nitrite+Nitrate, Total	4/7/94		Mg/l	ND	0.01
Phosphorous, Total	4/7/94	0.069	mg/l		
Hardness, Total	4/7/94	44	mg/l		
Calcium, Total	4/7/94	11.9	mg/l		
Magnesium, Total	4/7/94	3.1	mg/l		
Sodium, Total	4/7/94	8.4	mg/l		
Potassium, Total	4/7/94	1.36	mg/l		
Chloride, Total	4/7/94	2.9	mg/l		
Sulfate, Total	4/7/94	15	mg/l		
Fluoride, Total	4/7/94	0.32	mg/l		
Arsenic, Total	4/7/94		ug/l	ND	10
Barium, Total	4/14/93		ug/l	ND	100
Boron, Total	4/14/93		ug/l	ND	100
Cadmium, Total	4/14/93		ug/l	ND	1.0
Chromium, Total	4/14/93		ug/l	ND	10
Copper, Total	6/1/92		ug/l	ND	10
Iron, Total	4/7/94	520	ug/l		
Lead, Total	4/14/93		ug/l	ND	10
Thallium, Total	6/1/92		ug/l	ND	5.0
Silver, Total	4/14/93		ug/l	ND	1.0
Zinc, Total	4/14/93		ug/l	ND	50
Selenium, Total	6/1/92		ug/l	ND	5.0
Solids, Total, Dissolved	4/7/94	65	mg/l		
Mercury, Total	4/7/94		ug/l	ND	.5
Turbidity, Total	4/7/94	6.4	NTU		
Turbidity, Lab	4/7/94	6.5	NTU		

ND= not detected

Average Values, Water Quality Data for Cienega Creek 1987-1990. (Fonseca et al., 1990) (PAG Summary of Cienega Creek Surface and Groundwater Monitoring Program 1998).

Site	Ca dissolved (mg/l)	Mg dissolved (mg/l)	Na dissolved (mg/l)	K dissolved (mg/l)	HCO3 dissolved (mg/l)	SO4 dissolved (mg/l)	CL dissolved (mg/l)	F dissolved (mg/l)
Near Marsh Station	109.28	31.23	58	5.29	227.56	300.47	16.43	0.73
Near Jungle Road	130.57	32.26	57.29	4.14	252	316.14	12.07	0.75
Near Del Lago	125.33	32.78	70.18	5.25	232.33	304.17	19.88	0.67

Cienega Creek at Marsh Station, Below Davidson Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Specific Conductivity	Standard	9/28/98	--	980	umhos/cm	--
Specific Conductivity	Standard	9/28/98	--	993	umhos/cm	--
Dissolved Oxygen	Standard	9/28/98	--	97.5	percent	--
Dissolved Oxygen	Dissolved	9/28/98	--	8.13	mg/l	--
Temperature	Air	9/28/98	--	26.0	° C	--
Stream Width	Standard	9/28/98	--	2.8	FT	--
Temperature	Water	9/28/98	--	19.7	° C	--
Stream Depth	Total	9/28/98	--	0.13	FT	--
Turbidity	Total	9/28/98	--	1.04	NTU	--
Flow		9/28/98	--	0.257	CFS	--
Flow		9/28/98	--	0.53	FT/SEC	--
pH	Total	9/28/98	--	7.92	SU	--
Total Dissolved Solids	Dissolved	9/28/98	--	700	mg/l	10
Alkalinity, Phenolphthalein	Total	9/28/98	--	ND	mg/l	2
Nitrate + Nitrite	Total	9/28/98	--	0.14	mg/l	0.02
Total Suspended Solids	Suspended	9/28/98	--	ND		4
Kjeldahl Nitrogen	Total	9/28/98	--	0.2	mg/l	0.05
Calcium Carbonate	Total	9/28/98	--	290	mg/l	2
Ammonia As Nitrogen	Total	9/28/98	--	ND	mg/l	0.02
Fluoride	Total	9/28/98	--	0.68	mg/l	0.2
Potassium	Total	9/28/98	--	4.2	mg/l	0.5
Bicarbonate	Total	9/28/98	--	350	mg/l	2
Magnesium	Total	9/28/98	--	36	mg/l	1
Sulfate	Total	9/28/98	--	270	mg/l	10
Phosphorus	Total	9/28/98	--	ND	mg/l	0.02
Chloride	Total	9/28/98	--	12	mg/l	1
Calcium	Total	9/28/98	--	130	mg/l	5
Sodium	Total	9/28/98	--	64	mg/l	5

Cienega Creek at Marsh Station, Below Davidson Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Carbonate	Total	9/28/98	--	ND		2
Boron (Boron And Borates Only)	Dissolved	9/28/98	--	130	ug/l	100
Boron (Boron And Borates Only)	Dissolved	9/28/98	--	140	ug/l	100
Boron (Boron And Borates Only)	Total	9/28/98	--	150	ug/l	100
Lead And Compounds (Inorganic)	Dissolved	9/28/98	--	ND	ug/l	5
Lead And Compounds (Inorganic)	Dissolved	9/28/98	--	ND	ug/l	5
Lead And Compounds, inorg	Total	9/28/98	--	ND	ug/l	5
Beryllium And Compounds	Dissolved	9/28/98	--	ND	ug/l	0.5
Beryllium And Compounds	Dissolved	9/28/98	--	ND	ug/l	0.5
Barium And Compounds	Dissolved	9/28/98	--	ND	ug/l	100
Barium And Compounds	Dissolved	9/28/98	--	ND	ug/l	100
Selenium And Compounds	Dissolved	9/28/98	--	ND	ug/l	5
Selenium And Compounds	Dissolved	9/28/98	--	ND	ug/l	5
Beryllium And Compounds	Total	9/28/98	--	ND	ug/l	0.5
Mercury, Elemental	Dissolved	9/28/98	--	ND	ug/l	0.5
Mercury, Elemental	Dissolved	9/28/98	--	ND	ug/l	0.5
Arsenic, Inorganic	Dissolved	9/28/98	--	ND	ug/l	10
Arsenic, Inorganic	Dissolved	9/28/98	--	ND	ug/l	10
Barium And Compounds	Total	9/28/98	--	ND	ug/l	100
Selenium And Compounds	Total	9/28/98	--	ND	ug/l	5
Mercury, Elemental	Total	9/28/98	--	ND	ug/l	0.5
Arsenic, Inorganic	Total	9/28/98	--	ND	ug/l	10
Manganese	Dissolved	9/28/98	--	51	ug/l	50
Manganese	Dissolved	9/28/98	--	52	ug/l	50
Manganese	Total	9/28/98	--	64	ug/l	50
Chromium	Dissolved	9/28/98	--	ND	ug/l	10
Chromium	Dissolved	9/28/98	--	ND	ug/l	10
Antimony	Dissolved	9/28/98	--	ND	ug/l	5
Thallium	Dissolved	9/28/98	--	ND	ug/l	2
Thallium	Dissolved	9/28/98	--	ND	ug/l	2
Nickel	Dissolved	9/28/98	--	ND	ug/l	100
Nickel	Dissolved	9/28/98	--	ND	ug/l	100
Cadmium	Dissolved	9/28/98	--	ND	ug/l	1
Cadmium	Dissolved	9/28/98	--	ND	ug/l	1
Copper	Dissolved	9/28/98	--	ND	ug/l	10
Copper	Dissolved	9/28/98	--	ND	ug/l	10
Silver	Dissolved	9/28/98	--	ND	ug/l	1
Silver	Dissolved	9/28/98	--	ND	ug/l	1
Iron	Dissolved	9/28/98	--	ND	ug/l	100
Iron	Dissolved	9/28/98	--	ND	ug/l	100
Zinc	Dissolved	9/28/98	--	ND	ug/l	50

Cienega Creek at Marsh Station, Below Davidson Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Zinc	Dissolved	9/28/98	--	ND	ug/l	50
Chromium	Total	9/28/98	--	ND	ug/l	10
Thallium	Total	9/28/98	--	ND	ug/l	2
Nickel	Total	9/28/98	--	ND	ug/l	100
Cadmium	Total	9/28/98	--	ND	ug/l	1
Copper	Total	9/28/98	--	ND	ug/l	10
Silver	Total	9/28/98	--	ND	ug/l	1
Iron	Total	9/28/98	--	ND	ug/l	100
Zinc	Total	9/28/98	--	ND	ug/l	50

ND= not detected

Cienega Creek above Davidson Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	REPORTING LIMIT	UNITS
Antimony	Total	9/28/98	ND	--	5	ug/l
Arsenic, Inorganic	Dissolved	9/28/98	ND	--	10	ug/l
Arsenic, Inorganic	Total	9/28/98	ND	--	10	ug/l
Arsenic, Inorganic	Total	9/28/98	ND	--	10	ug/l
Barium And Compounds	Dissolved	9/28/98	ND	--	100	ug/l
Barium And Compounds	Total	9/28/98	ND	--	100	ug/l
Barium And Compounds	Total	9/28/98	--	100	--	ug/l
Beryllium And Compounds	Dissolved	9/28/98	ND	--	5	ug/l
Beryllium And Compounds	Total	9/28/98	ND	--	5	ug/l
Beryllium And Compounds	Total	9/28/98	ND	--	0.5	ug/l
Boron (Boron And Borates Only)	Dissolved	9/28/98	--	140	--	ug/l
Boron (Boron And Borates Only)	Total	9/28/98	--	150	--	ug/l
Boron (Boron And Borates Only)	Total	9/28/98	--	140	--	ug/l
Cadmium	Dissolved	9/28/98	ND	--	1	ug/l
Cadmium	Total	9/28/98	ND	--	1	ug/l
Cadmium	Total	9/28/98	ND	--	1	ug/l
Copper	Dissolved	9/28/98	ND	--	10	ug/l
Copper	Total	9/28/98	ND	--	10	ug/l
Copper	Total	9/28/98	ND	--	10	ug/l
Lead And Compounds (Inorganic)	Dissolved	9/28/98	ND	--	5	ug/l
Lead And Compounds (Inorganic)	Total	9/28/98	ND	--	5	ug/l
Lead And Compounds (Inorganic)	Total	9/28/98	ND	--	5	ug/l
Manganese	Dissolved	9/28/98	ND	--	50	ug/l
Manganese	Total	9/28/98	ND	--	50	ug/l

Cienega Creek above Davidson Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	REPORTING LIMIT	UNITS
Manganese	Total	9/28/98	--	67	--	ug/l
Mercury, Elemental	Dissolved	9/28/98	ND	--	0.5	ug/l
Mercury, Elemental	Total	9/28/98	ND	--	0.5	ug/l
Mercury, Elemental	Total	9/28/98	ND	--	0.5	ug/l
Selenium And Compounds	Dissolved	9/28/98	ND	--	5	ug/l
Selenium And Compounds	Total	9/28/98	ND	--	5	ug/l
Selenium And Compounds	Total	9/28/98	ND	--	5	ug/l
Silver	Dissolved	9/28/98	ND	--	1	ug/l
Silver	Total	9/28/98	ND	--	1	ug/l
Silver	Total	9/28/98	ND	--	1	ug/l
Phosphorus	Total	9/28/98	ND	--	0.02	mg/l
Phosphorus	Total	9/28/98	ND	--	0.02	mg/l
Zinc	Dissolved	9/28/98	ND	--	50	ug/l
Zinc	Total	9/28/98	ND	--	50	ug/l
Zinc	Total	9/28/98	ND	--	50	ug/l
Alkalinity, Phenolphthalein	Total	9/28/98	ND	--	2	mg/l
Alkalinity, Phenolphthalein	Total	9/28/98	ND	--	2	mg/l
Calcium Carbonate	Standard	9/28/98	--	450	--	mg/l
Calcium Carbonate	Total	9/28/98	--	280	--	mg/l
Calcium Carbonate	Total	9/28/98	--	290	--	mg/l
Carbonate	Total	9/28/98	ND	--	2	mg/l
Carbonate	Total	9/28/98	ND	--	2	mg/l
Chloride	Total	9/28/98	--	12	--	mg/l
Chloride	Total	9/28/98	--	12	--	mg/l
Fluoride	Total	9/28/98	--	0.68	--	mg/l
Fluoride	Total	9/28/98	--	0.67	--	mg/l
Specific Conductivity	Standard	9/28/98	--	1013	--	umhos/cm
Specific Conductivity	Standard	9/28/98	--	980	--	umhos/cm
Specific Conductivity	Standard	9/28/98	--	1000	--	umhos/cm
Sulfate	Total	9/28/98	--	320	--	mg/l
Sulfate	Total	9/28/98	--	270	--	mg/l
Calcium	Total	9/28/98	--	130	--	mg/l
Calcium	Total	9/28/98	--	130	--	mg/l
Chromium	Dissolved	9/28/98	ND	--	10	ug/l
Chromium	Total	9/28/98	ND	--	10	ug/l
Chromium	Total	9/28/98	ND	--	10	ug/l
Iron	Dissolved	9/28/98	ND	--	100	ug /l
Iron	Total	9/28/98	ND	--	100	ug/l
Iron	Total	9/28/98	ND	--	100	ug/l
Magnesium	Total	9/28/98	--	37	--	mg/l
Magnesium	Total	9/28/98	--	35	--	mg/l
Potassium	Total	9/28/98	--	4.1	--	mg/l
Potassium	Total	9/28/98	--	2.4	--	mg/l
Bicarbonate	Total	9/28/98	--	340	--	mg/l
Bicarbonate	Total	9/28/98	--	350	--	mg/l
pH	Total	9/28/98	--	7.51	--	mg/l

Cienega Creek above Davidson Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	REPORTING LIMIT	UNITS
pH	Total	9/28/98	--	7.9	--	mg/l
Total Dissolved Solids	Dissolved	9/28/98	--	720	--	mg/l
Total Dissolved Solids	Dissolved	9/28/98	--	710	--	mg/l
Total Suspended Solids	Suspended	9/28/98	ND	--	4	mg/l
Total Suspended Solids	Suspended	9/28/98	--	5	--	mg/l
Turbidity	Total	9/28/98	--	0.89	--	NTU
Turbidity	Total	9/28/98	--	0.38	--	NTU
Turbidity	Total	9/28/98	--	0.24	--	NTU
Sodium	Total	9/28/98	--	65	--	mg/l
Sodium	Total	9/28/98	--	62	--	mg/l
Temperature	Total	9/28/98	--	20.12	--	mg/l
Dissolved Oxygen	Dissolved	9/28/98	--	5.4	--	mg/l
Dissolved Oxygen	Standard	9/28/98	--	65.1	--	percent
Ammonia As Nitrogen	Total	9/28/98	ND	--	0.02	mg/l
Ammonia As Nitrogen	Total	9/28/98	ND	--	0.02	mg/l
Kjeldahl Nitrogen	Total	9/28/98	--	0.09	--	mg/l
Kjeldahl Nitrogen	Total	9/28/98	--	0.092	--	mg/l
Nitrate + Nitrite	Total	9/28/98	--	0.2	--	mg/l
Nitrate + Nitrite	Total	9/28/98	--	0.16	--	mg/l
Thallium	Dissolved	9/28/98	ND	--	5	ug/l
Thallium	Total	9/28/98	ND	--	5	ug/l
Thallium	Total	9/28/98	ND	--	2	ug/l
Nickel	Dissolved	9/28/98	ND	--	100	ug/l
Nickel	Total	9/28/98	ND	--	100	ug/l
Nickel	Total	9/28/98	ND	--	100	ug/l
Flow	Standard	9/28/98	--	0.35	--	ft/sec
Flow	Total	9/28/98	--	0.34	--	CFS
Stream Width	Standard	9/28/98	--	3.1	--	FT
Stream Depth	Total	9/28/98	--	0.13	--	FT

ND= not detected

Cienega Creek below Stevenson Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMITS
Boron (Boron And Borates Only)	Dissolved	9/30/98	--	120	ug/l	--
Boron (Boron And Borates Only)	Total	9/30/98	--	130	ug/l	--
Specific Conductivity	Standard	9/30/98	--	480	umhos/cm	--
Specific Conductivity	Standard	9/30/98	--	474	umhos/cm	--
Lead And Compounds (Inorganic)	Dissolved	9/30/98	--	ND	ug/l	5
Total Dissolved Solids	Dissolved	9/30/98	--	310	mg/l	--
Barium And Compounds	Dissolved	9/30/98	--	180	ug/l	--
Lead And Compounds (Inorganic)	Total	9/30/98	--	ND	ug/l	5
Dissolved Oxygen	Dissolved	9/30/98	--	6.18	mg/l	--
Barium And Compounds	Total	9/30/98	--	180	ug/l	--
Kjeldahl Nitrogen	Total	9/30/98	--	0.13	mg/l	--
Nitrate + Nitrite	Total	9/30/98	--	0.16	mg/l	--
Calcium Carbonate	Total	9/30/98	--	210	mg/l	--
Temperature	Air	9/30/98	--	28.6	° C	--
Stream Width	Standard	9/30/98	--	3.4	FT	--
Temperature	Water	9/30/98	--	18.2	° C	--
Phosphorus	Total	9/30/98	--	0.025	mg/l	--
Stream Depth	Total	9/30/98	--	0.24	FT	--
Bicarbonate	Total	9/30/98	--	260	mg/l	--
Potassium	Total	9/30/98	--	1.8	mg/l	--
Turbidity	Total	9/30/98	--	2.94	NTU	--
Magnesium	Total	9/30/98	--	8.8	mg/l	--
Fluoride	Total	9/30/98	--	0.4	mg/l	--
Turbidity	Total	9/30/98	--	1.4	NTU	--
Chloride	Total	9/30/98	--	7.6	mg/l	--
Manganese	Dissolved	9/30/98	--	ND	ug/l	50
Flow		9/30/98	--	0.88	FT/SEC	--
Flow		9/30/98	--	0.92	CFS	--
Sulfate	Total	9/30/98	--	33	mg/l	--
Calcium	Total	9/30/98	--	58	mg/l	--
Nickel	Dissolved	9/30/98	--	ND	ug/l	100
Sodium	Total	9/30/98	--	46	mg/l	--
Manganese	Total	9/30/98	--	ND	ug/l	50
Nickel	Total	9/30/98	--	ND	ug/l	100
pH	Total	9/30/98	--	7.94	SU	--
Total Suspended Solids	Suspended	9/30/98	--	ND	mg/l	4

Cienega Creek below Stevenson Canyon. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMITS
Ammonia As Nitrogen	Total	9/30/98	--	ND	mg/l	0.02
Carbonate	Total	9/30/98	--	ND	mg/l	2
Beryllium And Compounds	Dissolved	9/30/98	--	ND	ug/l	5
Selenium And Compounds	Dissolved	9/30/98	--	ND	ug/l	5
Mercury, Elemental	Dissolved	9/30/98	--	ND	ug/l	0.5
Arsenic, Inorganic	Dissolved	9/30/98	--	ND	ug/l	10
Beryllium And Compounds	Total	9/30/98	--	ND	ug/l	5
Selenium And Compounds	Total	9/30/98	--	ND	ug/l	5
Mercury, Elemental	Total	9/30/98	--	ND	ug/l	0.5
Arsenic, Inorganic	Total	9/30/98	--	ND	ug/l	10
Chromium	Dissolved	9/30/98	--	ND	ug/l	10
Thallium	Dissolved	9/30/98	--	ND	ug/l	5
Cadmium	Dissolved	9/30/98	--	ND	ug/l	1
Copper	Dissolved	9/30/98	--	ND	ug/l	10
Silver	Dissolved	9/30/98	--	ND	ug/l	1
Iron	Dissolved	9/30/98	--	ND	ug/l	100
Zinc	Dissolved	9/30/98	--	ND	ug/l	50
Chromium	Total	9/30/98	--	ND	ug/l	10
Thallium	Total	9/30/98	--	ND	ug/l	5
Cadmium	Total	9/30/98	--	ND	ug/l	1
Copper	Total	9/30/98	--	ND	ug/l	10
Silver	Total	9/30/98	--	ND	ug/l	1
Iron	Total	9/30/98	--	ND	ug/l	100
Zinc	Total	9/30/98	--	ND	ug/l	50

ND= not detected

Cienega Creek Location T16S R17E S29 acd. lower basin on the preserve. (SCCIE001.49). Data from ADEQ.

Parameter					Units	Limits
Date Sampled	**12/12/00**	**4/17/01**	**9/18/01**	**12/17/01**		
Stream Width (Feet)	9.2	9	4.8	7.8	Ft	
Temperature, Water °C	10.66	15.96	22.82	9.2	° C	
Temperature, Air °C	4	23	27	8	° C	
Flow, Stream, Instantaneous Cfs	2.43	1.2	0.55	1.76	Cfs	
Depth Of Stream, Mean (Ft)	0.71	0.16	0.14	0.23	Ft	
Turbidity,Hach Turbidimeter (Formazin Turb Unit)	1.22	1.14	1.2	0.71	Ntu	
Specific Conductance,Field (Umhos/Cm @ 25 °C)	698	1246	1377	1270	Umhos/Cm	
Specific Conductance (Umhos/Cm @ 25 ° C)	1200	1300	1400		Umhos/Cm	
Oxygen, Dissolved	5.85	7.12	6.42	8.29	mg/l	
Oxygen, Dissolved, Percent Of Saturation %	59.4	81.2	85	81	Percent	
Ph, Lab		8	8.2		Su	
Ph, Field	7.77	7.53	7.77	7.94	Su	
Alkalinity, Total (mg/l as Caco3)	270	300	330		mg/l	
Alkalinity, Phenolphthalein (mg/l)	ND	ND	ND		mg/l	2.0
Bicarbonate Ion (mg/l as Hco3)	330	370	400		mg/l	
Carbonate Ion (mg/l as Co3)	ND	ND	ND		mg/l	2.0
Nitrogen, Ammonia, Total (mg/l as N)	ND	ND	ND		mg/l	0.020
Nitrite Nitrogen, Total (mg/l as N)	7.9	ND			mg/l	0.020
Nitrate Nitrogen, Total (mg/l as N)	0.042					
Nitrogen, Kjeldahl, Total, (mg/l as N)	140	0.14	130		mg/l	
Phosphorus, Total (mg/l as P)	22	0.02	30		mg/l	
Hardness, Total (mg/l as Caco3)	630	600	660		mg/l	
Calcium, Total (mg/l as Ca)	150	150	180		mg/l	
Magnesium, Total (mg/l as Mg)	42	40	47		mg/l	
Sodium, Total (mg/l as Na)	63	62	75		mg/l	
Potassium, Total mg/l as K)	4.5	3.4	4.8		mg/l	
Chloride,Total In Water mg/l	8.2	12	18		mg/l	
Sulfate, Total (mg/l as So4)	390	460	470		mg/l	
Fluoride, Total (mg/l as F)	0.7	0.61	0.68		mg/l	
Arsenic, Dissolved (ug/l as As)	ND	ND	ND		ug/l	10
Arsenic, Total (ug/l as As)	ND	ND	ND		ug/l	10
Barium, Dissolved (ug/l as Ba)	120	ND	ND		ug/l	100
Barium, Total (ug/l as Ba)	120	ND	ND		ug/l	100
Beryllium, Dissolved (ug/l as Be)	ND	ND	ND		ug/l	0.50
Beryllium, Total (ug/l as Be)	ND	ND	ND		ug/l	0.50

Cienega Creek Location T16S R17E S29 acd. lower basin on the preserve. (SCCIE001.49). Data from ADEQ. Continued.

Parameter					Units	Limits
Date Sampled	**12/12/00**	**4/17/01**	**9/18/01**	**12/17/01**		
Boron, Total (ug/l as B)	140	140	150		ug/l	
Cadmium, Dissolved (ug/l as Cd)	ND	ND	ND		ug/l	1.0
Cadmium, Total (ug/l as Cd)	ND	ND	ND		ug/l	1.0
Chromium, Dissolved (ug/l as Cr)	ND	ND	ND		ug/l	10
Chromium, Total (ug/l as Cr)	ND	ND	ND		ug/l	10
Copper, Dissolved (ug/l as Cu)	ND	ND	ND		ug/l	10
Copper, Total (ug/l as Cu)	ND	ND	ND		ug/l	10
Iron, Total (ug/l as Fe)	150	ND	130		ug/l	
Lead, Dissolved (ug/l as Pb)	ND	ND	ND		ug/l	5.0
Lead, Total (ug/l as Pb)	ND	ND	ND		ug/l	5.0
Manganese, Total (ug/l as Mn)	240	72	230		ug/l	
Thallium, Dissolved (ug/l as Tl)	ND	ND	ND		ug/l	2.0
Thallium, Total (ug/l as Tl)	ND	ND	ND		ug/l	2.0
Nickel, Dissolved (ug/l as Ni)	ND	ND	ND		ug/l	100
Nickel, Total (ug/l as Ni)	ND	ND	ND		ug/l	100
Silver, Dissolved (ug/l as Ag)	ND	ND	ND		ug/l	1.0
Silver, Total (ug/l as Ag)	ND	ND	ND		ug/l	1.0
Zinc, Dissolved (ug/l as Zn)	ND	ND	ND		ug/l	50
Zinc, Total (ug/l as Zn)	ND	ND	ND		ug/l	50
Antimony, Dissolved (ug/l as Sb)	ND	ND	ND		ug/l	5.0
Antimony, Total (ug/l as Sb)	ND	ND	ND		ug/l	5.0
Selenium, Dissolved (ug/l as Se)	ND	ND	ND		ug/l	5.0
Selenium, Total (ug/l as Se)	ND	ND	ND		ug/l	5.0
Solids,Total Dissolved (Elect-Conductivity) mg/l		797	882	813		
Mercury, Dissolved (ug/l as Hg)	ND	ND	ND		ug/l	0.5
Mercury, Total (ug/l as Hg)	ND	ND	ND		ug/l	0.50
Turbidity,Lab Nephelometric Turbidity Units, Ntu	0.58	1.1	0.7		Ntu	
Hardness,Total Calculated(Ca,Mg,Fe) As Caco3 mg/l	640	540	640		mg/l	
Flow, Rate Ft/Sec	0.43	0.68	0.53	0.82	Ft/Sec	

ND= not detected; mg/l= milligrams/liter; ug/l= micrograms/liter

Cienega Creek Location: T16S R17E S34 bca, in the lower basin on the preserve. SCCIE002.66. Data from ADEQ.

Parameter	Results						Units	Limits
Date Sampled	**12/11/00**	**12/12/00**	**2/22/01**	**4/17/01**	**9/18/01**	**12/17/01**		
Stream Width (Feet)	5.5			8	4.5	6.5		
Temperature, Water (° C)	15.15			22.24	O	10.4	° C	
Temperature, Air (° C)	17			31	O	5	° C	
Flow, Stream, Instantaneous	1.28			0.75	0.69	1.12	Cfs	
Depth Of Stream, Mean (Ft)	0.3			0.19	0.13	0.23	Ft	
Turbidity,Hach Turbidimeter (Formazin Turb Unit)	0.89			0.74	0.75	0.77	Ntu	
Specific Conductance,Field (Umhos/Cm @ 25 ° C)	711			1101	1024	997	Umhos/Cm	
Specific Conductance, (Umhos/Cm @ 25 ° C)			1100	1100	1000		Umhos/Cm	
Oxygen, Dissolved	6.95			8.91	5.45	9.22	mg/L	
Oxygen, Dissolved, Saturation %	78.4			114	80	92	Percent	
Ph, Lab			8.2	8	8.2		Su	
Ph, Field	7.77			7.8	7.67	7.88	Su	
Alkalinity, Total (mg/l as Caco3)			240	260	260		mg/l	
Alkalinity, Phenolphthalein			ND	ND	ND		mg/l	2.0
Bicarbonate Ion (mg/l as Hco3)			290	320	317		mg/l	
Carbonate Ion (mg/l as Co3)			ND	ND	ND		mg/l	2.0
Nitrogen, Ammonia, Total (mg/l as N)			ND	ND	ND		mg/l	0.020
Nitrite Nitrogen, Total (mg/l as N)			ND	ND			mg/l	0.020
Nitrate Nitrogen, Total (mg/l as N)			ND	0.068			mg/l	0.050
Nitrogen, Kjeldahl, Total, (mg/l as N)			0.12	0.13	ND		mg/l	0.050
Nitrite Plus Nitrate (mg/l as N)			ND	ND	0.11		mg/l	
Phosphorus, Total (mg/l as P)			ND	ND	ND		mg/l	0.020
Hardness, Total (mg/l as Caco3)			510	510	480		mg/l	
Calcium, Total (mg/l as Ca)			140	140	120		mg/l	
Magnesium, Total (mg/l as Mg)			38	36	32		mg/l	
Sodium, Total (mg/l as Na)			62	59	53		mg/l	
Potassium, Total (mg/l as K)			3.6	3.6	4.1		mg/l	
Chloride,Total In Water			9.4	9.0	9.2		mg/l	
Sulfate, Total (mg/l as So4)			400	400	320		mg/l	
Fluoride, Total (mg/l as F)			0.63	0.7	0.71		mg/l	
Arsenic, Dissolved (ug/l as As)		ND	ND	ND	ND		ug/l	10
Arsenic, Total (ug/l as As)			ND	ND	ND		ug/l	10
Barium, Dissolved (ug/l as Ba)		140	ND	ND	110		ug/l	
Barium, Total (ug/l as Ba)			ND	ND	110		ug/l	
Beryllium, Dissolved (ug/l as Be)		ND	ND	ND	ND		ug/l	0.50
Beryllium, Total (ug/l as Be)			ND	ND	ND		ug/l	0.50
Boron, Total (ug/l as B)			120	ND	130		ug/l	
Cadmium, Dissolved (ug/l as Cd)		ND	ND	ND	ND		ug/l	1.0
Cadmium, Total (ug/l as Cd)			ND	ND	ND		ug/l	1.0
Chromium, Dissolved (ug/l as Cr)		ND	ND	ND	ND		ug/l	10
Chromium, Total (ug/l as Cr)			ND	ND	ND		ug/l	10
Copper, Dissolved (ug/l as Cu)		ND	ND	ND	ND		ug/l	10

Cienega Creek Location: T16S R17E S34 bca, in the lower basin on the preserve. SCCIE002.66. Data from ADEQ. Continued.

Parameter	Results						Units	Limits
Date Sampled	**12/11/00**	**12/12/00**	**2/22/01**	**4/17/01**	**9/18/01**	**12/17/01**		
Copper, Total (ug/l as Cu)			ND	ND	ND		ug/l	10
Iron, Total (ug/l as Fe)			ND	ND	ND		ug/l	100
Lead, Dissolved (ug/l as Pb)		ND	ND	ND	ND		ug/l	5.0
Lead, Total (ug/l as Pb)			ND	ND	ND		ug/l	5.0
Manganese, Total (ug/l as Mn)			ND	ND	65		ug/l	
Thallium, Dissolved (ug/l as Tl)		ND	ND	ND	ND		ug/l	2.0
Thallium, Total (ug/l as Tl)			ND	ND	ND		ug/l	2.0
Nickel, Dissolved (ug/l as Ni)		ND	ND	ND	ND		ug/l	100
Nickel, Total (ug/l as Ni)			ND	ND	ND		ug/l	100
Silver, Dissolved (ug/l as Ag)		ND	ND	ND	ND		ug/l	1.0
Silver, Total (ug/l as Ag)		ND	ND	ND	ND		ug/l	1.0
Zinc, Dissolved (ug/l as Zn)		ND	ND	ND	ND		ug/l	50
Zinc, Total (ug/l as Zn)			ND	ND	ND		ug/l	50
Antimony, Dissolved (ug/l as Sb)		ND	ND	ND	ND		ug/l	5.0
Antimony, Total (ug/l as Sb)			ND	ND	ND		ug/l	5.0
Selenium, Dissolved (ug/l as Se)		ND	ND	ND	ND		ug/l	5.0
Selenium, Total (ug/l as Se)			ND	ND	ND		ug/l	5.0
Solids,Total Dissolved mg/l	456			705	103	639	mg/l	
Mercury, Dissolved (ug/l as Hg)		ND	ND	ND	ND		ug/l	0.5
Mercury, Total (ug/l as Hg)			ND	ND	ND		ug/l	0.50
Turbidity,Lab Nephelometric,Ntu			0.15	1.4	0.3		Ntu	
Hardness,Total Calculated(Ca,Mg,Fe) As Caco3 mg/l			510	500	430		mg/l	
Flow, Rate	0.69			0.34	0.65	0.75	Ft/Sec	

ND= not detected; ug/L= micrograms/liter; mg/L= milligrams/liter

Cienega Creek Location T18S R17E S12 downstream of Pump Canyon (SCCIE010.20). Data from ADEQ.

Parameter	Results					Units	Limits
Date Sampled	**12/11/00**	**04/18/01**	**04/20/01**	**9/18/01**	**12/17/01**		
Stream Width (Feet)	8.3			1.5	3.5	Ft	
Temperature, Water ° C	10.99			19.64	8.92	° C	
Temperature, Air ° C	16			26	17	° C	
Flow, Stream, Instantaneous Cfs	2.24			0.8	1.38	Cfs	
Depth Of Stream, Mean (Ft)	0.55			0.53	0.66	Ft	
Turbidity,Hach Turbidimeter (Formazin Turb Unit)	1.75			9.89	1.99	Ntu	
Specific Conductance, Field ° C 25	359				564	Umhos/Cm	
Specific Conductance ° C 25	620	600	600	600		Umhos/Cm	
Oxygen, Dissolved mg/l	7.89			6.61	9.62	mg/l	
Oxygen, Dissolved, Saturation %	82.8			83.9	96	Percent	
Ph, Lab		8.2	8.2	8.2		Su	
Ph, Field	8.08			7.78	7.93	Su	
Alkalinity, Total (mg/l as Caco3)	270	260	260	250		mg/l	
Alkalinity, Phenolphthalein	ND	ND	ND	ND		mg/l	2.0
Bicarbonate Ion (mg/l as Hco3)	330	320	320	300		mg/l	
Carbonate Ion (mg/l as Co3)	ND	ND	ND	ND		mg/l	2.0
Nitrogen, Ammonia, Total (Mg/L as N)	ND	ND	ND	ND		mg/l	0.020
Nitrite Nitrogen, Total (mg/l As N)		ND	ND	ND		mg/l	0.020
Nitrate Nitrogen, Total (mg/l As N)		ND	ND	ND		mg/l	0.050
Nitrogen, Kjeldahl, Total, (mg/l as N)	170	0.16	0.16	83		mg/l	
Nitrite Plus Nitrate, Total (mg/l As N)	0.057	ND	ND	ND		mg/l	
Phosphorus, Total (Mg/L As P)	25	ND	ND	ND		mg/l	0.020
Hardness, Total (mg/l as Caco3)	210	200	200	210		mg/l	
Calcium, Total (mg/l As Ca)	59	58	58	63		mg/l	
Magnesium, Total (mg/l as Mg)	13	11	11	11		mg/l	
Sodium, Total (mg/l as Na)	58	55	55	50		mg/l	
Potassium, Total mg/l as K	2.6	2.1	2.1	2.2		mg/l	
Chloride,Total In Water mg/l	7.1	9	9	11		mg/l	
Sulfate, Total (mg/l as So4)	51	61	61	58		mg/l	
Fluoride, Total (mg/L As F)	0.4	0.39	0.39	0.39		mg/l	
Arsenic, Dissolved (ug/l as As)	ND	ND	ND	ND		ug/l	10
Arsenic, Total (ug/l as As)	ND	ND	ND	ND		ug/l	10

Cienega Creek Location T18S R17E S12 downstream of Pump canyon (SCCIE010.20). Data from ADEQ. Continued.

Parameter	Results					Units	Limits
Date Sampled	**12/11/00**	**04/18/01**	**04/20/01**	**09/18/01**	**12/17/01**		
Barium, Dissolved (ug/l as Ba)	0.22	180	ND	190		ug/l	
Barium, Total (ug/l as Ba)	210	180	180	180		ug/l	
Beryllium, Dissolved (ug/l as Be)	ND	ND	ND	ND		ug/l	0.50
Beryllium, Total (ug/l as Be)	ND	ND	ND	ND		ug/l	0.50
Boron, Total (ug/l As B)	140	150	ND	130		ug/l	
Cadmium, Dissolved (ug/l as Cd)	ND	ND	ND	ND		ug/l	1.0
Cadmium, Total (ug/l as Cd)	ND	ND	ND	ND		ug/l	1.0
Chromium, Dissolved (ug/l as Cr)	ND	ND	ND	ND		ug/l	10
Chromium, Total (ug/l as Cr)	ND	ND	ND	ND		ug/l	10
Copper, Dissolved (ug/l as Cu)	ND	ND	ND	ND		ug/l	10
Copper, Total (ug/l as Cu)	ND	ND	ND	ND		ug/l	10
Iron, Total (ug/l as Fe)	130	130	ND	230		ug/l	
Lead, Dissolved (ug/l as Pb)	ND	ND	ND	ND		ug/l	5.0
Lead, Total (ug/l As Pb)	ND	ND	ND	ND		ug/l	5.0
Manganese, Total (ug/l as Mn)	110	52	ND	130		ug/l	
Thallium, Dissolved (ug/l as Tl)	ND	ND	ND	ND		ug/l	2.0
Thallium, Total (ug/l as Tl)	ND	ND	ND	ND		ug/l	2.0
Nickel, Dissolved (ug/l as Ni)	ND	ND	ND	ND		ug/l	100
Nickel, Total (ug/l as Ni)	ND	ND	ND	ND		ug/l	100
Silver, Dissolved (ug/l as Ag)	ND	ND	ND	ND		ug/l	1.0
Silver, Total (ug/l as Ag)	ND	ND	ND	ND		ug/l	1.0
Zinc, Dissolved (ug/l as Zn)	ND	ND	ND	ND		ug/l	50
Zinc, Total (ug/l as Zn)	ND	ND	ND	ND		ug/l	50
Antimony, Dissolved (ug/l as Sb)	ND	ND	ND	ND		ug/l	5.0
Antimony, Total (ug/l as Sb)	ND	ND	ND	ND		ug/l	5.0
Selenium, Dissolved (ug/l as Se)	ND	ND	ND	ND		ug/l	5.0
Selenium, Total (ug/l as Se)	ND	ND	ND	ND		ug/l	5.0
Solids,Total Dissolved mg/l	230			97.7	361	mg/l	
Mercury, Dissolved (ug/l as Hg)	ND	ND	ND	ND		ug/l	0.5
Mercury, Total (ug/l as Hg)	ND	ND	ND	ND		ug/l	0.50
Turbidity,Lab Nephelometric, Ntu	1	3.1	3.1	7		Ntu	
Hardness,Total Calculated(Ca,Mg,Fe) as Caco3 mg/l	230	190	190	200		mg/l	
Flow, Rate	0.51			0.51	0.42	Ft/Sec	

ND=not detected; mg/l= milligrams/liter; ug/l= micrograms/liter

Cienega Creek Location: In the upper basin on BLM property. T19S R17E S13 aac. Downstream of Oak Creek Canyon (SCCIE014.39). Data from ADEQ.

Parameter	Results					Units	Limits
Date Sampled	**12/11/00**	**2/16/01**	**7/19/01**	**9/18/01**	**12/17/01**		
Stream Width (Feet)	4.5			1.7	1.8	Ft	
Temperature, Water ° C	4.95			18.42	2.35	° C	
Temperature, Air ° C	11			16	18	° C	
Flow, Stream, Instantaneous	0.63			0.24	1.05	Cfs	
Depth Of Stream, Mean (Ft)	0.21			0.22	0.16	Ft	
Turbidity,Hach Turbidimeter (Formazin Turb Unit)	8.85			13.3	3.66	Ntu	
Specific Conductance, Field 25 ° C	393			593	607	umhos/Cm	
Specific Conductance ° C 25	680	460	680	620		umhos/Cm	
Oxygen, Dissolved	6.44			6.09	9.55	mg/l	
Oxygen, Dissolved Saturation %	57.1			76.2	81.2	Percent	
Ph, Lab		8.1	8.2	8.4		Su	
Ph, Field	7.81			8.01	8	Su	
Alkalinity, Total (mg/l as Caco3)		250	340			mg/l	
Alkalinity, Phenolphthalein (mg/l)	ND	ND	ND	3.9		mg/l	
Bicarbonate Ion (mg/l as Hco3)	415	300	410	380		mg/l	
Carbonate Ion (mg/l as Co3)	ND	ND	ND	4.7		mg/l	
Nitrogen, Ammonia, Total (mg/l as N)	ND	ND	ND			mg/l	0.020
Nitrite Nitrogen, Total (mg/l as N)			ND			mg/l	0.020
Nitrate Nitrogen, Total (mg/l as N)		ND	ND			mg/l	0.050
Nitrogen, Kjeldahl, Total, (mg/l as N)	0.24	0.1	0.28			mg/l	
Nitrite Plus Nitrate, Total (mg/l as N)	0.13		ND	ND		mg/l	0.050
Phosphorus, Total (mg/l as P)	0.076	ND	0.071			mg/l	
Hardness, Total (mg/l as Caco3)	280	200	220	220		mg/l	
Calcium, Total (mg/l as Ca)	71	58	68	66		mg/l	
Magnesium, Total (mg/l as Mg)	15	13	15	12		mg/l	
Sodium, Total (mg/l as Na)	67	62	74	54		mg/l	
Potassium, Total (mg/l as K)	3.7	2.2	2.4	5		mg/l	
Chloride,Total In Water	8.8	13	11	13		mg/l	
Sulfate, Total (mg/l as So4)	27	34	37	5.7		mg/l	
Fluoride, Total (mg/l as F)	0.35	0.21	0.36	0.3		mg/l	
Arsenic, Dissolved(ug/l as As)	ND	ND	ND	ND		ug/l	10
Arsenic, Total (ug/l as As)	ND	ND	ND	ND		ug/l	10
Barium, Dissolved (ug/l as Ba)	270	250	ND	300		ug/l	
Barium, Total (ug/l as Ba)	280	140	250	290		ug/l	
Beryllium, Dissolved (ug/l as Be)	ND	ND	ND	ND		ug/l	0.50
Beryllium, Total (ug/l as Be)	ND	ND	ND	ND		ug/l	0.50
Boron, Total (ug/l as B)	110	ND	130	110		ug/l	
Cadmium, Dissolved (ug/l as Cd)	ND	ND	ND	ND		ug/l	1.0
Cadmium, Total (ug/l as Cd)	ND	ND	ND	ND		ug/l	1.0
Chromium, Dissolved (ug/l as Cr)	ND	ND	ND	ND		ug/l	10
Chromium, Total (ug/l as Cr)	ND	ND	ND	ND		ug/l	10

Cienega Creek Location: In the upper basin on BLM property. T19S R17E S13 aac. Downstream of Oak Creek Canyon (SCCIE014.39). Data from ADEQ. Continued.

Parameter	Results					Units	Limits
Date Sampled	**12/11/00**	**2/16/01**	**7/19/01**	**9/18/01**	**12/17/01**		
Copper, Dissolved (ug/l as Cu)	ND	ND	ND	ND		ug/l	10
Copper, Total (ug/l as Cu)	ND	ND	ND	ND		ug/l	10
Iron, Total (ug/l as Fe)	560	330	350	320		ug/l	
Lead, Dissolved (ug/l as Pb)	ND	ND	ND	ND		ug/l	5.0
Lead, Total (ug/l as Pb)	ND	ND	ND	ND		ug/l	5.0
Manganese, Total (ug/l as Mn)	350	230	180	59		ug/l	
Thallium, Dissolved (ug/l as Tl)	ND	ND	ND	ND		ug/l	2.0
Thallium, Total (ug/l as Tl)	ND	ND	ND	ND		ug/l	2.0
Nickel, Dissolved (ug/l as Ni)	ND	ND	ND	ND		ug/l	100
Nickel, Total (ug/l as Ni)	ND	ND	ND	ND		ug/l	100
Silver, Dissolved (ug/l as Ag)	ND	ND	ND	ND		ug/l	1.0
Silver, Total (ug/l as Ag)	ND	ND	ND	ND		ug/l	1.0
Zinc, Dissolved (ug/l as Zn)	ND	ND	ND	ND		ug/l	50
Zinc, Total (ug/l as Zn)	ND	ND	ND	ND		ug/l	50
Antimony, Dissolved (ug/l as Sb)	ND	ND	ND	ND		ug/l	5.0
Antimony, Total (ug/l as Sb)	ND	ND	ND	ND		ug/l	5.0
Selenium, Dissolved (ug/l as Se)	ND	ND	ND	ND		ug/l	5.0
Selenium, Total (ug/l as Se)	ND	ND	ND	ND		ug/l	5.0
Solids,Total Dissolved	251			279	389	mg/l	
Mercury, Dissolved (ug/l as Hg)	ND	ND	ND	ND		ug/l	0.5
Mercury, Total (ug/l as Hg)	ND	ND	ND	ND		ug/l	0.50
Turbidity,Lab Nephelometric Turbidity Units, Ntu	6.9	9.5	2.9	8.4		Ntu	
Hardness,Total Calculated(Ca,Mg,Fe) As Caco3 mg/l	270	200	230	210		mg/l	
Flow, Rate	0.56			0.24	0.62	Ft/Sec	

ND= not detected, mg/l= milligrams per liter, ug/l= micrograms/liter

Water Quality Data for Quitobaquito Pond and Spring. Data provided by Organ Pipe Cactus National Monument.

Sample Location	Parameter	Date Sampled							
Quitobaquito mid-ch pool		**2/11/98**	**6/24/98**	**6/25/98**	**9/24/98**	**9/25/98**	**2/17/99**	**6/24/99**	**9/24/99**
	pH	8.01	7.88			8.06	8.05	7.88	8.06
	Conductivity	1178	1374			1127	1143	1158	
	DO mg/l	7.5	5.86	6.57/6.84		7.17	7.48	6.95	8.16
	Alkalinity Total	256							
	Water Temperature	24	25.5	24.1/24.9		27	23.8	26.4	28
	Air Temperature		35						
Quitobaquito Pond- boat launch		**2/11/98**	**6/24/98**	**6/25/98**	**9/24/98**	**9/25/98**	**2/17/99**	**6/24/99**	**9/24/99**
	pH	8.81	9.56	9.53	9.6		8.99	9.79	9.88
	Conductivity	1170	1591	1328	1365		1159	1552	
	DO mg/l	10.83	15.30	6.72	1.49		14.30	11.60	13.44
	Alkalinity Total		252						181
	Water Temperature	17.5		26.7	26		15	33.26	34.5
	Air Temperature						25.8		

Sample Location	Parameter					
Quitobaquito Pond Deepest area		**6/24/98**	**6/25/98 no vegetation**	**6/25/98 vegetation**	**9/24/98 open**	**9/24/98 shade**
	pH	9.52			9.44	9.39
	Conductivity	1624			1394	1415
	DO mg/l	13.90	5.39	9.22/6.40	8.71	4.25
	Alkalinity Total					
	Water Temperature	31.5	25.7	27.6/26.2	26	25
	Air Temperature					

Water Quality Data for Quitobaquito Pond and Spring. Data provided by Organ Pipe National Monument. Continued.

Sample Location	Parameter	Date Sampled							
Quitobaquito Pond-middle		**6/24/98**	**6/25/98 vegetation**	**6/25/98 no vegetation**	**9/24/98**	**9/25/98**	**2/17/99**	**6/24/99**	**9/24/99**
	pH	9.56			9.45		8.95	9.71	9.44
	Conductivity	1591			1363		1175	1333	
	DO mg/l	15.30	9.95	9.76/7.73	7.51/9.5-10.5		15.43	15.90	15.21
	Alkalinity Total								
	Water Temperature	32	26.6	27.6/25.8	26		18	33.6	32.9
	Air Temperature	28			30				

Sample Location	Parameter								
Quitobaquito SW Spring		**2/11/98**	**6/24/98**	**6/25/98**	**6/25/98**	**9/25/98**	**2/17/99**	**6/24/99**	**9/24/99**
	pH	7.54*	7.54			7.59	7.52	7.48	7.51
	Conductivity	1112	1355			1132	1148	1160	
	DO mg/l	6.03	4.83	5.29	5.13	5.68	5.60	5.92	5.93
	Alkalinity Total	254				176	222		209
	Water Temperature	24.9	25.1	25.4	25.5	27	24.4	26	28
	Air Temperature								

*- average of four pH values

Chemical Constituents in Water at Quitobaquito, Arizona. From Description and Conservation Status of *Cyprinodan macularius eremus*. A New Subspecies of Pupfish from Organ Pipe Cactus National Monument, Arizona. Miller and Fuiman, 1987.

*Parameter	Quitobaquito Pond, 1982,	Quitobaquito Pond, 1963,1964	Quitobaquito Spring, 1982	Quitobaquito Spring, 1963-64
TDS	820		670	
TSS	<10		<10	
pH	9.22		8.07	
HCO3	220	411	300	316-402
F	4.9	5.3	4.1	4.3
Cl	190	383	150	148-318
PO4	<0.50		<0.50	
NO3	<0.50		9.9	
SO4	110	100	95	71-91
Na	230	350	188	191-284
K	3.1	7.0	2.7	4.5-6.0

No units were included in the journal article for this data, convention is mg/l for these parameters except pH, which is in standard units.

Sabino Canyon below Summerhaven. Data from ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Specific Conductivity	Standard	3/17/92	--	111	umhos/cm	--
Total Dissolved Solids	Dissolved	3/17/92	--	94	mg/l	--
Total Suspended Solids	Suspended	3/17/92	--	6	mg/l	--
Fecal Streptococci	Total	3/17/92	--	2	CFU/100	--
Calcium Carbonate	Total	3/17/92	--	38	mg/l	--
Fecal Coliform	Total	3/17/92	K	2	CFU/100	--
Temperature	Water	3/17/92	--	3.0	°C	--
Bicarbonate	Total	3/17/92	--	46	mg/l	--
Potassium	Total	3/17/92	--	1.23	mg/l	--
Magnesium	Total	3/17/92	--	2.5	mg/l	--
Chloride	Total	3/17/92	--	4.6	mg/l	--
Turbidity	Total	3/17/92	--	8.5	NTU	--
Calcium	Total	3/17/92	--	13.4	mg/l	--
Manganese	Total	3/17/92	--	70	ug/l	--
Carbonate	Total	3/17/92	--	1	mg/l	--
Sodium	Total	3/17/92	--	5	mg/l	--
Iron	Total	3/17/92	--	590	ug/l	--
pH	Total	3/17/92	--	7.36	SU	--
Alkalinity, Phenolphthalein	Total	3/17/92	--	ND	mg/l	2
Kjeldahl Nitrogen	Total	3/17/92	--	0.19	mg/l	--
Ammonia As N	Total	3/17/92	--	ND	mg/l	0.1
Nitrate + Nitrite	Total	3/17/92	--	ND	mg/l	0.1
Phosphorus	Total	3/17/92	--	ND	mg/l	0.1
Fluoride	Total	3/17/92	--	ND	mg/l	0.2
Sulfate	Total	3/17/92	--	ND	mg/l	10
Boron (Boron And	Total	3/17/92	--	ND	ug/l	100

Sabino Canyon below Summerhaven. Data from ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Borates Only)						
Lead And Compounds	Total	3/17/92	--	ND	ug/l	10
Beryllium And Compounds	Total	3/17/92	--	ND	ug/l	0.5
Barium And Compounds	Total	3/17/92	--	ND	ug/l	100
Selenium And Compounds	Total	3/17/92	--	ND	ug/l	5
Mercury, Elemental	Total	3/17/92	--	ND	ug/l	0.5
Arsenic, Inorganic	Total	3/17/92	--	ND	ug/l	10
Strontium	Total	3/17/92	--	ND	ug/l	100
Chromium	Total	3/17/92	--	ND	ug/l	10
Antimony	Total	3/17/92	--	ND	ug/l	5
Thallium	Total	3/17/92	--	ND	ug/l	5
Nickel	Total	3/17/92	--	ND	ug/l	100
Cadmium	Total	3/17/92	--	ND	ug/l	1
Copper	Total	3/17/92	--	ND	ug/l	10
Silver	Total	3/17/92	--	ND	ug/l	1
Zinc	Total	3/17/92	--	ND	ug/l	50

ND= not detected, K= Actual value is known to be less than the value given

Water Quality Data for Sabino Canyon, Site # SCSAB004.39, In Recreation Area. From ADEQ.

PARAMETER	SAMPLE DATE	RESULT	UNITS	DATA CODE	REPORTING LIMITS
Stream Width	04/18/01	39.7	FT		
Temperature, water	04/18/01	15.4	° C		
Flow, Stream instantaneous	04/18/01	29.53	CFS		
Depth of stream (mean)	04/18/01	1.33	FT		
Specific Conductance, Field	04/18/01	53	umhos/cm		
Specific Conductance	04/18/01	56	umhos/cm		
Oxygen Dissolved %	04/18/01	96.7	percent		
pH, FIELD	04/18/01	6.9	SU		
Alkalinity, Total (mg/l as CaCO3)	04/18/01	13	mg/l		
Bicarbonate ion	04/18/01	16	mg/l		
Carbonate ion	04/18/01		mg/l	ND	2.0
Nitrogen, Ammonia, Total	04/18/01		mg/l	ND	0.020
Nitrite, Nitrogen, Total	04/18/01		mg/l	ND	0.050
Nitrate, Nitrogen, Total	04/18/01	0.061	mg/l		
Nitrite+Nitrate, Total	04/18/01	0.061	mg/l		
Phosphorous, Total	04/18/01		mg/l	ND	0.020
Hardness, Total as mg/l CaCO3	04/18/01	18	mg/l		
Calcium, Total	04/18/01	5.3	mg/l		

Water Quality Data for Sabino Canyon, Site # SCSAB004.39, In Recreation Area. From ADEQ.

PARAMETER	SAMPLE DATE	RESULT	UNITS	DATA CODE	REPORTING LIMITS
Sodium, Total	04/18/01		mg/l	ND	5.0
Potassium, Total	04/18/01	0.71	mg/l		
Chloride in water, Total	04/18/01	3.4	mg/l		
Sulfate, Total	04/18/01	4	mg/l		
Arsenic Dissolved	04/18/01		ug/l	ND	10
Arsenic, Total	04/18/01		ug/l	ND	10
Barium, Dissolved	04/18/01		ug/l	ND	100
Barium, Total	04/18/01		ug/l	ND	100
Beryllium, Total	04/18/01		ug/l	ND	0.50
Boron, Total	04/18/01		ug/l	ND	100
Cadmium, Dissolved	04/18/01		ug/l	ND	1.0
Cadmium, Total	04/18/01		ug/l	ND	1.0
Chromium, Total	04/18/01		ug/l	ND	10
Copper, Dissolved	04/18/01		ug/l	ND	10
Copper, Total	04/18/01		ug/l	ND	10
Iron, Total	04/18/01	260	ug/l		
Lead, Total	04/18/01		ug/l	ND	5.0
Manganese, Total	04/18/01		ug/l	ND	50
Thallium, Total	04/18/01		ug/l	ND	2.0
Silver, Dissolved	04/18/01		ug/l	ND	1.0
Silver, Total	04/18/01		ug/l	ND	1.0
Zinc, Dissolved	04/18/01		ug/l	ND	50
Zinc, Total	04/18/01		ug/l	ND	50
Antimony, Total	04/18/01		ug/l	ND	5.0
Selenium, Dissolved	04/18/01		ug/l	ND	5.0
Selenium, total	04/18/01		ug/l	ND	5.0
Hardness, Ca, Mg Calculated (mg/l as CaCO3)	04/18/01	19	mg/l		
TDS (Elect-Conductivity)	04/18/01	33.7	mg/l		
Mercury, Dissolved	04/18/01		ug/l	ND	0.50
Turbidity, Field, NTU	04/18/01	3.44	NTU		

ND= not detected

San Pedro River Water Quality Data From PAG Report---Bingham Cienega Source Water.

San Pedro River	11/23/1998	03/19/1999	06/15/1999	09/10/1999	11/20/1999	03/30/2000	06/09/2000
Silicon, dissolved	14	13	13	13	12	15	15
Aluminum, dissolved	0	0	0	0	0	--	--
Calcium , dissolved	65	74	52	55	73	58	68
Magnesium, dissolved	15	17	14	16	16	16	15
Manganese, dissolved	0	0.01	0	0	0	0	0
Potassium , dissolved	0	4.6	0	6.6	4	0	0
Sodium , dissolved	50	56	51	56	56	56	60
Arsenic , dissolved	0.0054	0.005	0	0.005	0	0	0
Chloride, dissolved	15	--	17.2	19	19	18	17
Sulfate, dissolved	81.8	89.8	92.5	99	100	83	85
Fluoride , dissolved	0.8	--	--	0.8	1	1	1
Alk. as CaCO3	230	224	212	180	250	230	230
Lab TDS	370	370	390	300	340	250	390
Lab Conductivity	590	630	620	670	630	610	680
Lab pH	8.2	8.6	7.9	8	8	8	8

All results are in mg/l except pH (su) and conductivity (mmhos).

Water Quality Data for San Pedro River Near Redington. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMITS
Boron (Boron And Borates Only)	Total	8/13/91	K	100	ug/l	--
Lead And Compounds (Inorganic)	Total	8/13/91	--	5	ug/l	--
Specific Conductivity	Standard	8/13/91	--	550	umhos/cm	--
Specific Conductivity	Standard	8/13/91	--	590	umhos/cm	--
Alkalinity, Phenolphthalein	Total	8/13/91	--	0.5	mg/l	--
Total Dissolved Solids	Dissolved	8/13/91	--	340	mg/l	--
Total Suspended Solids	Suspended	8/13/91	--	80	mg/l	--
Dissolved Oxygen	Standard	8/13/91	--	109.9	percent	--
Dissolved Oxygen	Dissolved	8/13/91	--	7.20	mg/l	--
Fecal Streptococci	Total	8/13/91	--	128	CFU/100	--
Beryllium And Compounds	Total	8/13/91	K	5	ug/l	--
Ammonia As Nitrogen	Total	8/13/91	K	0.03	mg/l	--
Selenium And Compounds	Total	8/13/91	K	5	ug/l	--
Barium and Compounds	Total	8/13/91	--	99	ug/l	--
Nitrate + Nitrite	Total	8/13/91	--	0.40	mg/l	--
Mercury, Elemental	Total	8/13/91	K	0.2	ug/l	--
Kjeldahl Nitrogen	Total	8/13/91	--	0.3	mg/l	--
Calcium Carbonate	Total	8/13/91	--	183	mg/l	--
Temperature	Air	8/13/91	--	33.0	° C	--
Fecal Coliform	Total	8/13/91	--	60	CFU/100	--
Arsenic, Inorganic	Total	8/13/91	K	5	ug/l	--

Water Quality Data for San Pedro River Near Redington. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMITS
Stream Width	Standard	8/13/91	--	16.7	FT	--
Temperature	Water	8/13/91	--	32.0	° C	--
Phosphorus	Total	8/13/91	--	0.09	mg/l	--
Stream Depth	Total	8/13/91	--	0.24	FT	--
Bicarbonate	Total	8/13/91	--	183	mg/l	--
Magnesium	Total	8/13/91	--	12.9	mg/l	--
Carbonate	Total	8/13/91	--	0.5	mg/l	--
Hydroxide	Total	8/13/91	--	0.5	mg/l	--
Fluoride	Total	8/13/91	--	0.82	mg/l	--
Potassium	Total	8/13/91	--	4.4	mg/l	--
Strontium	Total	8/13/91	--	600	ug/l	--
Calcium	Total	8/13/91	--	57.4	mg/l	--
Manganese	Total	8/13/91	--	77	ug/l	--
Flow		8/13/91	--	1.11	FT/SEC	--
Flow		8/13/91	--	4.60	CFS	--
Chloride	Total	8/13/91	--	15	mg/l	--
Turbidity	Total	8/13/91	--	37	NTU	--
Sodium	Total	8/13/91	--	46.0	mg/l	--
Chromium	Total	8/13/91	K	10	ug/l	--
Antimony	Total	8/13/91	K	50	ug/l	--
Sulfate	Total	8/13/91	--	87	mg/l	--
Thallium	Total	8/13/91	K	5	ug/l	--
Iron	Total	8/13/91	--	2160	ug/l	--
Cadmium	Total	8/13/91	K	5	ug/l	--
Copper	Total	8/13/91	K	10	ug/l	--
Silver	Total	8/13/91	K	10	ug/l	--
Nickel	Total	8/13/91	K	20	ug/l	--
Zinc	Total	8/13/91	--	14	ug/l	--
pH- field	Total	8/13/91	--	8.40	SU	--
pH-lab	Total	8/13/91	--	8.2	SU	--

K= Actual value is known to be less than value given, method detection limit is listed in result column.

Nutrient Parameters from the Santa Cruz River at Cortaro Road, 1997 From USGS on-line database.

Parameter	Dates sampled	Result Range
Nitrogen, Ammonia, Dissolved	2/22/96-1/16/97	1.0-34.0 mg/l
Nitrite, Dissolved	2/22/96-1/16/97	0.7-0.98 mg/l
Nitrogen Ammonia + organic dissolved	2/22/96-1/16/97	20-38 mg/l
Nitrogen Ammonia + organic, total	2/22/96-1/16/97	22-38 mg/l
Nitrite + Nitrate, Dissolved	2/22/96-1/16/97	0.09-1.5 mg/l
Phosphorous, Total	2/22/96-1/16/97	3.4-5.2 mg/l
Phosphorous, Dissolved	2/22/96-1/16/97	2.8-4.2 mg/l

Total number of sampling events: 12

Major ions from the Santa Cruz River at Cortaro Road, 1997 From USGS on-line database.

Parameter	Sample Date Range	Result Range
Bicarbonate, Dissolved, Field	2/22/96—1/16/97	268—340 mg/l
Calcium, Dissolved	2/22/96—1/16/97	40—46 mg/l
Magnesium, Dissolved	2/22/96—1/16/97	5.5—6.8 mg/l
Sodium, Dissolved	2/22/96—1/16/97	100—120 mg/l
Potassium, Dissolved	2/22/96—1/16/97	13—15 mg/l
Chloride, Dissolved	2/22/96—1/16/97	76—95 mg/l
Sulfate, Dissolved	2/22/96—1/16/97	82—110 mg/l
Fluoride, Dissolved	2/22/96—1/16/97	0.5—1.0 mg/l
Silica, Dissolved	2/22/96—1/16/97	34—38 mg/l

Total number of sampling events: 12

Physical Properties of water in the Santa Cruz River at Cortaro Road, USGS on-line database.

Parameter	Sample Date Range	Result Range
Temperature, Water	2/22/96—1/16/97	17.5—29.7 °C
Specific Conductance	2/22/96—1/16/97	956—1063 μmhos/cm
Oxygen, Dissolved	2/22/96—1/16/97	2.0—3.7 mg/l
pH, Field	2/22/96—1/16/97	7.4—7.8
Alkalinity	2/22/96—1/16/97	220—279

Number of sampling events: 12

Summary of Dissolved Oxygen Field Measurements in the Santa Cruz River. Data from Pima County Wastewater Management Department, 2001.

Sample Location	Sample Date	# of Miles downstream from Roger Rd WWTP	# of Miles downstream from Ina Road WPCF	Dissolved Oxygen (mg/l)
SC-01	1/24/01	0.60	--	5.36
	8/13/01			5.47
SC-02	2/28/01	2.93	--	8.43
	8/13/01			4.83
SC-03	1/24/01	5.93	0.08	7.49
	2/28/01			10.13
	8/13/01			5.18
SC-04	8/13/01	7.70	1.85	3.28
SC-05	1/24/01	8.94	3.09	5.36
	8/14/01			4.83
SC-06	8/14/01	10.02	4.17	5.05
SC-07	1/24/01	12.11	6.26	6.81
	8/17/01			4.56
SC-08	2/13/01	13.23	7.38	6.58
	5/10/01			7.08
	8/16/01			4.31
SC-09	2/13/01	16.65	10.80	6.73
	5/10/01			8.99
	8/16/01			8.51
SC-10	2/13/01	17.93	12.08	7.92
	5/10/01			8.97
	8/16/01			7.88

Note: Samples are collected as a grab sample from a free flow portion of the stream. Each sample location is adjacent to groundwater monitor well locations.

Santa Cruz River at Cortaro Road, Water Quality. Data from ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Boron (Boron And Borates Only)	Dissolved	9/22/93	--	340	ug/l	--
Boron (Boron And Borates Only)	Total	9/22/93	--	390	ug/l	--
Specific Conductivity	Standard	9/22/93	--	1130	umhos/cm	--
Specific Conductivity	Standard	9/22/93	--	124	umhos/cm	--
Total Dissolved Solids	Dissolved	9/22/93	--	713	mg/l	--
Total Suspended Solids	Suspended	9/22/93	--	29	mg/l	--
Dissolved Oxygen	Standard	9/22/93	--	50.0	percent	--
Dissolved Oxygen	Dissolved	9/22/93	--	4.01	mg/l	--
Ammonia As Nitrogen	Total	9/22/93	--	16.4	mg/l	--
Nitrate + Nitrite	Total	9/22/93	--	1.16	mg/l	--
Kjeldahl Nitrogen	Total	9/22/93	--	21.1	mg/l	--
Calcium Carbonate	Total	9/22/93	--	204	mg/l	--
Stream Width	Standard	9/22/93	--	15.7	FT	--
Temperature	Air	9/22/93	--	22	° C	--
Strontium	Dissolved	9/22/93	--	660	ug/l	--
Manganese	Dissolved	9/22/93	--	50	ug/l	--
Phosphorus	Total	9/22/93	--	4.97	mg/l	--
Temperature	Water	9/22/93	--	22	° C	--
Bicarbonate	Total	9/22/93	--	249	mg/l	--
Stream Depth	Total	9/22/93	--	0.5	FT	--
Potassium	Total	9/22/93	--	16.9	mg/l	--
Magnesium	Total	9/22/93	--	18.1	mg/l	--
Fluoride	Total	9/22/93	--	0.52	mg/l	--
Turbidity	Total	9/22/93	--	13.8	NTU	--
Turbidity	Total	9/22/93	--	19.3	NTU	--
Strontium	Total	9/22/93	--	640	ug/l	--
Flow		9/22/93	--	18.88	CFS	--
Calcium	Total	9/22/93	--	58.3	mg/l	--
Manganese	Total	9/22/93	--	70	ug/l	--
Iron	Dissolved	9/22/93	--	100	ug/l	--
Chloride	Total	9/22/93	--	121	mg/l	--
Flow		9/22/93	--	2.25	FT/SEC	--
Sulfate	Total	9/22/93	--	209	mg/l	--
Sodium	Total	9/22/93	--	148	mg/l	--
Silver	Total	9/22/93	--	1	ug/l	--
Copper	Total	9/22/93	--	17	ug/l	--
Iron	Total	9/22/93	--	460	ug/l	--
Zinc	Total	9/22/93	--	70	ug/l	--
pH	Total	9/22/93	--	7.38	SU	--
pH	Total	9/22/93	--	7.79	SU	--
Alkalinity, Phenolphthalein	Total	9/22/93	--	ND	mg/l	2
Carbonate	Total	9/22/93	--	ND	mg/l	2
Lead And Compounds (Inorganic)	Dissolved	9/22/93	--	ND	ug/l	5
Lead And Compounds (Inorganic)	Total	9/22/93	--	ND	ug/l	5

Santa Cruz River at Cortaro Road, Water Quality. Data from ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Beryllium And Compounds	Dissolved	9/22/93	--	ND	ug/l	0.5
Barium And Compounds	Dissolved	9/22/93	--	ND	ug/l	100
Selenium And Compounds	Dissolved	9/22/93	--	ND	ug/l	5
Beryllium And Compounds	Total	9/22/93	--	ND	ug/l	0.5
Mercury, Elemental	Dissolved	9/22/93	--	ND	ug/l	0.5
Arsenic, Inorganic	Dissolved	9/22/93	--	ND	ug/l	10
Barium And Compounds	Total	9/22/93	--	ND	ug/l	100
Selenium And Compounds	Total	9/22/93	--	ND	ug/l	5
Mercury, Elemental	Total	9/22/93	--	ND	ug/l	0.5
Arsenic, Inorganic	Total	9/22/93	--	ND	ug/l	10
Chromium	Dissolved	9/22/93	--	ND	ug/l	10
Antimony	Dissolved	9/22/93	--	ND	ug/l	5
Thallium	Dissolved	9/22/93	--	ND	ug/l	5
Nickel	Dissolved	9/22/93	--	ND	ug/l	100
Cadmium	Dissolved	9/22/93	--	ND	ug/l	1
Copper	Dissolved	9/22/93	--	ND	ug/l	10
Silver	Dissolved	9/22/93	--	ND	ug/l	1
Zinc	Dissolved	9/22/93	--	ND	ug/l	50
Chromium	Total	9/22/93	--	ND	ug/l	10
Antimony	Total	9/22/93	--	ND	ug/l	5
Thallium	Total	9/22/93	--	ND	ug/l	5
Nickel	Total	9/22/93	--	ND	ug/l	100
Cadmium	Total	9/22/93	--	ND	ug/l	1

ND= not detected

Tanque Verde Creek at Sabino Canyon Road. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Specific Conductivity	Standard	8/1/89	--	99.9	umhos/cm	--
Boron (Boron And Borates Only)	Total	8/1/89	K	100	ug/l	--
Specific Conductivity	Standard	8/1/89	--	110	umhos/cm	--
Alkalinity, Phenolphthalein	Total	8/1/89	--	0.5	mg/l	--
Lead And Compounds (Inorganic)	Total	8/1/89	K	2	ug/l	--
Total Dissolved Solids	Dissolved	8/1/89	--	90	mg/l	--
Total Suspended Solids	Suspended	8/1/89	--	5	mg/l	--
Dissolved Oxygen	Standard	8/1/89	--	95.9	percent	--
Ammonia As Nitrogen	Total	8/1/89	--	0.25	mg/l	--
Beryllium And Compounds	Total	8/1/89	K	5	ug/l	--
Dissolved Oxygen	Dissolved	8/1/89	--	6.6	mg/l	--
Selenium And Compounds	Total	8/1/89	K	5	ug/l	--

Tanque Verde Creek at Sabino Canyon Road. From ADEQ.

PARAMETER	TYPE OF SAMPLE	SAMPLE DATE	DATA CODE	RESULT	UNITS	REPORTING LIMIT
Barium And Compounds	Total	8/1/89	K	20	ug/l	--
Nitrate + Nitrite	Total	8/1/89	K	0.06	mg/l	--
Mercury, Elemental	Total	8/1/89	K	0.2	ug/l	--
Kjeldahl Nitrogen	Total	8/1/89	--	0.5	mg/l	--
Calcium Carbonate	Total	8/1/89	--	32	mg/l	--
Arsenic, Inorganic	Total	8/1/89	K	5	ug/l	--
Temperature	Water	8/1/89	--	30.5	°C	--
Stream Width	Standard	8/1/89	--	22	FT	--
Phosphorus	Total	8/1/89	--	0.12	mg/l	--
Stream Depth	Total	8/1/89	--	0.31	FT	--
Bicarbonate	Total	8/1/89	--	32	mg/l	--
Fluoride	Total	8/1/89	--	0.12	mg/l	--
Carbonate	Total	8/1/89	--	0.5	mg/l	--
Hydroxide	Total	8/1/89	--	0.5	mg/l	--
Magnesium	Total	8/1/89	--	1.8	mg/l	--
Potassium	Total	8/1/89	--	2.1	mg/l	--
Chloride	Total	8/1/89	--	3.7	mg/l	--
Turbidity	Total	8/1/89	--	4.8	NTU	--
Manganese	Total	8/1/89	--	11	ug/l	--
Calcium	Total	8/1/89	--	11.2	mg/l	--
Strontium	Total	8/1/89	--	70	ug/l	--
Flow		8/1/89	--	0.94	FT/SEC	--
Flow		8/1/89	--	6.26	CFS	--
Sodium	Total	8/1/89	--	6.6	mg/l	--
Antimony	Total	8/1/89	K	10	ug/l	--
Sulfate	Total	8/1/89	--	13	mg/l	--
Chromium	Total	8/1/89	K	20	ug/l	--
Cadmium	Total	8/1/89	--	5	ug/l	--
Thallium	Total	8/1/89	K	5	ug/l	--
Copper	Total	8/1/89	K	10	ug/l	--
Silver	Total	8/1/89	K	10	ug/l	--
Nickel	Total	8/1/89	K	30	ug/l	--
Iron	Total	8/1/89	--	204	ug/l	--
Zinc	Total	8/1/89	--	18	ug/l	--
pH	Total	8/1/89	--	7.6	SU	--
pH	Total	8/1/89	--	8.4	SU	--

K= Actual value is known to be less than the value given, method detection limit is listed in the result column.

Nutrient Parameters from the Tanque Verde Creek. From USGS on-line database.

Parameter	Dates sampled	Result Range
Nitrogen, Ammonia, Dissolved	1/5/1991-9/3/1994	0.01-.5
Nitrite, Dissolved	1/5/1991-9/3/1994	<0.01-0.02
Nitrogen Ammonia + organic, total	1/5/1991-9/3/1994	0.2-1.1
Nitrite + Nitrate, Dissolved	1/5/1991-9/3/1994	0.077-0.37
Phosphorous, Total	1/5/1991-9/3/1994	0.02-0.59
Phosphorous, Dissolved	1/5/1991-9/3/1994	<0.01-0.29

Total number of sampling events: 7

Major ions from the Tanque Verde Creek. From USGS on-line database.

Parameter	Sample Date Range	Result Range
Bicarbonate, Dissolved, Field	7/7/1990-9/3/94	15-68
Calcium, Dissolved	7/7/1990-9/3/94	4.3-25
Magnesium, Dissolved	7/7/1990-9/3/94	1.0-4.6
Sodium, Dissolved	7/7/1990-9/3/94	4.1-10
Potassium, Dissolved	7/7/1990-9/3/94	0.7-6.5
Chloride, Dissolved	7/7/1990-9/3/94	2.1-7.2
Sulfate, Dissolved	7/7/1990-9/3/94	4.5-13
Fluoride, Dissolved	7/7/1990-9/3/94	<0.1-.2
Silica, Dissolved	7/7/1990-9/3/94	6.3-15

Total number of sampling events: 12

Physical Properties of water in the Tanque Verde Creek. From USGS on-line database.

Parameter	Sample Date Range	Result Range
Temperature, Water	7/7/1990-9/3/1994	9.0-23.5
Specific Conductance	7/7/1990-9/3/1994	47-290
Turbidity	7/7/1990-9/3/1994	5.2-1200
pH, Field	7/7/1990-9/3/1994	6.2-8.55
Alkalinity, total	7/7/1990-9/3/1994	12-56

Total number of sampling events: 13

Water Quality Requirements of Native Aquatic Species in Pima County

Prepared for the Pima County Comprehensive Plan and Sonoran Desert Conservation Plan

March 2002

Prepared By

Pima Association of Governments

PIMA ASSOCIATION OF GOVERNMENTS

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Water Quality Requirements of Native Aquatic Species in Pima County

Introduction

Background

Since 1998, Pima County has been working toward a comprehensive assessment of urban growth and the environment which has led to the creation of the Sonoran Desert Conservation Plan. Development of this plan has been prompted in part by the federal Endangered Species Act. In addition, the County is updating its Comprehensive Plan as required by the state's recently adopted Growing Smarter legislation. The two plans will contain a water quality element in order to meet the requirements of the Growing Smarter legislation, and to ensure the preservation of species dependent on surface water or shallow groundwater in Pima County.

Pima Association of Governments (PAG) is assisting with the preparation of the Water Quality Element at the County's request. This request was prompted in part by the fact that PAG is the state-designated Water Quality Planning Agency for Pima County under Section 208 of the Clean Water Act.

PAG's Section 208 Water Quality Management Plan consists of a document written in 1978 and all of the subsequent amendments and updates to that document. The 208 Plan addresses one of the major water quality concerns associated with growth, which is the disposition of waste. The original PAG 208 Plan and several amendments also identified various point- and non-point sources of pollutants. However, the 208 Plan has not had a recent comprehensive, countywide update and it does not include site-specific programs for unique aquatic habitats identified in the Sonoran Desert Conservation Plan. Therefore, reliance on the existing 208 Plan would probably not meet the County's needs, and development of additional planning materials is warranted.

This report attempts to identify the water quality requirements of aquatic species identified as priority species by the Sonoran Desert Conservation Plan. Used in conjunction with the two other water quality reports PAG prepared for the County's planning effort, *Water Quality Summary* and *The Water Quality of Priority Streams in Pima County*, this report could provide a tool for the County in its efforts to develop plans to protect these species. By knowing the quality of the various water sources in the County and the degree to which their quality is protected by law, and by comparing these to the water quality requirements of aquatic species, it should be possible to determine which water sources would be appropriate for supporting the priority aquatic species identified in the Plan.

Purpose

The purpose of this report is to summarize what is known about the water quality requirements of priority vulnerable aquatic species identified in the Pima County Sonoran Desert Conservation Plan.

Limitations

The information provided in this report is limited entirely to data that were available from published literature and other agencies' monitoring programs. PAG did not conduct any original research for this project. Also, PAG's literature search was significantly constrained by time and resources. The literature used for this study was primarily that which was readily accessible from the University of Arizona library, local agency contacts (particularly Pima County Flood Control District, Pima County Wastewater Management Department, Arizona Department of Environmental Quality, and Arizona Game and Fish Department), and the Internet. Additional information was probably available, but it was not included in this report.

An additional, important consideration is that this report does not address hydrologic factors affecting aquatic habitat. Preliminary indications from the County's on-going Water Quality Research Project suggest that physical characteristics of streams, such as flood frequency and streambed geology, are as important as water quality in determining which aquatic species are found in a stream.

Species Addressed in this Report

We reviewed and compiled existing data on the water quality requirements of the priority vulnerable aquatic species described in the SDCP (Table 1). In cases where data were very limited, available studies involving closely related species were used as well.

Table 1. Priority Vulnerable Aquatic Species in Pima County (Pima County, 2000a)

Species	Location
Chiricahua Leopard Frog *(Rana chiricahuensis)* Lowland Leopard Frog *(Rana yavapaiensis)*	Middle San Pedro, Cienega-Rincon, Altar Valley, and the Middle Santa Cruz watershed subareas.
Longfin Dace *(Agosia chrysogaster)* Desert Sucker *(Catostomus clarki)* Sonora Sucker *(Catostomus insignis)* Desert Pupfish *(Cyprinodon macularius macularius)* Gila Chub *(Gila intermedia)* Gila Topminnow *(Poeciliopsis occidentalis)*	Middle San Pedro, Cienega-Rincon, Altar Valley, and the Middle Santa Cruz watershed subareas

General Discussion of Water Quality

Little information was readily available on the specific water quality requirements of the aquatic species targeted by this study. Most studies we found were limited in scope. This is significant, because toxicity testing in aquatic environments is highly complex, due to the varying effects of hydrologic conditions, and the interrelationships between, and combined effects of, multiple water quality constituents.

Water quality factors generally associated with the health of streams and rivers, as well as fish survival rates, include the chemical characteristics of pH, buffering capacity, dissolved oxygen and nutrient levels. They also include physical characteristics such as stream width, temperature, substrate, water velocity, and volume. Several detailed studies have been done, but in general we need more data to establish meaningful water quality standards for fish and frogs in the Southwest.

Along these lines, Pima County Wastewater Management Department is conducting a major study on water quality: *The Arid West Water Quality Research Project* (WQRP). The objective of the WQRP is to determine whether existing federal and state standards for wastewater discharges to ephemeral streams need modification or if a new set of standards needs to be developed specifically to protect effluent-dependent aquatic and riparian habitat in the arid west. The scope of the project covers seven states and looks at 10 study sites. (Pima County Wastewater Management Department, 2001).

In contrast to the lack of data for the species listed in Table 1, there are large amounts of data on aquatic invertebrates and the impairment factors that affect their communities. Aquatic invertebrates are worms and insects like mayflies, stoneflies, and caddisflies that live in water. These animals are sensitive to water quality degradation and are more abundant in good quality streams. Therefore, they are useful in determining the relative quality of the water (USGS, 2000). Macroinvertebrates are good indicators of localized conditions because they are sensitive to their environment and relatively immobile (Lawson, 1995).

Water quality is affected by many factors. Riparian environments influence the physical and chemical characteristics of streams and are essential in the health of the waterbody. In higher reaches streamside trees provide shade that helps the water maintain a cool temperature, thereby increasing the stream's oxygen-carrying capacity. Also, the roots of these trees stabilize stream banks, reducing erosion and slowing down runoff, allowing sediments to settle out (Boquet River Association, 2001). The middle reaches of smaller streams in the Southwest that flow from higher elevations tend to be narrow, but widen somewhat as they reach valley floors before infiltrating into streambeds (Lawson, 2002).

Arizona Game and Fish Department stated that they typically monitor water that native fish inhabit for four basic water quality parameters throughout the year: pH, conductivity, dissolved oxygen and temperature (Blasius, 2001). The pH of a water indicates its degree of alkalinity or acidity. A pH of 7.0 indicates a water that is neither acidic nor alkaline. Natural, unpolluted waterbodies in southeastern Arizona are naturally alkaline and generally have a pH in the range of 6.9-8.6. Extreme pH values (high or low) can lead to the development of conditions that can be toxic to aquatic life. Changes of pH in a waterbody can be due to chemical, physical or biological processes. Most aquatic organisms have an optimum pH range of 6.5-8.5 (Lawson, 1995).

Conductivity, or specific electrical conductance (EC), is a measurement of the ability of water to carry an electric current. This ability depends on the presence of ions, their concentration, and the temperature. The conductivity of distilled water is in the range of 0.5-3.0 µmhos/cm, potable water is generally 50-1500 µmhos/cm, and some industrial wastewaters can have conductivities over 10,000 µmohs/cm. Since EC is an indirect measurement of the concentration of total dissolved solids in a solution, it can be used as an indicator of pollution problems in some cases (Lawson, 1995; Standard Methods, 1998). However, many waterbodies are naturally high in TDS.

Dissolved oxygen (D.O.) is necessary to all aquatic organisms that need oxygen for life processes. The solubility of oxygen in water depends on water temperature and air pressure. Because of this, warm water or water at high elevations cannot carry as much D.O. as cold water or water at lower elevations. Dissolved oxygen in water comes from the atmosphere, surface turbulence, and photosynthesis by aquatic plants. Waters that have consistently high D.O. are considered healthy. D.O. concentrations in unpolluted, southeast Arizona waters typically range from 7.5-8.3 mg/l. The State of Arizona has set water quality standards for D.O. as minimum numerical concentration limits or 90% dissolved oxygen saturation. In the Santa Cruz River, south of Pima County, at one springflow sampling site the water was found to be routinely 15-30% below saturation. Springflow is typically low in D.O. and the fish and aquatic insects living at this site did not show signs of stress from the D. O. levels (Lawson, 1995).

Temperature readings are used in the calculation of various forms of alkalinity, calculation of salinity and in general laboratory operations. Water temperatures generally closely follow air temperatures, and data imply that temperature dependent processes (chemical, physical, and biological) may be very dynamic (Lawson, 1995; Standard Methods, 1998).

Additional water quality constituents of potential concern include nutrients (nitrogen and phosphorus), pesticides, trace metals, and polycyclic aromatic hydrocarbons (PAHs) (Liston and Maher, 1997). High levels of nutrients can lead to eutrophication of aquatic environments, while pesticides, trace metals, and PAHs can be toxic to aquatic life. One form of nitrogen, ammonia (NH3), is also toxic. For example, ammonia is the major stressor of aquatic species below the Nogales Wastewater Treatment Plant on the upper Santa Cruz River.

Species-Specific Water Quality Studies

Longfin Dace

Lewis (1978) looked at the effects of mining wastes in streams and the acute toxicity of heavy metals in water on native fish species. A series of toxicity tests were conducted on juvenile longfin dace *(Agosia chrysogaster)* in hard water using copper, zinc, manganese, and copper-zinc and copper-manganese mixtures. The results indicate that the longfin dace is more sensitive to zinc and slightly less sensitive to copper than the commonly studied fathead minnow. The longfin dace appears to be more resistant to manganese than juvenile trout. It was shown that metals in combination generally exhibit additive toxicity, with the copper-zinc solutions being more toxic than any single-metal solution. The results are shown on Tables 2 and 3.

Table 2. Mean Concentration of Metal (mg/l) added as inorganic salt and percent survival (%) at 96 hours of juvenile *Agosia chrysogaster* exposed to toxicant levels. Values represent the mean of each test and replicate (Lewis, 1978).

Cu (mg/l)	Zn (mg/l)	Mn (mg/l)	Cu-Zn (mg/l)	Cu-Mn (mg/l)
20.4 (0%)	25.5(0%)	436 (0%)	20.0-23.0 (0%)	20.5-430 (0%)
4.0 (0%)	4.4 (0%)	269 (0%)	3.5-4.0 (0%)	3.4-219 (0%)
1.8 (0%)	2.4 (0%)	150 (0%)	2.0-2.3 (0%)	2.0-171 (0%)
1.3 (30%)	0.5 (60%)	84 (60%)	0.3-0.6 (0%)	0.8-100 (0%)
0.3 (80%)	0.3 (90%)	56 (90%)	0.2-0.4 (40%)	0.2-28 (80%)
			0.1-0.2 (100%)	0.1-14 (100%)

Table 3. 96 Hour Lethal Concentrations of Heavy Metals in mg/l, to Juvenile *Agosia chrysogaster* and Slope Functions of Response Curves to the Same Metals (Lewis, 1978).

Metal	° C	pH	DO* mg/l	Total hardness mg/l **	Test organisms exposed	Lethal Concentration ‡	Slope function †
Copper	19.3	7.7	9.5	221	100	0.86 (0.7-1.1)	1.53
Zinc	18.9	7.8	9.3	217	100	0.79 (0.4-1.5)	2.86
Manganese	19.0	7.6	8.7	224	100	130 (100-169)	1.50
Copper-Zinc	18.7	7.8	8.9	219	100	0.21 (0.15-0.29)	1.78
						0.28 (0.18-0.45)	2.14
Copper-Manganese	19.5	8.0	9.0	231	100	0.45 (0.31-0.64)	1.79
						64.0 (47-88)	1.75

* Experimental Conditions
** as CaCo3
‡ Number shown is 96-L.C. 50, which indicates the lethal concentration at which 50% of the test organisms died after a 96 hour test. Values include background concentrations in dilution water (mg/l): Cu-0.02, Zn-0.001, and Mn- 0.004. Numbers in () indicate 95% confidence limits.
†Values indicate variation of response of the test population to the poison.

Extensive monitoring of the Upper Santa Cruz River was conducted in the early 1990's. The most common fish in the river is the longfin dace, which is also the most abundant native minnow in Arizona's low elevation streams. The study, completed by ADEQ and volunteers, was conducted to document fish species occurrence and to determine if there were any environmental factors adversely affecting fish in the effluent dependant reach of the river.

Water quality in the study area was generally considered good. Metals concentrations did not appear to have a negative effect on aquatic life. Nutrients added to the river through the wastewater treatment plant discharges diminished downstream. This species, *Agosia chrysogaster*, is tolerant of high water temperatures, low D.O. (as low as 1.0 mg/l for short periods) and is able to gulp air when low D.O. conditions are present (Lawson, 1995). This fish was found in the greatest density at the control site (above the treatment plant) and at the sample location farthest downstream. Selected water quality data are shown on Table 4.

Table 4. Selected Parameters from the Santa Cruz River—Guevavi Ranch Control Site, Upstream from the Nogales International Wastewater Treatment Plant (Lawson, 1995)

Date Sampled	Temp Water (°C)	DO (mg/l)	EC (field) (µmhos /cm)	pH (field)	TDS (mg/l)	TSS (mg/l)	Turbidity (NTU)	Total Alkalinity (mg/l)	Total Phosphate (mg/l)	Nitrate (mg/l)
11/20/92	14.5	N/A	404	7.78	277	4	0.03	160	0.091	0.44
12/16/92	18.5	N/A	N/A	7.59	281	2	0.20	151	0.067	0.63
02/03/93	10	8.2	309	8.16	228	295	23	106	0.388	0.54
02/23/93	8.5	9.60	251	7.68	166	180	39	83.0	0.32	0.33
03/31/93	17.0	N/A	354	8.05	251	39	20	148	0.19	0.4
04/28/93	21.5	9.7	388	7.86	220	4	0.66	132	0.19	0.41
05/11/93	15.5	7.55	354	7.79	225	4	0.54	134	0.15	0.26
06/23/93	12.0	6.89	380	7.71	201	4	0.32	144	0.05	0.28
07/21/93	16.0	6.95	354	7.76	233	4	0.39	138	0.18	0.31
08/19/93	18.5	6.55	347	7.76	230	4	0.50	142	0.11	0.24
09/08/93	16.0	6.1	373	7.39	230	4	0.52	143	0.092	0.30
10/13/93	13.5	6.4	380	7.61	230	10	0.48	157	0.13	0.42

Gila Topminnow

The Gila topminnow (*Poeciliopsis occidentalis*) favors a habitat of shallow, warm, quiet waters in perennial and intermittent streams, marshes and riverbanks where there are dense mats of algae and debris and sandy substrate (Matthews, 1990). Though more information is needed on the specific water quality components of the fish's preferred environment, their temperature range is known to extend from near freezing under ice to 37 °C, with a maximum tolerance of 43 °C for brief periods. Topminnows can live in a fairly wide range of water chemistries, with recorded values of pH from 6.6-8.9, dissolved oxygen readings from 2.2 to 11 mg/l and salinities from very dilute to seawater. It has been reported that they can tolerate almost total loss of water by burrowing into the mud for 1-2 days (Weedman, 1998).

The biggest threats to this species are habitat destruction and the introduction of non-native species (Weedman, 1998). Minckley (1999) conducted a study for a recovery program for the Gila topminnow. This study noted that the reasons for the disappearance of the Gila topminnow from 96 locations was apparent: 57 were desiccated, 27 were lost to flooding, 6 to winter cold and 1 or 2 to mosquitofish, water quality, dredging or livestock overuse.

An early study of topminnow by Meffe and others (1983), showed that the steady decline of this species is correlated with and primarily attributed to habitat destruction and the introduction and establishment of mosquitofish and other exotic fishes. Between August 1979 and July 1981 all known populations of what was called the Sonoran topminnow were visited from one to 10 times. Several environmental parameters were measured at all sites. The minimum and maximum values of the environmental parameters encountered by *P. occidentalis* are presented on Table 5. The author considered these ranges to be a minimum of those tolerable to this species as these are considered "remnant habitats of a formerly wide-ranging fish…" (Meffe, et al., 1983).

The Sonoran topminnow was formerly considered to have two subspecies: the Gila topminnow *(P.o. occidentalis*) and the Yaqui topminnow (*P.o. sonorensis*). They are now considered to be two species with only the Gila topminnow (P.occidentalis) occurring in Pima County (Pima County, 2001). Natural populations of the Gila topminnow are found in some areas of the upper Santa Cruz River but are not found in the lower, effluent dominated portion of the Santa Cruz.

Table 5. Environmental Ranges under Which Extant Populations of Sonoran Topminnows are Found. From: Factors Resulting in Decline of the Endangered Sonoran Topminnow *Poeciliopsis occidentalis* (Atheriniformes: Poeciliidae) in the United States. By Meffe, Hendrickson, and Minckley (1983).

Site	Temp (°C)	O2 (mg/l)	Conductivity (umhos)	Alkalinity Total (meq/l)	pH	Cl (mg/l)	S04-S (mg/l)	Si (mg/l)	No3-N (mg/l)	Soluble reactive Phosphate (mg/l)	Total Dissolved Phosphate (mg/l)
Monkey Spring	26.5-27.5	2.4	990-1200	1.1-5.0	6.9*-7.6	4.0*-8.8	81.1-*563.0	1.3-3.7	0.09-0.32	0.00-0.04	0.002-0.096
Cottonwood Spring	26.0-31.0	-	1200-1350	3.3*	6.9*	6.8	73.5	2.9	0.02-0.28	0.00-0.10	0.001-0.16
Sheehy Spring	6.0-20.0	4.5-7.3	290-520	3.3	6.9-8.9	6.4-7.6	0.0-0.1	3.2-5.2	0.00-0.09	0.00-0.04	0.005-0.098
Unnamed Spring	7.0-26.8	2.7-6.1	290-540	3.0-5.9	7.4-8.8	2.2-15.2	0.3-25.0	3.4-5.7	0.01-0.03	0.00-0.06	0.014-0.12
Santa Cruz River	23.5	-	300	-	8.2	7.3	13.1	2.7	0.00-0.01	0.016-0.019	0.02-0.04
Redrock Canyon	14-24	-	1200-2300	2.8-3.3	7.4-8.5	-	-	-	-	-	-
Cienega Creek	10.5-22	-	470-535	4.0	-	8.8	18.3	4.0	0.00-0.01	0.002	0.001-0.003
Cocio Wash	22-29	8-11	1099-2210	3.8-5.6	7.5-7.6	-	-	-	-	-	-
Bylas Springs	17.0-36.7	3.0-9.0	1350-5050	2.0-3.4	6.6-8.5	8.5	26.1-52.3	4.4-11.1	0.00-1.1	0.00-0.02	0.001-0.025
San Bernadino Creek	11.7-32.0	6.8	540-680	3.4	7.6-8.5	14.2	16.7	4.6	0.02	0.12	0.17
Artesian Wells	22.0-29.1	2.2-8.1	390-500	3.7-4.0	7.2-8.6	8.2-9.5	5.6-9.2	4.0-4.9	0.64-1.3	0.003-0.076	0.003-0.083
Mesa Spring	18.2-23.0	2.2	-	-	-	-	-	-	-	-	-
Leslie Creek	12.7-21.0	-	620-660	-	7.3-7.6	6.8	36.0	5.7	6.2-8.3	0.00-0.02	0.001-0.016
Sonoita Creek	-	-	515-1000	4.2	7.0-7.8	10.1	36.0	5.5	0.00-0.01	0.009-0.024	0.006-0.034

If more than one reading for any parameter was available, then minimum and maximum values are presented. Otherwise the single available figure is given. *= from Schoenherr, 1974.

Gila Chub

The Gila chub (*Gila intermedia*) is often associated with cienegas and deep pools in smaller headwater streams provided with dense vegetative cover. During the day it spends its time under the cover of cutbanks, vegetative overhang or aquatic vegetation (Adams, no date). Habitat-specific water quality data are not readily available. The BLM has identified reaches of Cienega Creek occupied by the Gila chub. They inhabit portions of seven stream miles of approximately 24 miles of stream above Interstate 10. The status of the Gila chub in this area is considered stable and secure. The population is believed to be healthy, and pool habitat is stable with minimal threat of non-native species introduction (Weedman, 1996).

Arizona Game and Fish recommends that all existing Gila chub populations be identified, protected, and monitored. They believe that reduction of land erosion, preservation of habitat, and stream improvement structures on some sites could benefit Gila chub populations. Also, the removal of nonnative fish species from historic habitat areas, such as lower Sabino Canyon, will increase the survival rates of vulnerable juveniles. Habitats critical to their survival include cienegas, headwaters, spring-fed streams, and spring-fed ponds that are free of non-native species (Weedman, 1996).

Desert Pupfish

According to U.S. Fish and Wildlife Service in the *Desert Pupfish Recovery Plan*, "the desert pupfish (*Cyprinodon macularius*) occupied a diversity of habitats ranging from cienegas and springs to small streams and margins of larger bodies of water. Most habitats were shallow and had soft substrates and clear water." It is also noted that the pupfish can survive under conditions of very high water temperatures (to 45°C), low dissolved oxygen (concentrations of 0.1-0.4 mg/l) and high salinity (concentrations twice that of seawater). They can also survive abrupt changes in temperature and salinity that would be lethal to other fish species. In environments with other species the pupfish typically occupies shallower water than adults of the other species (Marsh and Sada, 1993).

In Pima County a large population of pupfish, *C. macularius eremus*, is endemic to Quitobaquito Springs (Miller and Fuiman, 1987). Some water quality data are available for the pond and the spring; the data are shown on Table 6.

Table 6. Chemical Constituents in Water at Quitobaquito, Arizona. From Description and Conservation Status of *Cyprinodan macularius eremus*. A New Subspecies of Pupfish from Organ Pipe Cactus National Monument, Arizona. Miller and Fuiman, 1987.

*Parameter	Quitobaquito Pond, 1982	Quitobaquito Pond, 1963, 1964	Quitobaquito Spring, 1982	Quitobaquito Spring, 1963-64
TDS	820		670	
TSS	<10		<10	
pH	9.22		8.07	
HCO3	220	411	300	316-402
F	4.9	5.3	4.1	4.3
Cl	190	383	150	148-318
PO4	<0.50		<0.50	
NO3	<0.50		9.9	
SO4	110	100	95	71-91
Na	230	350	188	191-284
K	3.1	7.0	2.7	4.5-6.0

* No units were included in the journal article for this data, convention is mg/l for these parameters except pH, which is in standard units

Transplanted stocks of desert pupfish have been found in Buehman Canyon in 1989 but as of 1993 their status was uncertain (Marsh and Sada, 1993).

According to information posted by a state fishery biologist on the California Department of Fish and Game's web site (Keeney, 2001), the presence of nonnative fishes may be the most significant threat to desert pupfish populations. However, Keeney also stated "pollution by toxic by-products of agricultural activities threaten the desert pupfish." Keeney cited a recent study concluding that high selenium levels in agricultural runoff posed a danger of reproductive failure.

Desert Sucker and Sonora Sucker

No studies specific to these fish were found. Limited information is included in the following section of this report ("Studies of Multiple Species").

Leopard Frogs

The vulnerable lowland leopard frog (*Rana yavapaiensis*) and the Chiricahua leopard frog (*Rana chiricahuensis*) are also of interest in Pima County. The lowland leopard frog is generally found in small-to-medium sized streams. It can also be found in stock ponds, springs, or large rivers. Large pools enhance its chances of survival as an adult and reproduction, whereas small pools and extensive marshy vegetation aid the survival of juveniles. Threats to this species are disease, flooding, alteration of riparian habitat by livestock grazing, destruction of in-stream habitats, and the introduction of non-native, predatory fish, crayfish and bullfrogs (Pima County, 2001).

The Chiricahua leopard frogs' habitat includes rocky streams with deep rocky pools, overflow pools and oxbows of rivers, permanent springs, ponds, and wetlands. It also utilizes stock tanks, wells, and mainstream river reaches. Ideal habitat includes permanent water during breeding season, deep pools with nearby shallow areas, undercut banks, overhanging terrestrial vegetation, and aquatic vegetation, which might not be present in streams experiencing sediment pollution. While the species can use a variety of aquatic habitats, generally perennial streams and springs are the most important. Potential threats to this species are introduced pest species, loss of habitat resulting from water diversion, sediment pollution, groundwater pumping, pollution, and anoxia (Pima County, 2001).

PAG found no information on water quality requirements for *Rana chiricahuensis* or *Rana yavapaiensis*. However, we found one study of the effects of nitrate and nitrite solutions on newly hatched larvae of five species of pond-breeding amphibians from the Pacific Northwest: *Rana pretiosa, Rana aurora, Bufo boreas, Hyla regilla*, and *Ambystoma gracile*. The ranid species had acute effects in water with nitrite. All species showed high mortality at 5 mg/l nitrite-N and significant larval mortality at 1 mg/l nitrite-N. Nitrate at 90 mg/l as N was highly toxic for R. pretiosa and A. gracile larvae (Marco et al.,1999).

We also found a study of declining populations of Tarahumara frog (Rana tarahumarae) in southern Arizona and northern Mexico (Hale et al., 1995). The authors noted that populations of Chiricahua leopard frogs (Rana chiricahuensis) and Yavapai leopard frogs (R. yavapaiensis) declined with the Tarahumara frog where they occurred together. The causes of the declines were not clear. However, frogs in a declining population at one site displayed signs of heavy metal poisoning. Affected streams had elevated levels of cadmium, and rain samples collected at two sites near declining frog populations in southern Arizona were very acidic. Levels of arsenic in streams were also occasionally elevated. The possibility of cadmium sensitivity being reduced by zinc was noted, along with the observation that, at two sites, frogs survived longest near springs where zinc concentrations were highest.

Studies of Multiple Species

Santa Cruz River

Friends of the Santa Cruz River monitored water quality in the Santa Cruz River downstream from the Nogales International Wastewater Treatment Plant (NIWTP) for seven years. Since 1995 they have seen an increase in total ammonia, nitrates and nitrites. They documented the negative effect the ammonia had on local fish populations including the endangered Gila topminnow. Also noted was a decline in longfin dace populations. The ammonia is a product of sewage and it has a toxic effect on fish. ADEQ documented the effects of ammonia on longfin dace populations at the Rio Rico Bridge site. It was determined that there was a strong correlation between fish mortality and frequency of diseased fish with the increased concentration of ammonia at that site (Floyd, 2000).

U.S. Fish and Wildlife Service took a closer look at the upper Santa Cruz and in October 1999 published a study by Kirke King and others entitled: *Contaminants as a Limiting Factor of Fish and Wildlife Populations in the Santa Cruz River, Arizona.* This study was prompted by the declining Gila topminnow populations in the Santa Cruz. Four native fish species (longfin dace, desert sucker, Sonoran sucker, and the Gila topminnow) were found in the Santa Cruz River at the various sampling stations. In 1997 the contaminant levels in water, sediment, invertebrates, fish, and birds were assessed. The normal pH of the water in the area ranged from 7.4-7.9. Un-ionized ammonia concentrations as high as 0.49 mg/l were measured. This value is in the range known to be toxic to invertebrates and fish. The water quality data from this study are shown on Table 7 (King et al., 1999).

Table 7. Santa Cruz River Water Quality Parameters, May 30, 1997 (King et al., 1999).

Site Name	Un-ionized Ammonia (mg/l)	pH	Residual Chlorine (mg/l)	Water Temperature °C
Nogales Wash	<0.01	7.9	<0.05	20.5
Rio Rico Bridge	0.49	7.8	<0.05	23.3
Rio Rico North	0.23	7.5	<0.05	23.8
Santa Gertrudis	0.03	7.6	<0.05	23.8
Tubac	<0.01	7.4	<0.05	23.8

The Nogales Wash sampling location is above the wastewater treatment plant. All other locations are downstream, varying from 1.7 to 11.3 miles from the treatment plant outfall.

Captive Populations

There are several captive native fish populations in Pima County. Represented in the captive populations are Gila chub, desert pupfish, Gila topminnow and desert suckers.

The following water quality problems have been noted in the captive populations:

- Winter die-off of aquatic vegetation causing nitrate poisoning of the desert pupfish at one location;
- High chlorine content of potable water supply;
- Desert pupfish adult predation of young due to lack of algae food supply (Pima County, 2000).

In the captive fish populations it has also been noted that the Gila topminnow populations are expanding, but one location noted that cleaning the pond system seems to stress the fish and cause some die-off. The desert pupfish seems to be more sensitive to water quality, i.e. chlorine (Pima County, 2000).

Additional Water Quality Data

Because the literature available on the water quality requirements of the aquatic species of interest were so limited, PAG compiled readily accessible water quality data for the streams in which these species have been found. Although these data do not indicate a water quality requirement for any of the species, they might be useful in a general sense for estimating an acceptable level of water quality.

ADEQ has a significant amount of data for several of the major streams in Pima County. Some of these streams currently support or historically supported several of the vulnerable aquatic species. Longfin dace, Gila topminnow, and Gila chub have been found in Cienega Creek, Davidson Canyon, Mattie Canyon, Santa Cruz River and Sabino Canyon Creek (Pima County, 2000). Buehman Canyon has longfin dace populations. It was also known to have populations of desert pupfish, but their status is currently uncertain. Although no historic records exist for the reach of the San Pedro River in Pima County, it is assumed that the same species of fish that exist or existed upstream of the Pima County line also existed here. Five species (longfin dace, speckled dace, desert sucker, Sonoran sucker and Gila chub) are known to occur in isolated canyon tributaries of the San Pedro in Pima County (Pima County, 2000). In addition, the Bingham Cienega supports populations of longfin dace and lowland leopard frogs. Canada del Oro and Agua Caliente Canyon were historic leopard frog locations and currently support native fish species. Table 8 includes sample results for four parameters from some of the significant streams in the county. There are currently no data in ADEQ's database for the following priority streams in Pima County: Mattie Canyon, Empire Gulch, Davidson Canyon, Rincon Canyon, Wakefield Canyon, and Romero Canyon.

Table 8. Selected Water Quality Data from ADEQ Database.

LOCATION *	Date Sampled	Temperature (water) °C	Specific Conductivity (µmhos/cm)	Dissolved Oxygen	pH
Agua Caliente Canyon	4/13/95	14.9	136	9.3 mg/l	7.28
Buehman Canyon (1)	5/18/00	21	461/460	56.5 % 4.44 mg/l	6.93 7.2
Buehman Canyon (2)	7/15/97	19.6	380/399	69.5 % 5.7 mg/l	7.32 7.48
Canada del Oro	4/7/94	13	102	9.6 mg/l	8.01
San Pedro	8/13/91	32.0	550/590	109.9 % 7.20 mg/l	8.4 8.2
Sabino Creek (1)	7/23/91	12.5	127	N/A	6.63
Sabino Creek (2)	4/18/01	15.4	53	96.7 % 9.5 mg/l	6.9
Cienega Creek (1)	9/28/98	19.7	993	97.5 % 8.13 mg/l	7.92
Cienega Creek (2)	9/29/98	20.2	703	57.4 % 4.59 mg/l	7.6

*Location Descriptions:
Agua Caliente Canyon at the national forest boundary; Buehman Canyon (1) two miles below confluence with Bullock Creek; Buehman Canyon (2) above the USFS roads 801 and 654;
Canada del Oro at the Pima/Pinal County line; Tanque Verde Creek at Sabino Canyon;
San Pedro River at Redington; Sabino Creek (1) below Summerhaven; Sabino Creek (2) above the visitor center near first rest stop; Cienega Creek (1) at Marsh Station Road; Cienega Creek (2) above the Diversion Dam.

Cienega Creek was monitored by ADEQ at several locations. Stream Ecosystem Monitoring was conducted below Stevenson Canyon and below the Narrows in 1998. No results are listed in the 305(b) report but ADEQ designated these sections as being Full Support. ADEQ monitored Cienega Creek above the Narrows for the Biocriteria Program from 1992-1996. This segment was also classified as being in Full Support and no results were provided in the report. Also, sampling in 1992 and 1993 below the Empire Cienega Resource Conservation Area indicated full support. The reach of Cienega Creek from Interstate 10 to the Del Lago Dam was monitored at several locations. In 1998 a sample was collected from above the diversion dam and was analyzed for Dissolved Oxygen. The result of 4.59 mg/l did not meet the standard, and ADEQ commented that the low DO was naturally occurring. Stream Ecosystem Monitoring was also conducted above and below Davidson Canyon in 1998. The DO result for above Davidson Canyon was 5.4 mg/l and did not meet the standard. The use support was designated full and ADEQ commented that there was "naturally low DO". Twenty samples were collected from Cienega Creek at Marsh Station Road 1991-1995 for analyses of Dissolved Oxygen. The results ranged from 4.75-11.2 mg/l with 1 of 25 not meeting the standard (ADEQ, 2000).

Summary and Conclusions

Little detailed information is readily available on the specific water quality requirements of Pima County's native aquatic species. Other threats aside, aquatic species generally thrive when the waterbodies in which they reside have water quality characteristics that are typical of "healthy" waterbodies. For Pima County this includes physical characteristics as well as chemical characteristics such as pH ranging from 6.5-8.5, EC from 50-1500 µmhos/cm (micromhos per centimeter), and DO between 7.5-8.3mg/l.

Some studies were found that focused on specific water quality concerns and particular species. The following conclusions can be drawn from those studies:

- Longfin dace are generally more sensitive to zinc toxicity and less sensitive to copper toxicity than fathead minnows.
- Metals in solution in combination generally exhibit additive toxicity with a copper-zinc solution being more toxic to the longfin dace than any single metal solution studied.
- Natural populations of longfin dace and Gila topminnow declined when un-ionized ammonia at concentrations of up to 0.49 mg/l were found in the upper Santa Cruz River.
- Desert pupfish can survive under conditions of very high water temperatures (45 °C), low DO (0.1-0.4 mg/l), and high salinity.
- Gila topminnows can live in waters with pH ranges from 6.6-8.9, DO levels from 2.2-11.0 mg/l and salinities as high as seawater.
- A study of several different species of frogs in the Pacific Northwest found that newly hatched larvae showed acute effects to nitrite. All the species studied showed high mortality at nitrite concentrations of 5 mg/l and significant larval mortality at 1 mg/l.
- Frogs are sensitive to heavy metal poisoning.

At this time a comprehensive project that is characterizing the unique aquatic and terrestrial habitats in the arid west in nearing completion. The Arid West Water Quality Research Project (WQRP) is being conducted by Pima County Wastewater Management Department with cooperation from the U.S. Environmental Protection Agency. The objective of this project is to determine if existing standards for dischargers to ephemeral streams need to be modified or if a new set of standards for dischargers should be developed to protect effluent-dependent aquatic and riparian habitat in the arid west. Other objectives are to define biological resources and their needs for protection, and to develop a habitat classification system for the arid west (Pima County Wastewater Management Department, 2001).

In addition, the University of Arizona is just beginning work on two projects aimed at studying water quality requirements of desert fishes. One project will look at temperature requirements of selected desert species, and the other will involve mapping stream conditions in Arizona and their relationship with fish distribution (Bonar, 2001).

Habitat destruction and the introduction of non-native species appear to be the major threats to these vulnerable species. However, additional water quality data are needed on the specific requirements and threats to the native species, and in particular the leopard frogs and the desert suckers. More regional information may be available with the completion of the above mentioned studies.

Native aquatic species seem to be able to tolerate low dissolved oxygen levels, a wide range of temperatures and pH, and high salinities. High concentrations of nutrients, especially nitrite and ammonia, and metals appear to be toxic.

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