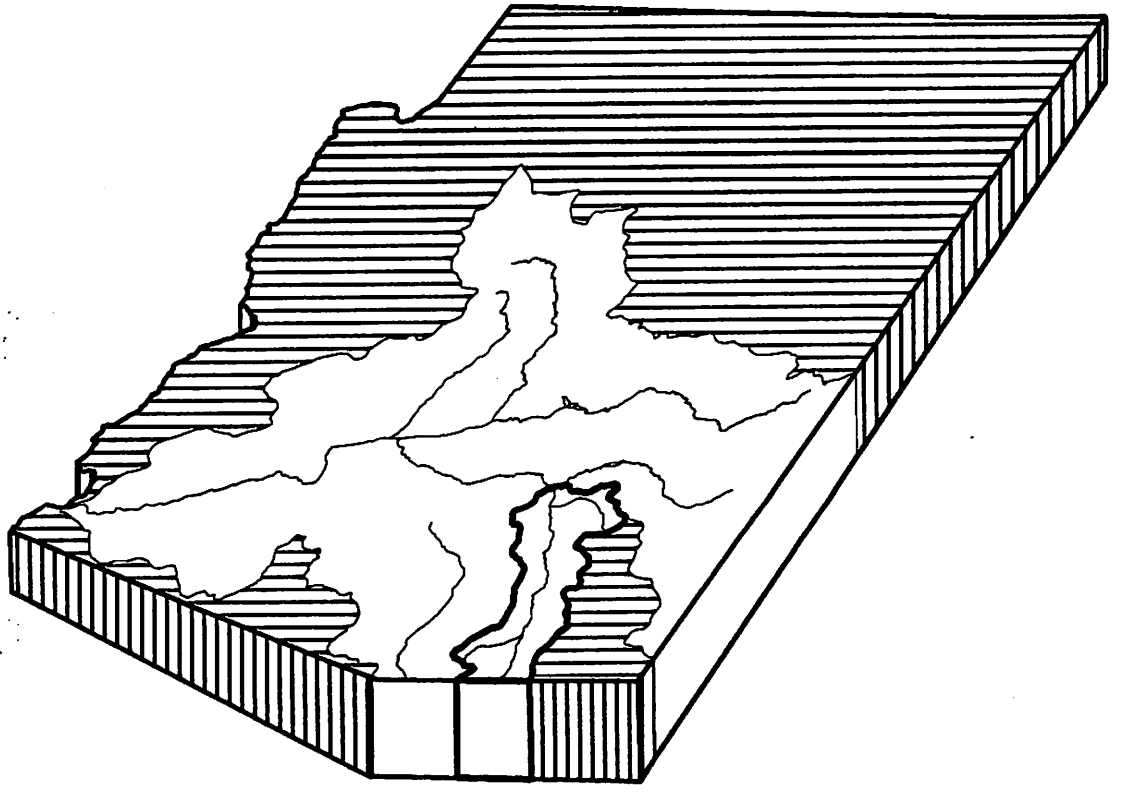
HYDROGRAPHIC SURVEY REPORT FOR THE SAN PEDRO RIVER WATERSHED

Volume 1: General Assessment

In Re The General Adjudication of the
Gila River System and Source



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LIST OF ABBREVIATIONS AND ACRONYMS

AC-FT	-	Acre-feet
ACWA	-	Aravaipa Canyon Wilderness Area
AF/YR	-	Acre-feet Per Year
AIS	-	Adjudication Investigation System
AMA	-	Active Management Area
ANC	-	Arizona Chapter of the Nature Conservancy
A.R.S.	-	Arizona Revised Statutes
BLM	-	Bureau of Land Management
CFS	-	Cubic Feet Per Second

CU	-	Consumptive Use
DM	-	Domestic
DWR	-	Arizona Department of Water Resources
FAA	-	Federal Aviation Administration
FRR	-	Federal Reserved Right
GPM	-	Gallons Per Minute
GRIC	-	Gila River Indian Community
G&SRBM	-	Gila and Salt River Base and Meridian
GW	-	Groundwater
HSR	-	Hydrographic Survey Report
ID	-	Industrial
INA	-	Irrigation Non-Expansion Area
IR	-	Agricultural Irrigation
MI	-	Mining
MIL	-	Military
MU	-	Municipal
ND	-	No Data Available
NL	-	Not Listed
OT	-	Other Irrigation
PIA	-	Practicably Irrigable Acres
PL	-	Public Law
POD	-	Point of Diversion
PS	-	Primary Storage
PWR	-	Potential Water Right
PWUA	-	Pomerene Water Users Association
RC	-	Recreational Irrigation
SCFIP	-	San Carlos Federal Irrigation Project
SCIDD	-	San Carlos Irrigation and Drainage District
SDID	-	St. David Irrigation District
SLD	-	Arizona State Land Department
SP	-	Stockpond
SPRNCA	-	San Pedro Riparian National Conservation Area
SR	-	Small Reservoir
SW	-	Stockwatering
USDA	-	United States Department of Agriculture
USGS	-	United States Geological Survey
UTM	-	Universal Transverse Mercator
WL	-	Wildlife

CHAPTER 1: INTRODUCTION AND BACKGROUND

The Arizona Department of Water Resources (DWR) has prepared this Hydrographic Survey Report (HSR) for the San Pedro River watershed as part of the General Adjudication of the Gila River System and Source. The General Adjudication of the Gila River System and the General Adjudication of the Little Colorado River System, also currently underway, encompass the majority of the geographic area of Arizona. Most of the water users in the state have been legally joined and are required to assert their claims to water in these large judicial determinations of the extent and priority of water rights within the two river systems. The adjudications are expected to finalize the water rights of cities, towns, farmers, ranchers, individual domestic users, state and federal government agencies, and Indian tribes.

Throughout the western United States, each state has adopted its own form of the general adjudication process to determine and finalize water rights. In Arizona, general adjudications are conducted under the authority and procedures of Arizona Revised Statutes (A.R.S.) §§ 45-251 to 45-260. These statutes specify that an adjudication is to be conducted in the State Superior Court in the county having the greatest number of potential claimants. Accordingly, the General Adjudication of the Gila River System and Source has been assigned to the Superior Court for Maricopa County, Judge Stanley Z. Goodfarb, presiding.

The role of DWR in the adjudication is to provide both administrative and technical assistance to the Court. Administrative support provided by DWR includes notifying all potential claimants of the commencement of judicial proceedings, receiving and transferring to the Court all claims filed, and responding to public inquiries. DWR provides technical assistance to the Court by gathering records and data, investigating the river system and claims filed, and preparing HSRs and technical reports for the Court.

Figure 1-1 shows the geographic scope of the Gila River general adjudication. As the map indicates, the adjudication has been divided into tributary watersheds. These tributary watersheds conform to the areas of the river system that were separately notified of commencement of proceedings and for which individual technical reports (or HSRs) will be prepared by DWR. The

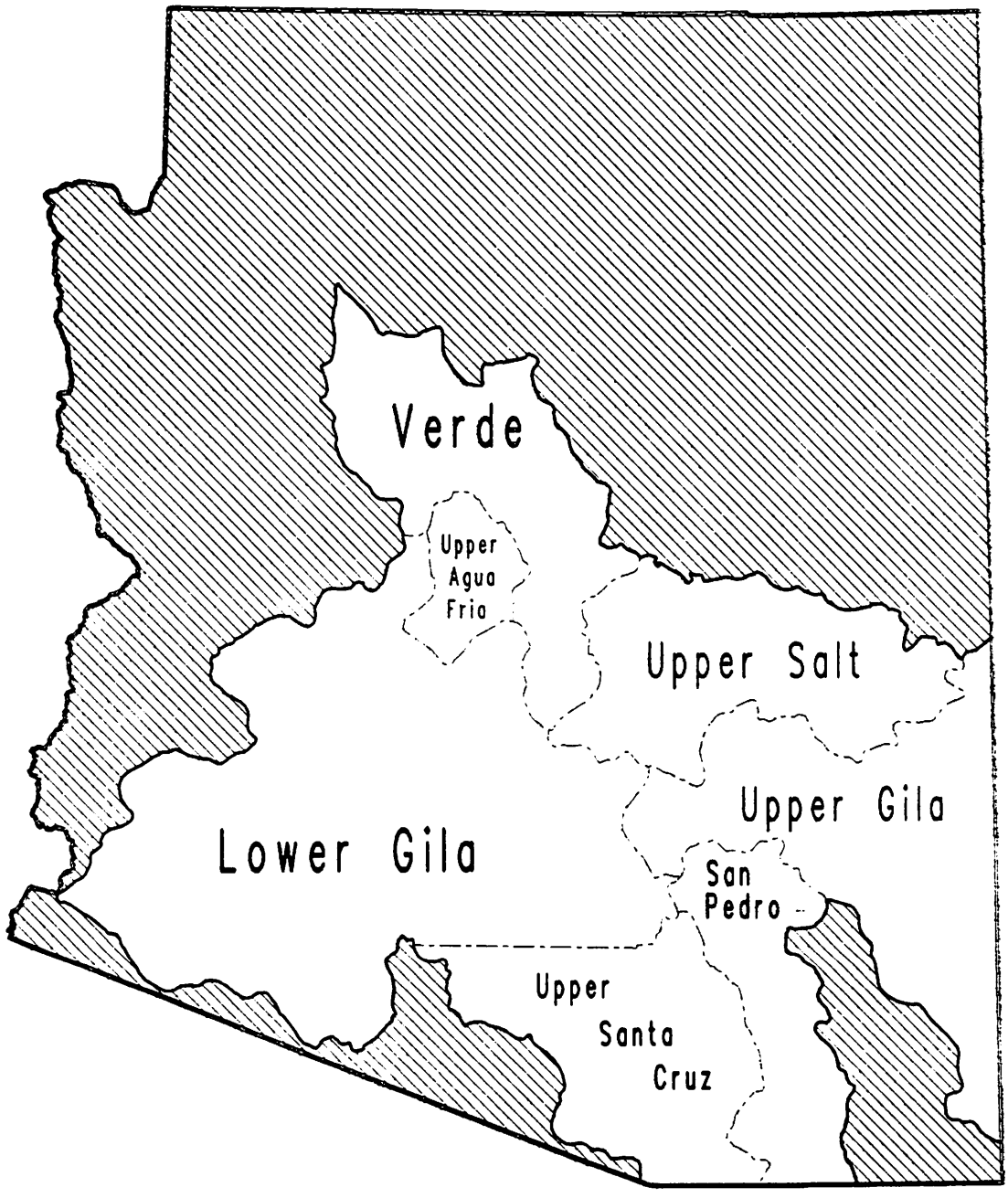


Figure 1-1. State of Arizona showing the Gila River System

drainage area of the San Pedro River is one of the tributary watersheds shown on Figure 1-1 and is the geographic area to which this report pertains.

The San Pedro River watershed HSR has been prepared in both a preliminary and final version. The purpose of the HSR is to provide the claimants with an opportunity to inspect the information which DWR has gathered and to file comments on its accuracy or other concerns. A previous preliminary HSR for the San Pedro River watershed was prepared and distributed in February 1987. However, the Court determined that the HSR needed to contain information on claims, quantities of use, and legal categories of water pumped from wells that was not included in the original preliminary HSR. Hence, DWR deemed it necessary to prepare a second preliminary HSR in order to provide the claimants with an opportunity to submit comments on these additional important determinations. The preliminary report was distributed in August 1990.

DWR received over 1,000 written comments and over 140 telephone calls concerning the second preliminary HSR. DWR has reviewed these comments and incorporated much of the information into the final HSR. This final HSR supersedes the preliminary HSR in its entirety and has been filed with the Court pursuant to the requirements of A.R.S. § 45-256.B and the provisions of Pre-Trial Order No. 1. Claimants may file formal objections to the information in the HSR, but the objections must be filed with the Court rather than with DWR. Formal hearings may be convened by the Special Master to resolve the objections.

To facilitate DWR's investigations, the San Pedro River has been divided into five subwatersheds as shown on Figure 1-2. The subwatersheds are separated at United States Geological Survey (USGS) stream gaging stations.

Due to the large number of water uses occurring within the San Pedro River watershed, this report has been divided into nine separate volumes. They are entitled:

1. General Assessment
2. Comprehensive Indices
3. Sierra Vista Subwatershed Watershed File Reports
4. Benson Subwatershed Watershed File Reports
5. Redington Subwatershed Watershed File Reports
6. Winkelman and Aravaipa Subwatersheds Watershed File Reports
7. Zone 2 Well Reports (formerly Wells Subject to Federal Claims)

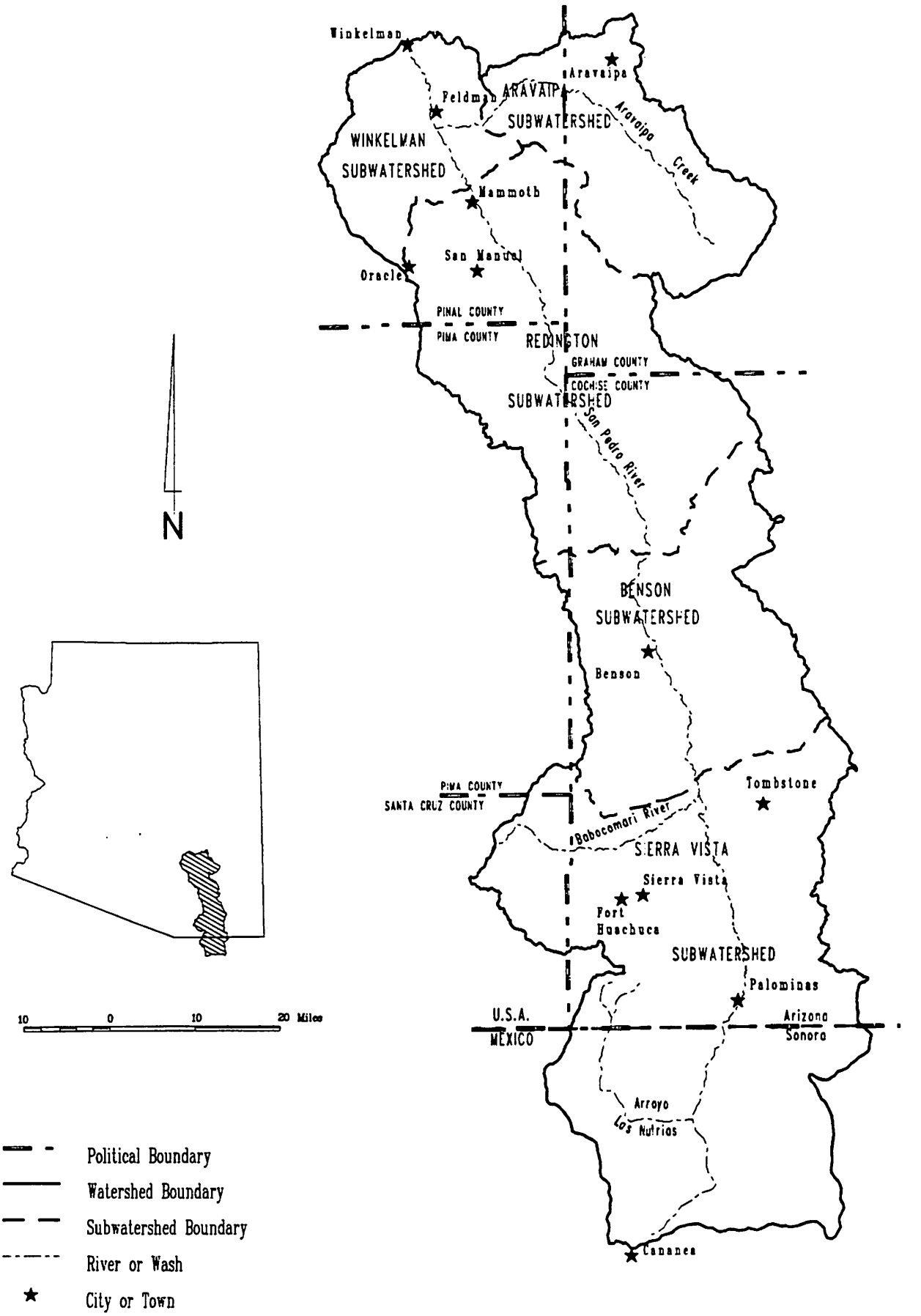


Figure 1-2. San Pedro River watershed

8. Catalogued Wells
9. Maps of Water Uses

Volume 1, the General Assessment, describes the nature of the adjudication proceeding, a hydrologic evaluation of the water supply, water uses (natural and cultural) and their relationship, the determination of Zones 1, 2, and 3 for wells, investigation criteria employed by DWR, the results of the investigations for major water users and non-Indian federal law claims, and quantification procedures utilized by DWR to estimate the amount of each user's water use.

Volume 2, the Comprehensive Indices, contains nine different indices which can be used to seek information about a water use or readily locate a watershed file report of interest by: the land owner's name, the type of use, the location of the use or the diversion, the apparent date of first use, the applicable adjudication filings, decrees, or the drainage area/water source.

Detailed investigation results of individual water uses are contained in Volumes 3 through 6.

Volume 7, Zone 2 Well Reports, lists those wells that have the potential to diminish the water resources available to federal reservations.

Volume 8, Catalogued Wells, lists those wells that DWR has determined may not be subject to state surface water jurisdiction or affecting the water supply available to federal reservations.

Volume 9 contains maps of the water uses described in Volumes 3 through 6, and Volume 7.

1.1 PURPOSE OF THE ADJUDICATION

In Arizona, the procedure for establishing and maintaining surface water rights has been distinctly different from the procedure for groundwater rights. Before Arizona achieved statehood, surface water rights were established simply by putting water to beneficial use or posting notice of intention to use surface water. After statehood, a water code was enacted which specified a permit system for acquiring a surface water right. Few of the surface water rights established before or after statehood have ever been examined to see if they remain valid.

With respect to groundwater, on the other hand, until 1980 any land owner could withdraw groundwater from beneath the land for reasonable and beneficial use. No posting or permit was required. Until recent years, neither surface water nor groundwater rights have been actively administered and verified, nor have the provisions and limitations of the rights been enforced. Many thousands of surface water and groundwater rights and claims are on file with the state, but the status of many of them is not known.

In addition to all of these groundwater and surface water rights on file with the state, water rights have been specified in a number of court decrees. The decrees normally establish the priority date and entitlement of rights, but few of these are actively administered or their current status known. Additionally, and most importantly, water rights which have been established under federal law are claimed by the United States and Indian tribes. Most of these rights have not yet been prioritized or quantified.

These diversely created and administered water rights need to be joined together in a single comprehensive determination of all rights. The apparent overappropriation of surface water in the Gila River system, along with groundwater overdraft and increasing growth of municipal uses are all compounding the problem of uncertain water rights. Proper management of water resources, whether from the standpoint of the individual entities that use or distribute water or from the standpoint of the state's general interest in providing for the public welfare, requires the final determination of all rights that the general adjudication process has been assigned to accomplish.

1.2 HISTORY OF PROCEEDING

The process of adjudicating water rights within the San Pedro River watershed began on April 3, 1978, when the American Smelting and Refining Company petitioned the Arizona State Land Department (SLD) for a determination of conflicting rights. At that time, the statutes governing adjudications placed responsibility for nearly all aspects of the adjudication with SLD. The Arizona Superior Court was called upon to confirm or modify SLD's order of determination. In February 1979, SLD notified 6,739 land owners within the San Pedro River watershed of commencement of adjudication proceedings and the need to file statements of claimant to protect their rights. Shortly thereafter, in April 1979, the Legislature replaced the prior statutes with the current statutes, A.R.S. §§ 45-251 to 45-260. The new statutes removed all authority and responsibility for conducting adjudications from SLD, and gave the Arizona Superior Court jurisdiction over all pending and future adjudications. The Arizona Water Commission, predecessor agency of DWR, was designated as the Court's technical assistant.

In accordance with the new statutes, the adjudication of the San Pedro River watershed was transferred in June 1979, from SLD to the Cochise County Superior Court. In March and April 1980, the Arizona Water Commission notified all water right holders of record, government agencies, downstream irrigation districts, and the Gila River Indian Community of the change in jurisdiction and of other information relating to the adjudication. The deadline for filing statements of claimant for all sources of water was extended several times and then finally set as follows:

July 11, 1980	Non-federal water claimants
September 30, 1980	Arizona State Land Department
January 4, 1982	Federal claimants (excluding San Carlos Apache Tribe)
January 4, 1985	Groundwater claimants
September 16, 1985	San Carlos Apache Tribe.

In November 1981, the Arizona Supreme Court granted a motion to consolidate the several separate adjudications taking place within the Gila River system into one proceeding. The adjudication for the San Pedro River watershed was transferred from the Cochise to the Maricopa County Superior Court to become a part of the larger general adjudication of the Gila River System and Source.

During the notification and filing period for the general adjudication, another large scale action involving water rights in the San Pedro River watershed was proceeding in the Federal District Court. In June 1978, the Gila River Indian Community filed suit seeking a declaratory judgment that it had first priority to the use of all the waters, including groundwater, in the San Pedro River watershed. Water users who were served a summons in this suit were required to respond to interrogatories. But in March 1980, further action in this suit was suspended when the late Judge Mary Ann Richey stayed the proceedings pending the outcome of the general adjudication taking place in state court.

Two other similar suits were brought by Indian tribes, in the Federal District Court, involving the Upper Salt River and Little Colorado River watersheds. The Federal District Court stayed or dismissed the suits in favor of a determination of the tribes' rights in the on going state court general adjudications. The tribes appealed the District Court's decisions to the Ninth United States Circuit Court of Appeals. In February 1982, the Ninth Circuit Court of Appeals reversed the District Court, finding that the state court lacked jurisdiction to adjudicate Indian water rights. In July 1983, the United States Supreme Court reversed the Ninth Circuit Court's decision, holding that the District Court was correct in deferring to the state proceedings.

During the period of those jurisdictional challenges the state court adjudications were stayed. But after the United States Supreme Court decision, the general adjudication of the Gila River system resumed. The remaining state law questions concerning jurisdiction to determine Indian water rights were decided by Judge Stanley Z. Goodfarb in March 1984. On special action review, the Arizona Supreme Court, in January 1985, affirmed Judge Goodfarb's ruling on state law jurisdictional issues.

In April 1984, Judge Goodfarb ordered a supplemental period for filing groundwater claims. On July 1, 1984, all persons having wells of record with DWR, located within the San Pedro River watershed, were notified of the opportunity to file a claim for their groundwater use on or before January 4, 1985. There were 371 claims filed by that deadline.

On May 29, 1986, Judge Goodfarb issued Pre-Trial Order No. 1 which established the procedures and sequence of events to be followed in conducting

the adjudication. The order specified procedures for filing documents and pleadings and notifying parties that they have been filed; established guidelines for filing motions with the Court; created a Steering Committee to assist with case management; established a sequence for resolution of legal issues; specified criteria for conducting discovery; and established the DWR reporting process.

Shortly thereafter, Judge Goodfarb appointed twelve attorneys to the Steering Committee (which presently has grown to seventeen members) and established the approved mailing list for distribution of pleadings. The organizational meeting of the Steering Committee was held on August 27, 1986.

The Steering Committee began the legal resolution process by compiling a master list of issues and setting a schedule of priorities for these issues. The Steering Committee recommends the issues to be resolved by the Court, which then sets a briefing schedule and date for oral argument. DWR submits a report presenting examples of factual situations related to the issues, and when appropriate, alternative resolutions.

To date, the Court has ruled on the First, Second, Third, Fourth, and Fifth Sets of Issues for Decision. The general subjects and dates of these orders are as follows:

A. First and Second Sets of Issues for Decision - administrative and procedural case management issues; May 28, 1987; August 11, 1987. These orders approved assignment and amendment forms and provided a procedure for refunding filing fees.

   An issue generated by the First Set of Issues was the status of statements of claimant filed within one year from the initial deadline but for which no motion to intervene under A.R.S. § 45-254(E) had been filed. The Court ruled on November 18, 1987, that all statements of claimant filed in the San Pedro River watershed, within one year from January 4, 1985, would be deemed timely filed, but a motion to intervene must be filed (except for a timely filed new use) for claims that are asserted more than one year after a deadline.

B. Third Set of Issues for Decision - scope of DWR investigations, and standards for investigating water claims and uses; January 29, 1988. This order instructed DWR as to the scope and format of information which

should be presented in its HSRs. Guidelines were established as to the investigatory and claims information which should be reported.

C. Fourth Set of Issues for Decision - confirmation of water rights and preservation of objections of downstream claimants; July 29, 1988. The issue of preservation of objections of downstream users was deferred until the disposition of the Fifth Set of Issues for Decision. DWR prepared a report and a supplement on this deferred issue.

D. Fifth Set of Issues for Decision - statutory context of HSRs, HSR hearings, administration and enforcement of decree, issue resolution, and DWR's role in the proceeding; August 2, 1989.

As part of the issue resolution process, DWR, in September 1988, submitted a report outlining proposed guidelines for the entitlement of water rights. A claimant moved the Court to reject this report. On March 17, 1989, the Court denied this motion and instructed DWR on the entitlement procedures to be followed, but only for reporting purposes and not for the adjudication of water quantities. These procedures are intended to provide information and are not a determination as to how entitlements will be adjudicated.

An early threshold issue was whether groundwater uses and claims are subject to adjudication by the Court. This issue presented significant state and federal law, and hydrological and technical questions, whose answers could influence the future direction of the adjudication. In October 1987, the Court heard testimony for one full week from technical experts on the interrelationship of groundwater and surface water. DWR submitted a report and presented testimony.

Shortly after this hearing, a group of municipal claimants moved the Court to exclude groundwater wells from this adjudication. The Court heard argument on this motion and eight associated issues. On September 9, 1988, the Court denied this motion, holding that groundwater is subject to adjudication if it meets certain criteria or if the water source is for a claim based on federal law. The Court established criteria for determining appropriable streamflow and instructed DWR as to the relevant information which should be compiled and reported.

On March 22, 1988, Judge Goodfarb issued Pre-Trial Order No. 3 which established specific discovery procedures for claimants; divided claimants into three classes, each with different responsibilities and duties in

discovery; fixed the timing and sequence of discovery; established DWR as a central repository of information; provided guidelines for discovery from DWR, including access to computerized information; and set procedures for the use of expert witness reports and the resolution of discovery disputes.

As a result of the Discovery Order, the Court directed DWR to prepare and send a questionnaire to Group 1 and 2 claimants in the San Pedro River watershed. This questionnaire was intended to serve as a substitute for written interrogatories and further discovery as to these claimants. In September 1988, DWR mailed 2,814 questionnaires, of which 1,921 were answered and returned to DWR. Updated answers to the questionnaires were deemed to be amendments to claims.

On June 2, 1988, Judge Goodfarb entered the Order Allowing New Use Statements of Claimant. The purpose of this order was to allow the filing of claims for water uses initiated after the original filing deadlines. In the San Pedro River watershed, this deadline was held to be January 4, 1985. Since October 13, 1988, DWR has sent by certified mail 7,166 summonses to potential claimants throughout the Gila River System, including the San Pedro River watershed. The summonses have been sent to persons who have drilled a well, registered a surface water right, or filed an application for an appropriative water right in the San Pedro River watershed between December 1, 1984 and June 30, 1990. These notifications of new users are made annually, the most recent being on November 1, 1991.

In February 1987, DWR published a draft preliminary HSR for the San Pedro River watershed. This HSR was widely publicized by electronic and print media, and copies of the pertinent parts of the report were mailed to all claimants and water users found in the watershed. A total of 640 comments were received. A large number of these comments, however, did not require DWR to take any action. DWR incorporated information generated by these comments into the preliminary HSR published in August 1990.

On September 26, 1989, the Arizona Supreme Court adopted a Special Procedural Order for Interlocutory Appeals and Certifications. The purpose of this order "is to establish a procedure for early review of all substantial questions in this general adjudication." Any party may petition the Supreme

Court to review, by interlocutory appeal, any ruling of the Superior Court, and the Superior Court may certify to the Supreme Court questions deemed substantial for review.

In February 1990, several parties appealed various prior rulings of the Superior Court, including portions of Judge Goodfarb's order of September 9, 1988. On June 27, 1990, the Supreme Court consolidated the petitions. On December 11, 1990, the Supreme Court granted review on six issues. Each issue will be briefed, argued, and determined separately. Currently, the first issue is under submission to the Supreme Court.

The statutes provide for the appointment of a master who will conduct hearings, receive evidence, and prepare a report for the Court setting forth findings of fact and conclusions of law. In October 1987, several claimants petitioned the Arizona Supreme Court to appoint a master. The Supreme Court requested comments from the trial court and claimants on the scope of the duties and responsibilities of the master. On January 18, 1989, the Supreme Court directed DWR to submit a list of three to five candidates. On August 1, 1989, DWR submitted a list of five names. On December 19, 1989, the Supreme Court appointed Mr. John E. Thorson as the Master.

On May 16, 1991, following the request of several parties and the submission of comments, the Arizona Supreme Court adopted a Special Procedural Order Providing for the Approval of Federal Water Rights Settlements, Including Those of Indian Tribes. This order establishes procedures for the claimants and the Superior Court to follow in submitting and approving a settlement agreement for Indian water rights or other federal reserved water rights. The first settlement to be considered under this rule will be the agreement which settles the water rights claims of the Salt River Pima-Maricopa Indian Community as set forth in the Salt River Pima-Maricopa Indian Community Water Rights Settlement Act of 1988, P.L. 100-512, 102 Stat. 2549.

1.3 TYPES OF WATER RIGHTS AND CLAIMS

In Arizona, water rights have been established or claimed over the years under five broad legal categories: 1) territorial and state surface water code, 2) state groundwater code, 3) court decree, 4) federal law, and 5) adjudication statements of claimant. In most cases, the first four categories are independent of one another; not only in the way in which the rights are initially acquired or claimed, but also by the manner in which they are administered or regulated. The adjudication process will need to address the issues raised within each of these categories as well as issues concerned with the integration of all five categories into a comprehensive decree for the Gila River system.

SURFACE WATER CODE

In 1864, the first territorial legislature of Arizona adopted a prior appropriation system for surface water rights in which those who are first in time to use water are also first in right. Since both the population and use of water were small at the time, no method was specified by the legislature for filing or receiving specific grants of right. By the late 1800s, however, rapid development of irrigated agriculture combined with drought years resulted in severe water shortages along the Salt and Gila Rivers. In 1893, the territorial legislature responded with a requirement that new water appropriations be posted at the point of diversion and recorded at the county recorder's office. But the legislature failed to establish any mechanism for making grants of right.

After statehood, the legislature enacted the state water code (also known as the Public Water Code or surface water code) effective June 12, 1919, which, except for several amendments over the years, remains essentially the same today. It requires that an application be filed with a state administrative agency (currently DWR) which, if all requirements are met, leads to a permit and finally to a certificate of water right.

In the 1970s, two registration acts were passed by the legislature. One claimed rights for stockpond use and the other claimed rights initiated prior

to the surface water code. The methods by which rights have been established or claimed under various provisions of the water code are further described below.

Notices of Appropriation

Prior to the 1919 Public Water Code, a person could appropriate water either by the mere application of water to a beneficial use or by posting a notice of intent to appropriate at the point of diversion and recording the notice with the county recorder in the county where the proposed dam, reservoir, or canal would be located. A recording system was enacted in 1893 by the Territorial Legislature and remained in effect until the 1919 Public Water Code. The 1893 legislation required an appropriator to identify the source, amount of water appropriated, point of diversion, location of any storage reservoir, means of diversion or conveyance, and the place of use. The notice was required to be recorded with the county recorder and a copy recorded with the Secretary of the Territory (after statehood, the Secretary of State).

The date of priority of the water right was the date of recording of the notice, if the water was applied to beneficial use "within a reasonable time thereafter." The "failure to within a reasonable time after posting and filing" to appropriate and beneficially use the water resulted in "a forfeiture of such right."

Many notices of appropriation were filed prior to 1893. DWR searched the public records of the Cochise, Gila, Graham, Pima, Pinal, and Santa Cruz County Recorders. DWR reviewed notices of appropriation filed from the earliest date on public record through June 12, 1919, the effective date of the Public Water Code. All notices which could be reasonably associated with a claimed water right or a found water use are reported under the prefix "10." In the San Pedro River watershed, 542 notices were found and reported. A comprehensive listing of these notices is available from DWR upon request.

Appropriable Subflow

The 1919 Public Water Code provided that "the waters of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite

underground channels . . . belong to the public and are subject to appropriation and beneficial use." A.R.S. § 45-141.A. The Arizona Supreme Court has stated that "the essential characteristics of a watercourse are a channel, consisting of well defined bed and banks, and a current of water." Maricopa County Municipal Water Conservation District No. 1 v. Southwest Cotton Co., 39 Ariz. 65, 85, 4 P.2d 369 (1931), mod. and reh. den., 39 Ariz. 367, 7 P.2d 254 (1932). Whether on the surface or underground, waters flowing in channels having these characteristics are subject to appropriation for beneficial use.

In Southwest Cotton, the Arizona Supreme Court not only identified the characteristics necessary to establish the existence of an underground stream but also adopted a test to determine the appropriability of a stream's subflow. The Court defined the subflow of a stream to be "those waters which slowly find their way through the sand and gravel constituting the bed of the stream, or the lands under or immediately adjacent to the stream, and are themselves a part of the surface stream." 39 Ariz. at 96. Physically, subflow waters constitute a part of the surface stream, and depend on the surface stream for the greater part of its supply.

The "best test" to determine "whether underground waters are as a matter of fact and law part of the surface stream" is: "does drawing off the subsurface water tend to diminish appreciably and directly the flow of the surface stream?" 39 Ariz. at 97. If it does, it is appropriable subflow. If it does not, the underground waters are not appropriable.

On September 9, 1988, Judge Goodfarb issued an order concerning technical and legal issues associated with the appropriability of subflow. DWR has considered these guidelines in its investigations of claims and has incorporated the technical criteria in the order into this report. In February 1990, several parties appealed portions of this order to the Arizona Supreme Court through interlocutory appeal. This appeal is pending.

"Old" Rights and "Claimed" Rights

Because the 1919 surface water code did not provide a method to recognize pre-1919 water rights, at the request of right holders SLD established a filing system to record these old rights. The filing system was divided into two categories: "old" rights and "claimed" rights. "Old" rights, commonly

referred to as "Os," were those filings which included a copy of the pre-1919 notice of posting or notice of intent to appropriate from a county recorder's office. "Claimed" rights, or "Cs," were those filings which claimed rights established prior to 1919 but did not contain proof of filing with the county recorder's office. In the San Pedro River watershed, there are thirteen "Cs" and ten "Os" on file with DWR.

Water Code Rights, A.R.S. §§ 45-151 to 45-167

Since June 12, 1919, a person seeking a surface water right has been required to file an application with a state agency (currently DWR) for a permit to appropriate the water. A permit authorizes the permittee to divert and construct the necessary works to put the water to beneficial use. After perfecting the right, the permittee receives a certificate of water right. All permits and certificates of water right are subject to prior vested water rights. In the DWR system, all applications, permits, and certificates are filed under the prefixes "33", "4A", or "3R." In the San Pedro River watershed, there are 246 33s, 162 4As, and 150 3Rs on record with DWR.

1974 Water Rights Registration Act, A.R.S. §§ 45-180 to 45-193

The Water Rights Registration Act, enacted in 1974, required most persons claiming surface water rights established prior to the effective date of the surface water code (June 12, 1919) to file a statement of claim no later than June 30, 1979. In 1988, the legislature amended this act to permit filing of registrations between September 30, 1988 and September 30, 1990. Cities and towns of a certain population had previously been permitted, for a period of thirty days in 1987, to file these registrations. Persons claiming rights to the Colorado River or rights obtained through a court decree were exempt from the filing requirement. This Act did not provide a process to determine the validity of the claims, apparently leaving that determination to a future adjudication. All statements of claim under this Act received prior to the filing deadline are filed under the prefix "36." In the San Pedro River watershed, there are 3,106 36s on file with DWR.

1977 Stockponds Registration Act, A.R.S. §§ 45-271 to 45-276

Because numerous stockponds were built after enactment of the 1919 surface water code without complying with its filing requirements, in 1977 the

legislature enacted the Stockponds Registration Act to provide a method for registering those stockponds which had been built between 1919 and 1977 and which did not have a "33" application, permit, or certificate applicable to the pond. The Act applies only to ponds which are used solely for watering livestock or wildlife and which have a storage capacity of no more than fifteen acre-feet. All stockpond claims under this Act are filed under the prefix "38." In the San Pedro River watershed, there are 1,922 38s on file with DWR.

GROUNDWATER CODE

On June 12, 1980, the Arizona legislature enacted a comprehensive groundwater management code governing the allocation and use of groundwater. The code was the culmination of decades of attempts to come to grips with the fact that Arizona uses considerably more groundwater each year than is returned to the groundwater supply by natural and incidental recharge.

The code applies to the entire state, but many of the major water management provisions apply only to certain geographic areas that, because of the severe overdraft problem, require more intensive management. These areas are known as active management areas (AMAs) and irrigation nonexpansion areas (INAs). The code created four AMAs: Phoenix, Pinal, Prescott, and Tucson. The code establishes a comprehensive system of groundwater rights, management goals, and mandatory conservation programs for the AMAs. In an AMA, a person may withdraw and use groundwater only in accordance with one of the four types of rights created by the code: 1) grandfathered rights (for persons who were withdrawing or using groundwater in an AMA prior to adoption of the code); 2) groundwater withdrawal permits (for new nonirrigation uses supplied by individual wells); 3) service area rights (for cities, towns, private water companies, and irrigation districts); and 4) exempt withdrawals (for small nonirrigation uses that are exempt from many restrictions in the groundwater code).

The code designated two INAs in which the expansion of irrigated agriculture is prohibited. The director of DWR has since established a third INA. These INAs are: Douglas, Harquahala, and Joseph City.

Outside of AMAs and INAs, a person may withdraw and use groundwater for reasonable and beneficial use.

In the San Pedro River watershed, there are no designated AMAs or INAs. Therefore, there are currently no restrictions on drilling wells or withdrawing groundwater in the San Pedro watershed other than the requirement that the wells be registered and drilled according to state well construction standards. In the San Pedro River watershed, there are 5,365 registered wells on file with DWR.

COURT DECREED RIGHTS

Decreed rights are water rights which have been determined by a state or federal court. A court action in which a water right is determined may be initiated when one water user seeks to know how his or her rights compare to the rights of other water users or seeks judicial relief from alleged interference with his or her rights by other water users. The ownership of water rights may be determined as part of a legal division of property. Finally, decreed rights may be determined through general adjudication proceedings.

Decreed rights often involve water uses which have already been granted some form of right under provisions of state law. The court process confirms the validity of those grants, determines whether there has been proper maintenance of the right over the years, and ranks the various rights according to their priority. Court decrees may also go beyond just confirming previously established rights by quantifying or prioritizing rights for the first time.

When a conflict exists over the use of a limited water supply, the decree may, in addition to confirming or establishing rights, specify terms under which the decreed rights may be exercised. These solutions to conflicting rights may involve a formula for distributing the available water supply, monetary mitigation of the conflict, or other means imposed by the Court.

Court decreed rights are considered to be the most valued or most certain rights because in the absence of abandonment or forfeiture, they are normally accepted as to their validity. Decreed rights may be included in later, larger scale decrees.

There are three major water right decrees in the Gila River system. They are:

1. The Kent Decree (Hurley v. Abbott) was entered in Territorial District Court in 1910. It established rights to the Salt River from diversions occurring at that time from Granite Reef and Joint Head Diversion Dams, which generally conforms to the present Salt River Project water service area.

2. The Gila Decree (Globe Equity Number 59) was entered in Federal District Court in 1935. It established rights to the Gila River mainstream from the diversions in the Duncan-Virden Valley in New Mexico downstream to diversions at Sacaton Dam on the Gila River Indian reservation.

3. The Benson v. Allison Decree was entered in State Superior Court in 1917. It established rights to the lower Agua Fria River, the Salt River below Joint Head Diversion Dam, and the Gila River from the Salt River confluence to the Buckeye Irrigation Company canal heading.

There are eleven known water right decrees in the San Pedro River watershed, all of which affect a small number of water users. They are:

1. Elijah Clifford et al., v. L. Larrieu, 2 Ariz. 202, 11 P. 397 (1886)

On August 2, 1886, the Supreme Court of the Territory of Arizona affirmed a ruling of the Cochise County Court enjoining the Defendant Larrieu from obstructing or interfering with the plaintiffs' water rights appropriated from the San Pedro River and conveyed through the St. Davids Canal. The plaintiffs, shareholders in the St. Davids Canal Company, constructed the canal to provide water "for irrigation purposes" to "some 600 acres of land" in and around St. David. The canal company was incorporated in May 1883. The Defendant Larrieu had appropriated water from the San Pedro River in December 1883 and finished his ditch in January 1884 above the point of diversion of the St. Davids Canal.

On appeal, Defendant Larrieu contended that the County Court had erred in not dismissing the complaint because the ditch was owned by a corporation and the corporation was not a plaintiff. The Territorial Supreme Court held that the owners of the lands served by a canal company

could sue to protect their water rights otherwise their rights "would be of little value if they were subject to the interest, whim, or caprice of the owner of the ditch."

The St. Davids Canal, now known as the St. David Ditch, is still in use and is operated by the St. David Irrigation District.

See watershed file report numbers 112-17-88 and 112-17-DCD-1.

2. **John Hill et al. v. E. Lenormand et al., 2 Ariz. 354, 16 P. 266 (1888)**

On January 17, 1888, the Supreme Court of the Territory of Arizona affirmed a ruling of the Cochise County Court enjoining the defendants from interfering with the plaintiffs' appropriative rights to the San Pedro River.

The plaintiffs and their predecessors-in-interest had appropriated, by means of a ditch, water from the San Pedro River in 1877. The ditch was located near the settlement of Contention and served the milling operations of the Contention Consolidated Mining Company. The defendants, in 1884, had constructed a diversion and ditch upstream from the plaintiffs to irrigate lands on both banks of the river. The trial court found that the defendants' "diversion affected the flow of water into plaintiffs' ditch."

The defendants claimed riparian rights from their ownership of land on both sides of the river. The Territorial Supreme Court held that "riparian rights do not apply," and rejected the defendants' claims of riparian rights. The Court held that "plaintiffs, as prior appropriators, had acquired vested rights in these waters, and the purchase and ownership of the lands on both sides of San Pedro river above plaintiffs did not divest these rights."

See watershed file report number 111-20-32.

3. **Charles Dyke v. P.V. Caldwell, 2 Ariz. 394, 18 P. 276 (1888)**

On May 25, 1888, the Supreme Court of the Territory of Arizona modified the ruling of the Territorial District Court enjoining Plaintiff Dyke from diverting water from pools located in the bed of the San Pedro River, but permitting the plaintiff to divert the water flowing over Defendant Caldwell's dam, after restoring the dam to its former height prior to a flood which had lowered the dam.

The plaintiff, prior to 1885, had constructed a dam in the streambed of the San Pedro River to collect and store water from pools for stockwatering. These pools were located closer to defendant's land than to plaintiff's property. The defendant, in December 1885 and February 1886, and constructed a ditch at the base of the dam to convey water to his land for irrigation. Defendant Caldwell had recorded a Notice of Appropriation with the county recorder in early 1886 on the ditch, although he had begun working on the ditch on December 12, 1885. This ditch was 150 feet long before Defendant Caldwell had been enjoined by the District Court.

The Territorial Supreme Court held that Plaintiff Dyke did not intend to "drain the pools, and no damage could arise unless they were drained," therefore, there was "no proof that irreparable injury would be done to" Defendant Caldwell. Plaintiff Dyke could use the water which flowed over the dam, after repairing the dam to its preflood height, but was "restrained from draining the pools." Defendant Caldwell would continue using the water in the pools for stockwatering.

See watershed file report number 113-12-BD-4.

4. William C. Miller v. Charles L. Douglas, 7 Ariz. 41, 60 P. 722 (1900)

On March 28, 1900, the Supreme Court of the Territory of Arizona modified a ruling of the Territorial District Court enjoining Defendant Miller from obstructing or interfering with the diversion or conveyance system of Plaintiff Douglas from the Babocomari River. The Court modified the trial court's ruling as to the amount of damages assessed against Defendant Miller.

The plaintiff and his predecessors-in-interest had constructed and maintained a dam and ditch on the Babocomari River since 1883 to provide water for irrigation and farming on 160 acres of land. In 1890, floods changed the course of the Babocomari River, leaving the pool and point of diversion used by Plaintiff Douglas "one thousand feet or more away" from the river's new channel. Plaintiff Douglas built a new dam and ditch to connect with the usable segment of the old ditch. Defendant Miller, in 1896, took possession of the "pasture field" through which Plaintiff had constructed the new ditch in 1890. Defendant Miller, however, did not assume titled ownership of this field which remained "unoccupied public

land." Defendant Miller proceeded to make a diversion above the plaintiff's new dam, construct a canal, and fill up plaintiff's ditch preventing "plaintiff from using his canal, or obtaining water from the" Babocomari River. As a result, Plaintiff Douglas' crops for the year 1897 were damaged and lost.

The Supreme Court held that Plaintiff Douglas was not a trespasser on the "pasture field" because defendant's predecessors-in-interest had acquiesced in the plaintiff's use of the "pasture field" for the new ditch (since 1890), or if the field had been public land when Miller came into possession, Defendant Miller obtained possession subject to the easements for water rights and canals he found. The Court, however, limited the amount of damages to the crop losses suffered in 1897 and disallowed damages for losses suffered in 1898. The Court held "that there can be no question, under the evidence in the record, about plaintiff's appropriation being prior to any appropriation of the waters of {Babocomari} Creek made by the defendant, Miller, or any of his predecessors."

See watershed file report number 111-20-32.

5. **Boquillas Land and Cattle Company v. The St. David Cooperative Comm. and Dev. Assn., 11 Ariz. 128, 89 P. 504, (1907), aff. sub no., Boquillas Land and Cattle Co. v. Curtis, 213 U.S. 339 (1909)**

Plaintiff Boquillas owned a tract of land granted, in 1833, by the Republic of Mexico to plaintiff's predecessors-in-interest, and title had been subsequently confirmed and patented in 1900. In 1877, members of defendant association had entered upon these lands, constructed a dam across the San Pedro River, and diverted water by means of a canal to irrigate their lands lying north of plaintiff's tract. In 1904, defendant undertook to construct a new dam to replace the prior structure that had been destroyed by a flood. Plaintiff Boquillas sued to enjoin defendant from entering its lands and diverting water from the San Pedro River off plaintiff's lands.

The trial court held that the defendant had a right of prior appropriation and found in favor of the defendant.

On appeal to the Territorial Supreme Court, Plaintiff Boquillas contended that: 1) by territorial legislation the doctrine of riparian

rights was at one time in force during the time plaintiff's predecessors-in-interest had owned the tract "and that such rights, having once attached, could not be taken away by subsequent legislation," and 2) plaintiff, claiming title under a Mexican land grant, "possesses all the right to the use of the water flowing through its land which its predecessors-in-interest had prior to the priority of right by virtue of priority of appropriation was not in force under the laws of Mexico at the time of the Gadsden Purchase in 1853."

The Territorial Supreme Court affirmed the trial court's ruling holding that: 1) the common law doctrine of riparian rights was never in force in the territory, and 2) the Territory of Arizona had the same sovereign and legislative authority held by Mexico, prior to the Gadsden Purchase, to determine the use of unnavigable streams, and the Territory had "chosen to deny to riparian owners exclusive rights and to confer upon others rights to the use of such water" without regard to ownership of land. The Court noted that, in an earlier case, it had held that the common law doctrine of riparian rights "has never been and is not now suited to conditions that exist here so far as the same applies to the uses of water," and that the Territorial legislature had expressly abolished the doctrine in 1887. The Court stated that the prior appropriation doctrine "was to some extent in force by custom" in the State of Sonora, prior to the Gadsden Purchase, including areas of Arizona's Santa Cruz valley. The Territorial water rights statutes "seem to have had their origin in the Mexican law, as modified by custom." Therefore, Plaintiff Boquillas was claiming riparian rights which its predecessors-in-interest "do not appear to have possessed" prior to the Gadsden Purchase.

Plaintiff appealed to the United States Supreme Court, which in 1909 affirmed the decision of the Territorial Supreme Court.

See watershed file report numbers 112-17-DCD-1 and 112-17-88.

6. **James Wolf v. Bailey Turner and Peter Haviland, District Court of the Second Judicial District of the Territory of Arizona, No. 4425 (April 27, 1907)**

On April 27, 1907, the Territorial District Court entered a judgment which granted Plaintiff Wolf "an equal, undivided one-half interest" in a water right acquired by predecessors-in-interest on March 1, 1892 to

divert water from the San Pedro River and a same interest in the dam and "irrigation ditch" used to divert and transport the water. The ditch traversed through lands owned by Defendant Turner.

The water right vested on March 1, 1892 was acquired by Peter Haviland and J.J. Quinam by recording a Location of Water Right, on March 29, 1892 in Book 3 of Miscellaneous Documents, Page 301, of the records of the Cochise County Recorder. The Location states that this right was for irrigation in the amount of 848 inches of flowing water with one-quarter inch fall to the rod.

The plaintiff was also granted an interest "to sufficient of the earth, gravel and rock contiguous to said ditch and dam to keep the same in repair and to the use of the lands bordering along said ditch when necessary in cleaning and repairing said ditch." The Court held that Defendant Turner had no ownership right or interest in any of the rights and easements granted to Plaintiff Wolf and enjoined Defendant Turner from interfering with any of the plaintiff's rights.

See watershed file report numbers 111-20-32 and 111-20-DDA-23.

7. **Henry Pyeatt v. Huachuca Queen Mining Company; Alice McFaddin and C.W. McFaddin, Cochise County Superior Court, No. 7069 (June 9, 1928)**

Plaintiff Pyeatt sought an injunction to prevent the defendants from pumping water from defendants' mining shaft and mine workings, as this pumping interfered with plaintiff's springs on his land. In 1927, the defendant corporation had begun operating a mine on claims owned by Defendants McFaddin. Plaintiff contended that "pumping the water from the mining shaft and mine workings of the defendants" interfered with the normal flow of the springs which plaintiff had beneficially used.

On June 9, 1928, the Cochise County Superior Court entered a judgment which "perpetually enjoined and restrained" the defendants from pumping water from their mining operations to such an extent that the water from plaintiff's springs would not flow as they had prior to the commencement of defendants' mining operations. The defendants were enjoined from interfering with "the flow of the underground or subterranean channel or watercourse feeding or supplying" the plaintiff's springs and "the normal flow of water therefrom as the same normally flowed prior to the commencement of mining operations." Plaintiff's

lands were in portions of Section 36, Township 21 South, Range 19 East, and Section 36, Township 21 South, Range 18 East, Gila and Salt Rivers Baseline and Meridian (G&SRBM).

See watershed file report number 111-19-DDC-1.

8. **Horace W. Clarkson and Eva F. Clarkson v. Leslie Wilcox, Cochise County Superior Court, No. 9205 (July 23, 1935)**

On July 23, 1935, the Cochise County Superior Court entered a stipulated decree which determined the water rights of these parties to the natural flow of Miller Creek flowing through Miller Canyon. The Court found that the predecessors in interest of the plaintiffs and defendants had appropriated, in 1907, all of the natural flow of Miller Creek for beneficial use. These prior appropriators had conveyed a two-thirds interest in their rights to Plaintiffs Clarkson, and a one-third interest to Defendant Wilcox. Both plaintiffs and defendant owned lands located near the mouth of Miller Canyon.

The Court found that both parties had, since 1907, beneficially used the waters of Miller Creek. The plaintiffs had constructed a pipeline in 1907 to divert water to their lands, while the defendant had used a previously constructed ditch (known as the Johnson-Browning & Pointer Ditch) to divert water to their lands.

The Court ruled that Plaintiffs Clarkson were entitled to the beneficial use of two-thirds of the natural flow of Miller Creek and Defendant Wilcox was entitled to the beneficial use of one-third of the natural flow. The point of diversion of both parties was located within the NW¼, NE¼, Section 24, Township 23 South, Range 20 East, G&SRBM. The plaintiffs would divert the entire flow of Miller Creek for two successive days and the defendant would divert the entire flow of the creek on the succeeding day, and this alternating schedule "shall continue as to amount and periods of use." Each party was entitled to use the other party's share of the water rights if a party was not able to use its share for any period of time.

Each party had the right to use ditches, flumes, pipelines, or the bed of Miller Creek to convey water, and Defendant Wilcox had the right to access plaintiffs' lands to construct a pipeline and repair or maintain his ditch or any pipeline constructed on plaintiffs' lands.

Each party was enjoined from wasting water or from interfering with the other party's use and means of diversion of the decreed water right.

See watershed file report number 111-23-DBB-26.

9. **Mae D. Davidson v. Wilford H. Claridge; George Claridge; Roy Claridge; Ray Claridge; and Hugh Claridge, Graham County Superior Court, No. 3061 (October 30, 1940)**

On October 30, 1940, the Graham County Superior Court entered a stipulated decree which established the ownership of four water rights originating in Stowe Gulch and diverted by means of the same pipeline. The pipeline took water from Stowe Gulch at a point located in the SE¼, SW¼, Section 1, Township 6 South, Range 19 East, G&SRBM. Each of the four water rights entitled the parties to divert an amount equal to one-half of the capacity of the one inch pipeline at four different places of use for stockwatering, domestic, and agricultural uses.

The first two rights were owned by Plaintiff Davidson and the other two rights were owned by Defendants Claridge. The date of priority of the first three rights was December 23, 1915, and the date of priority of the remaining right, owned by Defendants Claridge, was "immediately subsequent" to December 23, 1915.

The priority of the water rights was "based upon the water available at the source thereof in Stowe Gulch and not upon the amount of water in the pipeline." In times of insufficient water, the first three rights were to be satisfied fully and prior to the fourth right.

The four points of diversion from the pipeline were set as follows:

1. Davidson - SE¼, NE¼, Section 35, Township 6 South, Range 19 East;
2. Davidson - SW¼, Section 25, Township 6 South, Range 19 East;
3. Claridge - SW¼, NW¼, Section 24, Township 6 South, Range 19 East;
4. Claridge - SW¼, Section 12, Township 6 South, Range 19 East, G&SRBM.

The Court divided the ownership of the pipeline into two segments and allocated the responsibility for repairs and maintenance.

The Court retained jurisdiction to approve "such mechanical arrangements as may be necessary to divide and divert" the water in accordance with this decree and to enter supplemental orders implementing the decree. Lastly, no party was awarded damages.

See watershed file report numbers 115-5-34 and 115-5-AC-3.

10. George R. James et al. v. Max Baumkirchner, et al., Cochise County Superior Court, No. 17863 (December 12, 1960)

Max Baumkirchner et al. v. State Land Department, Obed Lassen; Raymond G. Corbett et al., Cochise County Superior Court, No. 19035 (December 12, 1960)

On December 12, 1960, the Cochise County Superior Court entered a judgment in both of these actions pursuant to the stipulation of the parties. In Cause No. 17863, Plaintiffs Corbett sought a determination that they had an appropriative right to Lowery Spring prior to that of the Baumkirchners. In Cause No. 19035, Plaintiff Baumkirchner filed an appeal for judicial review of the decision of SLD granting the Corbetts a permit to appropriate the waters of Lowery Spring for stockwatering. The Baumkirchners had protested the application.

The judgment entered on December 12, 1960, vacated the decision of SLD "in so far as it conflicts with this judgment," dismissed Cause No. 17863, and provided that both parties are "joint and equal appropriators and they stand in the relation of tenant in common as to the waters of" Lowery Spring. The Court held that the spring was to be used for domestic, stockwatering, and mining purposes. The spring is located in the SE¼, NW¼, Section 30, Township 23 South, Range 21 East, G&SRBM.

The Court did not quantify the water rights. The agreement of the parties, however, stipulated that "the parties will share equally in the waters of Lowery Spring, including the waters trapped by [the spring's] underground reservoir." The Corbetts' application had been approved for 300,000 gallons per year for stockwatering. The history found in SLD's file of the Corbetts' appropriative application shows that the Corbetts applied for stockwatering only and that the Baumkirchners were the domestic and mining users.

The Court did not establish a date of priority for these rights except "a period of years" prior to 1919. The history found in the file of the Corbetts' appropriative application indicates that the spring was used as early as 1901 or 1902 for stockwatering and possibly for domestic purposes.

The Court provided that metering devices would be installed in times of shortage "to provide for equal distribution of the waters to each of the parties." The parties would share equally the cost of installing metering devices and of repairs. No changes or improvements would be made to the spring without the written consent and approval of the parties. An arbitration procedure was established for resolving future disputes regarding the agreement of the parties, and the agreement was stipulated to be binding upon the successors-in-interest of the parties.

See watershed file report numbers 111-23-11 and 111-23-22.

11. **Delbert W. Basinger and Patricia M. Basinger v. Austin Moss and Marka Moss, Santa Cruz County Superior Court, No. 89 V-227 (1991)**

On April 18, 1991, the Superior Court of Arizona in and for the County of Santa Cruz entered a judgment quieting title in Plaintiffs Basingers to a well and well site located in the NW¼, NE¼, Section 33, Township 20 South, Range 18 East, G&SRBM and reforming the original sales agreement to include ownership of the well and well site.

The well was previously owned by the Collies, predecessors-in-interest of defendants. The Collies sold a parcel of their land to Plaintiffs Basingers in 1966. The parties agreed to include a well, situated approximately twenty feet beyond the property line and an easement to the well, as part of the sales agreement. Plaintiffs Basingers fenced the well and easement as part of their land in 1967. But the well was omitted from the recorded deed.

Plaintiffs Basingers did not learn the well and well site had been omitted from the deed until 1989, when they commenced this quit title action.

See watershed file report number 111-19-45.

FEDERAL LAW RIGHTS

Federal water law is based primarily upon case law handed down over the years in numerous federal court decisions. Some of the leading cases decided by the United States Supreme Court are:

1. Winters v. U.S., 207 U.S. 564 (1908)

The Court established in 1908 what is now known as the "Winters Doctrine." It found that an Indian reservation may reserve water for future use in an amount necessary to fulfill their purpose with a priority dating from the treaty, act of Congress, or executive order that established the reservation. These types of rights, based on a reservation of water by the federal government, are known as "reserved rights."

2. Arizona v. California, 373 U.S. 546 (1963), supp., 439 U.S. 419 (1979), supp., 460 U.S. 605 (1963)

This landmark decision, initially entered in 1963, confirmed the division of waters of the Colorado River among the lower basin states. The Court quantified the reserved rights of five Indian reservations on the basis of an amount of water necessary to irrigate all practicably irrigable acres on the reservation. This is known as the PIA method of quantifying reserved rights.

3. Cappaert v. U.S., 426 U.S. 128 (1976)

In 1976, the Court held that federal reserved rights can be protected from infringement by junior users of groundwater.

4. U.S. v. New Mexico, 438 U.S. 696 (1978)

In 1978, the Court found that the reserved water rights on national forests apply only to the preservation of timber resources and water flows and cautioned that the quantification of reserved rights should consider the potential effect on downstream junior state right appropriators.

In addition to Indian reservations, other court decisions have extended the reserved right doctrine to encompass certain water uses in national forests, national parks and monuments, military reservations, and lands administered by the Bureau of Land Management (BLM).

In the San Pedro River watershed, federal law claims have been filed by SLD, the Coronado National Forest, Coronado and Saguaro National Monuments, Fort Huachuca, BLM, and the San Carlos Apache Tribe. Downstream from the San

Pedro watershed, a very large claim for federal reserved rights has been filed by the Gila River Indian Community apparently claiming rights to waters originating in the San Pedro River watershed.

ADJUDICATION CLAIMS

All persons who claim to have water rights within the two river systems which have been petitioned for a general adjudication (the Gila and Little Colorado Rivers) are required to file a statement of claimant or risk the loss of their rights. DWR has assigned a prefix of "39" to all statements of claimant. There are 8,017 statements of claimant filed for rights within the San Pedro River watershed.

1.4 GEOGRAPHY

The San Pedro River watershed (Figure 1-2) is comprised of the San Pedro River and its two major tributaries: the Babocomari River and Aravaipa Creek. The San Pedro River and its tributaries are the major sources of surface water in southeastern Arizona.

The San Pedro River has a total drainage area of approximately 4,485 square miles with a total river length of about 151 miles in the United States. The headwaters of the San Pedro River are located near Cananea, Sonora, Mexico, approximately thirty miles south of the International Border. The Mexican portion of the watershed has a total drainage area of about 696 square miles. The watershed is generally characterized by a semi-arid valley oriented in a north-northwest direction.

Aravaipa Creek drains approximately 560 square miles from its headwaters to its confluence with the San Pedro River near Feldman. The Babocomari River drains about 308 square miles from its headwaters near Elgin to its confluence with the San Pedro River at Fairbank.

Figure 1-3. The San Pedro River located at the International Border with Mexico. This reach of the river between the border and Hereford is considered intermittent. The measured discharge was 2.0 cfs at the time of the photograph in March 1990.

TOPOGRAPHY

The topography of the San Pedro River watershed is defined by plains which slope gently from the base of the adjacent mountains. The elevation of the San Pedro River declines from 4,275 feet above mean sea level at the International Border to 1,920 feet where it joins the Gila River at Winkelman. The highest point in the watershed, Miller Peak, is 9,466 feet atop the Huachuca Mountains. Many of the mountain ranges exceed 6,000 feet in elevation. These ranges include the Santa Catalina, Rincon, Whetstone, Mustang, and Huachuca Mountains on the west and the Santa Teresa, Pinaleno, Galiuro, Winchester, Dragoon, and Mule Mountains on the east.

GEOLOGY

The San Pedro River lies entirely within the Basin and Range Physiographic Province. The San Pedro River occupies a structural trough bounded on the east and west by mountain ranges. The mountain ranges are composed of Precambrian to Tertiary aged strata. The major mountain building episode occurred during the Late Cretaceous to early Tertiary periods.

The structural trough has been filling with sediments deposited from the adjacent mountain ranges since the mid-Tertiary. The most important strata is composed of Tertiary and Quaternary sediments.

The Tertiary sediments have been divided into two broad stratigraphic units: the upper basin fill and the lower basin fill. These units consist of interfingering sand, gravel, silt, and clay beds. These units comprise the "older alluvium" and are an important regional aquifer unit. The Quaternary sediments occur in a narrow band along the floodplain of the San Pedro River. The Quaternary sediments are composed of recent, fluvial, unconsolidated, sands and gravels. This "younger alluvium" can be a very important local aquifer unit. These deposits are dissected and removed by tributaries that drain the watershed, such as Aravaipa Creek and the Babocomari River.

Figure 1-4. The San Pedro River located at the Hereford Bridge, approximately eight miles north of the International Border. The channel is densely populated with vegetation such as cottonwood and sycamore trees. The measured discharge was 3.3 cfs at the time of the photograph in April 1990.

Figure 1-5. Aravaipa Creek located approximately two miles east of the Aravaipa Canyon Wilderness Area boundary. This portion of Aravaipa Creek is considered perennial and supports a vigorous population of riparian vegetation within the narrow, steep walled canyon.

Figure 1-6. The eastern portion of the Sierra Vista subwatershed is shown with the Mustang Mountains in the background. The dense cottonwood-sycamore riparian vegetation delineates the channel of the Babocomari River.

CLIMATE

Precipitation in the San Pedro River watershed occurs as the result of two distinct processes. Winter precipitation results from large cyclonic storms originating over the North Pacific Ocean (Sellers and Hill, 1974). These storms are generally wide spread, of low intensity, and produce most of the usable surface water supply.

The Gulf of Mexico and the Gulf of California are the primary sources of moisture for convective thunderstorms that occur during the July through September summer monsoon season (Sellers and Hill, 1974). Much of the mean annual precipitation results from these high intensity, localized thunderstorms. The runoff from these storms tends to be short-lived and localized, consequently, these flows are of little use to surface water divertors. The summer runoff in the San Pedro River watershed does, however, provide water for cattle and wildlife by filling stockponds. April, May, and June are usually the driest months.

The upper elevations of the mountains are cooler and more moist than the remainder of the watershed. Mean annual precipitation, in the western portion of the watershed, exceeds thirty inches on the highest elevations of the Huachuca Mountains and twenty-five inches atop the Rincon and Santa Catalina Mountains. During the winter months, much of the precipitation at these higher elevations falls as snow. Figure 1-7 shows the annual precipitation for the watershed.

The climate of the valley floor becomes warmer and drier with decreasing elevation. Large portions of the valley floor receive less than twelve inches of precipitation annually. Summer high temperatures often exceed 100 degrees Fahrenheit. Table 1-1 lists normal climatic conditions for stations located in the watershed. The majority of these stations are located on or near the valley floor.

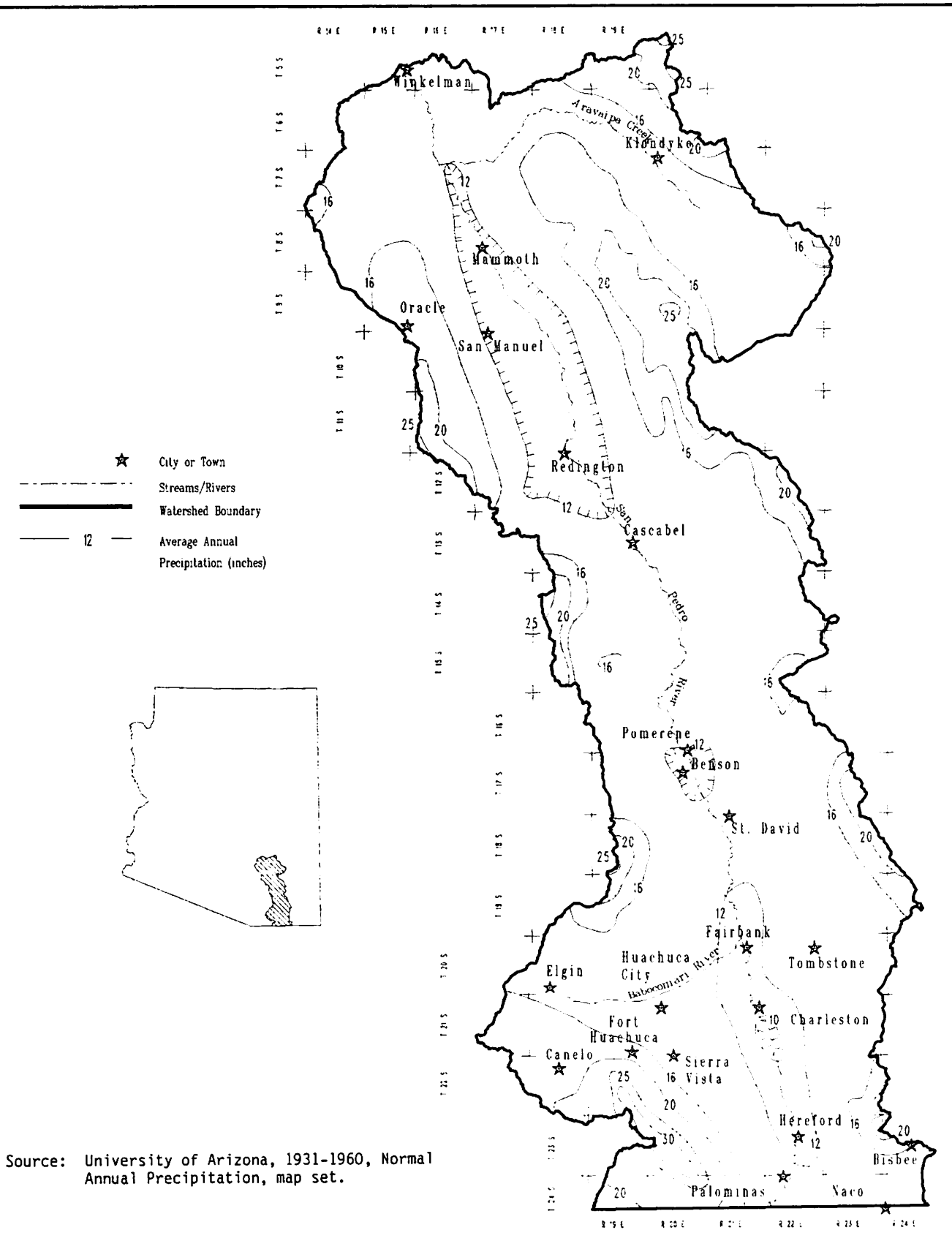
TABLE 1-1

TEMPERATURE AND PRECIPITATION DATA
FOR LOCATIONS IN THE SAN PEDRO RIVER WATERSHED

LOCATION (TOWN OR CITY)	ELEVATION (FEET)	PERIOD OF RECORD	TEMPERATURE (°F) AVERAGE DAILY MAXIMUM	TEMPERATURE (°F) AVERAGE DAILY MINIMUM	PRECIPITATION (INCHES) AVERAGE ANNUAL
Benson	3,590	1900-1975	80.3	45.2	11.40
Bisbee	5,350	1900-1982	74.3	48.7	18.44
Canelo	4,985	1910-1982	74.0	40.0	17.82
Elgin	4,900	1912-1970	ND	ND	15.01
Fairbank	3,850	1909-1973	ND	ND	11.80
Fort Huachuca	4,664	1900-1981	74.8	48.9	15.39
Klondyke	3,610	1953-1978	ND	ND	14.99
Oracle	4,540	1950-1982	75.5	49.0	21.03
Redington	2,869	1948-1982	ND	ND	13.11
San Manuel	3,560	1954-1982	79.1	50.8	13.46
Tombstone	4,610	1900-1982	77.4	49.1	13.85
Winkelman	2,075	1942-1980	84.3	46.0	14.05

Source: Brazel, et al., 1981.

ND - Data not available.



Source: University of Arizona, 1931-1960, Normal Annual Precipitation, map set.

Figure 1-7. Normal annual precipitation in the San Pedro River watershed

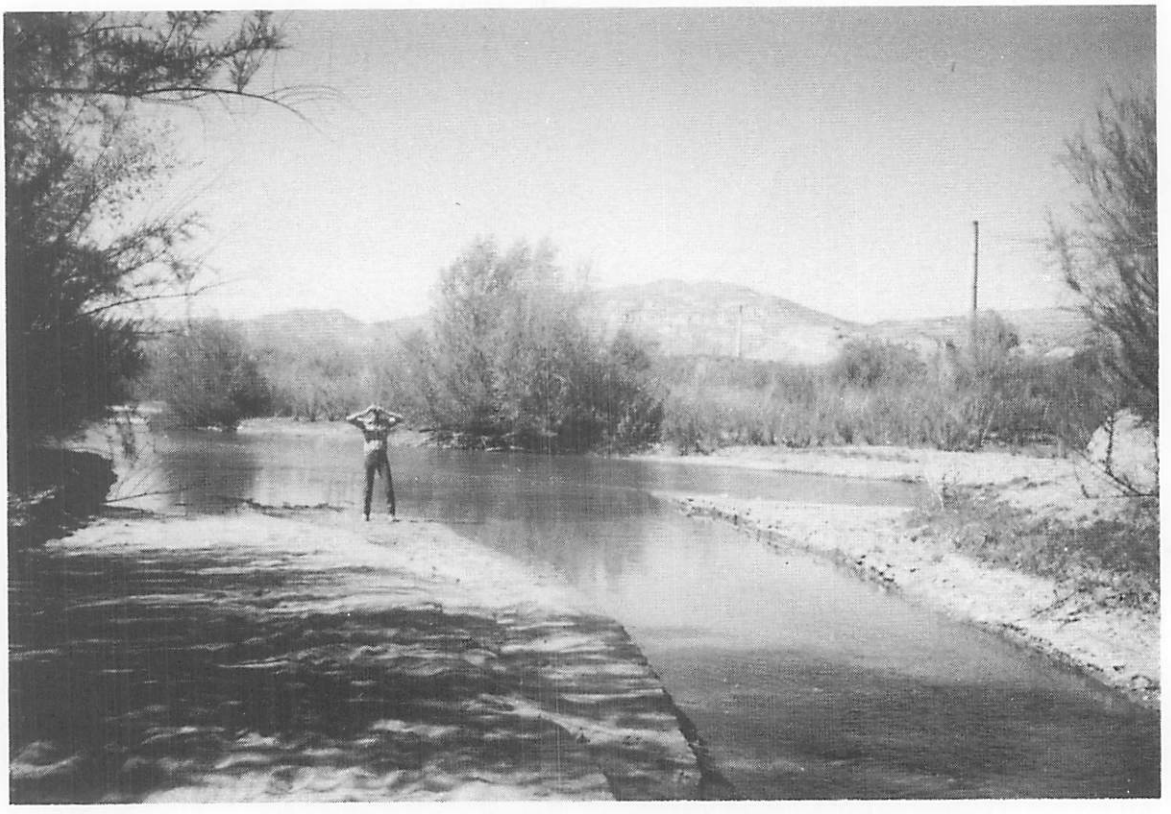
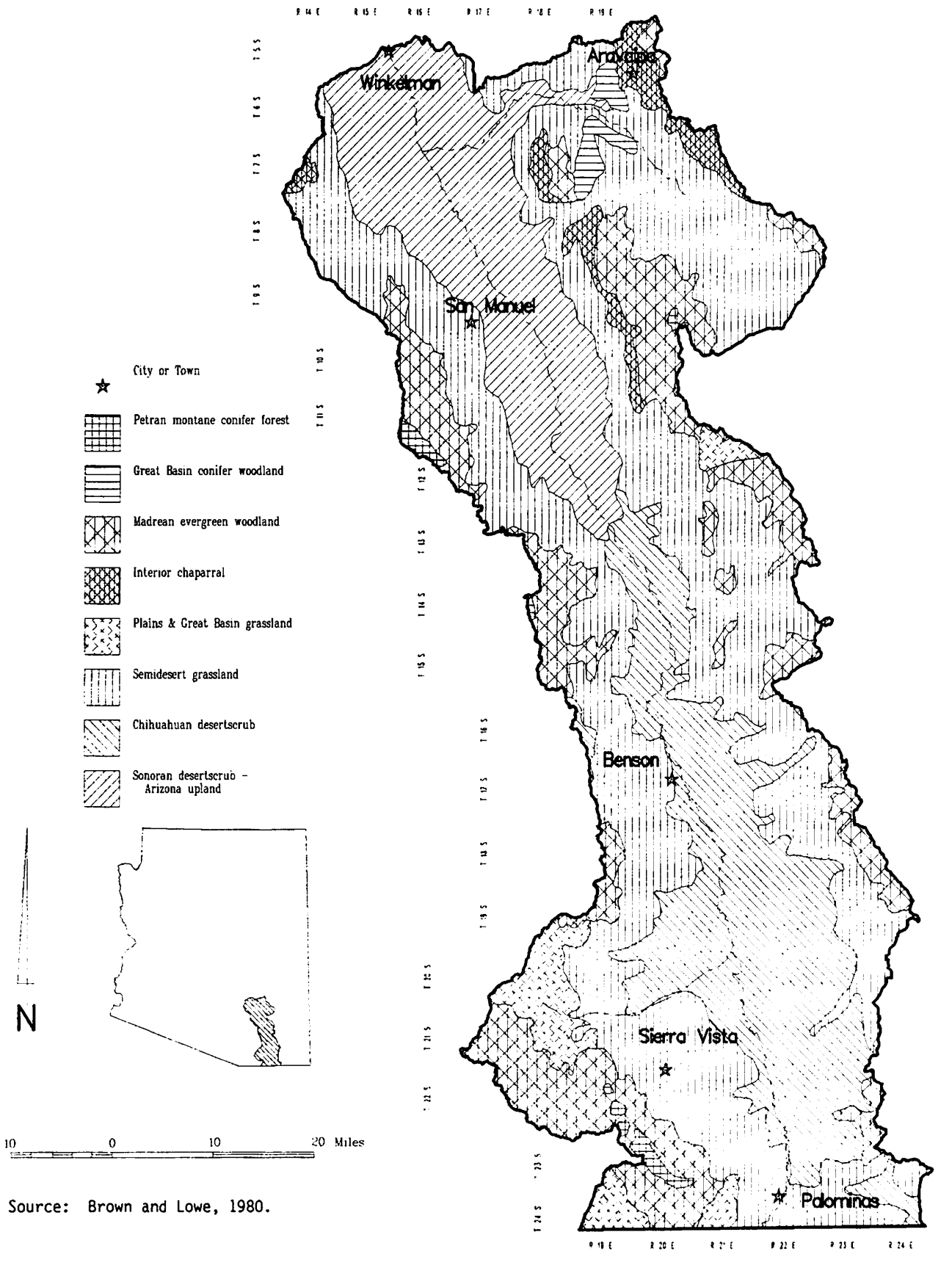


Figure 1-8. The confluence of the Gila River and the San Pedro River (foreground) located near Winkelman. The smelter smokestack in the background is located in Hayden.

VEGETATION

The vegetation in the watershed, shown in Figure 1-9, varies with elevation and available moisture. The cool, moist elevations above 6,500 feet support coniferous forests primarily comprised of Ponderosa Pine and Douglas Fir stands. At elevations between 4,500 and 6,500 feet, woodland vegetation, including oaks, junipers, and Pinyon Pine are commonly found. Small areas of interior chaparral exist in the northern portion of the watershed at these elevations.

Vegetation along the slopes of the basin fill, between 3,500 and 5,000 feet, primarily consist of semi-desert grasslands defined by several species of grasses including Grammas and Threeawns. These grasslands have been altered significantly since Anglo settlement. Mesquite and juniper have invaded large areas of the grasslands in the San Pedro River watershed.



Source: Brown and Lowe, 1980.

Figure 1-9. Vegetation in the San Pedro River watershed

Figure 1-10. The upper portion of the Aravaipa subwatershed is shown with the bajadas and pediments sloping down from the mountain fronts to the valley floor. Note the irrigated pasture acreage in the valley bottom, and the scattered juniper and desert grasslands present on the pediment slope.

Once dense perennial grass covers have been, and are being, replaced by scrub species, including mesquites, junipers, Mormon Tea, and ocotillo.

At elevations below 3,500 feet, the vegetation of the San Pedro River watershed is desert. The southern portion of the watershed is classified as Chihuahuan desertscrub, consisting of creosote bush, tarbush, whitethorn acacia, ocotillos, and mesquite. The northern lowlands are Sonoran desertscrub, further classified as the Arizona Upland Subdivision of the Sonoran desertscrub. The Sonoran vegetation has more associated woody species, such as: blue palo verde, ironwood, mesquites, and cat claw acacia, than the Chihuahuan type. Saguaros and numerous types of cholla are among the many species of cacti commonly found throughout the northern lowland portion of the watershed.

Within each of the vegetation communities in the watershed, distinct biomes exist where readily available water is in close proximity. The

incumbent vegetation is called riparian where it occurs along stream channels. Riparian zones are more diverse in both flora and fauna populations than the surrounding drier regions. Riparian vegetation is dependent upon instream flows and the regional groundwater aquifer. As a result, the riparian zones play important roles in the hydrology of the watershed.

Riparian stands typically occupy the floodplains of the perennial river systems in the southwest. The deep, well drained soils of these lands are potentially among the most agriculturally productive in the San Pedro River watershed, consequently, much of the irrigated acreage in the watershed occurs on lands that have been cleared of their original riparian vegetation. If allowed to go fallow, much of this agricultural land would return to riparian stands provided adequate water is available.

The dominant tree species found along the San Pedro River and its tributaries are cottonwood, mesquite, tamarisk or saltcedar, gooding willow, and seepwillow. Most of these species are phreatophytes, deep rooted plants which obtain water from an available aquifer.

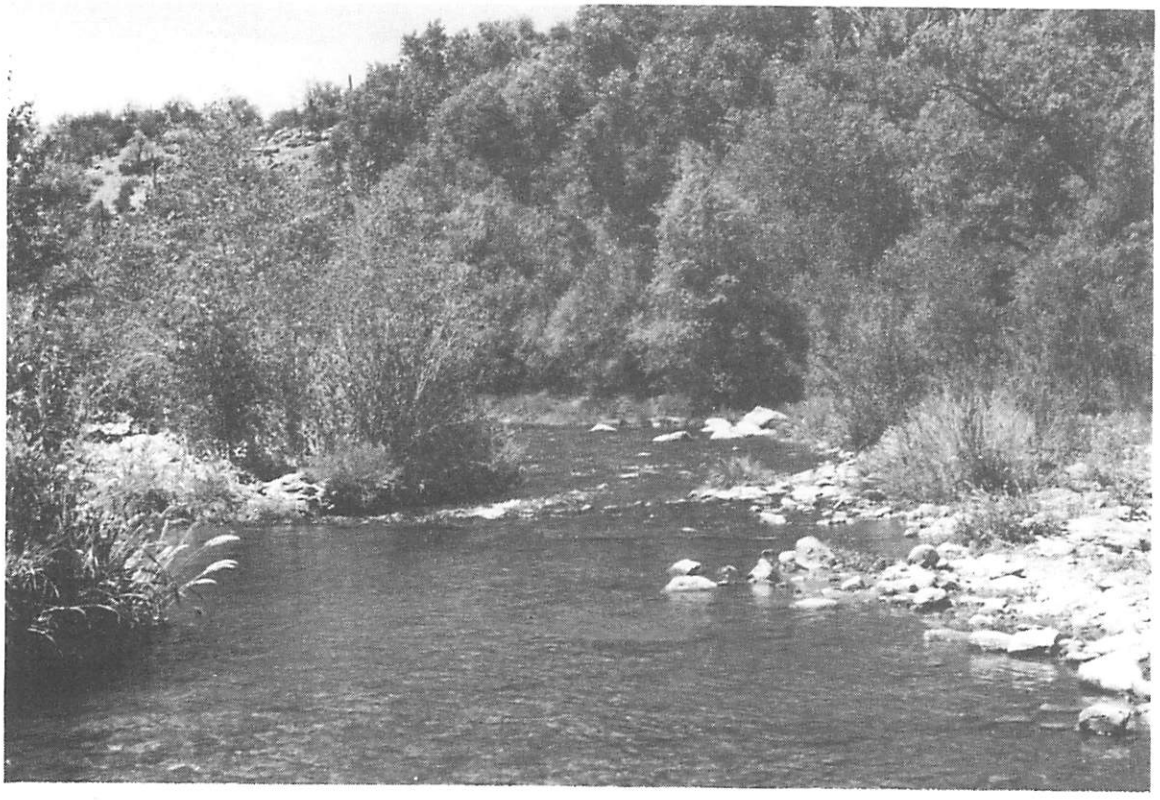


Figure 1-11. Aravaipa Creek, west of the Aravaipa Canyon Wilderness Area, supports dense riparian and phreatophyte vegetation communities with its stable, perennial baseflow. The measured discharge was 17.4 cfs at the time of the photograph in April 1990.

Riparian zones are becoming recognized for their many values such as wildlife habitat, recreational greenbelts, erosion control, and improved water quality to name a few. Most of the land along the San Pedro River south of St. David has been acquired by BLM and has been set aside as the nation's first riparian preserve: the San Pedro Riparian National Conservation Area (SPRNCA).

POPULATION

The total population of the San Pedro River watershed will grow at a moderate rate through the 1990s. An urbanizing economy and increasing immigration are factors for growth in the watershed.

There are ten principal communities that account for the majority of the population in the San Pedro River watershed.

Figure 1-12. The San Pedro River, within the San Pedro Riparian National Conservation Area, shows both the well established old growth overstory species of cottonwood and sycamore trees as well as juvenile cottonwoods. The measured discharge at this site was 8.7 cfs at the time of the photograph in March 1990.

In the 1980 to 1990 time period, the pattern of growth varied among these communities: 70 percent gained in population and 30 percent lost in population. Table 1-2 shows the percent change in population for the 1980 to 1990 time period and the projected populations for 1995, 2000, and 2005 for each of the ten principal communities.

TABLE 1-2

GROWTH OF POPULATION AND PROJECTIONS FOR PRINCIPAL COMMUNITIES WITHIN THE SAN PEDRO RIVER WATERSHED RANKED BY POPULATON SIZE - 1990

COMMUNITY	1980	1990	PERCENT CHANGE	1995*	2000*	2005*
Sierra Vista	24,937	35,868	43.8	40,346	45,731	50,369
San Manuel	5,443	5,450	0.13	5,475	5,500	5,700
Benson	4,190	4,029	-3.8	4,532	5,136	5,657
Oracle	2,484	2,640	6.2	3,100	3,500	3,940
Huachuca City	1,661	2,297	38.3	2,584	2,928	3,225
Tombstone	1,632	1,913	17.2	2,152	2,439	2,687
Mammoth	1,906	1,905	-0.05	1,980	2,050	2,400
Dudleyville	1,205	1,220	1.2	1,260	1,300	1,460
Winkelman	1,060	990	6.6	1,030	1,070	1,100
Elgin	253	270	6.7	280	289	299

Source: Arizona Department of Economic Security, Population Statistics Unit.

* Projected population

Overall, the projections in Table 1-2 imply that each principal community will slowly gain in population, except in the Sierra Vista area which is projected to continue its rapid growth throughout the 1990 to 2005 time period. The high population in Sierra Vista is due to the presence of Fort Huachuca. Fort Huachuca, with approximately 16,700 military and family members living on and off post, constitutes nearly 50 percent of Sierra Vista's population (Fort Huachuca, September 1991). With the recent Department of Defense reorganization, Fort Huachuca may gain a significant number of additional personnel due to the closing of Fort Devon in Massachusetts.

ECONOMY

Agriculture and mining currently are the predominant resource oriented activities in the San Pedro River watershed. These two primary industries combined with manufacturing, services and public administration form the economic base of the watershed. All of these industries account for 71 percent of employment from the ten principal communities.

The majority of the lands in the San Pedro River watershed are used for agriculture and livestock ranching. The lower San Pedro River valley which extends from the "Narrows" north of Benson to Winkelman is most prominent in metal production. The Magma Copper Company, located in San Manuel, operates an underground and open pit copper mine, concentrator, smelter, refinery, and rod manufacturing plant. The Magma Copper Company presently employs 3,800 persons. Agriculture and mining employ 24 percent of the persons living in the ten largest communities. Table 1-3 shows the type of industry and percent of total employment for the ten major communities in the San Pedro River watershed.

TABLE 1-3

TYPE OF INDUSTRY AND PERCENT OF TOTAL EMPLOYMENT FOR THE TEN MAJOR COMMUNITIES IN THE SAN PEDRO RIVER WATERSHED - 1980

TYPES OF INDUSTRIES	PERCENT EMPLOYMENT
PRIMARY INDUSTRIES	
Agriculture and Mining[1]	24.0
SECONDARY INDUSTRIES	
Construction	4.8
Manufacturing[1]	8.0
TERTIARY INDUSTRIES	
Transportation, Communication, and Public Utilities	3.5
Wholesale and Retail Trade	18.5
Finance, Insurance, and Real Estate	2.2
Service Sector	23.0
Public Administration (Government)[1]	16.0
TOTAL	100.0

Source: Arizona Department of Commerce, 1989.

[1]Denotes major industries

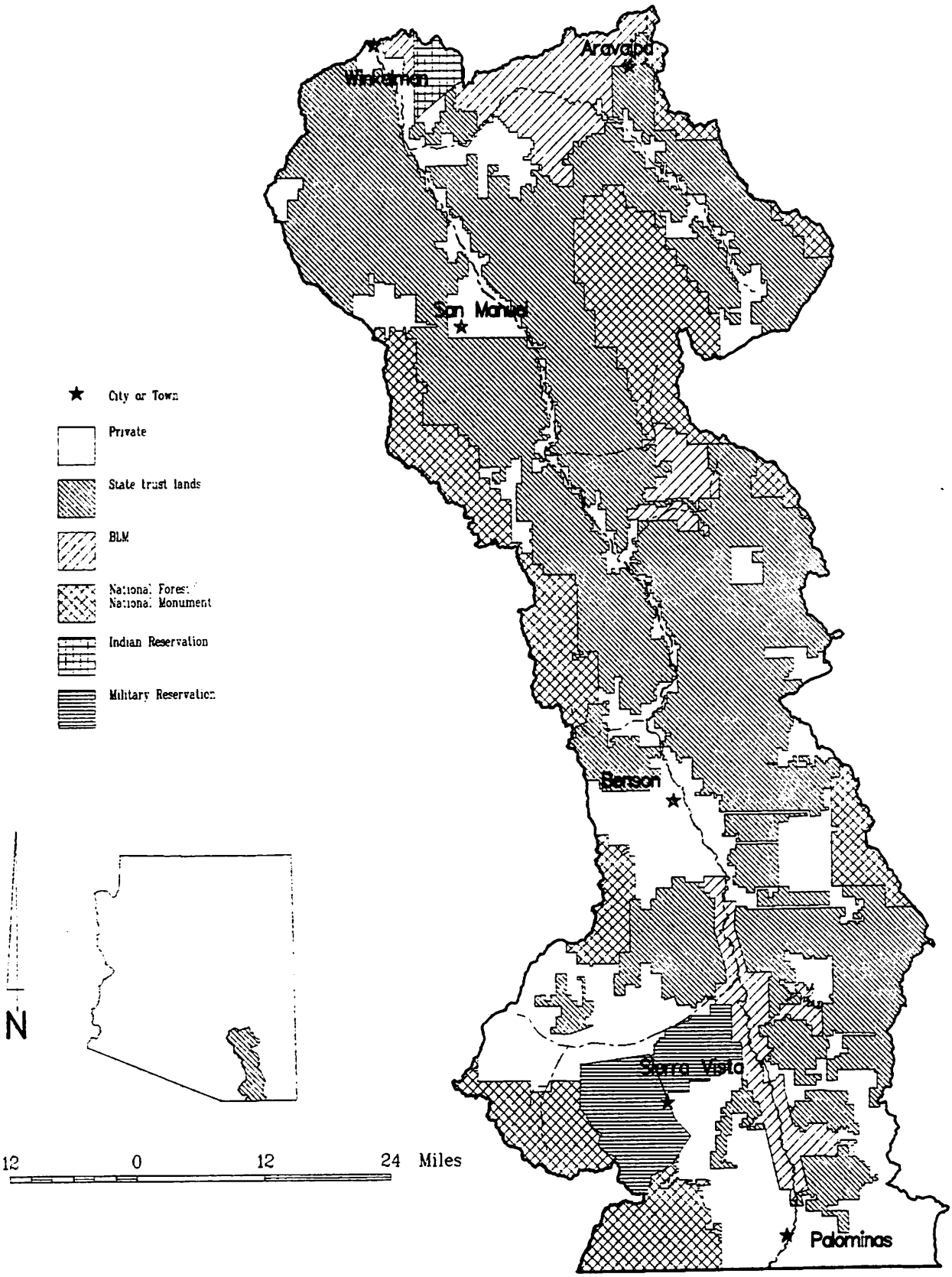
Manufacturing, services, and public administration employ the remaining 47 percent (Table 1-3). The largest manufacturer in the watershed is Apache Nitrogen Products, Inc. (ANPI) which is located south of Benson. ANPI employs 116 persons and manufactures mining explosives and nitrogen fertilizers. Tourism plays a major role in the service sector. The mild year-round climate and historical legacy of the San Pedro River valley support tourism. The Coronado National Memorial, south of Sierra Vista, and historical Tombstone and Bisbee are main points of interest. Bird watching, camping, and flourishing recreational vehicle parks also stimulate tourism.

Predictions point toward a more urban economy in the San Pedro River watershed based on primary growth in public administration (government) and secondary growth in manufacturing, tourism, and the expansion of retirement-type communities.

LAND OWNERSHIP AND ADMINISTRATION

The San Pedro River watershed is comprised of federal, state trust, Indian, and private lands (Figure 1-13). Federal lands account for 637,987 acres (26.5 percent) of the watershed. Federal lands are administered by the United States Department of Agriculture (USDA), the United States Department of the Interior (USDI), and the United States Department of Defense (DOD). The United States Forest Service, under the USDA, manages the Coronado National Forest. The Coronado National Forest comprises 376,135 acres (15.6 percent) of the watershed. The USDI administers 182,542 acres (7.4 percent) of the watershed of which the BLM manages 170,115 of the 182,542 acres. SPRNCA, the largest BLM land holding in the watershed, contains nearly 48,000 acres of public land in Coshise County between the International Border and St. David. The National Park Service manages the Saguaro National Momument comprised of 8,200 acres and the Coronado National Memorial comprised of 4,227 acres. DOD administers 79,270 acres (3.3 percent) of the watershed. Fort Huachuca, located in Sierra Vista, is the major DOD land holding in the watershed.

The remaining land owners in the San Pedro River watershed are state trust lands, Indian lands, and private lands. State trust lands, managed by SLD, account for 1,077,663 acres (44.9 percent). The San Carlos Indian Reservation has approximately 18,412 acres (0.8 percent) of land in the



Source: Watershed File Reports, Volumes 3 through 8 of this HSR.

Figure 1-13. Land ownership in the San Pedro River watershed

watershed. Private lands comprise 668,603 acres (27.8 percent). Private lands are located in cities, towns, and developed areas within the San Pedro River watershed's municipalities and counties. Figure 1-14 shows the percentage of land managed by federal, state trust, Indian, and private land holders.

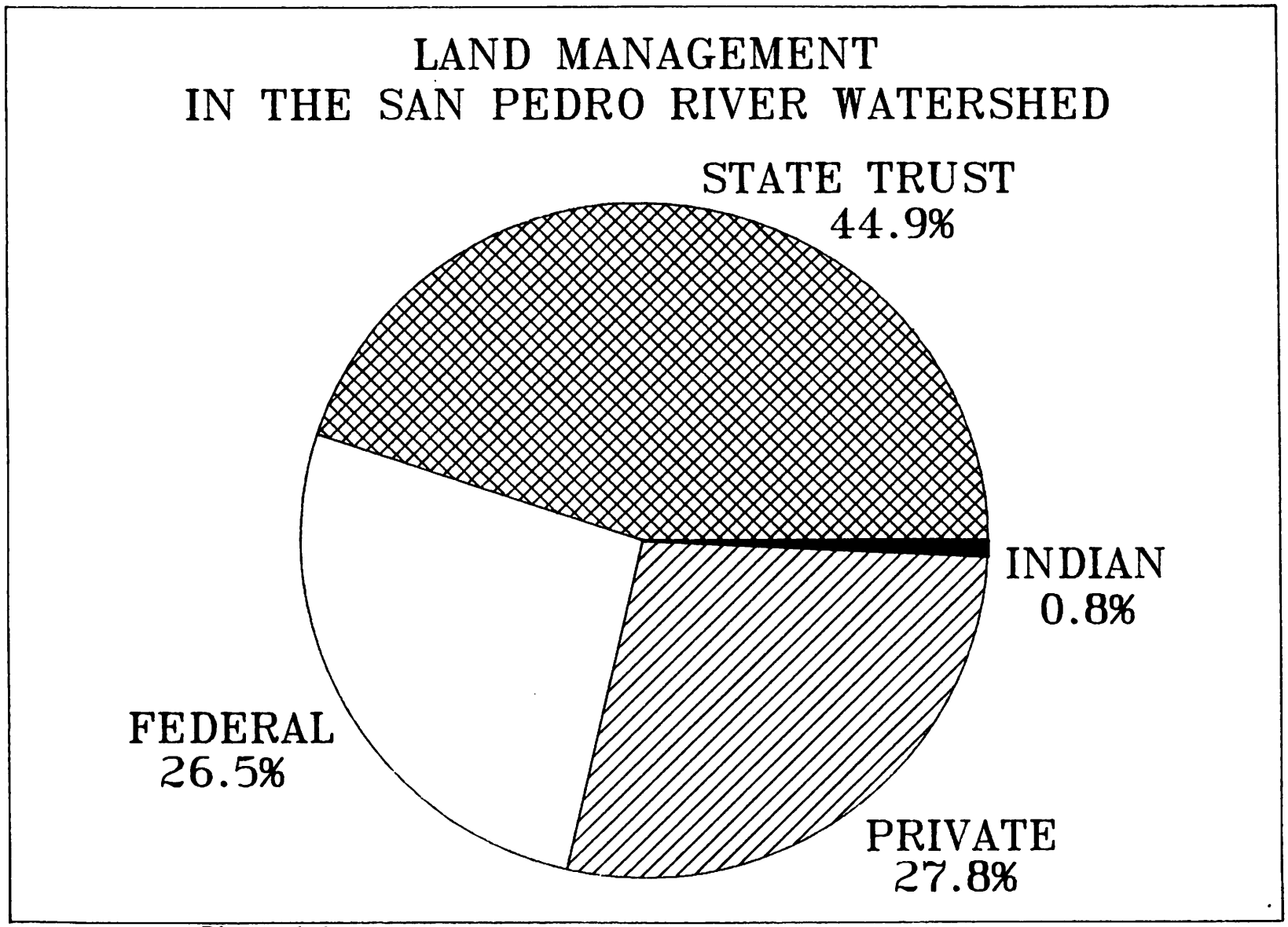


Figure 1-14. Land management in the San Pedro River watershed

1.5 HISTORY

The San Pedro River watershed contains a prolific cultural history. Prehistoric mammoth bones and spear points found in Aravaipa Canyon and at Lehner Ranch (southeast of Sierra Vista) indicate that man inhabited the area as early as 11,000 B.C. The Cochise culture occupied the eastern watershed area from about 5,000 B.C. until its demise around 1,000 A.D. The Hohokam, a culture based on irrigated agriculture, diverted water from the middle San Pedro River from about 500 A.D. until their disappearance about 1400 A.D. The Sobaipuri Indians, ancestors to the Pima and Papago, lived in the region until 1762 when the Spanish relocated them to the Santa Cruz valley to protect the missions of that area from hostile Indian raids. By the 17th century, the Athabascan speaking Apache had spread south from their northern domain to the river valleys of central and southern Arizona.

Spaniards first traveled up the San Pedro in 1539 when Friar Marcos De Niza journeyed north along the river during his search for riches. De Niza's false reports of cities made of gold caused Viceroy Mendoza of New Spain (Mexico) to send a large exploration party, headed by Francisco Vasquez de Coronado, up the San Pedro in 1540 to search for the fabled Seven Cities of Cibola. In 1692, Juan Matheo Ramirez also led a group of Spaniards along the San Pedro en route to New Spain. Between 1691 and 1702, Father Eusebio Kino traveled extensively within the watershed area while preparing maps of the region.

Anglo penetration into the area began in 1826 when James Ohio Pattie and his father Sylvester trapped beaver along the lower part of the San Pedro near its junction with the Gila River. During the Mexican War (1846-1848), the Mormon Battalion traveled across Southern Arizona and north along the San Pedro River on its way to Tucson. Members of the Battalion did not stay in the area at that time. The Treaty of Guadalupe Hidalgo (1848) brought a surge of Anglo activity when the United States government sent surveyors into the newly acquired area. In an effort to discover a feasible southern railroad route, John G. Parke surveyed the area between the Santa Cruz and Rio Grande Rivers and crossed the middle San Pedro River in 1854.

In 1880, settlers mapped out the present town of St. David and established a post office in 1882. The townspeople sold agricultural products to surrounding settlements. In 1881, town members built the St. Davids Canal

to transport water from the San Pedro River to users east of the river and organized the St. Davids Canal Company to oversee all aspects of irrigation. The water was then diverted from the ditch for individual use. The area near St. David was very marshy and many of the settlers were stricken with malaria. In 1887, an earthquake created fissures which formed washes that drained the area of excess water. The Canal Company reorganized as the St. David Irrigation District in 1936 and is still in operation.

Other settlements within the watershed grew around mines, military posts, and railroad crossroads. In 1878, the Neptune Company of Mule Gulch, now Bisbee, built a smelter on the west bank of the San Pedro. The community of Hereford developed around the smelter on the San Pedro and by the 1890s was headquarters for the Greene Cattle Company. During World War I, Hereford became a prominent railroad stop and shipping station for cattle.

Northwest of Hereford is Sierra Vista. It was originally called Fry after Oliver Fry who moved his family to the area in 1912 from Texas and homesteaded land near the main gate of Fort Huachuca. The city incorporated and changed its name in 1956. Sierra Vista primarily serves the military personnel at the fort which is located within city limits.

Across the San Pedro and northeast of Sierra Vista is historic Tombstone, the "town too tough to die." Miner Ed Schiefflin discovered one of the richest silver strikes of the day in 1878 near present day Tombstone. Tombstone was the largest town in Arizona at that time with a population of 15,000, however, Tombstone's boom was short-lived. In 1881, while sinking the main shaft in the large Grand Central mine, workers struck water at 520 feet. The flow was approximately 1,000 gallons per hour and Mayor John Clum urged town residents to use the excess water to sprinkle their lawns. Surface pumps were installed at the Contention and Grand Central mines, but in 1886 fire destroyed the Grand Central pump house and thus began the demise of Tombstone's mining activity. The remaining pumps at the adjoining Contention mine proved inadequate to serve both mines. A major flood occurred in the area in 1890 and fire destroyed the Contention pump house in 1892. As a result of these disasters, residents virtually abandoned Tombstone.

North of Tombstone, on the west side of the San Pedro River, is Benson. Founded in 1880, Benson served as an important Southern Pacific Railroad station during the territory's formative years. The railroad is still an

important economic factor to the community. Citizens of Benson formed the Benson Canal Company in 1908 to supplement the community's use of well water for irrigation. The canal was operable by 1912. This organization went bankrupt in 1927 and the Pomerene Water Users Association was formed in its place in 1936 as a nonprofit corporation.

Northwest of Benson is the tri-community area of San Manuel, Oracle, and Mammoth. Magma Copper Company purchased existing area mines in 1944 and named the immediate area San Manuel after the patron saint of one of its earliest prospectors. The town is now open for private home ownership and land development. Oracle is located northwest of San Manuel and was founded by Albert Weldon in the 1880s. By 1882, the community boasted eight dwellings. Mammoth, established as a mining post in 1883 by Frank Schultz, is northeast of Oracle. Unable to work at his mine site, Schultz constructed a stamp mill on the west bank of the San Pedro and named it Mammoth. The community nearly ceased to exist in 1895 due to low silver prices, but was revived in 1936 with molybdenum production (an element used to strengthen steel). The town was incorporated in 1958.

Winkelman is located on the lower northern end of the watershed at the confluence of the San Pedro and Gila Rivers. In 1877, a large number of farmers migrated to the region and a post office was established in 1903 near Peter Winkleman's ranch.

In November 1988, the San Pedro Riparian National Conservation Area (SPRNCA) was formed to preserve the natural habitat and beauty of the San Pedro River. In 1986, the BLM began acquiring land along the San Pedro River, and in 1988 an executive order designated the area as the first national riparian reserve in the country. Public access to the SPRNCA is limited in areas so that the wildlife and surrounding habitats remain undisturbed.

CHAPTER 2: WATER RESOURCES

The following three chapters of the Hydrographic Survey Report (HSR) examine the water sources, uses, and their interrelationships in the San Pedro River watershed. The first section of this chapter describes the primary sources of groundwater and surface water supplies within the United States portion of the watershed. The major groundwater sources are examined first, followed by a description of the San Pedro River surface water system. This is followed by sections describing the supplies within the Mexico portion of the watershed and special areas such as the San Rafael and Cienega Creek groundwater basins. Chapter 3 describes and quantifies the water uses. Chapter 4 provides the hydrologic analysis, describing and quantifying the relationships between supplies and uses.

2.1 SUPPLIES FROM THE UNITED STATES PORTION OF THE WATERSHED

This section examines the occurrence and quality of water from each of the major groundwater and surface water sources. The regional and floodplain aquifers are discussed, followed by a description of other aquifers within the San Pedro River watershed. Quantity and quality of streamflow and springflow complete this section.

GROUNDWATER RESOURCES

The San Pedro River watershed represents a typical valley within the Basin and Range Lowlands Hydrogeologic Province (White et al., 1963). It has a wide valley floor containing older alluvial deposits with younger alluvium along the stream channel courses. The valley is underlain by consolidated rock and is bounded on both sides by mountains of the same material. A generalized cross section through the Upper San Pedro River valley is shown in Figure 2-1. The general relationships between the consolidated bedrock and the valley alluvial materials are depicted.

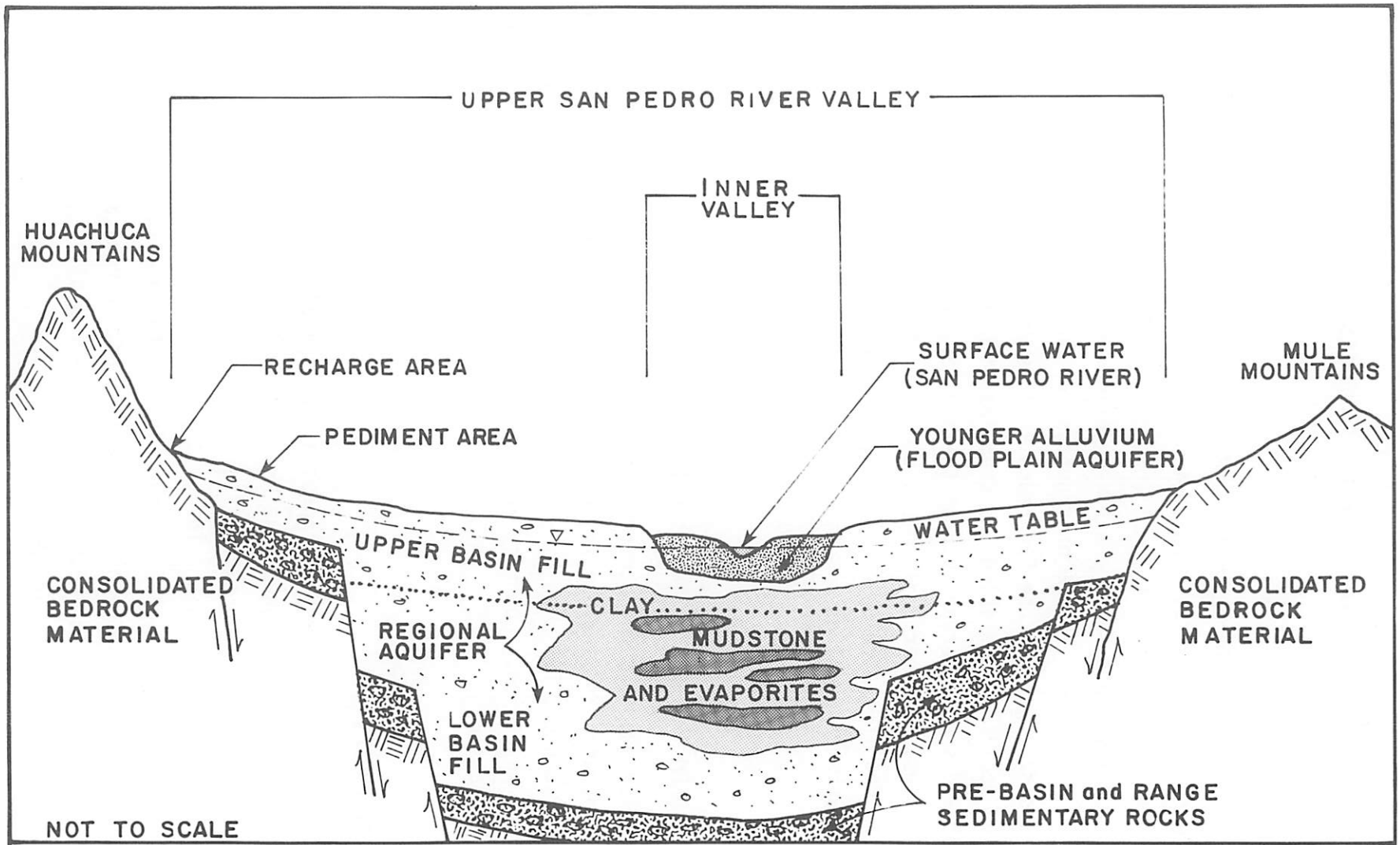


Figure 2-1. Generalized cross section of the Upper San Pedro River valley

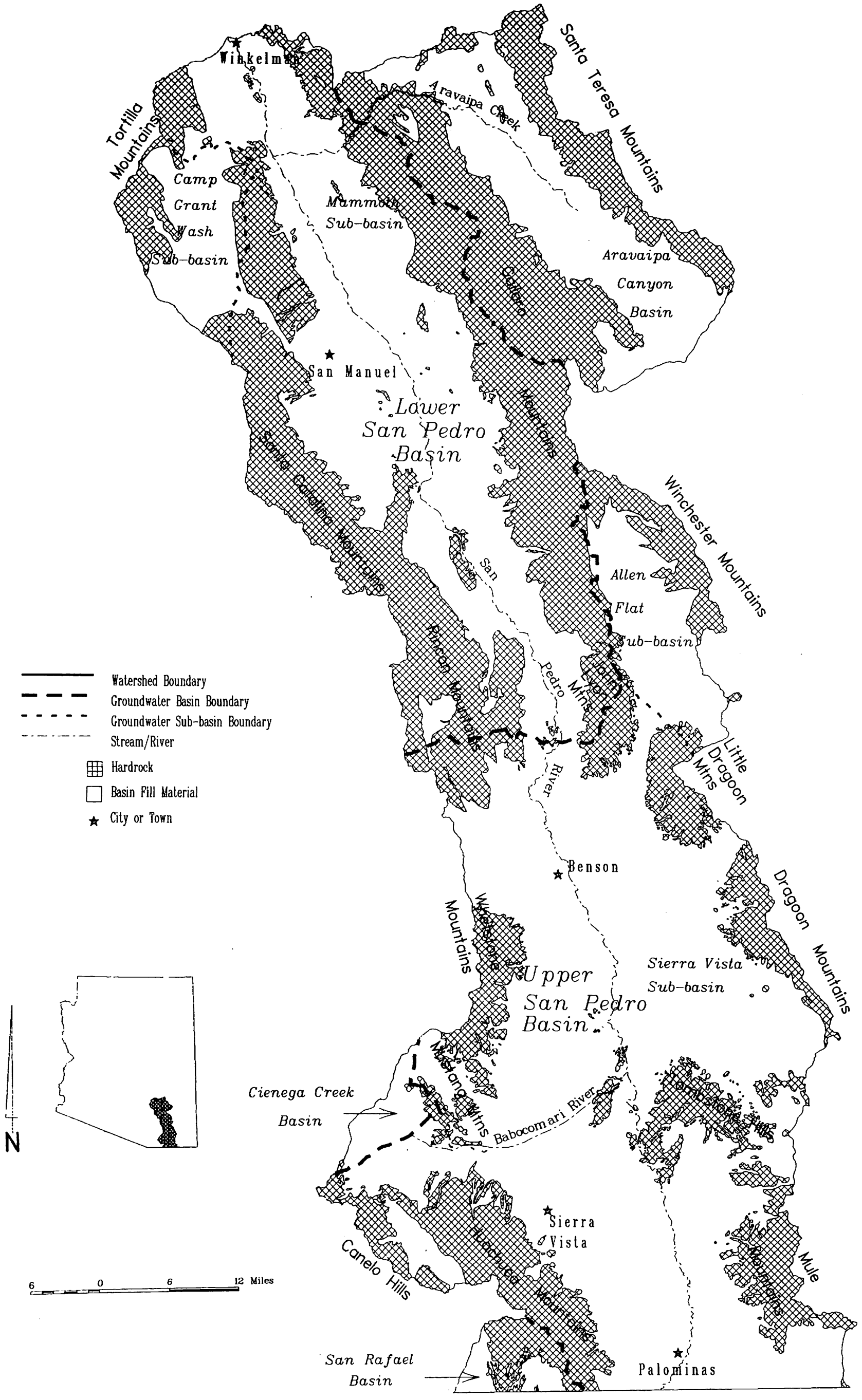
For the most part, the bedrock mountains help to identify the different groundwater basins within the watershed. Figure 2-2 shows the five groundwater basins and their sub-basins that have been identified by the Arizona Department of Water Resources (DWR) pursuant to sections §§ 45-403 and 45-404 of the Arizona Revised Statues (A.R.S.). The Upper and Lower San Pedro groundwater basins contain most of the groundwater and perennial surface water flows in the San Pedro River watershed. The Cienega Creek and San Rafael groundwater basins identified on Figure 2-2 are areas where the groundwater is non-tributary to the San Pedro River watershed but the surface water is tributary. Supplies and uses from these unique areas will be discussed in Section 2.3 of this chapter and in Chapter 3, Section 3.3.

The two primary sources of groundwater within the San Pedro River watershed are the older basin fill or regional alluvial aquifer and the younger floodplain alluvial aquifer (Figure 2-1). The regional aquifer is the largest source of groundwater in the watershed. It underlies the San Pedro River valley and its extent is defined by the consolidated rocks of the mountains that form the groundwater basin boundaries. The floodplain aquifer is present along the San Pedro River and major tributaries and overlies the basin fill aquifer along the stream courses. Groundwater also occurs in localized hard rock aquifers, but the total amount of water in storage and the total use from these aquifers is small and considered insignificant.

Figure 2-3 shows the areal extent of the alluvial aquifers and the hard rock outcrops. The occurrence and quality of groundwater for each of the aquifers is discussed below.

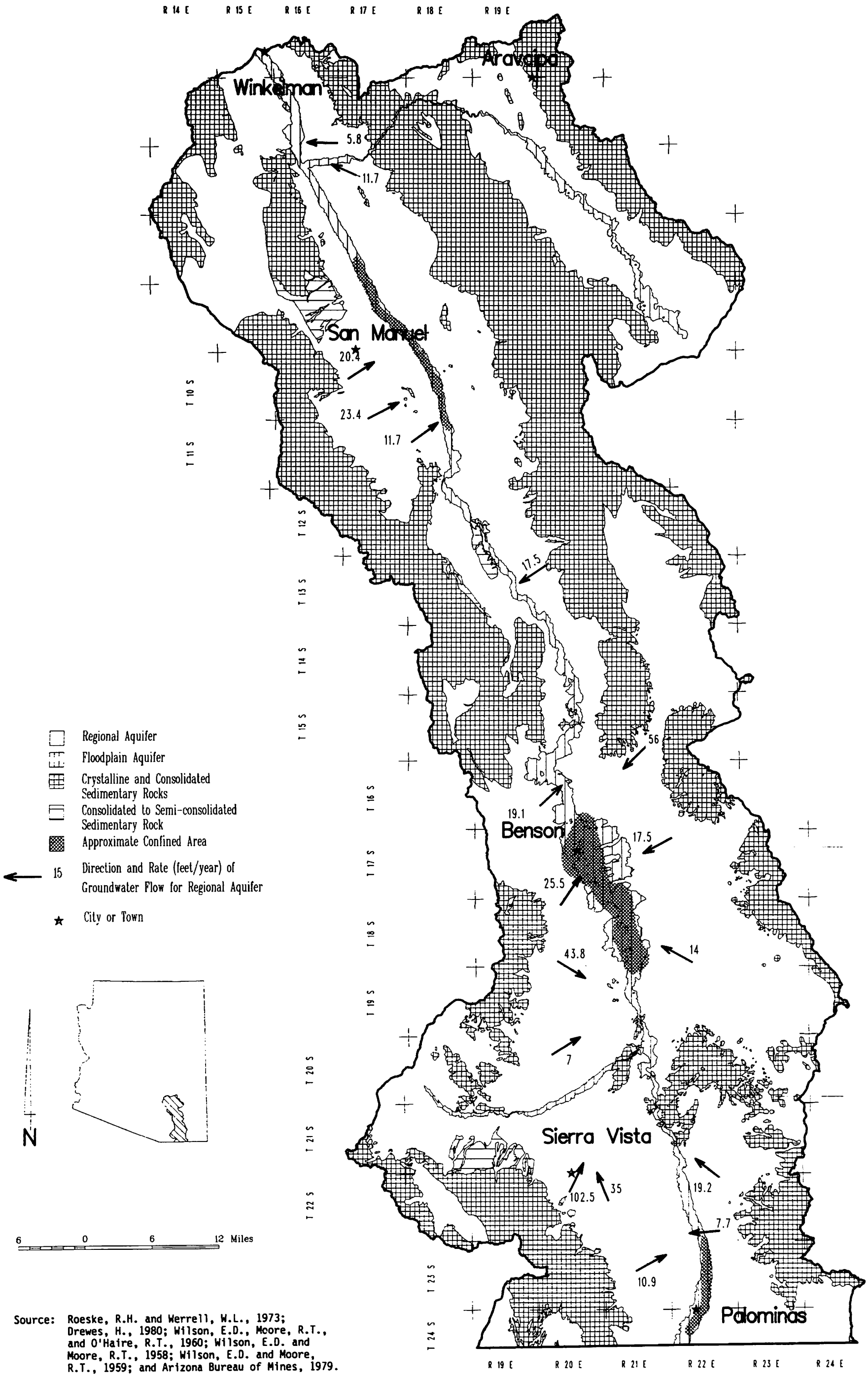
Regional Aquifer

The regional aquifer shown on Figures 2-1 and 2-3 was formed when material weathered from the surrounding mountains was deposited in the central valley trough between the mountain blocks. These mountain blocks and the central valley trough were formed by tectonic activity or deformation of the earth's crust from warping and fracturing. Within the San Pedro River watershed, the composition of the sedimentary material making up the basin fill varies with depth, distance from the mountains, and from region to region. This variance is due to the differing parent material within the mountain blocks and the sediment transport and depositional processes historically occurring within the watershed.



Source: Arizona Department of Water Resources, 1982.

Figure 2-2. Groundwater basins and sub-basins in the San Pedro River watershed



Source: Roeske, R.H. and Werrell, W.L., 1973; Drewes, H., 1980; Wilson, E.D., Moore, R.T., and O'Haire, R.T., 1960; Wilson, E.D. and Moore, R.T., 1958; Wilson, E.D. and Moore, R.T., 1959; and Arizona Bureau of Mines, 1979.

Figure 2-3. Areal extent of alluvial aquifers and hard rock outcrops.

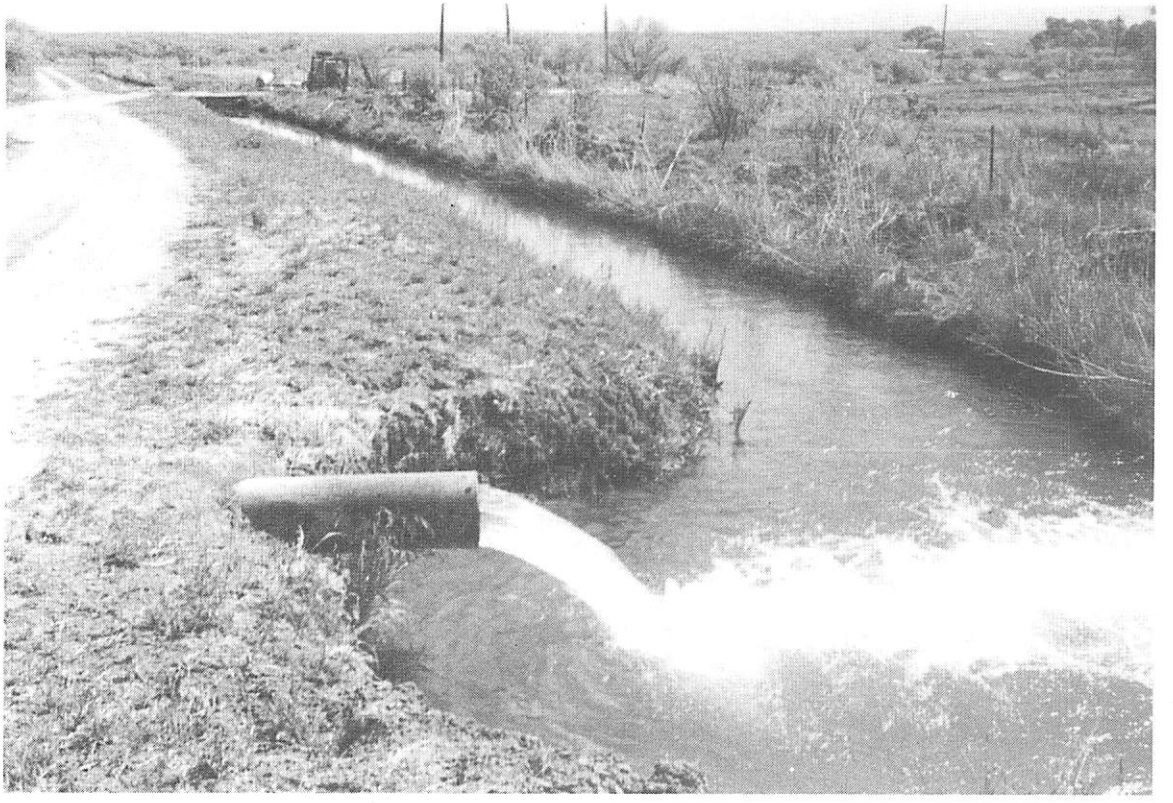


Figure 2-4. Groundwater resources play an important part in the supply of water within the San Pedro River watershed. Shown here is the St. David Irrigation District well W2 discharging into the district's ditch.

The basin fill can be divided into a lower and upper unit. The lower unit consists of interbedded sandstone and gravels that are poorly sorted. The gravels contain a mixture of silt, sand, pebbles, cobbles, and boulders (Brown, 1966). The coarser grained materials (fan gravels) are near the valley margins with the more easily transported fine-grained (silt and clay) material being deposited in the central part of the valley where the tectonic depression is the deepest. The lower unit of the basin fill deposits ranges in thickness from a few tens of feet along the valley sides to possibly more than 1,000 feet in the valley center (Roeske and Werrell, 1973).

The upper unit of the basin fill deposits consists of poorly cemented and compacted clayey and silty gravel beds near the mountains and well-bedded silt and sandy silt in the central valley. The upper unit may be as thick as 800 feet in the Upper San Pedro basin. However, erosion has removed most of the upper unit of the basin fill in the northern part of the valley (Roeske and Werrell, 1973).

Occurrence and Movement of Groundwater

The large areal extent and composition of well-bedded semi-consolidated to unconsolidated material make the regional aquifer the largest source of groundwater in the San Pedro River watershed.

The regional aquifer receives most of its recharge from the mountain fronts and from stream channel infiltration. The mountain front recharge (Figure 2-1) consists of that amount of surface runoff that leaves the hard rock formations and flows over and infiltrates into the permeable basin fill alluvium and eventually reaches the water table. Streamflow infiltrates through the streambeds and continues downward, eventually reaching the water table. Recharge from direct infiltration of precipitation on the valley floor is generally thought to be insignificant since less precipitation and higher evaporation rates occur in the valley (Freethey, 1982 and Putman et al., 1988). Water recharged to the regional aquifer is eventually withdrawn by groundwater pumping within the watershed, discharged to the San Pedro River, or flows out of the watershed as groundwater underflow near Winkelman. Underflow is defined as the downgradient flow of water through the permeable deposits underlying the valley.

Where saturated, the lower and upper alluvial units of the basin fill are in direct hydraulic connection with each other. Because of their vertical and horizontal changes in composition, the upper and lower basin fill units behave as one hydrologic unit (Freethey, 1982).

Within the saturated portions of the regional aquifer, groundwater generally occurs under unconfined or water table conditions. The exception to this is in areas where the permeable and saturated beds of the lower unit are overlain by impervious silt or clay lenses of the upper basin fill unit. Groundwater in these areas occurs under confined or artesian conditions. Figure 2-5 is a generalized schematic that shows both confined and unconfined conditions that exist in the San Pedro River watershed.

The regional aquifer is locally confined between Palominas and Hereford, between St. David and Benson, and near Mammoth as shown on Figure 2-4. Within these areas, a well completed in the confined zone of the aquifer would exhibit artesian conditions (Figure 2-5). In an artesian well, water rises in the well to some level above the top of the aquifer. For example, in the

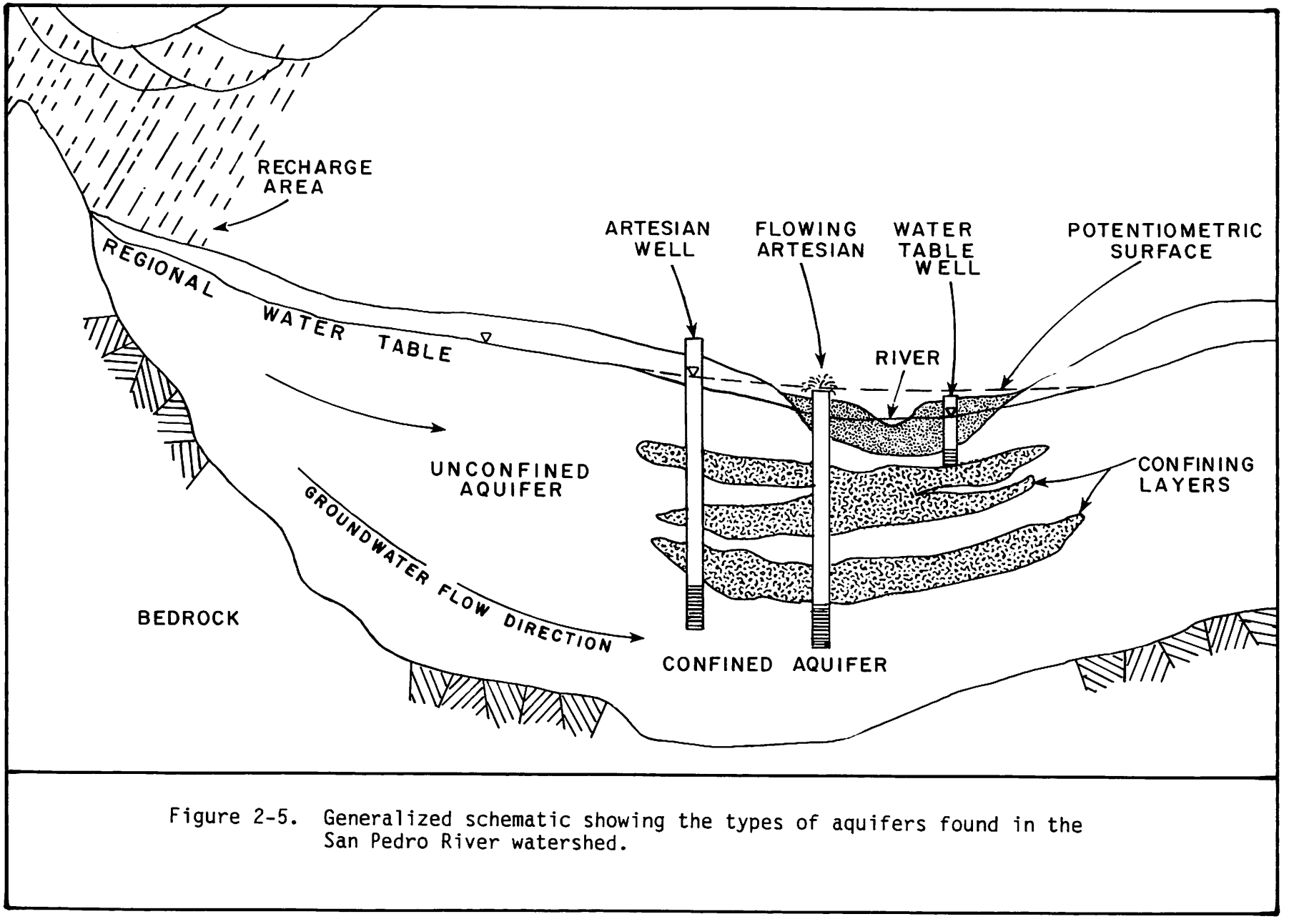


Figure 2-5. Generalized schematic showing the types of aquifers found in the San Pedro River watershed.

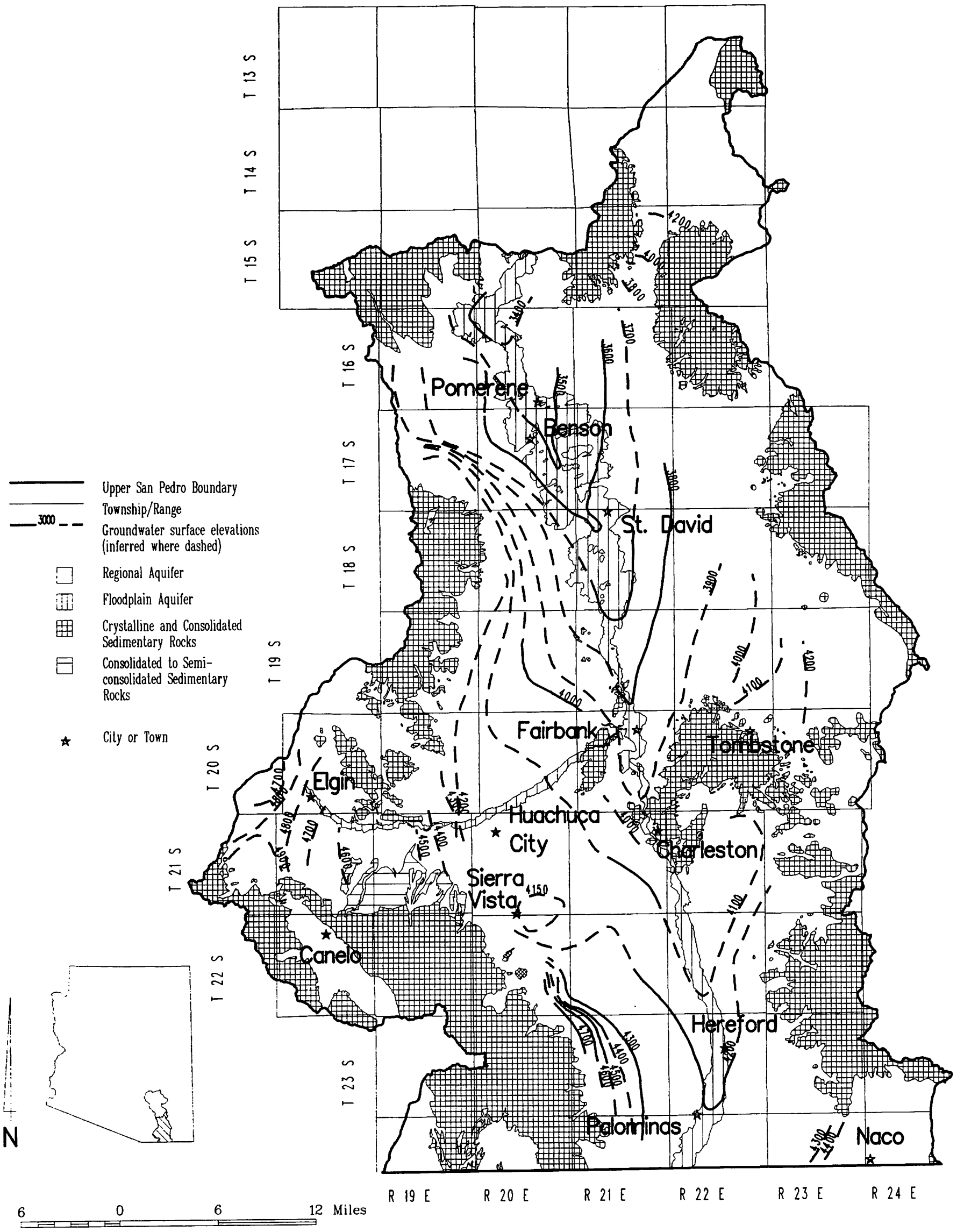
Palominas - Hereford confined aquifer area, water under artesian conditions is encountered by wells drilled to depths greater than 200 feet and rises to near the land surface (Putman et al., 1988).

Some wells north of Benson actually flow at the surface (flowing artesian wells). These wells encountered artesian conditions at depths of over 500 feet below the land surface (Roeske and Werrell, 1973). This confined area in the vicinity of St. David - Benson is the most extensive in size of the three major confined zones in the watershed. It covers an area along the San Pedro River that is approximately fifteen miles long by three miles wide. Artesian wells in the St. David - Benson area have experienced a decline in head which may be due to the practice of allowing some wells to discharge freely over a period of many years, thereby allowing a gradual pressure release from the confined aquifer.

In the Mammoth area, a layer of clay up to 200 feet thick confines the regional aquifer from the overlying floodplain alluvium creating artesian conditions. Wells producing artesian flow occur south of Mammoth for a distance of about ten miles along the San Pedro River valley.

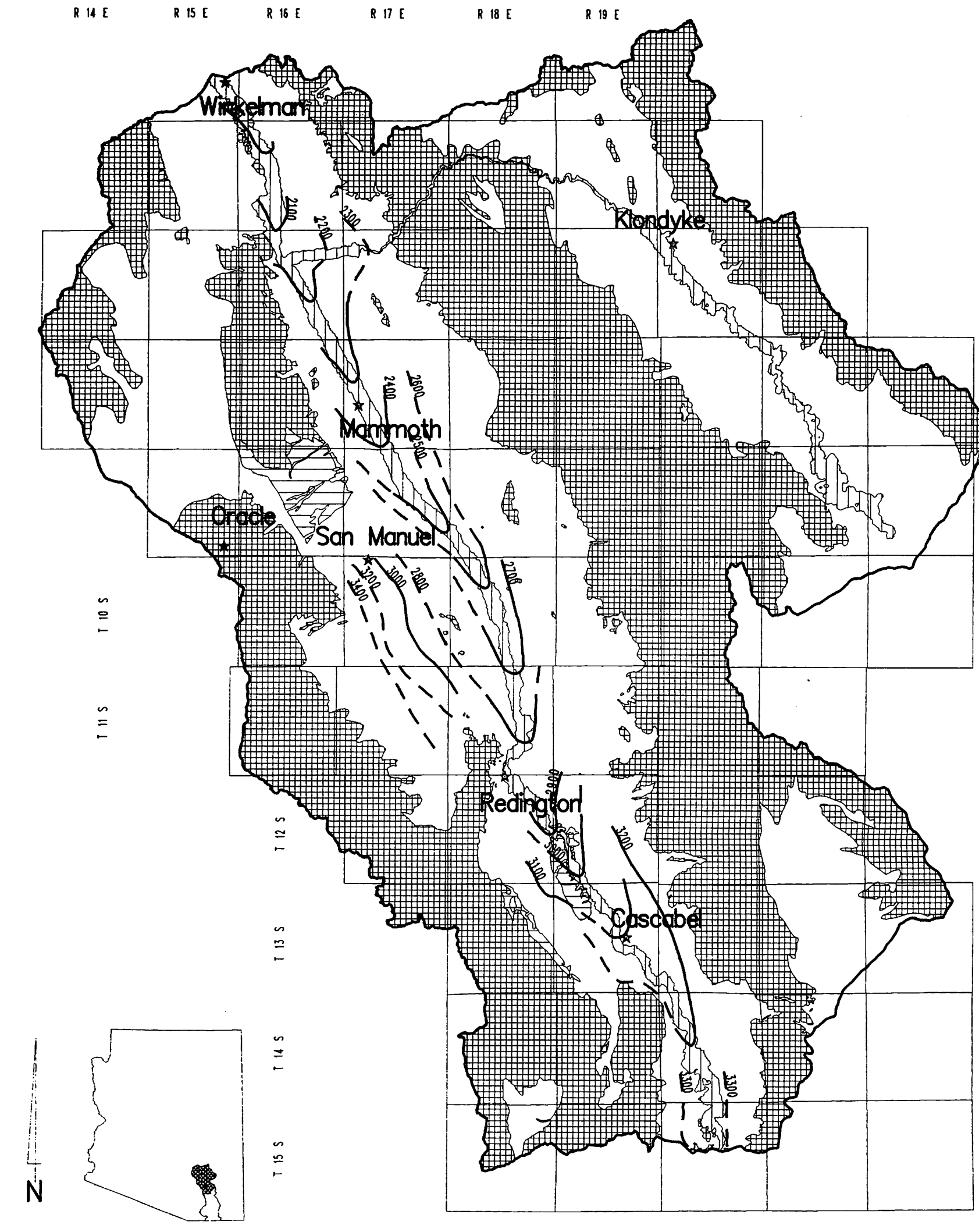
Figures 2-6 and 2-7 show the elevations of the groundwater surface for the upper (under 1978 conditions) and the lower (under 1979 conditions) watershed areas, respectively. Groundwater flow is perpendicular to the lines of equal groundwater elevation and is generally from the valley margins near the mountains toward the San Pedro River. Upon reaching the inner valley, groundwater flow follows the general direction of surface water flow which is northward along the valley's axis toward Winkelman. An exception to the flow of groundwater being toward the river is occurring locally within the area of Sierra Vista - Fort Huachuca (Figure 2-6). Extensive pumping in this area has resulted in local changes in the flow patterns that are toward the cone of depression. Figure 2-8 shows the cone of depression in the area of Sierra Vista - Fort Huachuca under December-January, 1985-1990 conditions.

Since the material comprising the regional aquifer (basin fill) varies in composition, size, sorting, and cementation, the aquifer varies in permeability or its capacity to transmit water from one location and depth to another. This ability to transmit water or an aquifer's hydraulic conductivity is one of the primary controls on the movement of groundwater within the aquifer. Another control is the aquifer's storage coefficient or



Source: Konieścki, A.D., 1980.

Figure 2-6. Regional and floodplain aquifers - groundwater surface elevations - Upper San Pedro River watershed (1978 conditions).



Source: Jones, S.C., 1980.

Figure 2-7. Regional and floodplain aquifers - groundwater surface elevations - Lower San Pedro River watershed (1979 conditions).

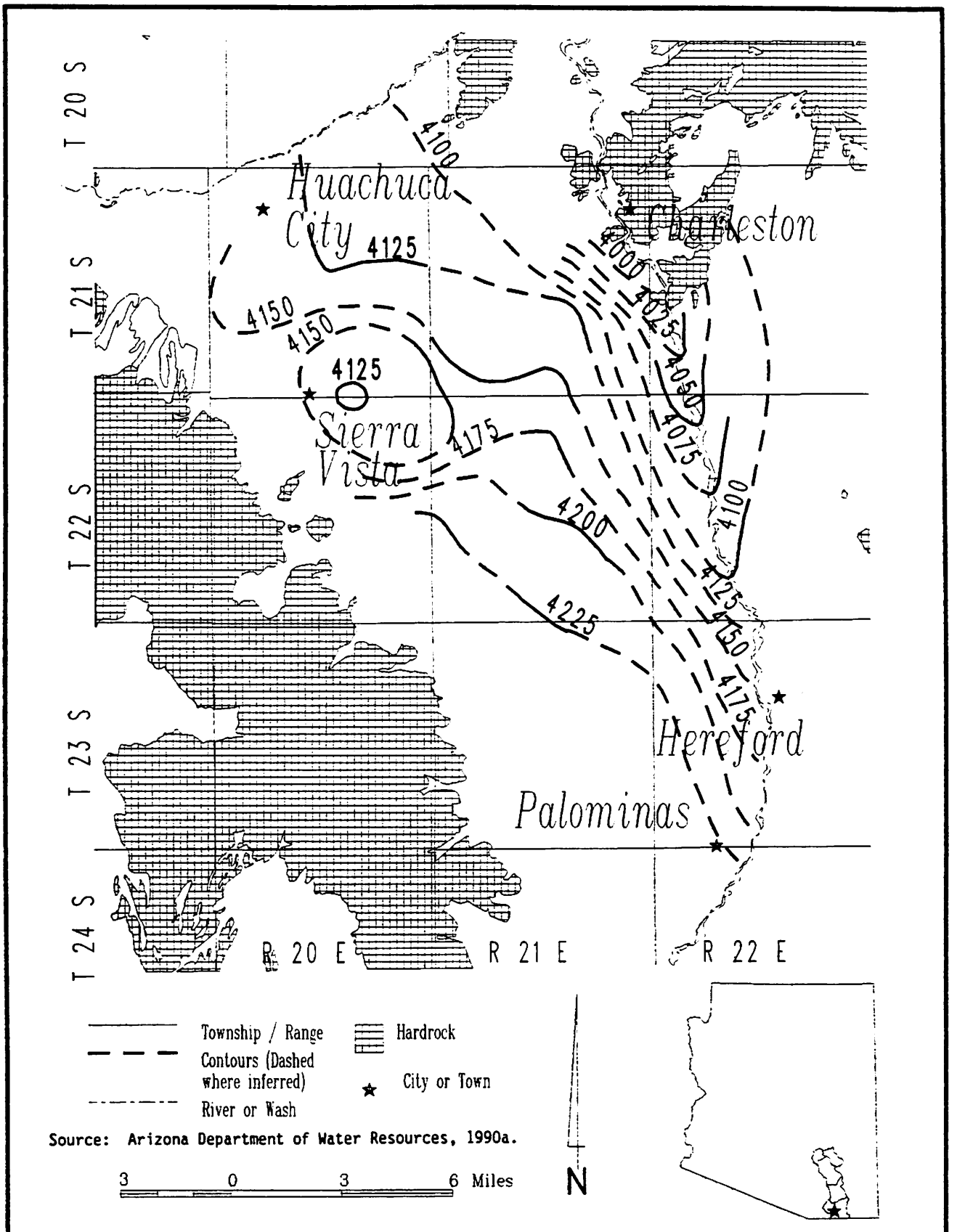


Figure 2-8. Current groundwater surface elevations in the vicinity of Sierra Vista - Fort Huachuca (December-January, 1985-90).

the volume of water an aquifer can release from or take into storage. These two properties, hydraulic conductivity and storage coefficient, are important because they can be used to estimate regional groundwater flow rates, storage volumes, and the effect of a pumping well on the aquifer and other nearby wells.

Storage coefficients in the San Pedro River regional aquifer range from 0.02 to 0.15 for the unconfined portions (Harshbarger and Associates, 1974) and approximately 1×10^{-5} for the confined zones (Freethey, 1982). This difference between the storage coefficient for an unconfined (water table) and confined (artesian) aquifer is due to the nature of the systems. A storage coefficient of 0.15, for an unconfined system, means that 15 percent of the total volume of the aquifer material is composed of water that will drain freely by gravity. The remaining 85 percent of the volume is composed of aquifer material (sand, clay, gravel) and of water that is bound to the aquifer material and will not flow to a well. Under a confined system, the aquifer is under higher than atmospheric pressure causing a slight compression of the aquifer material and the water in storage. When a well penetrating this aquifer is pumped, the pressure is reduced. This results in some of the water being forced out of the aquifer and made available for withdrawal by the pump.

The permeability or hydraulic conductivity of an aquifer when multiplied by the full saturated thickness of the aquifer becomes the transmissivity of the aquifer. Transmissivity is usually expressed in feet squared per day. Transmissivity values for the San Pedro River regional aquifer typically range from 500 to 15,000 feet squared per day (Harshbarger and Associates, 1974). The rate of groundwater movement within an aquifer is governed by the hydraulic conductivity of the aquifer and the hydraulic gradient or slope of the water table (or potentiometric surface under confined conditions). The calculated rate of groundwater flow in the regional aquifer at eighteen sample locations range from 5.8 to 102.5 feet per year (Figure 2-4). These values indicate the sluggish nature of groundwater movement. Many years or even centuries may be required for a particular particle of groundwater recharged at the mountain fronts to transit through the regional aquifer to the center of the valley. The average rate of flow for the eighteen sample sites is twenty feet per year. The lower portion of the watershed exhibits a lower average flow rate (15.1 feet per year) than the upper watershed (22.6 feet per

year). These averages do not necessarily provide a statistical representation for the watershed, but rather give general values. Furthermore, the rate of groundwater flow can be greatly affected by pumping wells. A detailed discussion of these effects on the hydrologic system is given in Section 4.3 of this volume.

Within an aquifer, the types of material and the geologic and chemical history determine the number of pores and open spaces that will exist. When saturated, these voids determine the volume of water that will be held in storage within the aquifer. However, not all of the water that is stored within an aquifer is free to be released from storage. Some water is retained in the voids by molecular attraction. The amount that will actually be released is of more concern from a water supply standpoint than the total volume held. The total volume of recoverable groundwater held in storage in the regional aquifer within the San Pedro River watershed to a depth of 1,200 feet below the land surface is estimated to be approximately 83.5 million acre-feet. Table 2-1 breaks this value down by subwatershed. The volume of storage is based on estimated basin fill surface areas, derived from geographic information, average depths of the basin fill alluvium, and average specific yield estimates derived from literature. APPENDIX A describes further the methodology used in calculating storage estimates.

TABLE 2-1

RECOVERABLE GROUNDWATER HELD IN REGIONAL AQUIFER STORAGE
SAN PEDRO RIVER WATERSHED

SUBWATERSHED	GROUNDWATER IN STORAGE (IN MILLION ACRE-FEET)
Sierra Vista	31.8
Benson	27.1
Redington	13.0
Aravaipa	6.2
Winkelman	5.4
TOTAL	83.5

Groundwater in most cases is a renewable resource. However, it can be temporarily depleted when an aquifer is over pumped. If groundwater withdrawals exceed the replenishment of, or recharge to the aquifer, then a

groundwater "mining" or overdraft situation exists. Groundwater overdraft may be characterized by groundwater declines that form a large cone of depression around the pumped well or in the vicinity of an active well field. Over time, if the pumping rates continue to exceed recharge to the aquifers, the cone of depression will expand or move outward from the pumping well(s). The rate of water level decline and growth of the cone of depression are a function of the aquifer's hydraulic characteristics, geohydrology of the area, rate and volume of water pumped, and the amount of water available for recharge to the aquifer. As long as water withdrawn exceeds the rate of groundwater recharge, a cone of depression will continue to expand outward.

Within the San Pedro River watershed, there is one major area that has been identified as showing signs of long-term overdraft of the regional aquifer. The Sierra Vista - Fort Huachuca area obtains water from wells completed in the regional aquifer. The cone of depression that is associated with this pumping activity has expanded in size from approximately 5 square miles in 1978 (Konieścki, 1980) to approximately 7.5 square miles in 1986 (Putman et al., 1988). See Figure 2-8 for current water level map in the area of Sierra Vista - Fort Huachuca.

Another potential groundwater overdraft area exists in the vicinity of the Town of San Manuel. Magma Copper Company maintains a well field that supplies groundwater from a confined area of the regional aquifer to its mine, smelter, refinery and the Town of San Manuel. In 1989, this well field furnished over 17,000 acre-feet of groundwater from the regional aquifer (refer to Chapter 5, Section 5.3). Groundwater recharge to the entire Redington subwatershed has been estimated to be approximately 20,400 acre-feet per year. Therefore, a withdrawal of 17,000 acre-feet per year, if the 1989 pumping rate continues, would represent a localized overdraft to the groundwater system in the area of San Manuel. It has been estimated by the water budget analysis that an overdraft condition of approximately 16,200 acre-feet exists in the Redington subwatershed. See water budget analysis, Chapter 4, Section 4.7.

These and other groundwater depletions and their potential effect on the surface water system will be discussed further in the following sections of this report.

Water Quality

Most precipitation is corrosive and as it enters the ground, percolates to the water table and moves through an aquifer, it chemically reacts with and dissolves minerals from the surrounding material. These dissolved salts are taken into solution. The amount and character of the salts taken into solution depend upon the chemical composition of the water; the mineralogical and physical structure of the rocks encountered; and the temperature, pressure, and duration of contact.

Groundwater increases in mineral content as it moves along until a combined equilibrium or balance of the dissolved substances is reached. During this process of trying to reach equilibrium, the water takes on the chemical characteristics of the material around it. Specific cations and anions are taken into solution, allowing groundwater to be classified on the basis of the dominant ions contained within it. Typically, water in the regional aquifer of the San Pedro River watershed is of a calcium bicarbonate type. With few exceptions, the concentration of total dissolved solids in the regional aquifer is less than 500 milligrams per liter (Thompson, Nuter, and Anderson, 1984).

Many chemical constituents may be present in groundwater, and its mineral content can vary from aquifer to aquifer and from place to place within an aquifer. The level of elements and compounds in the water may be of concern, especially if they reach a level that may be harmful or detrimental to the purpose for which the water is to be used. Water quality standards have been set for specific uses such as municipal, domestic, irrigation, and stockwatering (United States Environmental Protection Agency, 1979 and 1986). These standards contain the acceptable mandatory limits of the various elements, compounds, and organisms that may be contained in water and still be used for the designated purpose. For example, the guidelines set forth in the Federal Drinking Water Act of 1974 give the allowable safe level of total dissolved solids in drinking water to be 500 milligrams per liter (United States Environmental Protection Agency, 1979).

Chemical quality of groundwater in the regional aquifer is suitable for most uses. However, fluoride and sulfate concentrations have been noted to be high in some wells within the watershed (Roeske and Werrell, 1971). In wells pumping groundwater from the regional aquifer, high amounts of fluoride have

been noted in the area of St. David - Benson, near Winkelman, along Aravaipa Creek, and south of Mammoth (Heindl, 1952). High sulfate concentrations have been noted from several wells in the Benson - Pomerene area and from near Cascabel.

The Apache Nitrogen Products location west of St. David has been classified as a toxic waste cleanup site by the Environmental Protection Agency (EPA) and placed on their Federal Superfund National Priority List. In 1988, a Preliminary Public Health Evaluation prepared by the EPA concluded that the primary chemical contaminants of concern at the site included nitrate, ammonia, arsenic, barium, chromium, lead, strontium, and zinc. The Apache Nitrogen Products plant has produced, in the past, nitroglycerin-based explosives, ammonia, sulfuric acid, and water gel high explosives. The plant is located west of the San Pedro River and constitutes a potential source of water quality contamination to both the groundwater and surface water systems of the San Pedro River.

Studies conducted by Hargis & Associates, Inc. (1990 and 1991) in response to an EPA Administrative Order on the Apache Nitrogen Products site has shown that leakage from unlined surface impoundments contributes to a perched groundwater mound where these impoundments are active. Extremely high concentrations of nitrate-nitrogen have been recorded within the perched groundwater and to a lesser extent in nearby private and shallow aquifer monitoring wells. Other contaminates have been noted to have high concentrations such as fluoride, arsenic, and chromium. Studies of the site and its impact to the water quality of the San Pedro River system are continuing. At this time, there is no remediation schedule planned at the Apache Nitrogen Products site.

Floodplain Aquifer

The floodplain alluvium consists of unconsolidated gravel, sand, and silt laid down by recent stream action along the San Pedro River and its tributaries. The alluvium forms a long, narrow, and shallow aquifer beneath and on both sides of the San Pedro River. At the surface, the floodplain alluvium forms an "inner valley" which will be called younger alluvium in this report. Figure 2-9 depicts this younger alluvium (inner valley) and shows some of the hydrologic components that are involved.

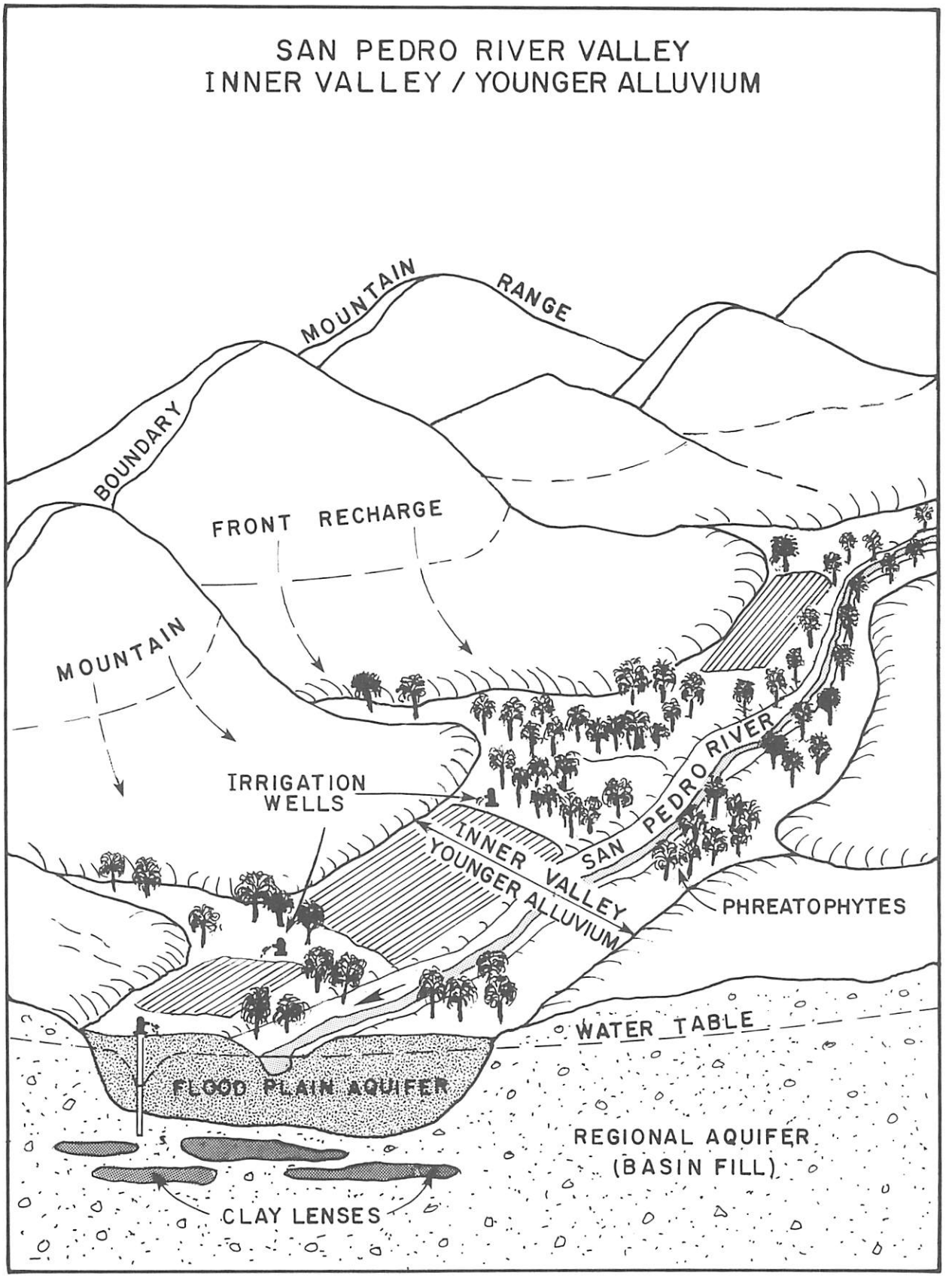


Figure 2-9. Schematic of the younger alluvium of the San Pedro River watershed

Occurrence and Movement of Groundwater

The unconsolidated nature of the floodplain alluvium gravels and sands give the floodplain aquifer high values of hydraulic conductivity and porosity. Transmissivity values range from 200 to 12,000 feet squared per day while storage coefficients typically range from 0.04 to 0.23 (ADWR, 1990e and Freethey, 1982). These hydraulic characteristics result in a high rate of groundwater flow within the aquifer that is generally parallel to the direction of surface water flow. Wells completed in this aquifer generally yield large amounts of groundwater. Roeske and Werrell (1973) gave a range for well yield in the Upper and Lower San Pedro basins to be 200 to 1,800 and 250 to 2,700 gallons per minute, respectively.

Groundwater in the floodplain aquifer occurs in unconfined or water table conditions. The lower parts of the aquifer are saturated throughout the inner valley of the San Pedro River. The water table elevation fluctuates up and down during the year and from year to year in response to natural and cultural uses and surface runoff.

The floodplain alluvium is recharged by infiltration of surface water from the San Pedro River and its tributaries, by lateral flow from the regional aquifer, by vertical leakage upward from the underlying regional aquifer where confining clay layers result in artesian conditions, by deep percolation from agricultural areas, and by underflow within the floodplain aquifer across the International Boundary from Mexico.

The floodplain aquifer is important in that, it acts as one of the main conduits for interaction between the surface water and groundwater systems. It provides the necessary water for phreatophytes within the riparian zone of the inner valley, and it is a major source of irrigation water along the San Pedro River and its major tributaries.

The amount of water in storage within the floodplain aquifer of the inner valley is quite small compared to the volume stored within the regional aquifer. An estimated 1.3 million acre-feet of water is stored within the floodplain aquifer (see APPENDIX A).

Water level changes in the floodplain alluvium show seasonal fluctuations and occasional upward and downward trends. These trends reflect seasonal cycles of evapotranspiration and surface water runoff. Flood flows recharge the alluvium each summer and winter, often filling the available storage space

to capacity. Hydrographs showing typical annual and seasonal water level changes in the floodplain aquifer are shown in Figures 2-10 and 2-11, respectively. There have been no long-term declines in the water levels of the floodplain alluvium, although water levels have remained low for several years in the past before rising due to stream recharge (Figure 2-10).

Groundwater flow in the floodplain alluvium enters the Upper San Pedro basin at the International Border. It follows the gradient of the river channel and moves north through the watershed. The amount of underflow entering the United States portion of the watershed through the floodplain aquifer under 1989 development conditions is estimated by DWR at 900 acre-feet per year. Freethey (1982) estimated the underflow into the United States to be between 700 and 3,400 acre-feet. Floodplain aquifer underflow from the Lower San Pedro basin at Winkelman is estimated by DWR to be approximately 1,570 acre-feet per year (under 1990 development conditions).

Water Quality

The chemical quality of the water in the floodplain aquifer of the San Pedro River watershed is generally good and suitable for most uses. However, like in the regional aquifer, exceptions do exist. High fluoride concentrations have been noted in some wells in the St. David - Benson area and south of Mammoth to Winkelman. High sulfate concentrations exist in some wells within the Benson - Pomerene area and near Cascabel (Roeske and Werrell, 1973). The EPA superfund site at Apache Nitrogen Products is continuing to be monitored. The dissolved solids content is generally higher in the floodplain aquifer than within the regional aquifer. Typically, the quality of water in the floodplain aquifer is similar to that of the surface water within the San Pedro River. The principal ionic constituents within the groundwater of the floodplain aquifer are sodium and bicarbonate (Roeske and Werrell, 1973).

Other Aquifers

Aside from the regional and floodplain aquifers, a few localized hard rock aquifers exist in the mountains and hills surrounding the San Pedro River valley. These aquifers are the source of water for some springs and may be tapped by a few stock or domestic wells. Their extent is not well known, but they are thought to be of small size in comparison to other sources of groundwater. Regional characteristics of generalized flow directions and

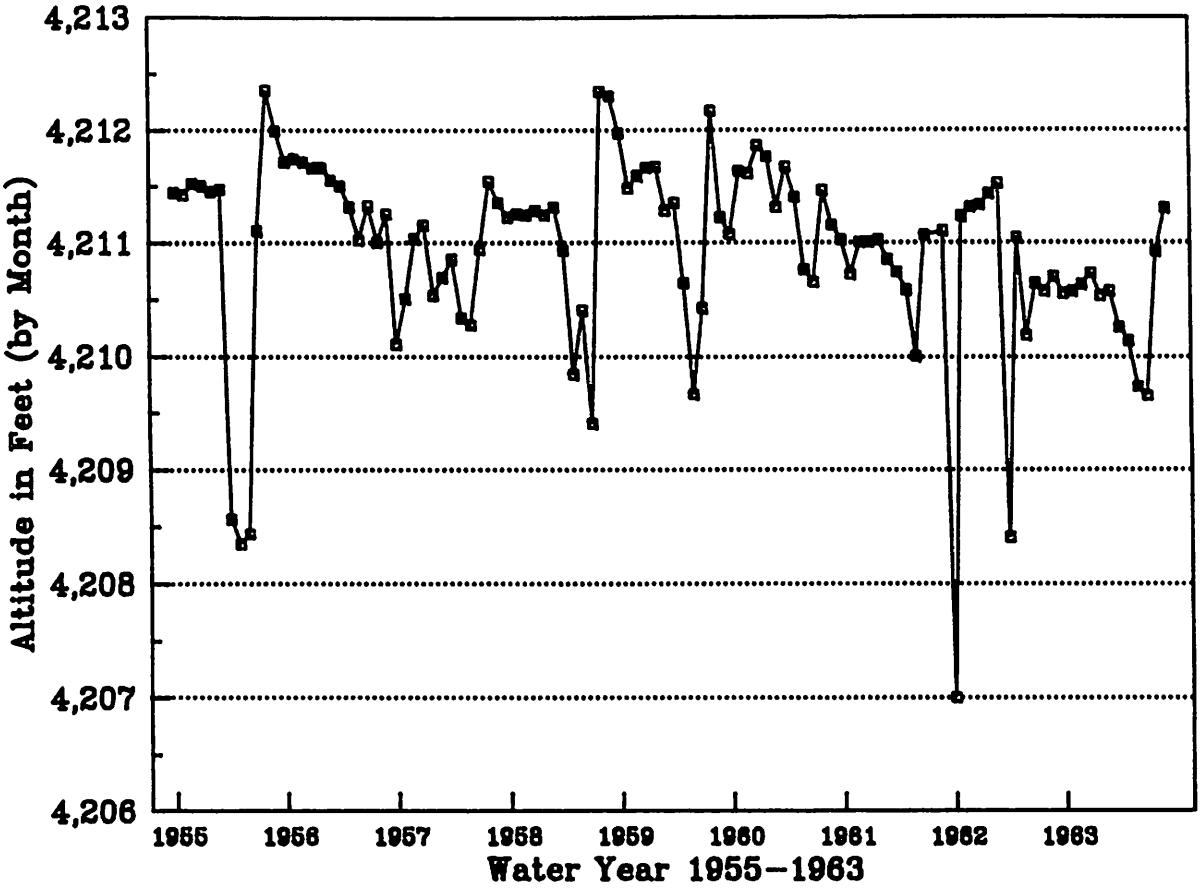


Figure 2-10. Hydrograph of monthly water level changes in the floodplain aquifer (well D-23-22-33DCD2).

general availability of groundwater do not exist in these minor aquifers. They only exist locally in either the consolidated to semi-consolidated sedimentary rocks or the older crystalline and consolidated sedimentary rocks of the mountains. Both of these units are shown on Figure 2-4.

The consolidated to semi-consolidated sedimentary rocks consist mainly of gravelly sandstone and conglomerate with some mudstone, siltstone and other Tertiary age deposits. This unit is exposed in the hills southwest of Mammoth and south of Redington and on the northern slopes of the Huachuca Mountains. This unit is generally low in permeability and porosity. However, where it is saturated, it may yield small to moderate amounts of water to wells, and where it is weakly cemented, the sandstone and conglomerate may yield several hundred gallons per minute of water (Roeske and Werrell, 1973).

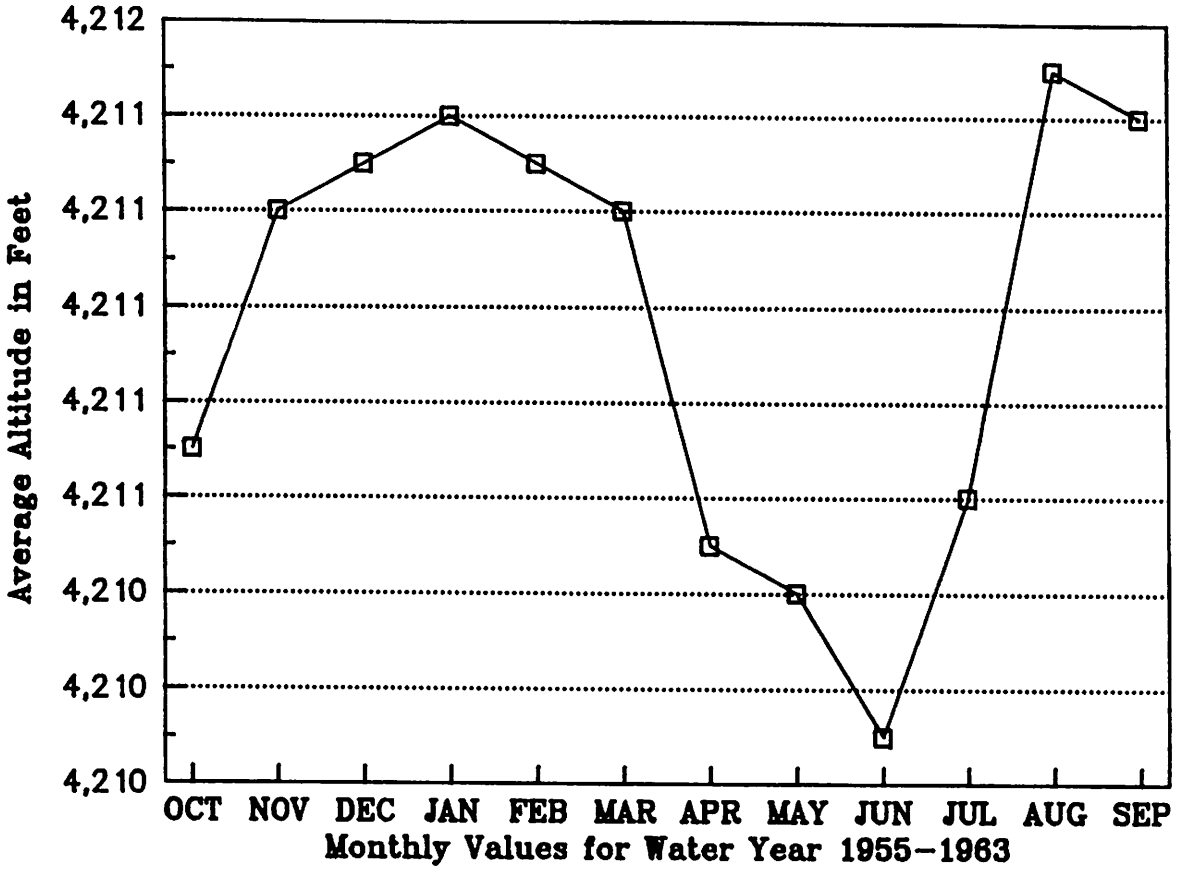


Figure 2-11. Hydrograph of seasonal water level changes in the floodplain aquifer (well D-23-22-33DCD2) for water years 1955-1963.

The crystalline and consolidated sedimentary rock unit shown on Figure 2-4 borders and underlies the San Pedro River valley. It consists of crystalline granitic igneous and metamorphic rocks, volcanic rocks, and consolidated sedimentary rocks that include mainly limestone, sandstone, shale, and conglomerate (Roeske and Werrell, 1973). This unit is referred to as the bedrock within this report. The bedrock unit is relatively impermeable and usually will yield only small amounts of water where the unit is sufficiently fractured to store water. Wells drilled in it generally yield only enough water to meet domestic and small stockwatering requirements. However, several hundred gallons per minute flow from large springs in the Huachuca Mountains (Roeske and Werrell, 1973).

SURFACE WATER RESOURCES

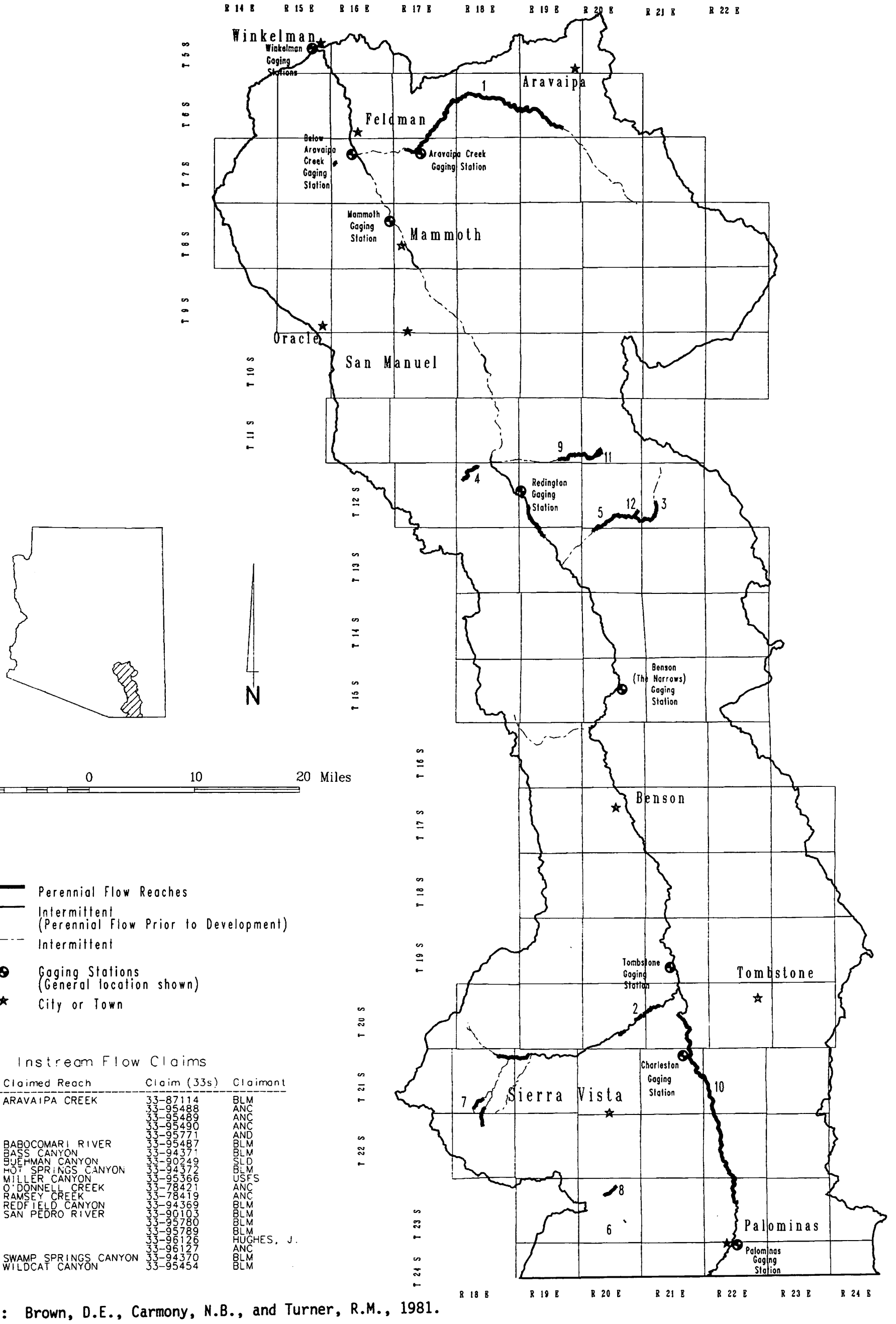
This section describes the streamflows and springs within the San Pedro River watershed along with its surface water quality.

Streamflow

Surface water characteristics of the San Pedro River watershed are comprised of two components, runoff and baseflow. The runoff component results from precipitation within the watershed and snowmelt from the surrounding mountain ranges. The baseflow component is the direct result of the discharge of groundwater to the stream and is characterized by sustained low flows (baseflows) showing very little daily fluctuation. Baseflow may provide most of the streamflow during years of low annual streamflow (Putman et al., 1988).

There are several stream reaches on the San Pedro River which are perennial in nature (consistent, year round flow). The remainder of the mainstem San Pedro River is considered intermittent, and only flows in direct response to precipitation events or limited periods of sustained baseflow. Prior to cultural development some of the present day intermittent reaches may have been perennial in nature (Brown, Carmony, and Turner, 1981). There are also tributary drainages which contain perennial reaches including a twenty mile reach along Aravaipa Creek. For the San Pedro River and its tributaries, Figure 2-12 depicts the perennial reaches as well as the intermittent reaches that may have been perennial prior to cultural development. This figure also gives the perennial reaches that have instreamflow claims assigned to them. Each claim will be described in detail in Chapter 6, Section 6.3 of this volume.

There are two principal reasons for the perennial streamflow reaches within the San Pedro River watershed. The first is due to the discharge of groundwater to the stream which provides a steady and reliable source of water to the river. The second is caused by the presence of geological restrictions forcing the water to the surface of the river channel where it appears as streamflow. An example of the first component appears in the reach from Hereford to south of Charleston. Within this reach, there is gradient flow of groundwater to the stream from the surrounding alluvium. In the reach near



Instream Flow Claims

ID#	Claimed Reach	Claim (33s)	Claimant
1	ARAVAIPA CREEK	33-87114	BLM
		33-95488	ANC
		33-95489	ANC
		33-95490	ANC
		33-95771	AND
2	BABOCOMARI RIVER	33-95487	BLM
3	BASS CANYON	33-94371	BLM
4	BUEHMAN CANYON	33-90249	SLD
5	HOT SPRINGS CANYON	33-94372	BLM
6	MILLER CANYON	33-95366	USFS
7	O'DONNELL CREEK	33-78421	ANC
8	RAMSEY CREEK	33-78419	ANC
9	REDFIELD CANYON	33-94369	BLM
10	SAN PEDRO RIVER	33-90103	BLM
		33-95780	BLM
		33-95789	BLM
		33-96126	HUGHES, J.
		33-96127	ANC
11	SWAMP SPRINGS CANYON	33-94370	BLM
12	WILDCAT CANYON	33-95454	BLM

Source: Brown, D.E., Carmony, N.B., and Turner, R.M., 1981.

Figure 2-12. Perennial and intermittent reaches, instream flow applications, and historical streamflow gaging stations in the San Pedro River watershed

Figure 2-13. Perennial surface water flows occur at the confluence of the Babocomari River (on the right) with the San Pedro River.

the Charleston Hills, an exposure of volcanic deposits effectively dams the groundwater and forces the water table to the surface, illustrating the second factor causing perennial streamflow.

Within the Sierra Vista subwatershed, perennial flows have been identified in the Huachuca Mountains (Miller and Ramsey Canyons). Although small, Miller Canyon's perennial reach has furnished water to the City of Tombstone since 1881 by way of an inverted siphon. The Canelo Hills region (several miles southwest of Elgin) contains areas which are described as "cienegas" (Spanish for "swamp"). These relatively short reaches are boggy with small pools of standing water and support dense stands of riparian vegetation. These cienegas appear to be caused by geologic restrictions which force the water table to the surface (Putman et al., 1988). The O'Donnell Creek cienega and Turkey Creek cienega are considered perennial, while Lyle Canyon to the east appears to be intermittent in nature.

The Babocomari River, which drains the western half of the Sierra Vista subwatershed, contains several perennial reaches starting with an area near

the headquarters of the Babocomari Ranch. This particular area appears to be strongly influenced by the presence of a volcanic dike which restricts the flow of groundwater and forces it to the surface. O'Donnell Creek, Turkey Creek, and Lyle Canyon also drain into the Babocomari River just upstream from the Babocomari Ranch and may contribute surface flow to the river.

The Babocomari River appears to have a short perennial reach in the vicinity of Huachuca City and further downstream near the confluence with the San Pedro River. This last stretch also appears to be related to a geological control as the Babocomari River is confined to a narrow, deep canyon prior to its confluence with the San Pedro River at Fairbank. Approximately twelve miles of the Babocomari River exhibits perennial streamflow.

The San Pedro River, within the Sierra Vista subwatershed, is for the most part perennial. This perennial reach has been identified to encompass the length of river from just north of Hereford to the point of diversion of the St. David Irrigation District ditch approximately five miles south of St. David. Perennial flow within this reach is maintained by discharge of groundwater to the river and the geologic influence of the Charleston Hills area which force the water in the floodplain alluvial aquifer to the surface. Most of this reach of the San Pedro River is within the newly created San Pedro Riparian National Conservation Area (SPRNCA) and is managed by the Bureau of Land Management (BLM). The SPRNCA is described in detail later within this volume (Chapter 6, Section 6.3).

The only perennial stream reach identified within the Benson subwatershed appears on the San Pedro River. The remaining portion of the mainstem San Pedro River is intermittent within this subwatershed.

The Redington subwatershed contains several minor tributary drainages which have short perennial reaches (Swamp Springs Canyon, Bass Canyon, Redfield Canyon, and Hot Springs Canyon). These are all located on the west flank of the Galiuro Mountains and they will be discussed further in Chapter 6, Section 6.3. West of the small community of Redington, there is a tributary drainage of the San Pedro River called Buehman Canyon. Buehman Canyon has a fairly significant length of perennial streamflow and a well established riparian habitat.

Most of the San Pedro River within the Redington subwatershed is intermittent. South of Redington, groundwater is forced to the surface by hard rock resulting in a four mile stretch of perennial stream.

Within the Winkelman subwatershed, the San Pedro River is considered intermittent. There is a cienega-like feature at Cook's Lake which is approximately 1.5 miles downstream from the confluence of Aravaipa Creek and the San Pedro River.

The Aravaipa subwatershed contains a long perennial stretch of Aravaipa Creek from the eastern end of Aravaipa Canyon to approximately six miles above the confluence with the San Pedro River. The headwater portion of Aravaipa Creek is for the most part intermittent to ephemeral.

Table 2-2 lists the important perennial reaches found within the San Pedro River watershed and is referenced by subwatershed, stream, and

TABLE 2-2

PERENNIAL STREAM REACHES IN THE SAN PEDRO RIVER WATERSHED

SUBWATERSHED	STREAM	APPROXIMATE LENGTH (IN MILES)
Sierra Vista	Babocomari River	8
	Miller Canyon	<1
	O'Donnell Canyon Cienega	2
	Ramsey Canyon	2
	San Pedro River	28
	Turkey Creek Cienega	2
Redington	Bass Canyon	3
	Buehman Canyon	3
	Hot Springs Canyon	7
	Redfield Canyon	6
	San Pedro River	4
	Swamp Springs Canyon	1
	Wildcat Canyon	<1
Winkelman	Aravaipa Creek	1
	Putnam Wash	<1
Aravaipa	Aravaipa Creek	22
	TOTAL	92

Note: Values have been rounded off to nearest mile.

approximate length in miles. The approximate length of perennial stream reach is just that, approximate. These perennial reaches can grow and shrink in length from season-to-season and from year-to-year depending upon the overall climatic conditions of the system. For example, during dry years a certain perennial reach could be thousands of feet shorter than during a wet year.

Much of the San Pedro River exhibits an intermittent flow regime, i.e., a seasonal appearance and disappearance of surface water. This is typically due to the regional climate and the timing of water uses along the stream. During seasons of low water use (winter and early spring), the rate of groundwater discharge to the river exceeds the rate of use by phreatophytes and agriculture and the excess of supply over demand appears in the river channel as surface flow. During other seasons, the rate of water use by riparian vegetation and by crops near the river exceeds the rate of groundwater discharge to the river and the surface flows disappear, except perhaps immediately after rainfall events.

Historically, there have been a number of stream gaging stations within the San Pedro River watershed. At the present time there are three active gaging stations on the mainstem San Pedro River. The Charleston and Redington stations are monitored by the United States Geological Survey (USGS) and the Palominas station is presently monitored by the United States Section of the International Boundary and Water Commission. There is also an active USGS gage on Aravaipa Creek approximately five miles upstream from the confluence with the San Pedro River. The locations of the major historical gages are given in Figure 2-12. Figure 2-14 visually displays the period of record by water year for each station. A water year is a twelve month period from October 1 through September 30 and is designated by the calendar year in which it ends. General locations of each gage are also shown on Figure 2-12.

For the gaging stations on the San Pedro River and Aravaipa Creek, the average annual discharge for the common period of record 1968 to 1976 and corresponding runoff data per year per square mile is given in Table 2-3. The average annual discharges shown on Table 2-3 do not represent the long-term average discharges in the San Pedro River watershed.

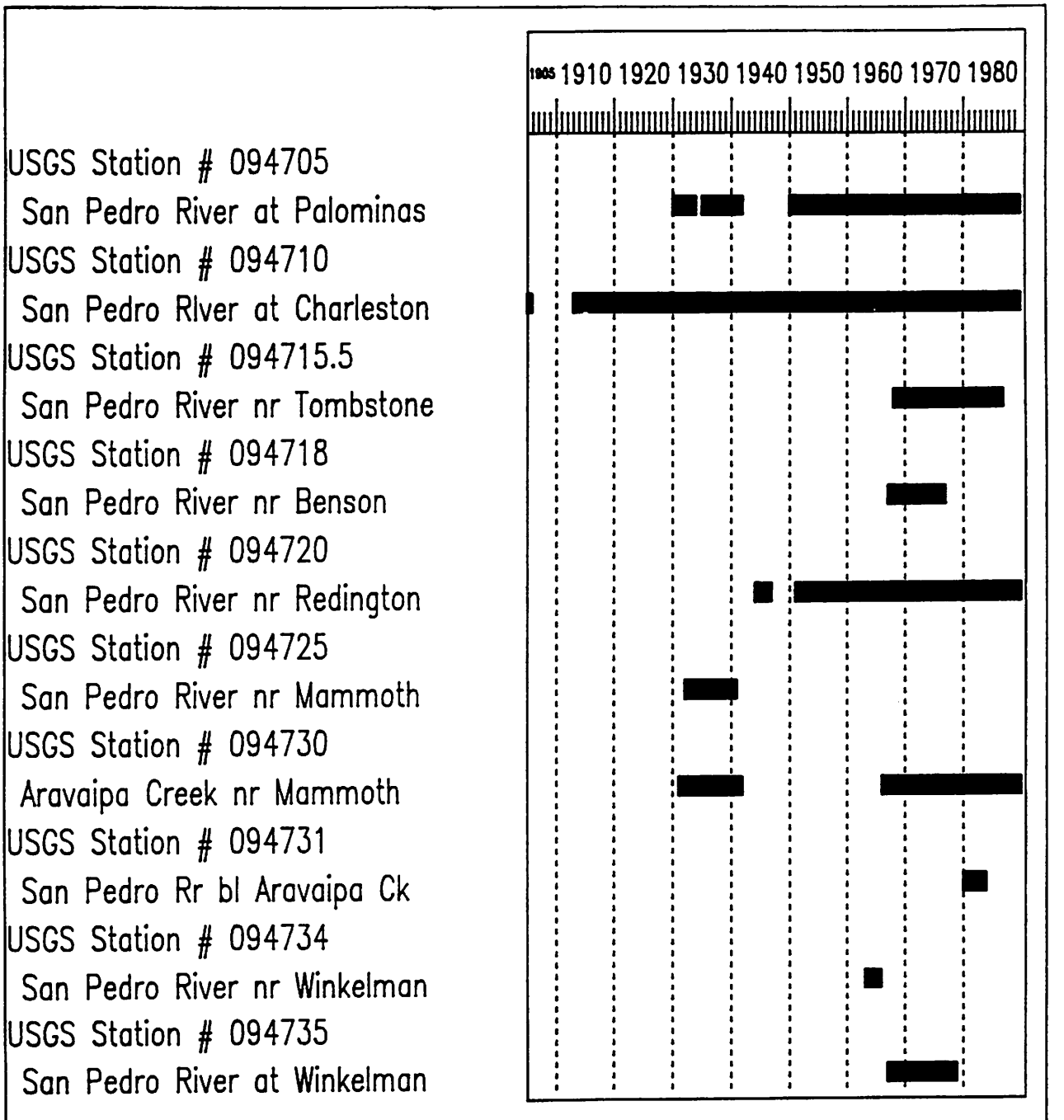


Figure 2-14. Historical gaging stations and period of records
San Pedro River watershed
For water years 1905-1990
(common period of record 1968-1976)

TABLE 2-3

AVERAGE ANNUAL DISCHARGE AND RUNOFF FOR STREAMFLOW STATIONS IN THE SAN PEDRO RIVER WATERSHED FOR THE COMMON PERIOD OF RECORD 1968-1976

GAGING STATION	AVERAGE ANNUAL DISCHARGE (ACRE-FEET)	RUNOFF (ACRE-FEET PER YEAR PER SQUARE MILE)
Palominas	17,000	22.9
Charleston	28,000	23.0
Tombstone	29,700	17.1
Benson	23,400	9.4
Redington	22,800	7.8
Aravaipa Creek	16,600	30.7
Winkelman	35,100	7.9

In supplement to the USGS gaging stations, BLM maintains two gages on Aravaipa Creek at the eastern and western ends of the Aravaipa Canyon Wilderness Area. They also conduct instantaneous stream gaging on a bi-weekly basis within the SPRNCA on the upper San Pedro River.

The headwaters of the San Pedro River are in Mexico except for a small portion on the southwest flank of the Huachuca Mountains which is in the United States. The contributing watershed in Mexico encompasses approximately 696 square miles. Little is known about the perennial nature of the San Pedro River in the headwaters region. It appears that the river is partly perennial, at least, in the area of the International Border. There are several land owners which irrigate fairly substantial acreages just south of the border. The long-term annual runoff entering the United States from Mexico is estimated at over 23,400 acre-feet, or about 30 acre-feet of runoff per square mile.

Flows in the San Pedro River and its tributaries are variable, fluctuating radically from season-to-season and year-to-year. Longer term variations are also evident.

Figure 2-15 shows the annual flows at the Charleston gage (Figure 2-12) for the period 1913-1990. The ten year moving average is given along with a line representing the average annual flow. Although lower than average flows predominate, high flows may occur several years in succession and low annual flows may follow high annual flows, or vice versa.

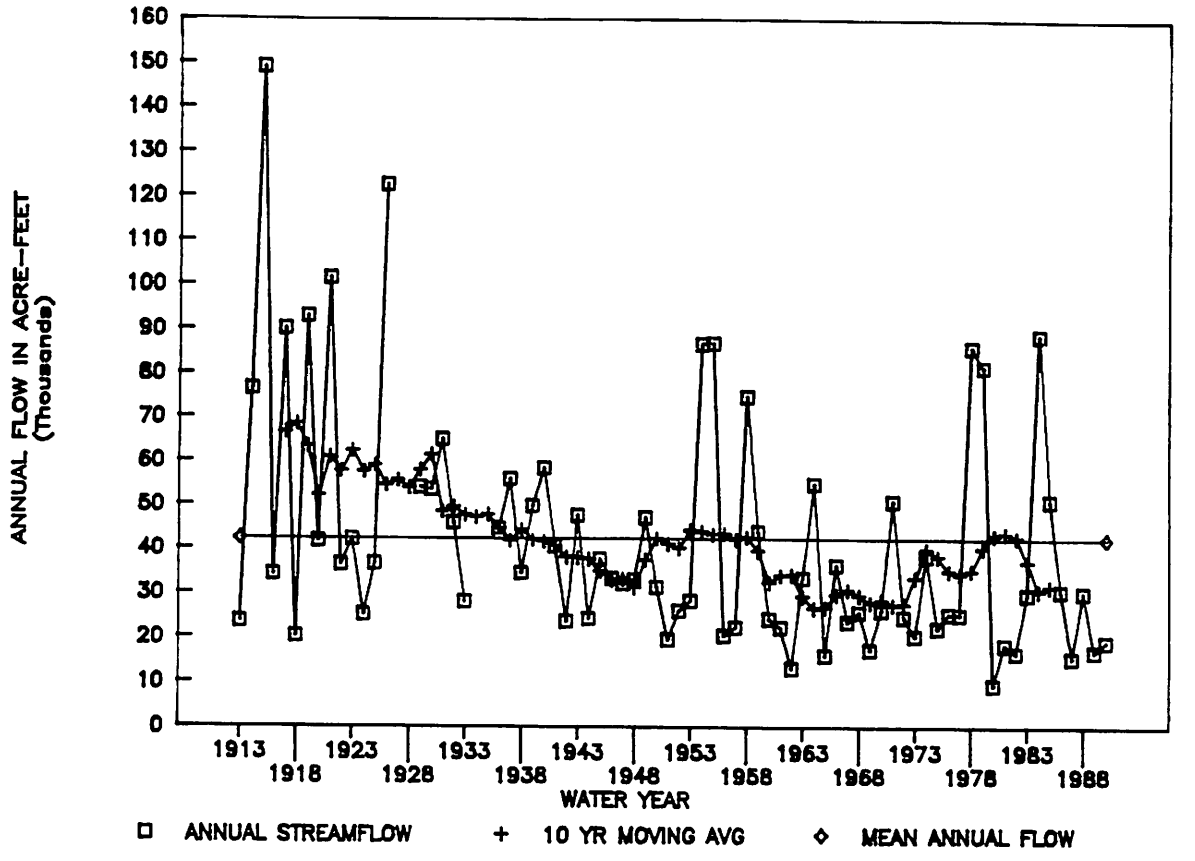


Figure 2-15. Annual streamflow of the San Pedro River at Charleston (water year 1913-1990)

The monthly flows on the San Pedro River are characterized by annual minimum flows in late fall and late spring of each year and annual maximum flows in the summer of each year. The minimum flows occur during the drier parts of the year, while the high flows are generally a result of summer thunderstorm activity or cyclonic storms in the fall. Figure 2-16 shows the variability of monthly streamflow at the Charleston gage. Plotted are the average monthly flows for the water years 1913 to 1990.

Springs

Natural springs are found in consolidated rocks throughout the watershed and are fed by groundwater. Most springs yield only several gallons per minute. A few large springs discharging from limestone beds in Huachuca Mountains produce up to several hundred gallons per minute.

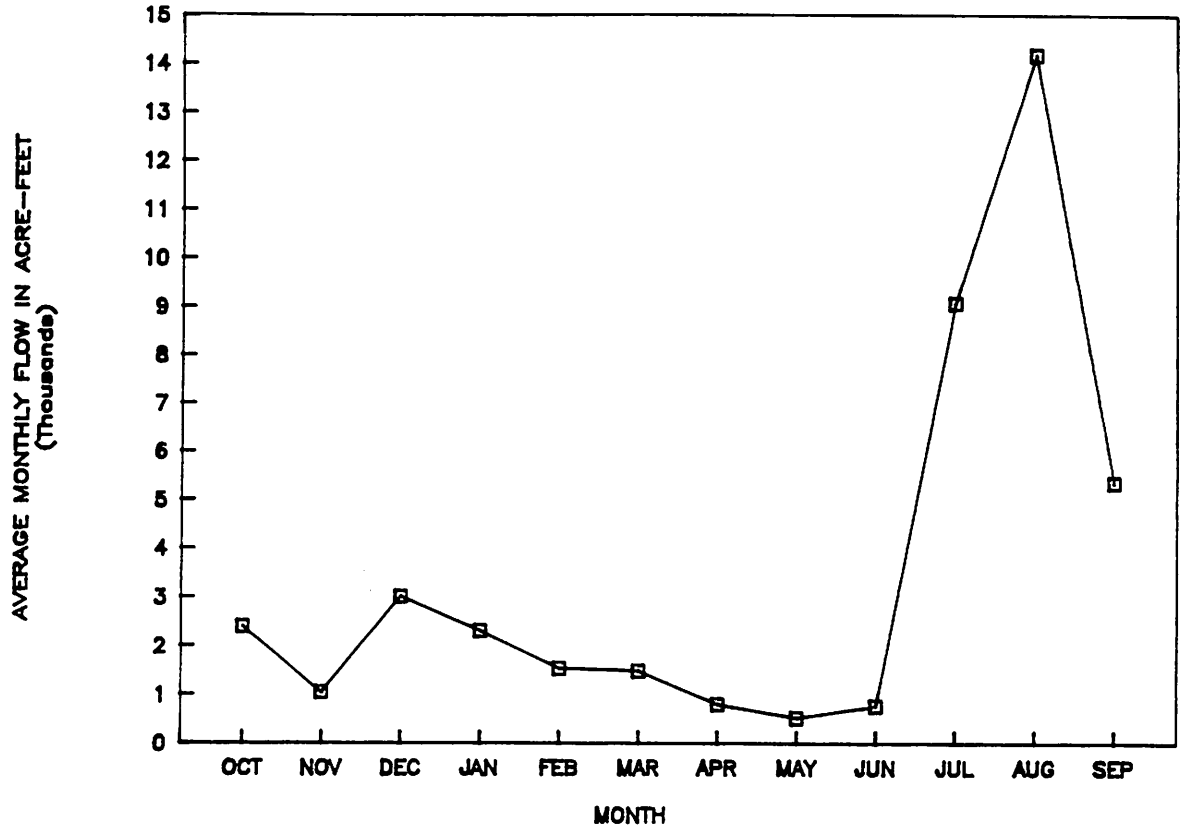


Figure 2-16. Average monthly streamflow of the San Pedro River at Charleston (water year 1913-1990)

Since the late 1800s, the City of Tombstone has relied on springs in Miller Canyon in the Huachuca Mountains for a good portion of its water supply. The city received 156 acre-feet of water per year from those springs during the period 1973 through 1977 which comprised more than half of the city's annual water supply.

Fort Huachuca has also relied upon water from springs for a part of its water supply. The Fort receives spring water from Garden and Huachuca Canyons in the Huachuca Mountains. During the years 1958 through 1963, springflow averaged 665 acre-feet per year in Garden Canyon and 171 acre-feet per year in Huachuca Canyon (Brown, 1966). Prior to 1983, Fort Huachuca used approximately 144 acre-feet of spring water per year as its water supply. Since 1983, however, the amount of runoff that was formally diverted from

Garden and Huachuca Canyons for the fort is now ponded and not used. The remaining runoff from these canyons is lost to evaporation and transpiration or is recharged to the groundwater system.

Surface Water Quality

The water quality of the San Pedro River and its tributaries has been studied in several reports. A study was carried out in 1977 by the Water Resources Research Center (WRRC) at the University of Arizona for the Arizona Department of Health Services (DHS) (DeCook et al., 1977). This study showed the river water to be predominantly a calcium-bicarbonate type with an average total dissolved solids (TDS) concentration level of about 250 milligrams per liter from the International Border to a sampling point on the San Pedro River near Curtis (south of St. David). The TDS level downstream from this point rises to about 400 milligrams per liter at "The Narrows" (DeCook et al., 1977).

There are several known surface water quality problem areas along the San Pedro River. Some of these include nitrate contamination in the St. David region, bacterial contamination from cattle grazing activities, and acid mine drainage from Cananea, Mexico (Putman et al., 1988).

The nitrate contamination in the St. David area greatly exceeds state standards for drinking water (Reents, 1985). The area of major concern is the Apache Nitrogen Products EPA Superfund site west of St. David. Studies by Hargis & Associates, Inc. (1990 and 1991) have revealed higher concentrations of nitrate-nitrogen and several routine constituents and trace metals downstream from the site than recorded upstream. Studies are continuing at this site to determine the extent that contamination is affecting the surface water system of the San Pedro River.

The bacterial contamination occurs along the San Pedro River in the form of high coliform counts measured immediately after precipitation events (DeCook et al., 1977). Studies indicate that these high fecal coliform counts are the result of runoff from cattle grazed rangelands (Putman et al., 1988).

The heavy metals contamination of the San Pedro River appears to be the result of wastewater spills from the Cananea Copper Mine in Sonora, Mexico (Putman et al., 1988). There were two large spills in the winters of 1977 and 1978-1979 (Eberhardt, 1981). Modifications to the mine operation were

implemented in 1981 to prevent future wastewater spills, although as late as 1986 mining wastewater spills have still occurred which polluted stretches of the San Pedro River north of the International Border (Self, 1987).

Other areas which have had surface water quality problems include: 1) acid mine drainage in the Greenbush Draw (United States Environmental Protection Agency, 1985), 2) cyanide leaching solution spill in Walnut Gulch (Kennett, 1985), and 3) raw sewage releases in Greenbush Draw (Self, 1987). None of these areas have current water quality problems (Self, 1987).

Reports have indicated that sewage effluent pollution has occurred in several urban areas (DeCook, 1977). Modifications and upgrades to the municipal sewage plant systems have resulted in fewer violations of state standards for fecal coliform (Self, 1987).

2.2 SUPPLIES FROM MEXICO PORTION OF THE WATERSHED

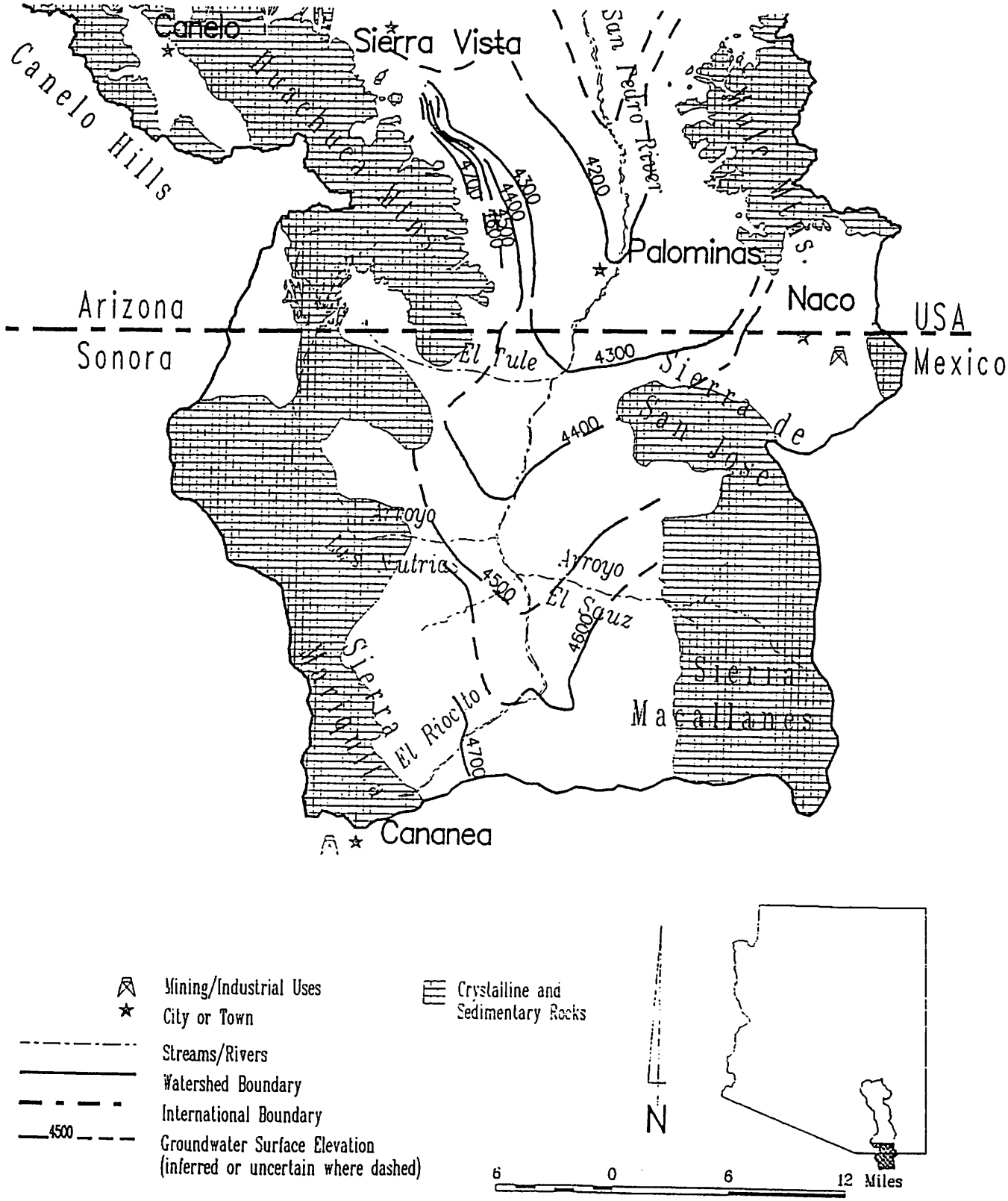
Information on water supplies and uses (Chapter 3, Section 3.2) in the Republic of Mexico portion of the San Pedro River watershed are included in the HSR in order to account for the entire surface water and groundwater supply originating within the watershed. The headwaters of the San Pedro River watershed lie within the Republic of Mexico. The Mexican portion of the watershed encompasses 696 square miles and is shown on Figure 2-17. This area supplies both groundwater and surface water to the downstream portion of the watershed that is important to the overall hydrologic system of the San Pedro River within the United States.

GROUNDWATER RESOURCES

Comprehensive information relating to the Mexican groundwater resources is scarce. To obtain a complete assessment for the San Pedro River watershed, assumptions are made for the Mexican portion of the watershed based upon the characteristics of the United States portion. The assumptions made are that the geology is similar between the Mexican and American portions of the San Pedro River valley, that similar hydrologic conditions exist in both, and that water table systems dominate in both portions.

The hydrogeology of the Mexican portion of the watershed consists of the same floodplain and regional aquifers as found within the United States portion. The main source of inflow to these aquifers is from mountain front recharge from the bordering mountains such as the Sierra de San Jose, Sierra Macellanes, and Sierra Mariquite (Figure 2-17). Secondary porosity may account for a small quantity of inflow to the basin fill. However, the impermeable character of the surrounding mountains inhibit groundwater movement from adjacent groundwater basins (Freethey, 1982).

An exception to this occurs in the headwaters area of the Arroyo Las Nutrias. The groundwater system of this area has been defined by DWR as being part of the San Rafael groundwater basin (Figure 2-2), even though the land surface is part of the San Pedro River system. Within this area, a natural groundwater gradient is believed to exist that results in groundwater flow away from the San Pedro River and toward the adjacent Santa Cruz River system. Further description of this area is found in Section 2.3 of this chapter and



Source: Koniescki, A.D., 1980 (Geology)
International Boundary and Water Commission, 1990.

Figure 2-17. Mexico portion of the San Pedro River watershed

in Chapter 3, Section 3.3 of this volume under supplies and uses within non-tributary groundwater basins. Throughout the remaining portions of the Mexico portion of the San Pedro River watershed, groundwater flow is generally toward the San Pedro River.

A groundwater level contour map was constructed based on data obtained from Cananea Mining Company wells drilled near Cananea, Sonora, Mexico (International Boundary and Water Commission, 1990). Figure 2-17 also shows the occurrence and movement of the groundwater in the Mexican portion of the watershed. Water level elevations range from approximately 4,730 feet above mean sea level near the mountain fronts to approximately 4,608 feet near the San Pedro River. Figure 2-17 indicates that groundwater is flowing in a trend toward the International Border. Water elevations are higher on or near the watershed margins and are lower along the river close to the valley center. This is similar to what is observed in the United States (Konieścki, 1980). Depth to water ranges from approximately 144 feet along the basin margins and decreases to approximately 58 feet near the river. This trend is also consistent with what occurs in the United States portion of the watershed. Water level contours indicate that the direction of groundwater flow generally follows the trend of the river along a hydraulic gradient of approximately 0.005.

Groundwater subflow into the United States from Mexico across the International Border is small. Most of the groundwater is discharged as evapotranspiration or as streamflow before it reaches the boundary (Freethey, 1982). Groundwater in Mexico flows from the watershed margins to the center of the valley where it is discharged to the stream. The groundwater surface elevations shown on Figure 2-17 depict the flow direction in that groundwater flow will be at right angles to the contour lines. Therefore, groundwater underflow from Mexico, west of the river, flows toward the river roughly parallel to the International Border. This results in little or no groundwater crossing over into the United States in the area west of the San Pedro River. However, east of the river, underflow moves in a northwesterly direction and crosses the International Border at a rate of approximately 2,100 acre-feet per year (ADWR, 1990f). This flow rate was calculated using a flow net analysis from the information provided in Figure 2-17 and represents underflow from the regional aquifer only. It has been estimated that

approximately 900 acre-feet of outflow occurs within the floodplain aquifer making the total groundwater flow across the International Border from Mexico equal to approximately 3,000 acre-feet per year

SURFACE WATER RESOURCES

The entire San Pedro River drains an area of 4,483 square miles within the United States and Mexico (Figure 1-2). Of this total drainage area, 696 square miles or 16 percent lies within Mexico. However, the Mexican watershed is approximately 28 percent of the drainage area upstream from Benson, and provides a significant component of the surface water supply in the United States portion of the San Pedro River watershed.

Major tributaries to the San Pedro River in Mexico are the Arroyo El Sauz and the Arroyo Las Nutrias. The headwaters of the Arroyo Las Nutrias lies within the United States. In this area, Bear and Joaquin Creeks collect runoff from the southwest flanks of the Huachuca Mountains as it heads south

Figure 2-18. Surface water contributions from Mexico are reflected here at the Palominas gaging station on the San Pedro River about four miles north of the International Border.

into Mexico. The Arroyo El Tule also drains part of the United States and delivers available runoff to the Mexican portion of the San Pedro River. In total, approximately fifty-six square miles of United States land on the south flanks of the Huachuca Mountains drains into Mexico before reaching the San Pedro River.

Data for surface water resources in Mexico is also scarce. Much of what is known about the Mexican portion of the watershed is gained through measuring surface water flows at the USGS gaging stations along the San Pedro River in the United States. Although approximate, measuring surface water flows at the USGS Palominas gage in the United States is the most accurate available method of accounting for the flows across the International Border from Mexico. The average flow of the San Pedro River at the Palominas gage is approximately 23,420 acre-feet per year (USGS, 1990).

Like its United States counterpart, the Mexican portion of the San Pedro River watershed probably exhibits ephemeral streamflow conditions in most of its tributary drainages. However, the mainstem portion of the San Pedro River may exhibit intermittent to perennial flows within Mexico especially immediately upstream of the International Border.

No data was available to determine the amount of precipitation occurring within the Mexican portion of the watershed. However, it is probably quite similar to that of the United States portion with approximately 12 inches of precipitation occurring along the valley bottom near the river and from 16 to 25 inches occurring in the mountainous areas. Of this precipitation, very little actually becomes streamflow. As in Arizona, most precipitation is lost to evaporation, transpiration, and percolation to groundwater. The average flow of the San Pedro River at Palominas amounts to less than 0.6 inches which is less than 4 percent of the average precipitation of 15 inches (International Boundary and Water Commission, 1979).

2.3 SUPPLIES FROM NON-TRIBUTARY GROUNDWATER BASINS

In the semi-arid alluvial valleys of the southwest, groundwater under a watershed typically flows in the general direction of the slope of the land surface, that is, down a natural groundwater gradient toward the valley's center. Also the groundwater divide or the highest groundwater elevation is generally associated with the topographic high or the watershed divide. Within the San Pedro River watershed, most groundwater does, in fact, flow downgradient toward the San Pedro River and the groundwater basin divides match the topographic divides. However, two exceptions to these characteristics exist within the San Pedro River watershed.

An area around and west of the Town of Elgin on the headwaters of the Babocomari River and an area on the southwest slopes of the Huachuca Mountains exhibit a groundwater flow direction that is away from the San Pedro River watershed. Within these areas, the surface water flow is downslope toward the San Pedro River while the groundwater flow is downgradient away from the river and out of the San Pedro River watershed. Groundwater under these portions of the San Pedro River watershed is not part of the San Pedro River hydrologic system but rather it is part of the hydrologic system of the adjacent watersheds. In essence, these areas represent groundwater basins that are non-tributary to the San Pedro River watershed even though the surface water system is tributary to the San Pedro River. Figure 2-19 is a schematic showing the relationship of a non-tributary groundwater basin to surface water and groundwater flow directions.

Figure 2-2 identifies these two non-tributary groundwater basins as the Cienega Creek groundwater basin (near Elgin) and the San Rafael groundwater basin (on the southwest slope of Huachuca Mountains). The boundaries shown on Figure 2-2 for these two non-tributary groundwater basin areas were derived from determinations made by DWR in the early 1980s in response to sections §§ 45-403 and 45-404 of the Arizona Revised Statutes.

CIENEGA CREEK GROUNDWATER BASIN

The Cienega Creek groundwater basin area is located between the Whetstone Mountains and the Canelo Hills around and west of the Town of Elgin (Figure 2-2). Although this area does not include any of the surface water drainage

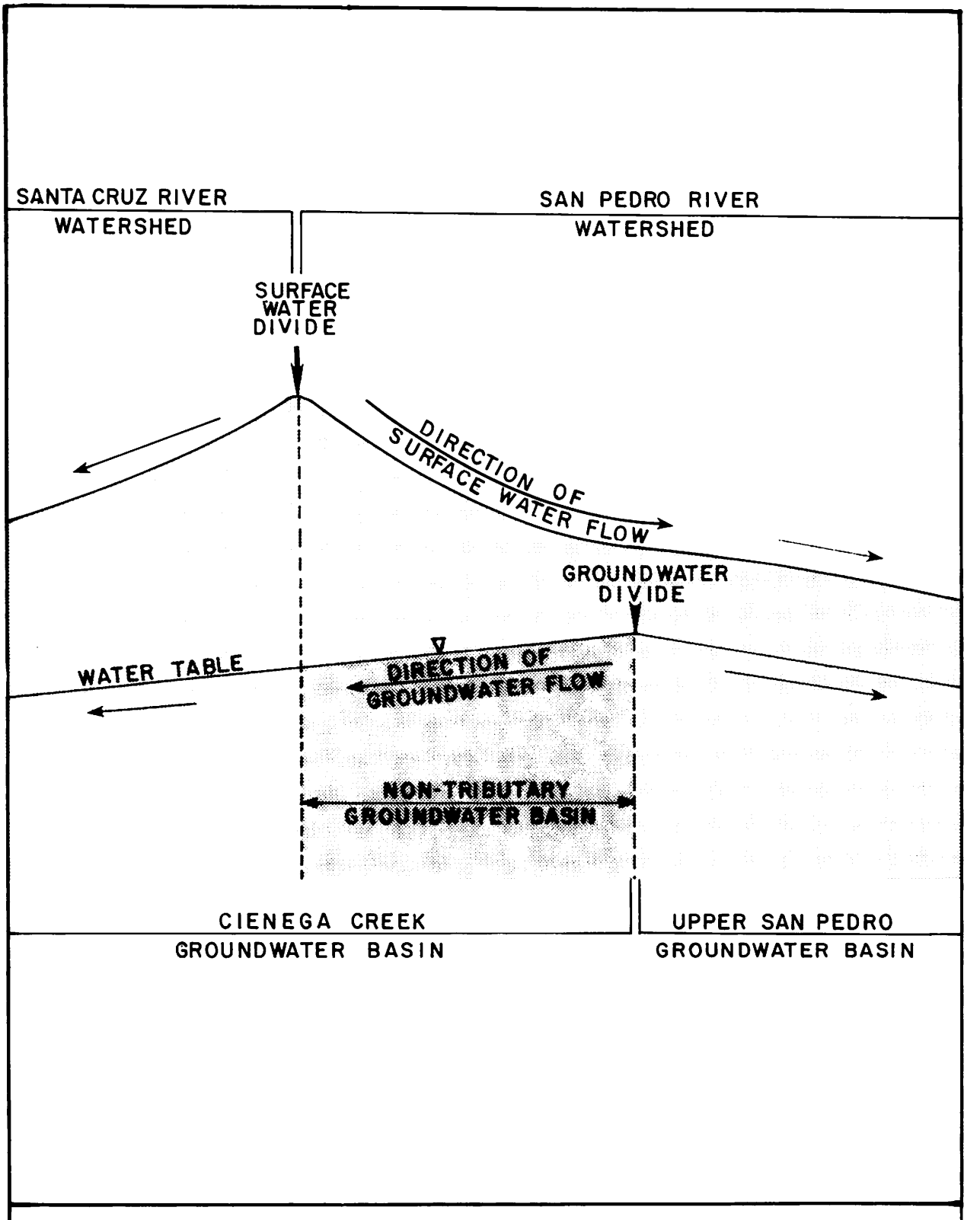


Figure 2-19. Schematic showing the relationship of a non-tributary groundwater basin to surface and groundwater flow directions

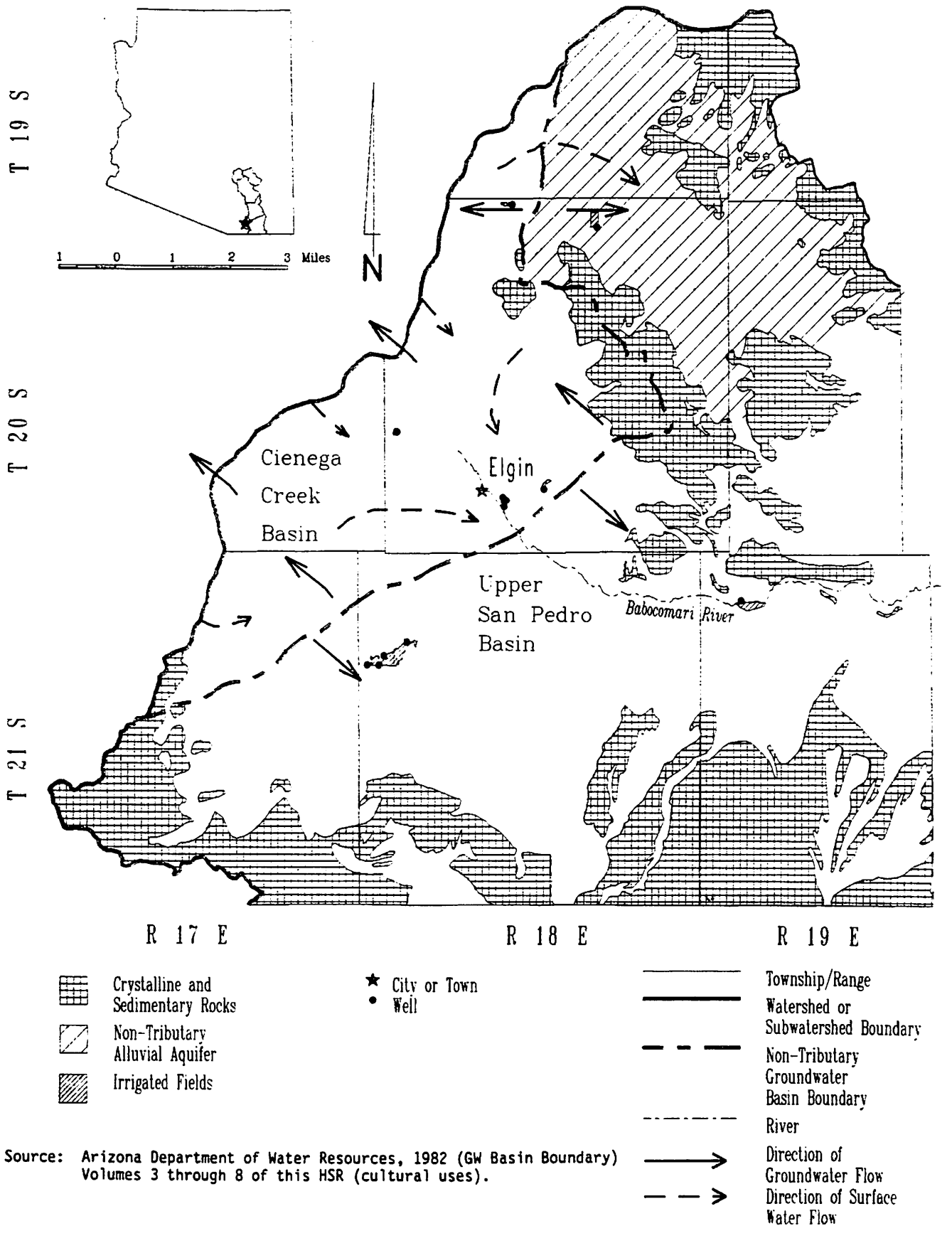
of Cienega Creek within its boundary, groundwater underlying this area flows out of the San Pedro River watershed into the Cienega Creek watershed (part of the Santa Cruz River system). The area encompasses approximately thirty-three square miles within the San Pedro River watershed and is shown on Figure 2-20.

As stated, groundwater flow within this area is away from the San Pedro River or west out of the watershed. The general direction of groundwater flow is shown on Figure 2-20 by arrows. The eastern boundary of this area represents a groundwater divide. This is much like a topographic divide in that water on either side of this imaginary line flows in opposite directions away from the line. Within the boundary of this area, the depth to groundwater increases as you move west of Elgin. Depths to groundwater of approximately thirteen feet occur in the northern portion of the area and are approximately forty feet in the southern portion. Along the western border of this area the depth to groundwater is approximately 220 feet. Water level elevations range from approximately 4,860 feet in the eastern portion to approximately 4,640 feet above sea level on the western boundary. This apparent gradient toward the west indicates that groundwater flows out of the San Pedro River watershed and into the Cienega Creek watershed (Koniescki, 1980).

Surface water runoff from the area represented by the Cienega Creek groundwater basin feeds the Babocomari River, which is a major tributary to the San Pedro River. This area receives seasonal precipitation during the winter cyclonic storms and the summer monsoons. These storms, if intensity is such and they are localized over the area, may produce surface runoff that may in turn fill stockponds in the area and temporarily contribute to flows in the Babocomari River. However, due to the small geographic area and generally low relief, this area does not produce large quantities of surface runoff. Only one spring in the area has been identified by DWR's investigations.

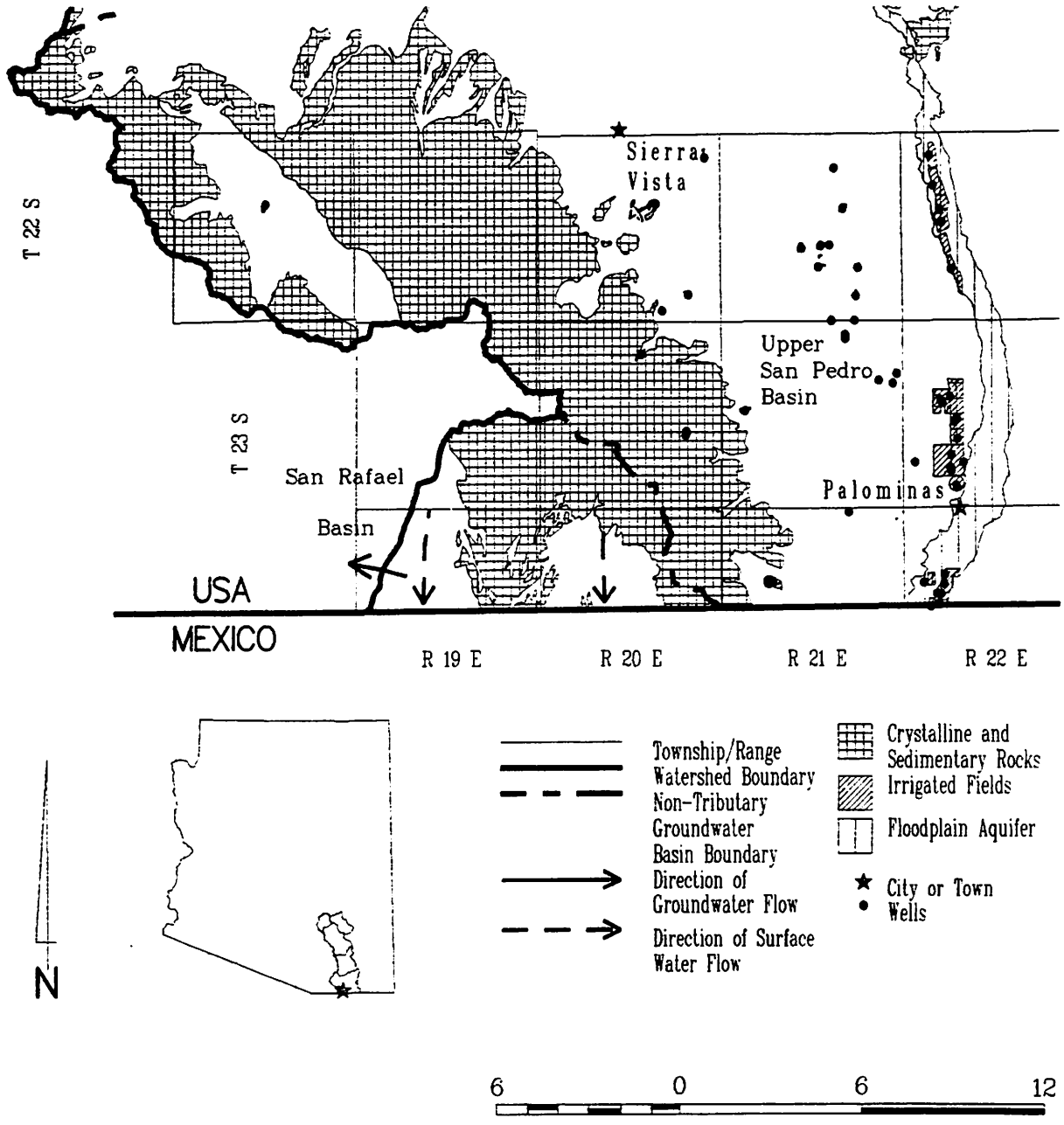
SAN RAFAEL GROUNDWATER BASIN

The San Rafael groundwater basin area is located on the southwest flank of the Huachuca Mountains and is south of the Canelo Hills (Figure 2-2). It encompasses approximately fifty-six square miles of the San Pedro River watershed as shown on Figure 2-21.



Source: Arizona Department of Water Resources, 1982 (GW Basin Boundary)
Volumes 3 through 8 of this HSR (cultural uses).

Figure 2-20. Cienega Creek non-tributary groundwater basin.



Source: Arizona Department of Water Resources, 1982 (GW Basin Boundary)
Volumes 3 through 8 of this HSR (cultural uses).

Figure 2-21. San Rafael non-tributary groundwater basin.

Groundwater under this portion of the San Pedro River watershed is not tributary to the Upper San Pedro groundwater basin but rather is tributary to the San Rafael groundwater basin which is in turn tributary to the Santa Cruz River system. There is insufficient data in this area to determine exact groundwater movement. Pumpage is limited to two wells (ADWR, 1990a). However, based on topographic maps, groundwater in this area flows either south into Mexico before turning west or it flows west depending upon the location in the area. Figure 2-21 shows the probable flow directions for groundwater in this area. Based on available information, depth to water in this area ranges from eleven to sixteen feet below the land surface. Groundwater elevations range from approximately 5,800 feet to 5,230 feet above sea level.

Surface water runoff from this area flows south into the Mexican portion of the San Pedro River watershed before turning north and crossing the International Border back into Arizona. Surface runoff from this area is derived from winter cyclonic storms that produce rainfall and snowmelt runoff, and from the summer monsoons. Runoff events would contribute to stockponds and if they are of significant intensity could contribute to flows in the San Pedro River. This area is slightly larger and has a higher topographic relief than the San Pedro River portion of the Cienega Creek groundwater basin and therefore should produce more runoff to the San Pedro River. Brown et al. (1981) identified a small stretch of perennial streamflow on a minor tributary with this area, the extent of which has not been confirmed by DWR. However, DWR has identified twenty-seven springs within the area.

2.4 SUMMARY AND CONCLUSIONS

A summary regarding the water resources of the San Pedro River watershed is presented below:

1. The two primary sources of groundwater within the San Pedro River watershed are the regional and floodplain aquifers. These two aquifers are in direct hydraulic connection with each other except possibly in areas that have a confining unit between them.

2. The regional aquifer receives most of its recharge from the mountain fronts and stream channel infiltration. Water recharged to the regional aquifer is eventually discharged to the San Pedro River, flows out of the watershed as groundwater underflow near Winkelman, or withdrawn by groundwater pumping within the watershed.

3. In most locations of the regional aquifer, groundwater is traveling toward the San Pedro River or a major tributary stream and is discharging into the younger alluvium or floodplain aquifer where it may ultimately become a significant part of the surface water supply.

4. The floodplain aquifer is recharged by surface water infiltration, lateral and upward flows from the regional aquifer, deep percolation from irrigated land, and underflow from Mexico. The floodplain aquifer is the main conduit for interaction between the surface water and groundwater systems. Groundwater flow in the floodplain aquifer follows the gradient of the river channel and moves north through the watershed.

5. The total volume of recoverable groundwater held in storage in the regional and floodplain aquifers within the San Pedro River watershed to a depth of 1,200 feet below the land surface is estimated to be approximately eighty-four million acre-feet.

6. In most areas, the chemical quality of groundwater in the regional and floodplain aquifer is suitable for most uses. However, there are local areas of high fluoride, sulfate, and nitrate-nitrogen concentrations.

7. Surface water of the San Pedro River watershed is comprised of precipitation and snowmelt runoff and baseflow from groundwater

discharges. Although baseflow supports some perennial stream reaches within the San Pedro River, much of the river exhibits an intermittent flow characteristic.

8. Flows in the San Pedro River and its tributaries are variable, fluctuating radically both seasonally and yearly. They generally exhibit a low flow nature. These low flows occur in the fall and spring while the maximum flows occur in the summer as a result of thunderstorm activity.

9. Springs have played an important role in the establishment of Fort Huachuca and Tombstone. However, springs in general within the watershed are only of adequate size to be used for stockwatering and domestic use.

10. In general, surface water quality is acceptable for agriculture, municipal, and stockwatering purposes. However, local problems of nitrate, bacterial, and heavy metals contaminations exist.

11. Nearly 700 square miles of the headwaters region of the San Pedro River watershed lies within Mexico. From this area, the United States portion of the watershed annually receives approximately 3,000 acre-feet from groundwater inflow and 23,400 acre-feet of surface water flow across the International Border.

12. There are two non-tributary groundwater basins within the San Pedro River watershed that furnish surface runoff to the San Pedro River but do not contribute groundwater flow. These are the Cienega Creek and San Rafael groundwater basin areas, both of which contribute groundwater flows to the Santa Cruz River system.

CHAPTER 3: WATER USES

This chapter describes the occurrence and general characteristics of natural and cultural water uses within the San Pedro River watershed. Its purpose is to provide a watershed summary of the amount of use, source of supply, irrigated acres, types of crops grown, number and size of stockponds, and other statistics associated with each of the principal categories of water use in the watershed. A hydrologic evaluation of natural and cultural uses and their interrelationship with water supplies and watershed outflow is presented in Chapter 4.

The information contained in this chapter is based primarily upon the results of the Arizona Department of Water Resources' (DWR) investigations within the San Pedro River watershed. This investigation was first conducted between 1984 and 1986 for the draft preliminary Hydrographic Survey Report (HSR) for the San Pedro River watershed produced in 1987, and then updated with investigations conducted between 1987 and 1991 to provide the information which appears in this report. This chapter is divided into five sections: 1) natural uses within the United States portion of the watershed, 2) cultural uses within the United States portion, 3) uses within the Mexico portion, and 4) uses within groundwater basins not tributary to the San Pedro River watershed, and 5) summary and conclusions.

Natural uses are those which occur without intentional diversion. They include evaporation of streamflow and the use of water by riparian vegetation along the major stream channels. Cultural uses are water uses for specific beneficial purposes including: irrigation, municipal, domestic, mining, industrial, stockwatering, reservoirs, recreation, and others. The locations of the primary cultural water uses (especially irrigated lands) within the San Pedro River watershed are shown on Plates 2 through 10.

Natural water uses are reported in this chapter as depletions while cultural uses are primarily reported as diversion amounts. Cultural use depletions are estimated for the purpose of the water budget analysis found in Chapter 4. Depletions are the amount of water consumptively used and no longer available as a water source. Diversions are the total amount of water diverted from the source (groundwater and/or surface water system). Many of

the reported uses divert more water than they consumptively use. A portion of the diverted water may return to the hydrologic system. Therefore, depletions represent diversions minus return flows. Stated another way, diversions and depletions represent gross and net withdrawals from the hydrologic system, respectively. Natural uses such as channel evaporation and evapotranspiration from phreatophytes are believed to deplete all of the water which they divert. Therefore, the diversions and depletions for natural uses are considered to be equal. The total diversion for natural uses (depletion of 60,690 acre-feet) and cultural uses (diversion of 109,400 acre-feet) within the United States portion of the San Pedro River watershed is estimated to be approximately 170,090 acre-feet per year.

Return flows may result in the exchange of waters between the surface water and groundwater systems and vice versa. For example, excess water from a surface water diversion may either return to the stream channel, percolate to the groundwater system, or evaporate. Groundwater withdrawals also can result in return flows to surface water systems.

The total depletion volume within the San Pedro River watershed for all natural and cultural uses within the United States portion as estimated in this report is 125,330 acre-feet per year (see the water budget analysis in Chapter 4, Section 4.7 and APPENDIX F). Domestic and municipal water uses are increasing along with the population in portions of the watershed, particularly within the Sierra Vista subwatershed. However, in most of the watershed, population levels, and corresponding development related water uses are relatively stable. Although annual water supply within the San Pedro River watershed fluctuates depending upon yearly variations in available precipitation, water uses exhibit much less variation due to the dependability of supply provided by pumpage from wells within the watershed.

3.1 NATURAL USES WITHIN THE UNITED STATES PORTION OF THE WATERSHED

There are two primary components of natural losses from the San Pedro River hydrologic system: evaporation from bare soils and water flowing in the streams, and evapotranspiration from riparian vegetation. These losses, while having somewhat different effects on the hydrologic system, both result in natural depletions to the hydrologic system with no return flows.

The San Pedro River's floodplain is relatively wide and provides favorable conditions for vegetative growth along the river's banks or within the riparian zones. Many of the plant species which occupy these zones are phreatophytes, plants whose root systems can tap local groundwater supplies.

CHANNEL AND BARE SOIL EVAPORATION

Water flowing in open channels is subject to the same evaporative loss as any shallow free water surface, such as lakes or ponds. An estimated 880 acre-feet per year is lost by direct evaporation on flowing stream reaches in the watershed.

Of greater importance than free water evaporation from flowing streams, is the evaporation from bare alluvial soils in and along the stream courses. This situation arises from the intermittent and ephemeral nature of most of the streams in the watershed. Evaporation has been documented even from alluvial soils underlain by groundwater at depths exceeding four feet (Gatewood et al., 1950). While alluvial soil evaporation is not immediately reflected in surface water measurements, subsequent flows will be lessened by water infiltrating from streams into the alluvium, filling the voids that have resulted from this evaporation. It is estimated that approximately 5,710 acre-feet of water is lost annually to evaporation from the alluvial soils along the San Pedro and Babocomari Rivers and Aravaipa Creek. Therefore, the total loss from evaporation from channel flows and alluvial soils is estimated to be 6,590 acre-feet per year. Procedures utilized to quantify evaporative losses from free water surfaces and bare alluvial soils are contained in APPENDIX B.

PHREATOPHYTES

Riparian vegetation, composed largely of phreatophytic species, occurs on floodplains of river systems and uses considerable quantities of water by tapping local groundwater supplies. Their effects are similar to channel soil evaporation on the surface water system. Water used by vegetation is replaced by increased infiltration of surface water flows. This vegetation can also spread floodflows out over the floodways resulting in sediment deposition and enhanced infiltration. Many of the agricultural lands irrigated by surface water in the American Southwest have been cleared of riparian cover in order to utilize the floodplains. Continued maintenance of these lands is required to prevent re-establishment of phreatophytic species. As a counterbalance to their depletion of the water supply, these areas of riparian vegetation are now recognized not only for their positive hydrologic properties such as increased infiltration and erosion control, but they are also recognized for their aesthetic, recreational, and wildlife values.

Figure 3-1. The San Pedro River located approximately four miles north of the International Border at Palominas. Notice the juvenile cottonwood riparian vegetation within the floodplain and the deposition of salts due to evaporation in the nonvegetated portion of the channel. The measured discharge was 1.5 cfs in March 1990.

Water consumption by phreatophytes is dependant upon the plant species, climatic conditions, availability of groundwater, and the areal extent and density of the vegetation. Mesquite, willow, tamarisk, ash, sycamore, and cottonwood are common species found in riparian communities in the San Pedro River watershed. Some species, cottonwood and willow for example, tend to be shallow rooted and are found only where groundwater lies close to the surface. Other species, such as mesquite and tamarisk, can have root depths exceeding fifty feet and are more typically found along stream reaches in which water is at substantial depths below the streambed. These species are also found on the floodplains and terraces at elevations above the channel grade.

The distribution of riparian vegetation in floodplains of the San Pedro River watershed was mapped by techniques described in APPENDIX B. Evapotranspiration losses from riparian vegetation has been estimated by subwatershed and species and are presented in Table 3-1. These values represent total water use and include evaporation from the bare soil within the vegetative zones, as well as evapotranspiration from the plants themselves. The mean annual water use by phreatophytes in the watershed is calculated to be 54,100 acre-feet per year, based on the distribution of vegetation in 1986. Procedures utilized to quantify evapotranspiration losses from the San Pedro River watershed are contained in APPENDIX B.

TABLE 3-1

SAN PEDRO RIVER WATERSHED
RIPARIAN VEGETATION EVAPOTRANSPIRATION
(ACRE-FEET PER YEAR)

	COTTONWOOD/ SYCAMORE	TAMARISK/ MESQUITE	DENSE MESQUITE	MEDIUM DENSE MESQUITE	WILLOW	CIENEGA/ DENSE GRASS	SAN PEDRO RIVER* WATERSHED TOTAL
Sierra Vista	5,575	---	3,860	4,585	165	263	14,450
Benson	1,122	7,772	5,658	1,795	---	1,344	17,690
Redington	1,794	760	9,587	73	---	1,182	13,400
Winkelman	416	854	2,742	3.048	---	---	7,060
Aravaipa	1,209	---	84	205	---	---	1,500
TOTALS	10,116	9,386	21,931	9,706	165	2,789	54,100

* Values rounded to nearest tens.

3.2 CULTURAL USES WITHIN THE UNITED STATES PORTION OF THE WATERSHED

There are eight major categories of cultural water uses discussed in this section: irrigation, water exports, municipal, mining, industrial/commercial, reservoirs, stockponds, domestic uses. Although other small cultural uses occur in the watershed such as stockwatering from windmills and springs, the amount of water use is considered to be a negligible component of overall use within the watershed and therefore these other small uses have not been quantified. The estimated diversion for all cultural uses in the United States portion of the watershed is 109,400 acre-feet per year and the estimated depletion for all cultural uses is about 64,600 acre-feet per year. Irrigation uses make up 57 percent (62,750 acre-feet per year) of the diversions and 50 percent of the depletions (30,640 acre-feet per year due to evapotranspiration depletions and 1,830 acre-feet per year due to additional unrecoverable losses). Chapter 4, Section 4.7 contains more information regarding the depletion from cultural uses. APPENDIX C describes DWR's procedures for quantifying cultural uses.

Before discussing the various cultural water uses that occur in the San Pedro River watershed, it is necessary to identify and briefly discuss the different types of water supply sources reported by DWR in this HSR. The Court has directed DWR to report all water uses supplied by surface water sources which include surface streamflow, springs, and seeps. The Court entered a comprehensive order on the legal relationship between groundwater and surface water under both state and federal law on September 9, 1988. This order also included several directives for DWR to follow in providing additional information on underground water that is withdrawn by wells.

Chapter 4, Section 4.6 of this volume of the HSR describes in detail DWR's technical interpretation of these directives and the methodology used to implement them. DWR has established three reporting zones for water withdrawn from wells. Together these zones encompass the entire San Pedro River watershed. "Zone 1" is the area which results from DWR's application of the Court's criteria for identifying wells which, for purposes of the HSR, are presumed to be withdrawing appropriable subflow. The applicable technical directive from the Court's order is as follows:

1. As to wells located in or close to that younger alluvium, the volume of stream depletion would reach 50 percent or

more of the total volume pumped during one growing season for agricultural wells or during a typical cycle of pumpage for industrial, municipal, mining, or other uses, assuming in all instances and for all types of use that the period of withdrawal is equivalent to 90 days of continuous pumping for purposes of technical calculation.

2. A well is designated on state records as an in lieu well.

3. A well is designated by state certification as pumping surface flow.

The boundaries of Zone 1 are referred to as "brightlines" in this report. Water withdrawn by wells located in this zone is classified as "GROUNDWATER: ZONE 1."

"Zone 2" describes an area in which wells (supplying uses other than stockwatering, domestic, or irrigation less than two acres) are determined to be capable of diminishing the supply of surface water available to meet federal reserved water right claims. The Court's directive to DWR states the following:

> In determining a prioritization of such claimed federal reserved right, it will be necessary to determine all stream users or diversions of either surface water or groundwater which affect those sources reasonably on, at, or near the federal parcel which would be available to fulfill the determined entitlement.

A well located in Zone 2 will be classified and reported as "GROUNDWATER: ZONE 2."

"Zone 3" is the area in which water withdrawn from wells has been determined to have no significant effect on diminishing the water supply available to meet rights claimed or established under either state or federal law. Wells located in Zone 3 and the exempt wells in Zone 2 are classified and reported as "GROUNDWATER: CATALOGUED."

In summary, DWR is reporting the following sources of water and their classification:

SURFACE WATER
GROUNDWATER: ZONE 1
GROUNDWATER: ZONE 2
GROUNDWATER: CATALOGUED

and various combinations of the above sources.

Considering well withdrawals from within these three zones together with surface water supplies, there are fifteen possible ways in which uses can be supplied. Table 3-2 lists these fifteen possible sources of supply within the San Pedro River watershed. It should be noted that there are currently no water uses other than domestic uses in the San Pedro River watershed that involve withdrawals from wells located in Zone 3. However, Magma Copper Company and Oracle Ridge Mining do remove water from mine shafts located within Zone 3 as part of their mining operations.

TABLE 3-2

POSSIBLE SOURCE OF SUPPLY COMBINATIONS IN THE SAN PEDRO RIVER WATERSHED

Surface water
Zone 1 groundwater
Surface water + Zone 1 wells
Zone 1 + Zone 2 wells
Zone 2 groundwater
Surface water + Zone 2 well
Surface water + Zone 1 + Zone 2 wells
Zone 3 wells
Surface water + Zone 3 wells
Zone 2 + Zone 3 wells
Surface water + Zone 2 + Zone 3 wells
Zone 1 + Zone 2 + Zone 3 wells
Surface water + Zone 1 + Zone 2 + Zone 3 wells
Surface water + Zone 1 + Zone 3 wells
Zone 1 + Zone 3 wells

Figures 3-2 through 3-5 provide illustrations of the first seven possibilities presented in Table 3-2. These are the only combinations of source categories included within potential water rights created by DWR and which are provided in Volumes 3 through 7.

Figure 3-2 "A" illustrates irrigation uses, IR1 and IR2, supplied solely by surface water from a diversion D1, an instream pump P1, and a spring S1. There is no well component and the delineations of Zone 1 and Zone 2 do not apply in this case. Uses supplied solely by surface water are reported in the watershed file reports in Volumes 3 through 6 of this HSR.

Figure 3-2 "B" depicts irrigation supplied by well W1 located within Zone 1. In this situation, well W1 is classified as a Zone 1 well in the watershed

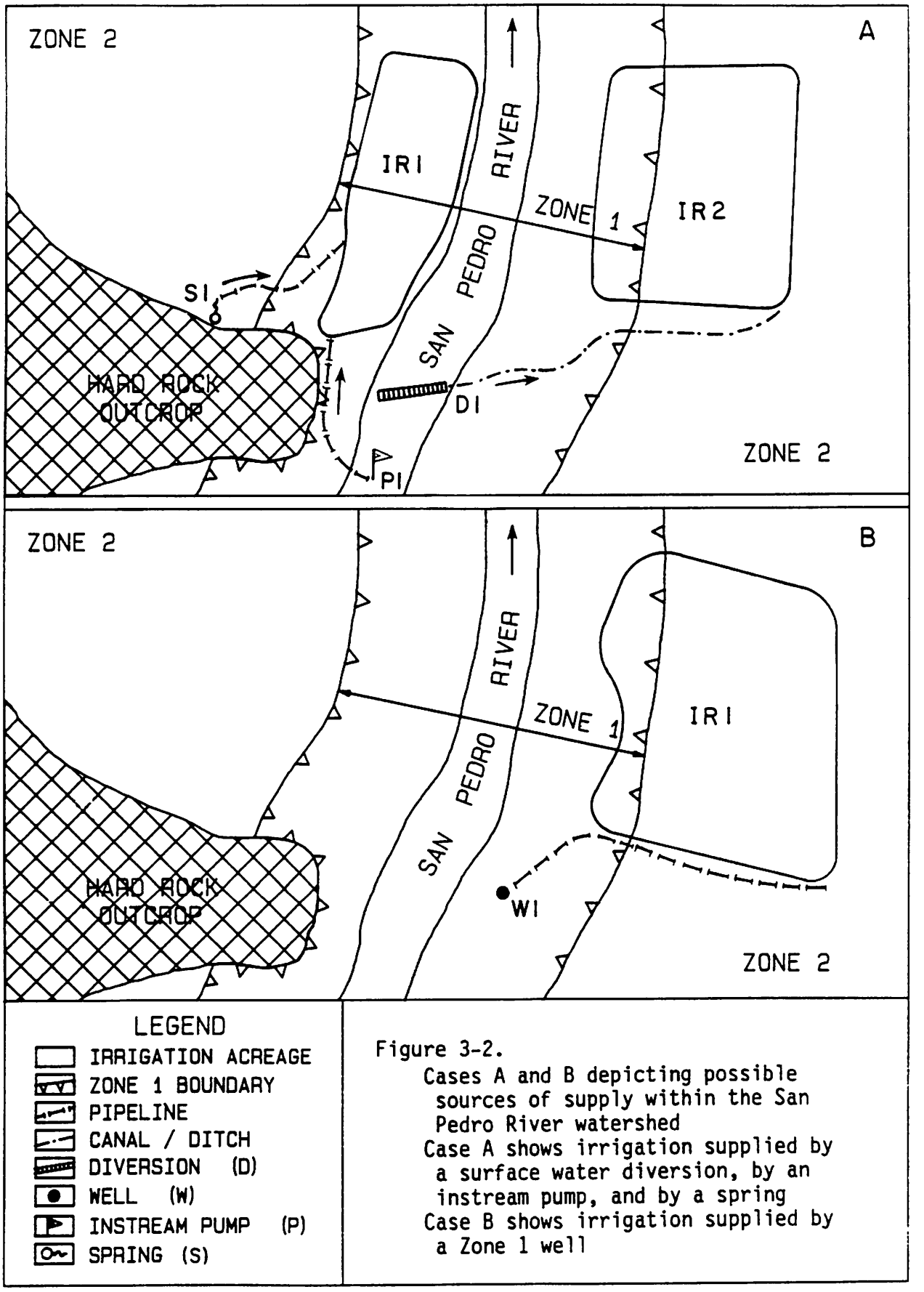
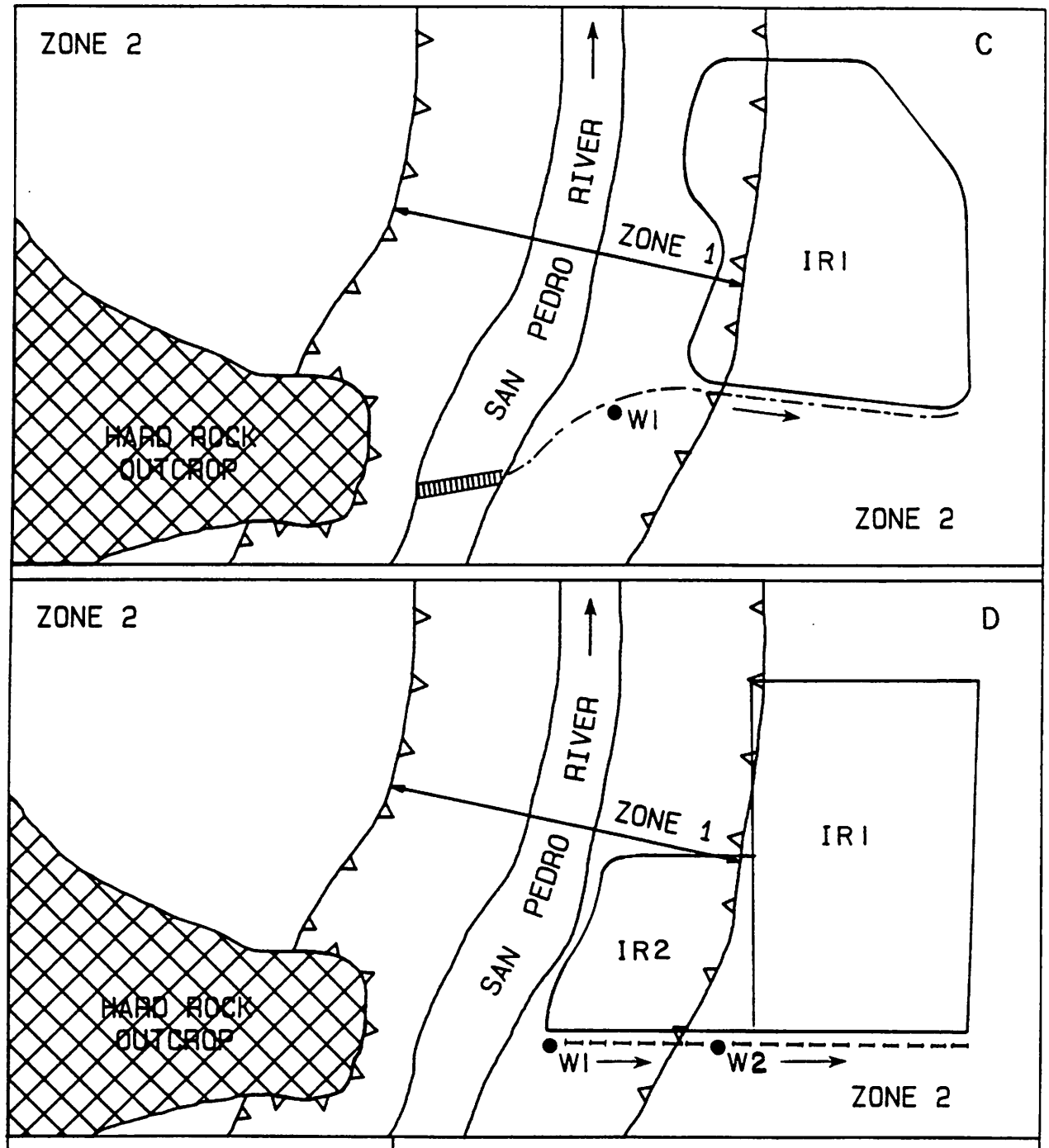


Figure 3-2.
Cases A and B depicting possible sources of supply within the San Pedro River watershed
Case A shows irrigation supplied by a surface water diversion, by an instream pump, and by a spring
Case B shows irrigation supplied by a Zone 1 well



LEGEND

- IRRIGATION ACREAGE
- ZONE 1 BOUNDARY
- PIPELINE
- CANAL / DITCH
- DIVERSION (D)
- WELL (W)
- INSTREAM PUMP (P)
- SPRING

Figure 3-3.
Cases C and D depicting possible sources of supply within the San Pedro River watershed
Case C shows irrigation supplied by a surface water diversion and a Zone 1 well
Case D shows irrigation supplied by a Zone 1 well (W1) and by a Zone 2 well (W2)

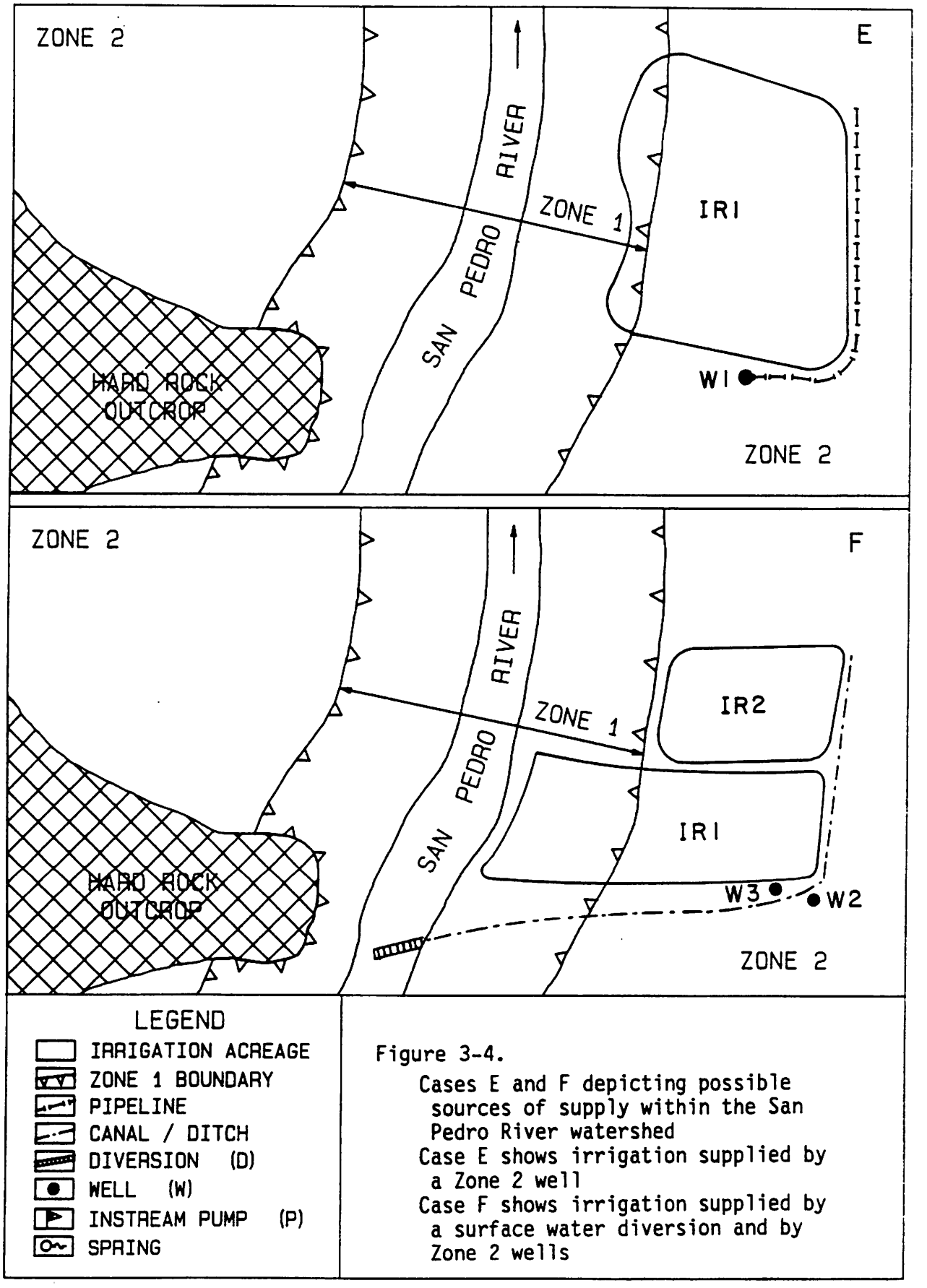
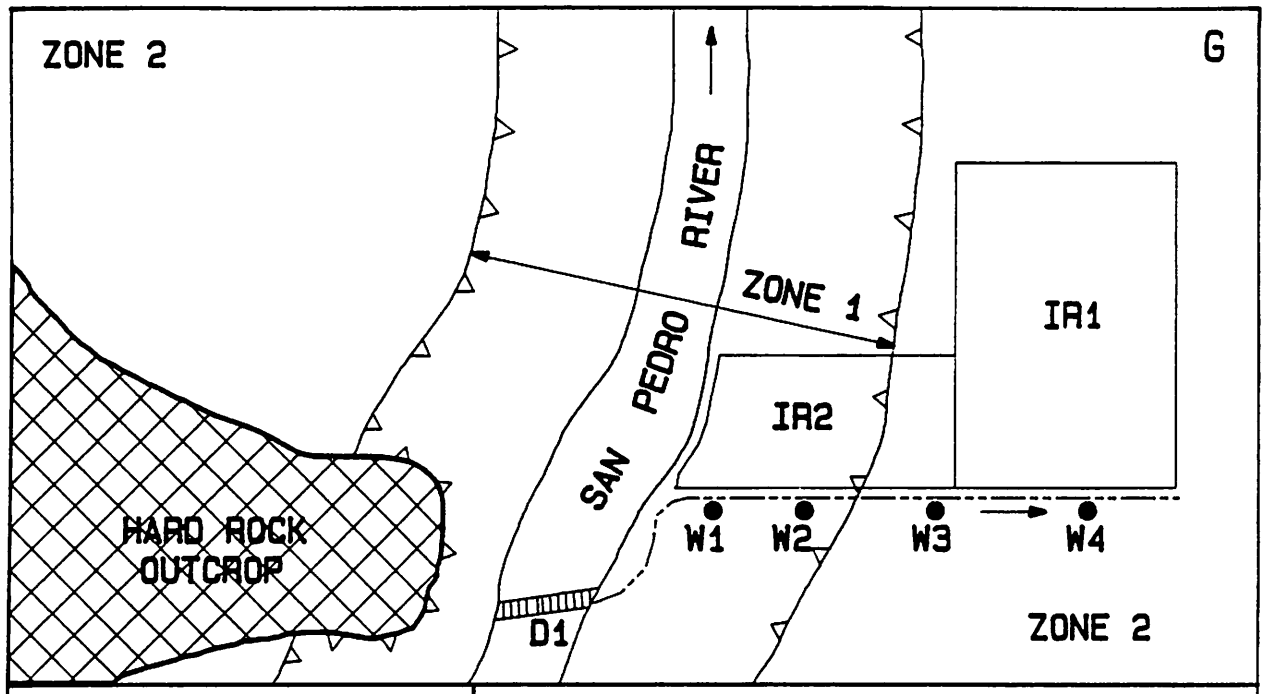


Figure 3-4.
Cases E and F depicting possible sources of supply within the San Pedro River watershed
Case E shows irrigation supplied by a Zone 2 well
Case F shows irrigation supplied by a surface water diversion and by Zone 2 wells



LEGEND

- IRRIGATION ACREAGE
- ZONE 1 BOUNDARY
- PIPELINE
- CANAL / DITCH
- DIVERSION (D)
- WELL (W)
- INSTREAM PUMP (P)
- SPRING

Figure 3-5.

Case G depicting possible sources of supply within the San Pedro River watershed
Case G shows irrigation supplied by surface water diversions, Zone 1 wells (W1 and W2), and by Zone 2 wells (W3 and W4)

file report. Since the point of diversion, well W1, is within Zone 1, all of the acreage supplied is categorized as Zone 1 acreage and is reported in Volumes 3 through 6.

Figure 3-3 "C" illustrates an irrigated parcel which is served by a surface water diversion D1, and well W1 located within Zone 1. Again, it does not matter that a portion of the irrigated acreage is in Zone 2, as the sources D1 and W1 are surface water and Zone 1 respectively. The report quantifying the acreage and volumes of use would be found in the watershed file reports in Volumes 3 through 6.

Figure 3-3 "D" depicts two irrigated parcels, IR1 and IR2, served by two wells, W1 and W2. Well W1 lies within Zone 1 and well W2 within Zone 2. In this situation, the acreages are supplied by a mixed source of Zone 1 and Zone 2 water. The acreage is categorized as receiving water from a well outside Zone 1 and is possibly subject to federal claims. DWR will report the acreage in the watershed file reports in Volumes 3 through 6 and in Volume 7, Zone 2 Well Reports.

Figure 3-4 "E" depicts a well W1 supplying an irrigated parcel IR1 through a pipeline. Well W1 is in Zone 2. This activity will only be reported in Volume 7, Zone 2 Well Reports.

Figure 3-4 "F" illustrates two irrigated parcels, IR1 and IR2, which are supplied by a surface water diversion D1 and two wells, W2 and W3, located in Zone 2. DWR will report the determinations for this situation in the watershed file reports in Volumes 3 through 6 and in the reports contained in Volume 7 of this HSR.

Depicted in Figure 3-5 "G" are two irrigated parcels, IR1 and IR2, which receive water from all three water source categories: surface water from diversion D1; two wells, W1 and W2, located within Zone 1; and two wells, W3 and W4, located in Zone 2. DWR will report these situations in the watershed file reports in Volumes 3 through 6 and in Volume 7.

IRRIGATION USES

Irrigation in the San Pedro River watershed probably was first undertaken between 500-1500 A.D. by settlements of Hohokam Indians who lived along the Babocomari River and in the Tres Alamos Wash region. Some evidence of these ancient canal systems can still be found (Wilken and Galante, 1987). The Sobaipuri Indians also cultivated irrigated crops along the banks of the upper San Pedro River. Father Eusebio Kino described the upper San Pedro valley in his diary as a lush agricultural area with an extensive irrigation system. Kino reported that some of the crops raised were wheat, barley, chili, sugar cane, sweet potatoes, and watermelons (Wilken and Galante, 1987). It was not until the late 1860s and early 1870s that settlers again made their way into the San Pedro River valley. Epigmenio Salazar settled on a small tract of land on the eastern end of Aravaipa Canyon in 1867 and raised crops with water diverted from Aravaipa Creek.

In 1877, the community of St. David was settled by five Mormon families. In 1881, the St. David diversion ditch began diverting surface water from the San Pedro River for agricultural purposes. The farmers in the St. David area supplied the mining town of Tombstone with grains and fresh produce.

A major earthquake struck the San Pedro River valley in 1887. This earthquake caused the swamps and cienega-like areas in St. David to drain and dry up. The quake also caused artesian pools to appear, and many existing wells and wells drilled after the earthquake began to flow under artesian conditions.

Just north of St. David, the small town of Pomerene constructed a diversion dam on the San Pedro River in 1912. This diversion diverts surface water from the San Pedro River into a partially concrete lined canal which is applied to acreages northeast of present day Benson.

By the turn of the century, there were approximately 2,500 acres of irrigated lands in the San Pedro River valley. Some lands near Hereford were irrigated by surface water diverted from the San Pedro River. Acreage in the St. David area was supplied by artesian wells and surface water. The irrigated acreage in and around the Pomerene area was supplied by surface water from the canal or individually owned wells.

Groundwater development within the San Pedro River valley has increased to the point where most of the irrigated acreage is now supplied by wells.

The majority of these wells appear to have been drilled within the last forty to fifty years. Some of the irrigators in the Benson and Aravaipa subwatersheds supplement available surface water with water from privately owned wells. Table 3-3 and Figure 3-6 show the history of development of the irrigated acreage based upon DWR's determinations of the date of apparent first use for each irrigation potential water right.

The following section gives a brief description of the irrigated lands within each subwatershed of the San Pedro River watershed. A general discussion of irrigation practices, crop types raised, and statistical information is presented.

Description of Irrigated Lands

Each of the delineated subwatersheds within the San Pedro River watershed is relatively unique in irrigation practices, water sources utilized, acres irrigated, and crops grown. In one subwatershed, groundwater may be utilized almost exclusively, and in the next, the majority of the irrigation may revolve around established surface water diversions supplemented with well pumpage.

Sierra Vista Subwatershed

The Sierra Vista subwatershed extends northward from the International Border to a point south of St. David, including the Babocomari River drainage, and contains approximately 2,598 acres of actively irrigated land. This acreage is almost exclusively supplied by pumpage from wells. There are also nearly 4,071 acres of discontinued irrigated acres, which are those acres cultivated within the last ten years, but not irrigated within the last five years.

Of the 2,598 actively irrigated acres, approximately 2,525 acres were cropped at the time of DWR's field crop surveys. Of the surveyed total, 1,475 acres were classified as "pasture related crops" (including permanent pasture; winter and summer pasture; double cropping pasture with small grains; and deficit irrigated permanent, winter, and summer pastures) comprising 58 percent of the total. Pasture related crops were followed by just over 257 acres of alfalfa, or 10 percent of the cropped acreage. There were also

TABLE 3-3

SUMMARY OF IRRIGATION DEVELOPMENT BY IRRIGATION CLASSIFICATION (1)

IRRIGATION CLASSIFICATION	1800 TO 1880	1881 TO 1890	1891 TO 1900	1901 TO 1910	1911 TO 1920	1921 TO 1930	1931 TO 1940	1941 TO 1950	1951 TO 1960	1961 TO 1970	1971 TO 1980	1981 TO 1990	TOTAL
Agricultural Irrigation (IR)	902.9	1,208.1	374.4	137.6	1,446.5	618.4	571.4	418.6	2,307.8	2,511.9	5,297.4	4,618.9	20,413.9
Other Irrigation (OT)	3.2	7.5	0.0	0.9	20.5	0.0	1.3	0.0	4.7	5.3	21.8	24.6	89.8
Recreational Irrigation (RC)	0.0	5.1	0.0	0.0	2.7	0.0	2.0	0.0	97.6	54.2	14.4	162.6	338.6
TOTAL	906.1	1,220.7	374.4	138.5	1,469.7	618.4	574.7	418.6	2,410.1	2,571.4	5,333.6	4,806.0	20,842.2
CUMULATIVE TOTAL	906.1	2,126.8	2,501.2	2,639.7	4,109.4	4,727.8	5,302.5	5,721.1	8,131.2	10,702.6	16,036.2	20,842.2	

(1) Data source: watershed file reports Volumes 3 through 8 of this HSR.

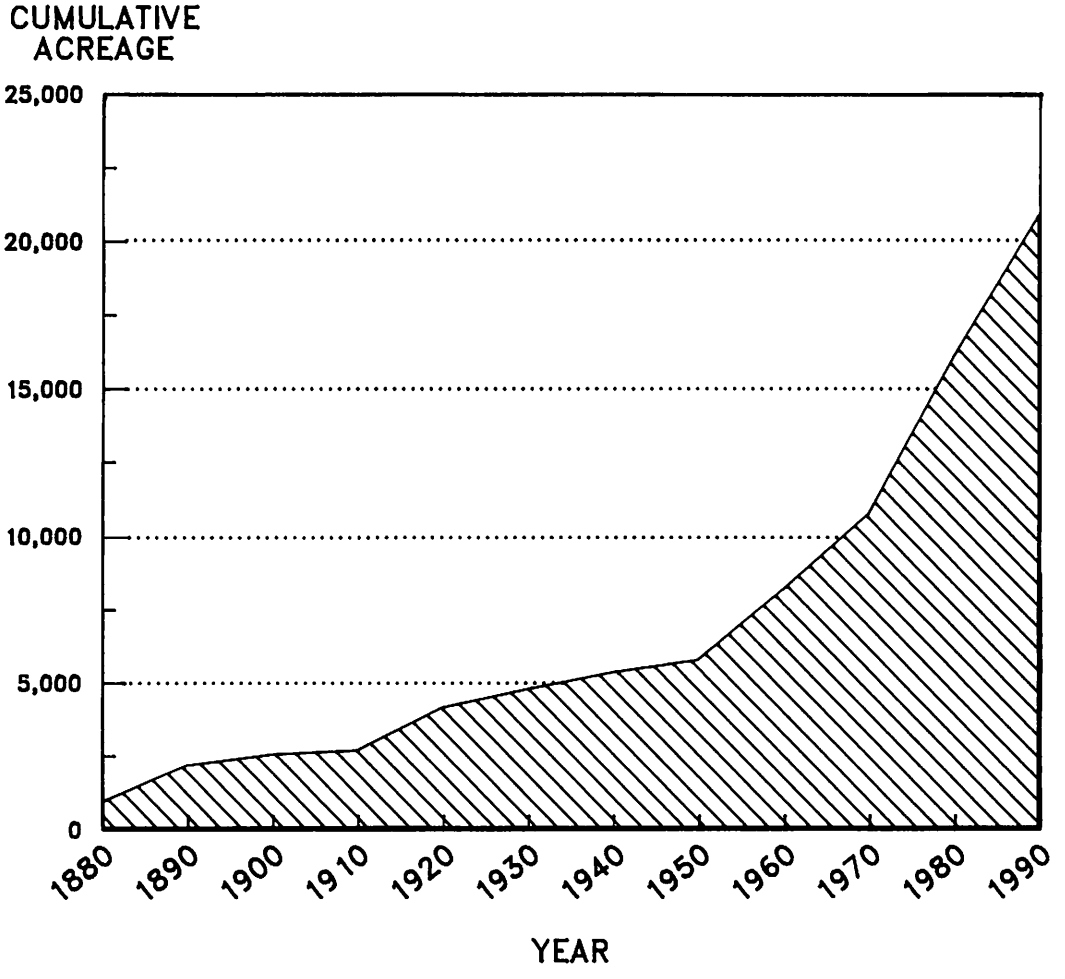


Figure 3-6. History of irrigation development

seventy-three acres which were classified as "no crop." This classification was the result of a crop not having been irrigated at the time of DWR's crop survey.

In the westernmost portion of the Sierra Vista subwatershed, near Elgin, vineyards are becoming prevalent, in some cases replacing native pasture lands. There appears to be a trend toward replacing low value pasture croplands with high value cash crops such as grapes, pecan, and fruit tree orchards. This trend is most pronounced in the Sierra Vista and Benson subwatersheds.

Croplands within the Sierra Vista subwatershed are irrigated predominantly with flood systems without tailwater recovery systems or pumpbacks. Approximately 1,318 acres of the 2,525 cropped acres, or 52 percent, are served by flood systems (wild flood, border flood, etc.). Sprinkler systems supply water to an additional 864 acres of cropland, or 34 percent of the total. The larger pasturage in the subwatershed is served by

Figure 3-7. An onion field irrigated with gated pipeline and furrows in the Sierra Vista subwatershed. This type of irrigation is relatively rare in this subwatershed where sprinkler irrigated pastures predominate.

center-pivot or side-roll sprinkler systems. Much of the smaller acreages are served by solid-set sprinkler systems.

There are also just over 324 acres, or 13 percent of the cropped total which are supplied by highly efficient drip irrigation systems. Of the 324 acres, about 241 acres are classified as vineyard and are located in the Elgin area. The remainder of the drip irrigated crop types are orchard and landscape associated crops.

There are one or two irrigators which divert surface water from springs located in the canyons on the east flank of the Huachuca Mountains. A small amount of pasture and orchard are irrigated from a pipeline from these springs.

The Bureau of Land Management (BLM) acquired the lands which now comprise the San Pedro Riparian National Conservation Area (SPRNCA) in 1986. The former land owner, Tenneco West, Inc., had approximately 1,946 acres under cultivation until the time of the acquisition. This acreage is not being actively cultivated or irrigated at the present time and is currently classified as discontinued irrigation not having been irrigated in the last five years.

Benson Subwatershed

The Benson subwatershed has about 5,885 acres under active irrigation. Of the total, about 3,069 acres are cultivated as pasture related crops (permanent, summer, and winter pasture; double cropped pasture with alfalfa, small grains, corn, and sorghum; and deficit irrigated permanent, summer, and winter pasture), comprising 52 percent of the cropped total. The second most common crop type is alfalfa related crops (alfalfa, deficit irrigated alfalfa, and alfalfa double cropped with sorghum and small grains) on 1,574 acres, or nearly 27 percent of the cropped total.

Approximately 3,214 cropped acres in the subwatershed are served by flood irrigation systems (level basin, border, wild flood) without tailwater recovery or pumpbacks. Another 2,211 acres are supplied by sprinkler systems such as side-roll, center-pivot, and for smaller acreages, solid-set sprinklers.

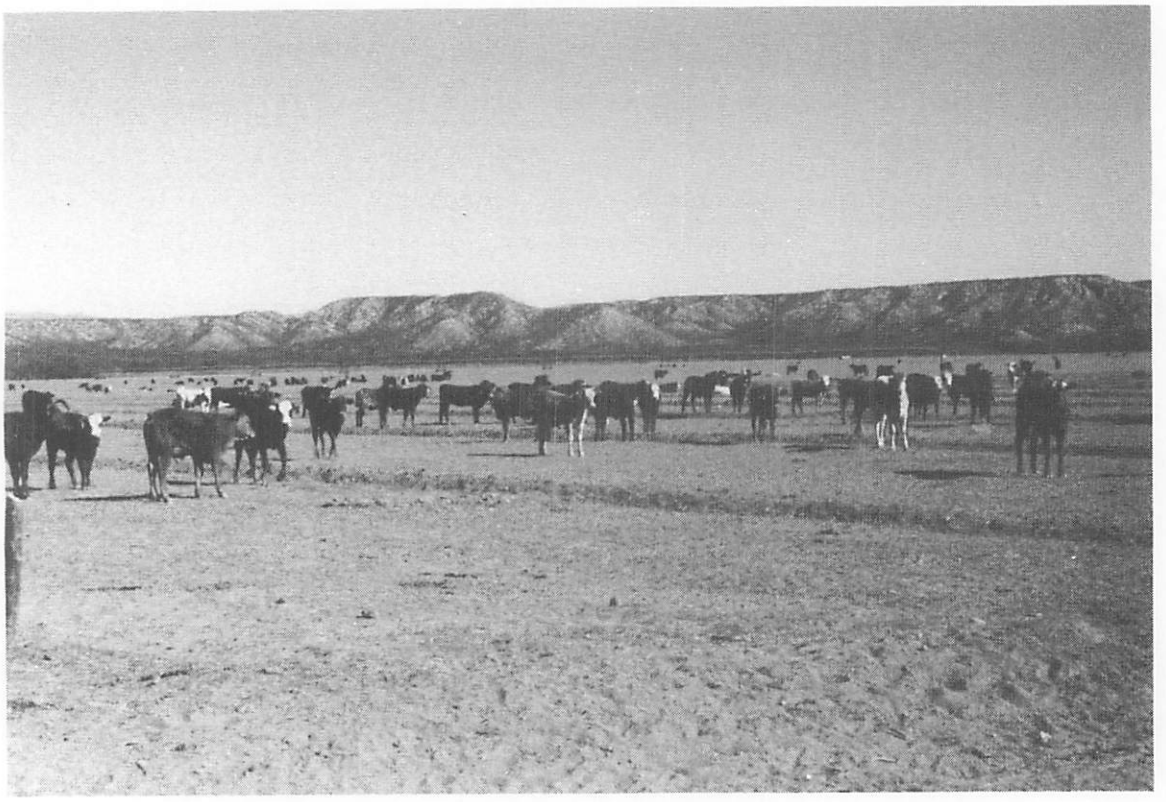


Figure 3-8. A cattle operation located north of Benson. Note the border-flood irrigated pasture in the foreground, and the center-pivot sprinkler irrigated pasture in the background.

Within the Benson subwatershed, there are also approximately 671 acres classified as discontinued irrigation. These acres have not been irrigated within the last five years, but were irrigated within the past ten years.

The Benson subwatershed extends from approximately three miles north of Fairbank to the "Narrows" several miles north of Benson. This subwatershed contains the two major surface water irrigation water providers found within the San Pedro River watershed. The St. David Irrigation District (SDID) is located in and around the community of St. David. The Pomerene Water Users Association (PWUA) is located in and around the small town of Pomerene, just northeast of Benson.

The SDID was formed in 1881 when an earthen diversion dam was constructed which diverted the entire flow of the San Pedro River into an unlined earthen ditch. This ditch conveyed surface water, when available, to acreage located on the east side of the San Pedro River south of the community of St. David. The length of the original ditch was approximately six or seven miles.

In 1916, a major realignment of the SDID ditch system was implemented. This resulted in the addition of irrigable acreage to the district and approximately three miles of new ditch. As of 1990, there were roughly 502 acres of land which had been brought into production since the realignment of 1916. There is still visible evidence of the old ditch system throughout portions of the district. Portions of the old ditch are still utilized by irrigators as internal delivery systems.

During the period 1921-1923, the Arizona State Water Commissioner conducted a detailed analysis of irrigation activity within the San Pedro River watershed as part of the Gila River determination. An analysis of the published State Water Commission (SWC) maps reveal that the SDID had approximately 424 acres under active cultivation. Another 525 acres were classified as "previously cultivated" prior to the period 1921-1923.

The SDID drilled two wells: the first in 1947 and the second in 1952. Both of these wells are located near the southern (upstream) end of the district and are utilized to provide supplemental water when surface water is scarce or unavailable. Currently, the wells are operated by using natural gas powered motors. During much of the irrigation season, the wells are the district's sole source of water for irrigation water supply.

At the present time, SDID supplies water to just over 1,087 acres. The dominant crop type cultivated is pasture related crops (permanent, summer, and winter pasture; deficit permanent pasture; pasture double cropped with small grains) with just over 893 acres, or 82 percent of the cropped total. Orchard related crops (pecans and fruit trees) are the next most common SDID crop type with about fifty-three acres, or nearly 5 percent of the total.

For more information on the SDID, refer to Chapter 5, Section 5.2 found in this volume of the HSR. The watershed file report (WFR) that pertains to the SDID is #112-17-88.

The PWUA diverts surface water from the San Pedro River between St. David and Benson. The Pomerene Canal conveys the water by an earthen ditch located on the east side of the San Pedro River. The length of the canal from the diversion to its end (just northeast of Pomerene) is approximately seven miles. Construction of the Pomerene Canal and diversion were completed in 1912. The original diversion dam was destroyed by a flood in August 1931. A

new diversion dam was completed in April 1934 and was located nearly three-quarters of a mile upstream from the old diversion.

The SWC maps were also examined in the area of PWUA. During the period 1921 through 1923, PWUA had nearly 768 acres under active cultivation and another 781 acres classified as "previously cultivated."

The Pomerene Canal presently supplies water to approximately 1,052 acres of irrigated land. The dominant crop type raised in the PWUA service area is pasture related crops (permanent, summer, and winter pasture; deficit pasture; and pasture double cropped with alfalfa, corn, and mixed vegetables) with just over 557 acres, or 53 percent of the total. The second most common crop type is small grains including small grains double cropped with sorghum and alfalfa with about 312 acres, or 30 percent of the PWUA cropped total.

The PWUA does not supplement surface water with well water. However, many individual irrigators do utilize private wells during periods when surface water is scarce or unavailable. One irrigator does pump water into a concrete lined portion of the canal to convey it to more distant properties.

For more information on the PWUA, refer to Chapter 5, Section 5.2 found in this volume of the HSR. The WFR that pertains to the PWUA is #112-17-89.

The predominant irrigation systems utilized within the irrigation districts are approximately 1,110 acres of maintained flood irrigation systems without pumpbacks or tailwater recovery systems. There are also an additional 674 acres of poorly maintained flood systems without pumpbacks or tailwater recovery systems. In the SDID, there is one land owner which utilizes a tailwater recovery system to irrigate nearly 178 acres of pasture crops. Some irrigators utilize solid set sprinkler systems on the smaller pastures.

Within the St. David - Benson region there are several pecan or fruit tree orchards which are irrigated with well maintained drip irrigation systems. North of Pomerene along the Redington Road, there are some very large pastures which are irrigated with side-roll and center-pivot sprinklers supplied by wells.

Redington Subwatershed

Within the Redington subwatershed there are many large irrigators who utilize wells to irrigate pasture acreages. One land owner also diverts

surface water from the San Pedro River to supplement his well water. Most of the irrigation is located within the floodplain of the San Pedro River and is generally irrigated with side-roll or center-pivot sprinkler systems. The exception being the San Manuel golf course, which is located some distance from the San Pedro River and is sprinkler irrigated.

There are approximately 3,770 acres of active irrigation in the entire subwatershed. The dominant crop raised is pasture related (comprised of permanent pasture; summer and winter pasture; deficit permanent and winter pasture; and pasture double cropped with small grains and sorghum) with 2,441 acres, or nearly 65 percent of the cropped acreage. The second most common crop type is classified as small grain related (small grains, and small grains double cropped with sorghum) with almost 746 acres, or nearly 20 percent of the total. There are lesser amounts of alfalfa and orchard crops. With the exception of the orchard crops (predominantly pecans), the majority of the crops raised are associated with cattle ranching and are grown as forage or silage for the livestock.

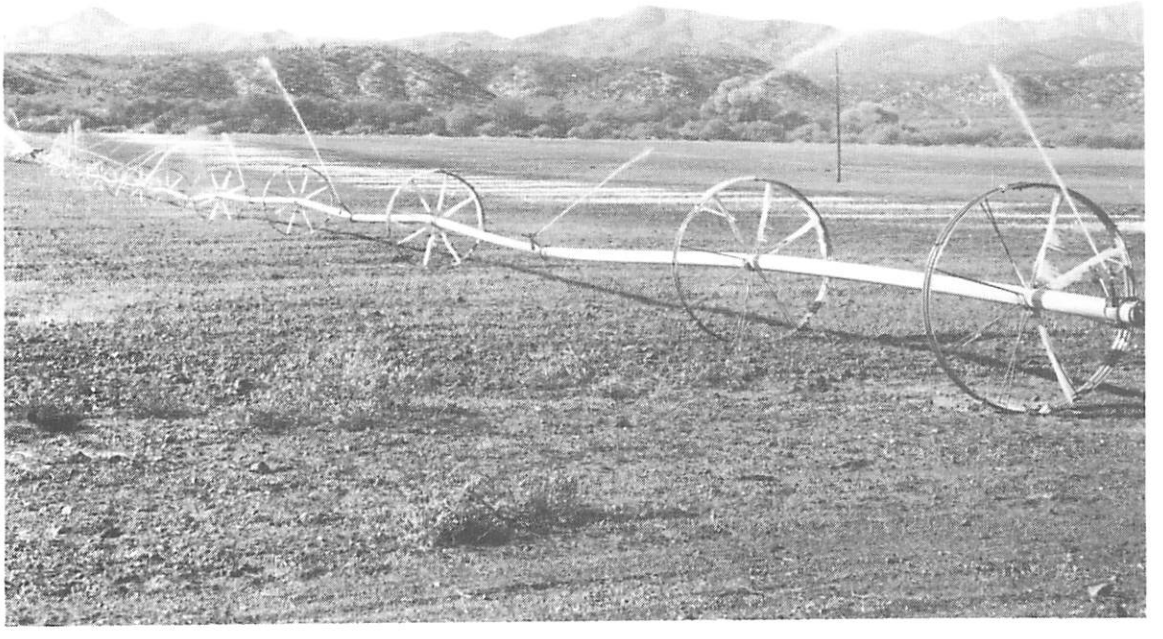


Figure 3-9. A side-roll sprinkler irrigated pasture, located in the Redington subwatershed, is supplied by pumped well water. The large pasture acreages are operated in conjunction with livestock ranching.

The Redington subwatershed also contains nearly 720 acres which DWR has classifed as discontinued irrigation acreage which has not been irrigated within the last five years, but was irrigated within the last ten years.

Specifically, the Redington subwatershed exhibits two major irrigation system types. There are 1,898 acres of flood irrigated acres without tailwater recovery or pumpbacks. Flood systems identified are level basin, graded border, furrow, and wild flooding. There are also 1,814 acres of sprinkler irrigated croplands, predominantly center-pivot and side-roll sprinkler systems.

Winkelman Subwatershed

The Winkelman subwatershed contains some of the most sophisticated irrigated systems within the watershed. Some of the larger irrigators within the subwatershed utilize concrete lined ditches, level basins, borders, and furrows. Many of the crops raised are agriculturally intensive such as

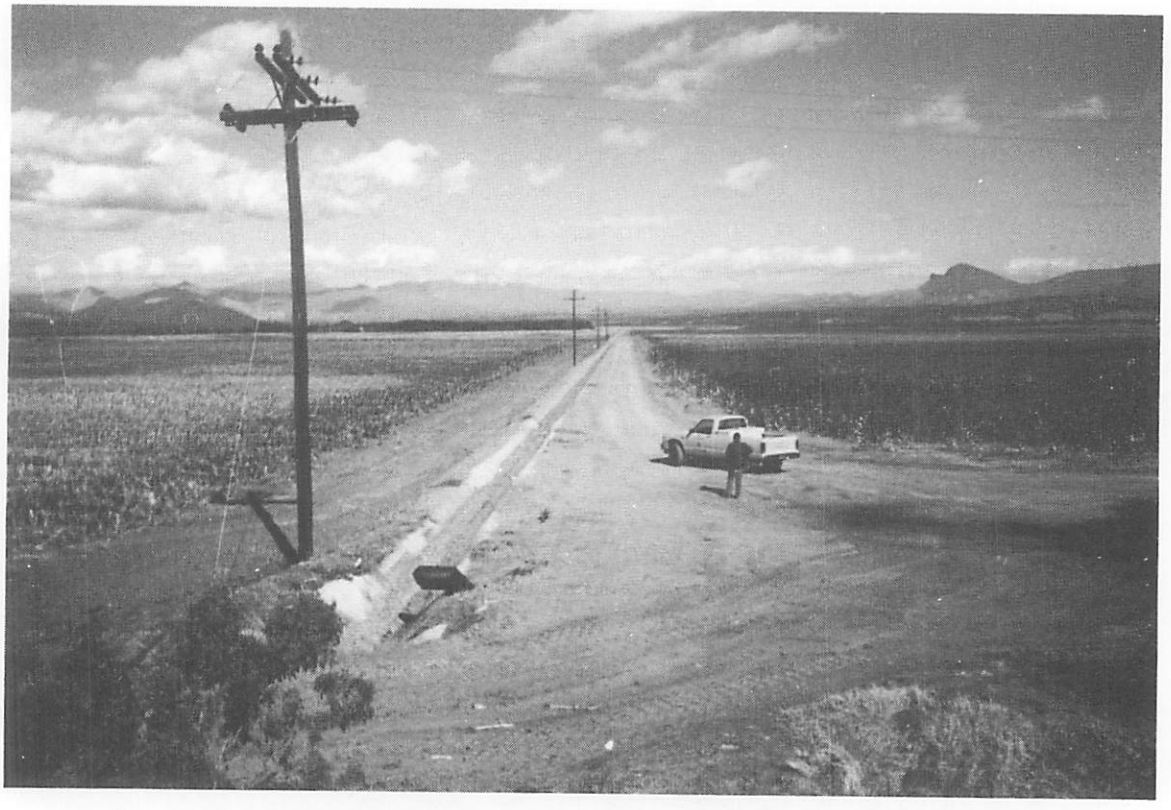


Figure 3-10. The harvested cotton field (right side of photograph) is irrigated by pumped well water near Winkelman. Note the pipeline supplying the concrete lined ditch and the level fields which are typical of the more efficient irrigation systems in this subwatershed.

cotton, vegetables, beans, and small grains, as well as pasture-type crops (hay, and alfalfa). There are currently about 1,990 acres being actively irrigated, with small grain related crops (small grains, deficit small grains double cropped with okra, alfalfa, corn, pasture, and some bean crops) accounting for 568 acres, or nearly 29 percent of the cropped total. Field investigations and crop surveys have identified approximately 135 acres of discontinued irrigation that have not been irrigated in the last five years, but have been irrigated in the last ten years.

The Winkelman subwatershed contains approximately 1,328 acres served by flood irrigation systems without tailwater recovery systems or pumpbacks. There are an additional 390 acres served by sprinkler systems such as side-roll and center-pivot operations.

One irrigator, the Paul L. Sale Investment Company, is presently converting irrigated pasture acreage to commercial fish-rearing ponds. Of the original 201 irrigated acres, only about 150 acres remain irrigated. There are now nearly forty surface acres of ponds which are utilized for commercial fish-rearing purposes. For more information on the Paul L. Sale Investment Company, see Chapter 7, Section 7.3 in this volume of the HSR. For a detailed description of the acres irrigated, pond uses, and capacities, refer to WFR #114-4-BAB-7.

Aravaipa Subwatershed

The Aravaipa subwatershed contains approximately 882 acres of irrigated cropland. Much of this irrigation is served by small surface water diversions from Aravaipa Creek. Some of these diversions utilize earthen dams which divert the entire flow of the creek into unlined ditches. Other irrigators have installed small portable instream pumps which pump water into pipelines or hoses. Many irrigators supplement available surface water with water from privately owned wells.

The predominant crop type cultivated is pasture related crops (permanent, summer, and winter pasture; deficit permanent pasture, and pasture double cropped with small grains) with nearly 603 acres, or 68 percent of the cropped acreage. The second most common crop type is small grains with approximately 100 acres, or nearly 11 percent of the cropped total. The subwatershed

contains 121 acres classified by DWR as discontinued irrigation which have not been irrigated in the last five years, but have been irrigated within the last ten years.

Irrigation systems utilized in the Aravaipa subwatershed generally tend toward the inefficient wild flood or border flood methods to irrigate pasture or small grain crops. Where instream pumps have been installed, some irrigators utilize pipelines or hoses to supply sprinklers or to convey the water to individual trees within an orchard. There are two large irrigators in the headwaters region that utilize center-pivot and side-roll sprinklers to irrigate approximately 571 acres. Surface water supplied flood irrigation (border flood, wild flood, level basin) systems serve 273 acres of cropland.

Two major flooding events impacted acreage along Aravaipa Creek in the winter of 1978-1979 and again in October 1983. During both of these floods, acres of irrigable land were damaged or removed through stream avulsion. Currently, most of the acreage has been reclaimed and is being actively irrigated. See Chapter 7, Section 7.1 of this volume for a detailed discussion of the flood damage along Aravaipa Creek.

Principles and Methods of Quantifying Irrigation Usage

Irrigation water usage can be determined by direct measurement of the water diverted or delivered to a field or by an indirect estimation. An indirect estimation is often based upon formulas to compute crop water use requirements and irrigation management efficiencies. Outside of the Active Management Areas and irrigation districts along the Colorado River, there are few records of direct measurements of irrigation water usage available in Arizona. To carry out the Court's directive to report quantities of irrigation water usage, DWR must utilize indirect estimation techniques in the upper watershed areas of the Gila River system.

Over the past century, many methods have been developed to indirectly estimate irrigation water usage. None have yet found universal acceptance by all government agencies or other experts in this field. Research continues to improve confidence in the understanding of the underlying principles and results obtained for applying the various methods.

To estimate irrigation water usage by the indirect method, DWR must determine three basic components: the amount of acreage irrigated, the amount

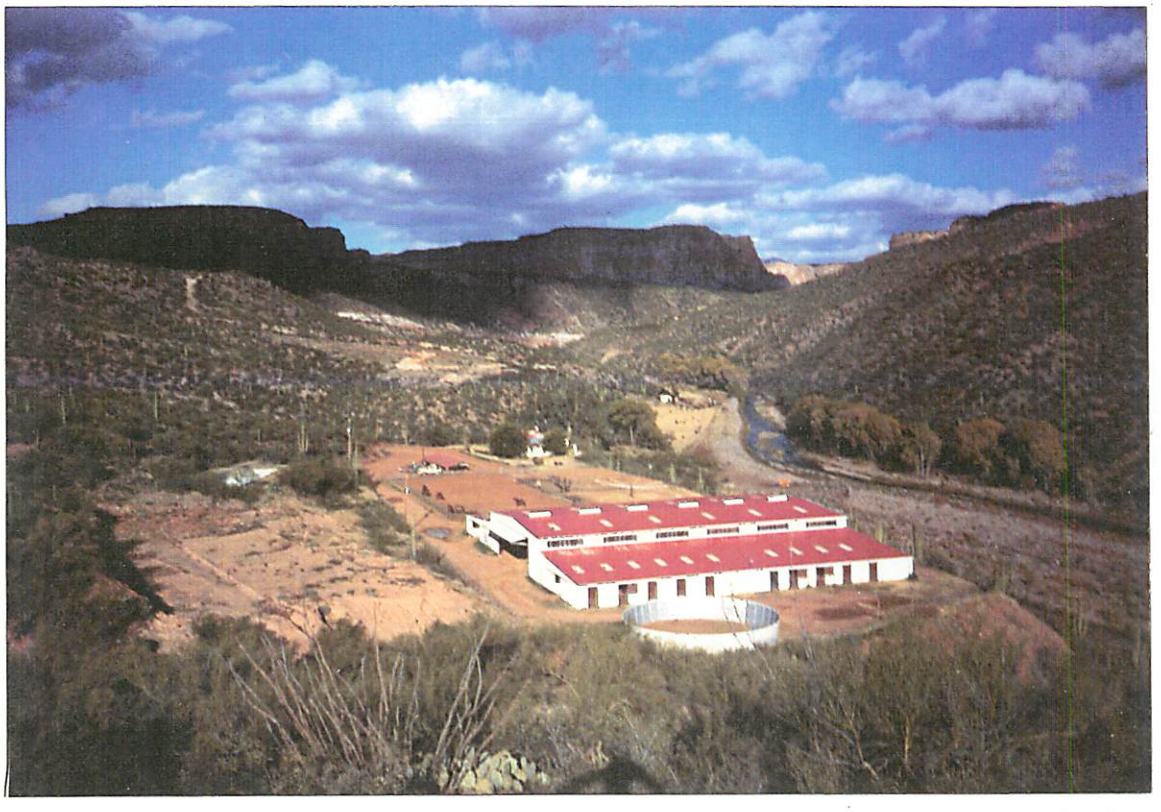


Figure 3-11. A horse ranching operation situated at the west end of the Aravaipa Canyon Wilderness Area. The ranch is supplied by surface water from a spring and pumped well water for a small amount of irrigation, domestic, and stock uses.

Figure 3-12. A furrow irrigated pasture supplied by pumped well water conveyed in a concrete lined ditch located within the Pomerene Water Users Association service area. The well maintained system and level field results in a high irrigation efficiency.

of irrigation water consumed by the crop, and the effectiveness of the irrigation water in supplying crop water needs. The amount of irrigated acreage is determined from aerial photography and field investigations. The amount of irrigation water consumed by the crop is determined by the FAO-24 Blaney-Criddle method. The effectiveness of the irrigation water in supplying crop water needs (efficiency) is determined by field investigation of water delivery systems and water management practices. These determinations and how they can be associated with specific PWRs are discussed below.

Consumptive Use of Water by Crops

The consumptive use of water by agricultural crops can be defined as the amount of water that is needed by the crop for growing and cooling. A small amount of water used by plants is stored in plant tissue while the large majority of the water is utilized in direct evaporation of water from plant surfaces and the adjacent soil. This process is termed evapotranspiration (ET) and can be quantified as an amount of water equal to the consumptive use of water by plants. The amount of water used by the plant at any given time is dependent upon the type of plant, climatic conditions, and management decisions. A crop will not use as much water on a cool, moist day as it will on a hot, dry day. Similarly, a crop that is stressed for water (i.e., not much water is available in the soil) will not use as much water as a crop that has an ample supply of water available in the soil. The variability in water use over the growing season and from one year to the next must be considered. Any computed water duty should reflect average irrigation water use over a long period of time. Hydrologic analysis, on the other hand, often requires water use by plants over a shorter period of time to depict current water use.

Direct determination of crop consumption is usually accomplished through soil monitoring techniques. These methods employ various devices with which to measure changes in soil moisture due to crop water consumption. These direct measurements are costly and involve years of data collection to derive an ET value that is representative of average long-term consumptive use and are only valid within the area where measured. Most direct measurements made within Arizona were made within the Salt River valley and do not apply to other areas in the state due to differences in climate. Directly measured values can, however, be used to derive a relationship between climatic

conditions and crop ET. This relationship can then be used in another area to compute ET when local climatological data is entered into the relationship. These relationships, or empirical formulas, are seldom 100 percent correct when predicting crop ET. This can be due to an improperly derived formula, but more often the problem lies in the relationship's ability to consider all of the factors which influence crop ET.

Most ET calculation methods fall under four main approaches: radiation equations, combination equations, pan evaporation methods, and temperature equations. The goal of most of these approaches is to separate crop ET into a component that can be directly measured and will remain constant in many locations and a component that represents local climatological effects on crop consumptive use. The directly measured constant is usually specific for a particular crop and can vary within the crop growing season to represent different growth stages of the crop. The crop specific constant is usually referred to as the crop coefficient (Kc) while the climatic component is usually referred to as the reference crop consumptive use (ETo). Most methods predict the reference crop (usually grass or alfalfa) ET for a given climate and then multiply ETo by Kc to obtain the crop ET. The approaches differ in the factors and computations of these two coefficients.

The Food and Agriculture Organization of the United Nations Paper 24 (FAO-24) by Doorenbos and Pruitt (1977) discusses a version of each of the four approaches. All four versions utilize the same Kc coefficient and will be considered representative of the four approaches for the sake of discussion. The radiation method mentioned above and represented in FAO-24 computes the ETo portion of the equation by considering mean relative humidity, wind speed, temperature, altitude, and solar radiation. This method requires that the climatic data for air temperature and solar radiation be measured while the other factors can be estimated. The FAO-24 combination equation (modified Penman) requires measured maximum and minimum air temperature, average dew point, total wind travel, and solar radiation. The dew point is the only factor that can be estimated. The FAO-24 pan evaporation method requires pan evaporation data and a pan coefficient which considers the type of pan used, wind conditions, and relative humidity while the FAO-24 Blaney-Criddle temperature method is based upon the original and Soil Conservation Service (SCS) versions of the Blaney-Criddle equation. The original and SCS versions of this equation do not utilize a crop coefficient

that is independent of climatic conditions. The FAO-24 Blaney-Criddle crop coefficient is independent of climatic conditions. The FAO-24 Blaney-Criddle equation computes a grass reference ETo by considering relative humidity, temperature, latitude, wind speed, and possible sunshine hours. The only factor which cannot be estimated is temperature. All other factors are second order variables and do not have as much influence on the outcome as does the temperature data.

Some of the methods mentioned above are considered to be more successful in predicting crop ET than others, some are more successful in specific climates than are others. Jensen, Burman, and Allen (1990) evaluated a number of different procedures by correlating estimated ET with directly measured ET from weighing lysimeters. According to this analysis, the combination methods had the highest correlation to lysimeter ET. The radiation method and temperature method discussed above were respectively placed behind the combination method. The evaporation pan method above was ranked below radiation and FAO-24 temperature methods while the SCS Blaney-Criddle temperature method was ranked lower than the evaporation pan method.

Typically, the equations that attempt to model climatic conditions with more climatic factors tend to predict more accurately over a broad range of climates than do those that consider only a few climatic conditions. Many areas may not have all climatic data required for the more complex models. In the analysis presented above by Jensen, Burman, and Allen (1990), all methods evaluated were able to utilize a wider variety of measured weather data inputs than is commonly found in Arizona watersheds. As stated by the authors, "Poor data quality tends to more heavily penalize the physically based methods . . . compared to single parameter methods, such as air temperature . . . ." Air temperature data is readily available for most locations in Arizona and tends to be of a higher quality more of the time than many other climatic data inputs. Methods of computing ET were not evaluated for accuracy when the data required is scarce and/or of poor quality.

DWR utilizes the FAO-24 Blaney-Criddle method of predicting crop ET when measured ET values are not available. This method has several advantages including fewer accurate climatic requirements, acceptance of the model by many professionals, the ability to further localize the model with input adjustment procedures, the fact that other important climatic factors are considered, and consistency of procedures within DWR.

Irrigation Efficiency

The effectiveness of irrigation practices in supplying water to the crop is generally termed the efficiency and is a ratio of the beneficial uses of the water (aiding the plant) to the amount of water applied. It can also be thought of as a measure of the water losses associated with irrigation. For example, an irrigation efficiency value of 60 percent denotes that of the amount of water supplied to a field, 60 percent of the water was beneficial to the crop while 40 percent was not available for crop consumption.

These losses may be caused by a number of factors. One of the largest losses occurs when water percolates past the crop's root zone where it cannot be reached by the plant. This happens because no irrigation system can apply water in an exactly uniform manner. Too much water is applied in some areas in order to apply enough water for the crop needs in all areas of the field. Other losses of water may occur by seepage and evaporation of the water from conveyance systems and reservoirs, leaks in pipelines, sprinkler evaporation and runoff. Due to these losses or "inefficiencies," an irrigator must divert and apply more water than is actually required by the crop to obtain full crop yield. Figure 3-13 illustrates some of the possible uses of irrigation water.

The effectiveness of the irrigation water in supplying water to the crop is defined in several ways and quantifies different types of irrigation effectiveness. DWR represents irrigation effectiveness with a value termed here as "Farm Irrigation Efficiency." This is a ratio of the total amount of water supplied to the farm to the total amount of water consumptively used by the crop. This measure of irrigation effectiveness reduces the variability in seasonal changes and allows for a more accurate measurement of irrigation effectiveness on an annual basis.

However, farm irrigation efficiency is difficult and costly to measure. Although one factor, the total amount of water supplied to the farm, is relatively easy to obtain on an individual basis, the amount of water consumptively used by the crop is a very elusive value. A given crop will consume different amounts of water based on a wide variety of climatic and management conditions. DWR must often use values of farm irrigation efficiency obtained from areas outside of the study area. These values can often be localized by considering single event irrigation efficiencies obtained within or near the study area. Although these values are not

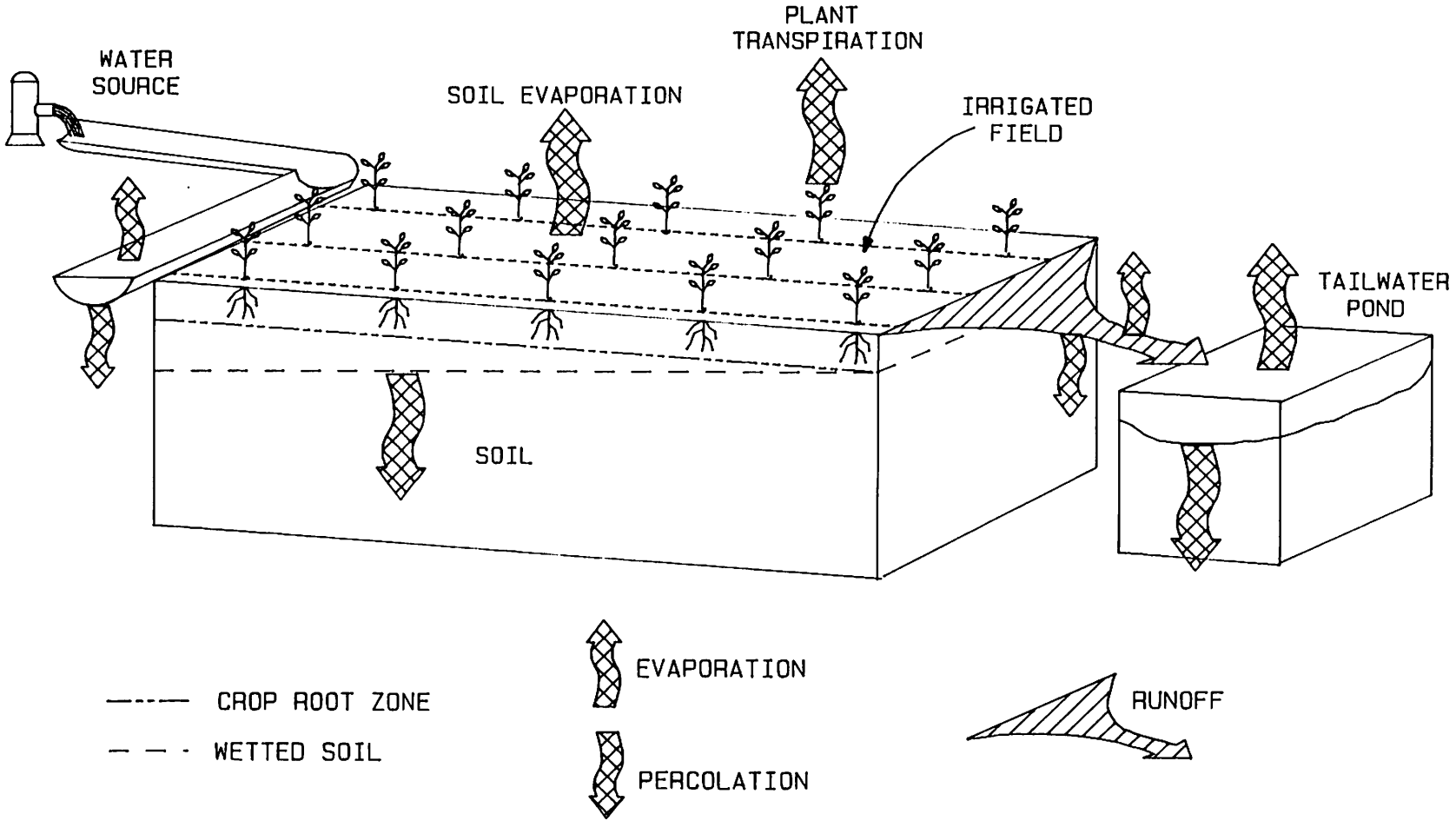


Figure 3-13. Representation of several facets of an irrigation operation depicting some possible water uses including evaporation, percolation, and transpiration

necessarily equal to the seasonal effectiveness of irrigation practices, they are, nonetheless, indicative. When taken in an objective comparison of farm irrigation efficiencies measured elsewhere as well as with other known factors about the study area, general farm irrigation efficiencies for the study area can be derived. These can be applied to individual PWRs based on similar characteristics between the field on which the efficiency was derived and the PWR.

Deficit Irrigation

The crop ET and irrigation efficiency computation methods mentioned previously are intended to model maximum crop yield irrigation practices. This exemplifies a situation in which the crop yield is not reduced due to a shortage of irrigation water. However, in many situations, maximizing yields does not maximize profits. The extra cost of applying the increment of water required to maximized yields is often higher than the additional returns. Irrigating for maximum profits in this situation may involve a decision to under-irrigate the crop, saving the costs associated with a larger irrigation application. As a result, the plant is stressed and yields are decreased. This type of irrigation practice is termed "deficit irrigation." A number of situations can occur which may cause irrigators to deficit irrigate, including shortages of water supply and unintentional under-irrigation. These situations may be more common in Arizona than a policy of irrigating for maximum profit since this practice (excluding pasture crop deficit irrigation) requires a higher degree of management technology than is exhibited by most irrigators in rural watersheds.

DWR identifies deficit irrigation practices during field investigations and crop surveys. An estimation is made as to whether a field has less vegetative matter than other similar fields with the same crop type. Variations in planting dates and other factors such as disease, fertilizer applications, and soil conditions are subjectively considered. The amount of water applied to fields that are identified as deficit irrigated is assumed to fall within a range of application amounts with the majority falling within a much narrower range.

Deficit irrigation practices lower crop ET and raise irrigation efficiencies. When moisture deficits exist in the soil, water molecules are held tighter by the soil particles. This makes plant uptake of the water more

difficult and the crop does not consume as much water as a crop that is not stressed. Irrigation efficiencies are also improved. Compared to irrigating for maximum yield, deficit irrigation practices allow more of the applied water to be used by the crop.

With higher irrigation efficiencies and lower crop ET values, the amount of irrigation water required to follow a policy of deficit irrigation is reduced. Implications of deficit irrigation can greatly impact water duties and reflect a more realistic view of water usage in a watershed than if it were assumed that all irrigators irrigated for maximum yield.

Water Duties

Water duties reflect the amount of water diverted or delivered for irrigation purposes. Regardless of the units of measurement reported by the water duty, acres per cubic feet per second, feet or inches, all water duty values represent a volume of water used for irrigation. DWR expresses water duties as "feet" of water applied and "acres" irrigated. This is the depth of water which is applied to the field over a year and expresses the amount of water much as does reporting rainfall in inches. The entire amount of the water duty, however, is limited by the area which is irrigated. To compute the volume represented by the water duty, the area irrigated is multiplied by the depth of applied water. Representing water duties by a depth of application allows DWR to associate each PWR to a water duty regardless of acreage irrigated.

Quantification of Irrigation Uses

The Court's Minute Entry of March 17, 1989 concerning the "entitlements issue" confirmed the methods by which DWR should report quantities of irrigation use in its HSRs. In addition to quantities associated with prior decrees or certificates of water right, the HSR will also include two additional determinations of quantities of use: a maximum observed amount and a regional amount. In response to comments received on the preliminary San Pedro River HSR, DWR is also now reporting irrigation quantification by a third standard: a maximum potential amount.

The maximum observed quantity is applied to each irrigation water use equal to or greater than two acres and represents DWR's estimate of actual

water use observed during DWR's field investigations. This quantification type utilizes data specific to each irrigation PWR such as: crop type and acreage, water application methods, and field conditions. The maximum observed quantity is the combination of factors which result in the highest amount of water use in any one year during DWR's investigation period.

The regional quantity of use is based upon typical farm conditions found in a watershed or in a particular region of a watershed and the total acres that received irrigation water during DWR's five year investigation period. The typical condition was determined from an analysis of the kinds of crops grown, water application and farm management practices, sources of water supply, soil conditions, climate, and topography and includes only crops that are irrigated for maximum yield.

The maximum potential quantification is applied to each irrigation water use equal to or greater than two acres and represents DWR's estimate of maximum potential water use for an irrigation potential water right (PWR). The maximum potential quantity is based on the highest water using crop reasonably grown in the area, region or watershed, the total acres irrigated during DWR's five year investigation period, and the irrigation efficiency designated for the irrigation operation. For the San Pedro River HSR, the "Maximum Potential" quantification is based upon growing alfalfa.

The Court also directed DWR to provide information pertaining to surface water diversions. This diversion information pertains to: the maximum capacity of the diversion, any applicable decreed rate, and the maximum rate needed to supply all lands served during the month of peak crop demand for all ditches and canals which directly divert from surface water streams.

None of the preceding methods provide a direct assessment of the amount of water actually being used by irrigation during a single year, which is necessary for proper hydrologic accounting in a water budget analysis. Therefore, DWR also determines irrigation water use based upon the number of acres and actual crops being irrigated at the time of DWR's crop surveys.

Within the San Pedro River watershed, DWR conducted detailed crop survey investigations in April 1990 and September 1990. DWR investigators examined all irrigated acreages supplied by surface water and acreages greater than two acres supplied by well pumpage. Crops were identified and field irrigation delivery systems were reanalyzed to determine current farm irrigation

efficiencies. A detailed aerial photographic analysis was also performed on DWR's most recent photography (October 1990).

These detailed crop surveys and photo analyses allowed DWR to classify irrigated acreages as "active irrigation" and "not actively irrigated." DWR was also able to better identify those acreages which are rotated. For example, a distinct irrigation PWR may have a portion of its total acreage actively cropped with small grains and the remainder in a fallow state. The identification of field boundaries and crop types within an individual PWR allowed DWR to calculate potential water duties and PWR irrigation efficiencies.

Within the watershed file reports found within Volumes 3 through 7 of this HSR, the crop type and irrigation efficiency depicted under the "maximum observed" quantification were identified during these field crop surveys. For a listing of all of the crop types identified during the crop survey see APPENDIX C, Table C-2.

Table 3-4 presents the total irrigation acreage by subwatershed associated with six different acreage quantification types (maximum observed, regional, discontinued, maximum potential, crop surveyed actively irrigated, and crop surveyed not actively irrigated) utilized within the San Pedro River watershed.

This section of the report deals primarily with the acreages and quantities of use determined from the maximum observed, regional, and maximum potential use methods that are applied to each irrigation PWR. As a result, these quantifications result in a larger diversion amount in the aggregate than the quantity of diversion associated with a typical single year under current development conditions.

Referring to Table 3-4, note that the acreage reported under the regional method is always equal to or greater than the corresponding acreage reported under the maximum observed method. The reason is because the regional method is applied to the sum of acreage that has received irrigation water during DWR's five year investigation period while the maximum observed method is applied to the acreage under cultivation during the year of highest use. Therefore, the difference in acreage between the two methods reflects field rotation activities.

TABLE 3-4

ACREAGE TYPES UTILIZED IN THE ANALYSIS AND QUANTIFICATION OF IRRIGATION USES

ACREAGE TYPE	SUBWATERSHED ACREAGE					
	SIERRA VISTA	BENSON	REDINGTON	WINKELMAN	ARAVAIPA	TOTALS
Maximum Observed	2,518.9	5,706.1	3,699.2	1,917.6	870.2	14,712.0
Regional	2,597.7	5,884.8	3,769.6	1,990.3	882.0	15,124.4
Discontinued	4,070.7	761.0	719.7	135.4	121.0	5,717.8
Total Mapped Acres (1)	6,668.4	6,555.8	4,489.3	2,125.7	1,003.0	20,842.2
Maximum Potential	2,378.1	5,804.2	3,691.8	1,975.3	870.2	14,719.6
Crop Surveyed Actively Irrigated	2,181.2	5,329.6	3,417.7	1,715.2	765.4	13,409.1
Crop Surveyed Not Actively Irrigated	4,487.2	1,222.4	1,041.5	409.0	228.6	7,388.7
Total Crop Surveyed (2)	6,668.4	6,552.0	4,459.2	2,124.2	994.0	20,797.8

(1) Total Mapped Areas is the sum of the Regional acreage and Discontinued acreage.

(2) Total Crop Surveyed is the sum of the Actively and Not Actively Irrigated acreage.

Table 3-5 shows the acreages and volumes of use determined under the three quantification methods (maximum observed, regional, and maximum potential) for the seven observed water source combinations discussed previously and listed in Table 3-2. Figure 3-14 depicts the number of acres (regional) and source of supply.

It can also be readily observed from Table 3-5 that the volume of use for the regional method is different than the volume for the maximum observed and maximum potential methods. The regional method is based upon representative efficiencies, water duties, and crops for irrigated lands within the watershed, while the maximum observed method utilizes field observations of actual practices, efficiencies, and crops for each irrigation potential water right and includes an assessment of deficit irrigation (i.e., irrigating with less water than what is required for optimum crop production). The maximum potential method considers the actual farm practices, efficiencies, and highest water using crop in the watershed for each irrigation potential water right. Consequently, the maximum potential volume of use will in all cases be the highest quantification reported.

TABLE 3-5

IRRIGATION WATER USE SUMMARY BY SOURCE OF SUPPLY

SOURCE OF SUPPLY	MAXIMUM OBSERVED ACREAGE (ACRES)	MAXIMUM OBSERVED VOLUME (AF/YR)	REGIONAL ACREAGE (ACRES)	REGIONAL VOLUME (AF/YR)	MAXIMUM POTENTIAL ACREAGE (ACRES)	MAXIMUM POTENTIAL VOLUME (AF/YR)
Surface water only	130.3	751.1	228.6	755.5	127.6	926.7
Zone 1 wells	5,106.7	23,050.3	7,224.7	28,496.3	5,255.9	34,381.5
Zone 2 wells	4,172.3	17,524.4	7,429.9	21,250.6	3,928.6	25,956.4
Surface water + Zone 1 wells	249.9	1,756.2	283.9	1,351.1	249.9	1,946.8
Zone 1 + Zone 2 wells	2,475.6	11,212.4	2,922.6	13,934.7	2,580.5	17,686.5
Surface water +	1,706.2	10,726.4	1,825.9	9,347.9	1,706.1	13,579.3
Surface water + Zone 1 + Zone 2 wells	871.0	5,001.8	926.6	4,707.2	871.0	6,677.5
TOTAL IRRIGATED ACRES	14,712.0	70,022.5	20,842.2	79,843.3	14,719.6	101,190.7

Table 3-6 shows the number of irrigation uses associated with each source of supply.

TABLE 3-6

SAN PEDRO RIVER WATERSHED
NUMBER OF IRRIGATION USES FOR EACH SOURCE OF SUPPLY

SOURCE(S)	NUMBER OF IRRIGATION USES
Surface water only	46
Zone 1 wells only	272
Surface water + Zone 1 wells	16
Zone 1 + Zone 2 wells	39
Zone 2 wells only	339
Surface water + Zone 2 wells	161
Surface water + Zone 1 + Zone 2 wells	31
Zone 3 wells only	0
Surface water + Zone 3 wells	0
Zone 2 + Zone 3 wells	0
Surface water + Zone 2 + Zone 3 wells	0
TOTALS	906

The acreage quantifications presented in Table 3-5 can be further disaggregated into three irrigation use classifications utilized in this HSR: agricultural irrigation (IR), other irrigation (OT), and recreational irrigation (RC) (Table 3-7). The IR classification is applied to crops grown for human or animal consumption. The OT classification includes irrigation associated with cemetery landscaping, landscaping around office buildings, or industrial plants. The RC classification applies to irrigated acres which are utilized for recreational purposes such as golf courses, playgrounds, or school yards. Irrigation which is supplied by municipal or water company supply systems are accounted for under the municipal water use category and is not assigned an IR, OT, or RC classification.

Referring to Table 3-7, each irrigation acreage quantification is relatively unique in the type of irrigation use classification which comprises the total acreage value. For example, the maximum observed quantification includes the classifications of IR (excluding discontinued irrigated acreage) and RC acreages. The regional quantification includes all IR type acreages (normal and discontinued irrigation), OT acreage, and RC classified acreages. Finally, the maximum potential quantification includes only normal irrigation classified acres (IR). The maximum potential quantification does not consider RC classified acres as DWR assumes that these acreages will not be replanted with the highest water using crop.

General Characteristics of Irrigation Uses

Since the draft preliminary San Pedro River watershed HSR was prepared in 1987, DWR has continued to monitor and investigate changing irrigation activities in the watershed. The 1987 report identified 19,730 acres developed for irrigation. During the intervening four years, some acres have been discontinued from an active irrigation status (most noticeably all of the former Tenneco West, Inc. irrigated lands now owned by the BLM), while other acres have been brought into production for the first time. Currently, there are about 20,842 acres of irrigable land identified within this HSR.

Cropland in the San Pedro watershed is irrigated by several different irrigation systems and sources, however, the majority of the acreage is supplied by pumpage from wells. For larger tracts of acreage, sprinkler systems predominate. Within irrigation districts and smaller tracts of acreage, generally flooding systems (border-flood, wild-flood) prevail.

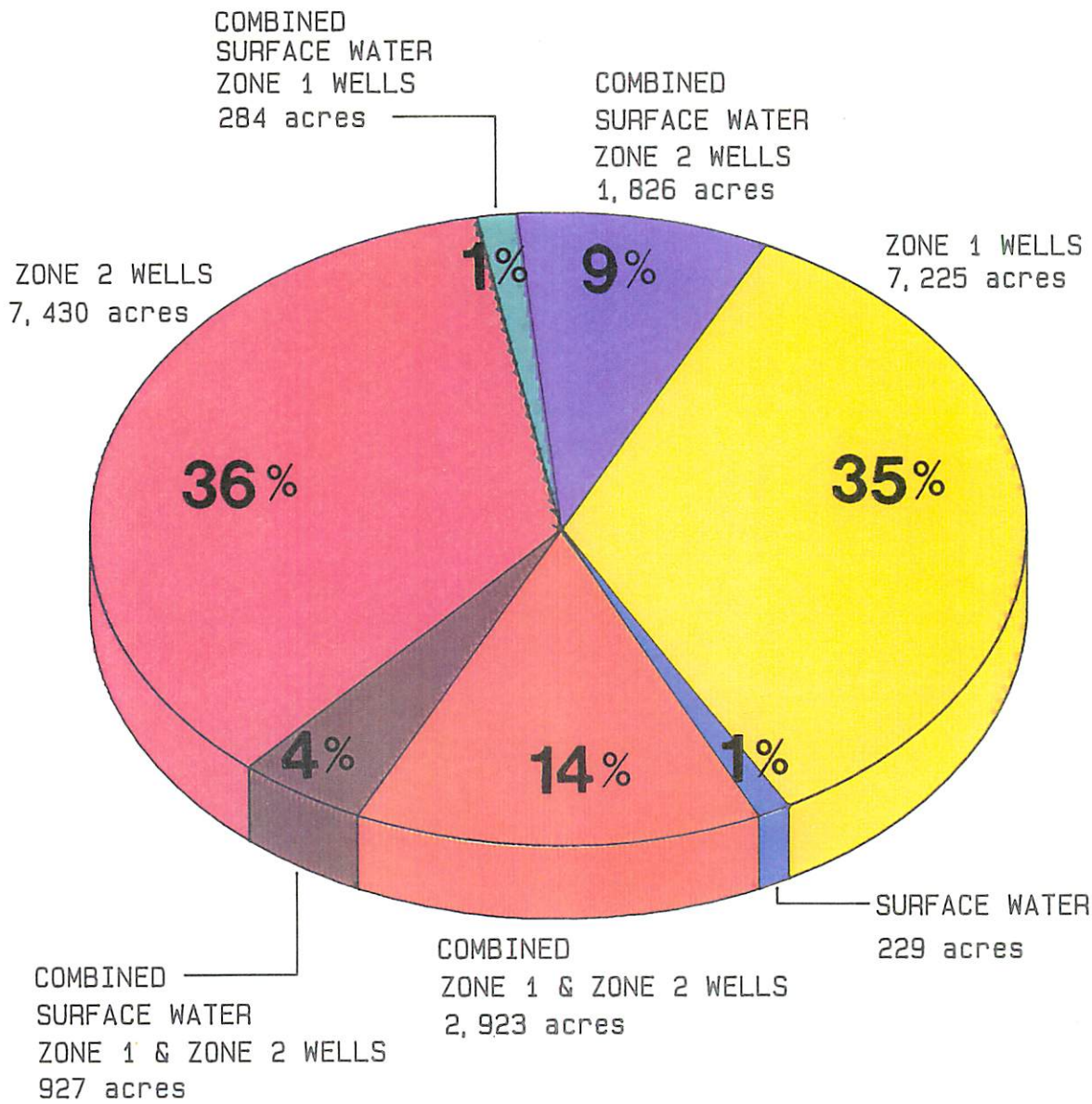


Figure 3-14. Irrigated acres by source of supply - San Pedro River watershed

TABLE 3-7

IRRIGATION USE CLASSIFICATION IN EACH SUBWATERSHED OF THE SAN PEDRO RIVER WATERSHED

	SIERRA VISTA			BENSON			REDINGTON			WINKELMAN			ARAVAIPA		
	MAXIMUM OBSERVED	REGIONAL	MAXIMUM POTENTIAL	MAXIMUM OBSERVED	REGIONAL	MAXIMUM POTENTIAL	MAXIMUM OBSERVED	REGIONAL	MAXIMUM POTENTIAL	MAXIMUM OBSERVED	REGIONAL	MAXIMUM POTENTIAL	MAXIMUM OBSERVED	REGIONAL	MAXIMUM POTENTIAL
Normal Irrigation (IR)	2,304.9	2,378.1	2,378.1	5,658.8	5,805.2	5,804.2	3,629.3	3,691.8	3,691.8	1,910.2	1,975.3	1,975.3	870.2	870.2	870.2
Discontinued Irrigation (IR9x)	0.0	4,070.7	0.0	0.0	671.0	0.0	0.0	719.7	0.0	0.0	135.4	0.0	0.0	97.4	0.0
Other Irrigation (OT)	0.0	5.6	0.0	0.0	32.3	0.0	0.0	7.9	0.0	0.0	7.6	0.0	0.0	11.8	0.0
Discontinued Other Irrigation (OT9x)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.6	0.0
Recreation Irrigation (RC)	214.0	214.0	0.0	47.3	47.3	0.0	69.9	69.9	0.0	7.4	7.4	0.0	0.0	0.0	0.0
TOTAL	2,518.9	6,668.4	2,378.1	5,706.1	6,555.8	5,804.2	3,699.2	4,489.3	3,691.8	1,917.6	2,125.7	1,975.3	870.2	1,003.0	870.2

Within the Benson - St. David area, along portions of Aravaipa Creek, and near Redington, there are surface water diversions which are utilized for irrigation purposes. In some of the mountainous regions of the watershed, springs have been diverted which supply small parcels of irrigated pasture or gardens.

The number of acres of each major identified crop type, which together comprise the 20,842 acres of irrigation of which 14,712 acres are actively irrigated, is shown on Table 3-8. This crop type inventory is derived from field investigations conducted by DWR during its five year investigation period. This list is composed by utilizing the predominant crop type within a PWR. For a more detailed list of crops and acreages refer to APPENDIX C. As can be seen from Table 3-8, pasture accounts for nearly 5,539 acres or 38 percent of all actively irrigated land in the watershed. Much of the crop classification multiple crops and multiple double crops includes pasture as an

TABLE 3-8

ACTIVELY IRRIGATED
CROPS GROWN IN THE SAN PEDRO RIVER WATERSHED

	IRRIGATED ACRES (MAXIMUM OBSERVED)
Alfalfa	755.6
Corn	39.1
Cotton	84.7
Double crops	202.8
Fallow	50.0
Fruit trees	65.7
Grapes	239.9
Landscaping	32.2
Multiple crops	3,191.4
Multiple double crops	3,049.7
Orchard	40.5
Pasture	4,666.8
Pasture (summer)	601.0
Pasture (winter)	271.0
Pecans	142.2
Pecans (with ground cover)	33.5
Pine trees	3.0
Small grains (fall)	836.1
Sorghum	41.6
Turf	349.1
Vegetables	16.1
TOTAL	14,712.0

identified rotational crop. Consequently, the amount of pasture cultivated at any given time could be higher than the values depicted for permanent, summer, and winter pasture.

Of the 20,842 acres irrigated within the San Pedro River watershed, only about 2,139 acres (or 10 percent) are contained within the St. David and Pomerene Irrigation Districts. Of the 2,139 acres, approximately 1,979 are actively irrigated, or nearly 13 percent of the watershed's actively irrigated total of 14,712 acres. Within the St. David and Pomerene Irrigation Districts, pasture related crops are the prevalent crop type accounting for 1,450 acres, or 73 percent of the actively irrigated total. Second is small grains with about 312 acres, or 15 percent of the total.

The irrigated acres within the districts are supplied by surface water diverted from the San Pedro River, but well water pumped from the districts and private wells provides the primary source of supply during the height of the irrigation season (May through September). For a more detailed analysis of surface water and well water components within the irrigation districts, see Chapter 5, Section 5.2 in this volume. Table 3-9 presents the water sources utilized by each of the irrigation districts and the acreage and volumes associated with each source type. During the winter months and sporadically throughout the summer monsoon season, the San Pedro River provides water for irrigation use.

The nondistrict actively irrigated acreage totals nearly 12,733 acres, or 87 percent of the 14,712 actively irrigated acres found in the San Pedro River watershed. The most common crop types are pasture related crops totalling about 4,089 acres, or approximately 28 percent of the nondistrict total. Pasture crops are also extensively double cropped with small grains, alfalfa, corn, sorghum, and mixed vegetables. Multiple crops and multiple double crops account for the next greatest amount of acreage in the nondistrict portion of the watershed. Common crops which are actively double cropped are small grains, pasture, sorghum, corn, alfalfa, hay crops, and vegetables. There are co-equal amounts of these crop types with both totalling just over 3,000 acres which are actively irrigated.

The next section describes and quantifies all of the major surface water diversions within the San Pedro River watershed and the irrigated acreage served by them.

TABLE 3-9

IRRIGATION SUMMARY BY IRRIGATION WATER PROVIDERS AND SOURCE OF SUPPLY

IRRIGATION WATER PROVIDER	WATER SOURCE	MAXIMUM OBSERVED (ACRES)	MAXIMUM OBSERVED (AF/YR)	REGIONAL (ACRES)	REGIONAL (AF/YR)	MAXIMUM POTENTIAL (ACRES)	MAXIMUM POTENTIAL (AF/YR)
St. David Irrigation District (SDID)	Surface water	13.9	53.4	28.8	69.7	11.2	82.6
	Surface water + Zone 1 wells	2.1	3.2	2.1	11.3	2.1	15.5
	Surface water + Zone 2 wells	687.9	3,776.9	717.1	3,729.8	687.9	5,535.0
	Surface water + Zone 1 + Zone 2 wells	291.8	1,848.5	303.9	1,575.7	291.8	2,286.8
	TOTAL	995.7	5,682.0	1,051.9	5,386.5	993.0	7,920.0
Pomerene Water Users Association	Surface water	7.5	74.3	7.8	42.1	7.5	78.0
	Surface water + Zone 1 wells	0.0	0.0	0.0	0.0	0.0	0.0
	Surface water + Zone 2 wells	757.4	5,383.1	823.5	4,202.8	757.3	6,181.1
	Surface water + Zone 1 + Zone 2 wells	218.6	1,567.6	254.9	1,184.2	218.6	1,781.3
	TOTAL	983.5	7,025.0	1,086.2	5,429.2	983.4	8,040.3

Quantification of Major Surface Water Diversions

DWR has also developed information pertaining to the two irrigation districts and six privately owned diversion systems, as shown in Table 3-10.

The maximum theoretical discharge has been determined for each diversion system. This discharge sets an upper limit to the physical capacity of the existing diversion structure and canal to divert water from the stream.

The maximum demand rate shows the amount of water which needs to be diverted to optimally supply the gross irrigation requirement (GIR) after accounting for canal system losses during the month of peak demand. The maximum demand rate can be compared to the maximum theoretical discharge and the maximum and average measured discharges to evaluate whether the diversion

TABLE 3-10

SUMMARY OF IRRIGATION DISTRICT/PRIVATE LAND OWNERS MAJOR SURFACE WATER DIVERSION SYSTEMS

	DISTRICT/LAND OWNER NAME									
	ST. DAVID IRRIGATION DISTRICT	POMERENE WATER USERS ASSOCIATION	BAYLESS & BERKALEW CO.	NATURE CONSERVANCY	GELDMACHER, DONALD E.	CLARIDGE, WILFORD H.	SALAZAR, EPIGENIO	ANDERSON DEVELOPMENT		TOTALS
Diversion Name	St. David Irrigation District Ditch	Pomerene Canal	Bayless Ditch	Westerfield Diversion	Unnamed	Unnamed	East Diversion #4	East Ditch	West Ditch	
Acres served (1)	1,087.1	1,051.9	149.4	15.0	9.7	41.6	16.7	199.0 (2)	199.0 (2)	2,570.4
Maximum theoretical discharge (CFS)	24.3	20.0	13.8	5.7	7.9	22.7	1.0	19.6	20.8	---
Maximum demand discharge (CFS)	22.0 (3)	13.0 (4)	3.6	0.2	0.3	0.6	0.5	3.5	3.5	---
Maximum measured discharge (CFS)	22.3	10.2	12.4	1.0	4.0	20.3	1.0	0.0	0.0	---
Average measured discharge (CFS) (5)	6.1 (6)	2.2	0.9 (7)	0.3	2.7	2.1	0.3	0.0	0.0	14.6
Acres/CFS diverted	178.2	478.1	166.0	50.0	3.6	19.8	55.7	---	---	---
Total volume diverted (AC-FT)	4,425.4	1,563.5	660.9 (8)	123.1 (9)	1,971.3	465.9 (10)	228.2	0.0	0.0	9,438.3
Total AF/AC diverted	4.1	1.5	4.4	8.2	203.2	11.2	13.7	0.0	0.0	---
System canal seepage (AC-FT)	229.7	35.8	96.9	0.0	0.0	0.0	0.0	0.0	0.0	362.4
System canal evaporation (AC-FT)	16.1	1.5	4.4	0.0	0.0	0.0	0.0	0.0	0.0	22.0
Total losses (AC-FT)	245.8	37.3	101.3	0.0	0.0	0.0	0.0	0.0	0.0	384.4
Net volume delivered (AC-FT)	4,179.6	1,526.2	559.6	123.1	1,971.3	465.9	228.2	0.0	0.0	9,053.9
Net AF/AC delivered	4.0	1.5	3.7	8.2	203.2	11.2	13.7	0.0	0.0	3.0
Net average flow delivered (CFS)	5.8	2.1	0.8	0.3	2.7	2.1	0.3	0.0	0.0	14.1
Acres/CFS delivered	187.4	500.9	186.8	50.0	3.6	19.8	55.7	---	---	---
								AVERAGE ACRES/CFS DIVERTED		176.1
								AVERAGE ACRES/CFS DELIVERED		182.3

(1) Regional acres.

(2) Both the East and West Ditches serve the same acreage.

(3) At the peak consumption actively irrigated area of 920.6 acres.

(4) At the peak consumption actively irrigated area of 735.4 acres.

(5) In all cases measured by DWR except for SDID and PWUA which utilized USGS gaging data (period 1968-1971).

(6) Does not include any well water component.

(7) Does not include the high flow rate of 12.4 cfs taken on June 3, 1985.

(8) Does not include the high flow rate of 12.4 cfs taken on June 3, 1985.

(9) Calculated at an assumed diversion operation time of fifteen days per month.

(10) High flow rate of 20.3 CFS taken on April 18, 1989 was assumed to have operated for only five days during that month.

system is capable of fully meeting all demands during the course of a growing season. It is, in other words, one of several standards utilized to evaluate whether a particular diversion is diverting more water than needed to meet crop demand, or conversely, whether the present configuration of the canal system or available supply is capable of meeting the needs of those provided water.

The maximum and average measured discharges for the six privately utilized surface water diversions are based upon measurements made by DWR for the period 1982 to 1990. The SDID's and PWUA's maximum discharges were also measured by DWR. However, the average measured discharge for these two districts were compiled using USGS gaging station data (Station No. 471560 and No. 471590) for the period of record 1968 to 1971. Within SDID and PWUA, the utilization of pumped groundwater is a common practice during the irrigation season due to the lack of reliable surface water flows. In the case of SDID, some of this pumped water is supplied by the district as well as individual irrigators. However, within the PWUA, pumped well water is supplied solely by individual irrigators.

Under the totals found in Table 3-10 the sum of all of the average surface water deliveries is 14.6 cubic feet per second (cfs). A commonly used method for quantifying diversion rights in western states adjudications is to specify a maximum acres per cfs diversion rate. Dividing the 2,570 total acres served by the two irrigation districts and six privately operated diversion systems by the 14.6 cfs average diversion discharge results in an irrigation season average diversion of about 176 acres per cfs. In most decrees which employ this standard of quantification, these values usually fall within a range of sixty to ninety acres per cfs.

If the system losses such as evaporation and seepage are included, then these losses decrease the amount of water actually available for application at the field. This results in a diversion rate of about 182 acres per cfs needed to make up these losses. The value of 182 acres per cfs indicates that most of the irrigators utilizing surface water in the San Pedro River watershed cannot meet the gross irrigation requirement with surface water alone. Examining the results on a diversion-by-diversion basis reveals significant variations from the average.

The net average surface water delivery to the fields varies from a low of 1.5 acre-feet per acre for PWUA to a high of just over 200 acre-feet per acre for a privately operated diversion on Aravaipa Creek. The reason for this abnormally high value is that the irrigator is attempting to reclaim acreage lost in the flood of October 1983. This irrigator is diverting Aravaipa Creek into several shallow basins (formerly pasture) to allow the deposition of silts. One of the privately operated diversion systems has a net average surface water delivery value of 0.0 acre-feet per acre. This is the result of DWR not having been able to physically measure either of the two diversions when surface water was actually present. This irrigator utilizes primarily well water for his irrigation supply. A maximum theoretical discharge value was calculated for both diversions based upon field measurements of the diversion systems.

Table 3-10 also quantifies losses for three of the measured diversion systems. Losses to a diversion system typically are seepage losses and evaporation of water in the canal or ditch. It can be seen from the table that five of the private diversion systems have no conveyance losses. These are systems which have short runs from the point of diversion to the point of application at the field. In the case of the Anderson Development Corporation, the two diversions have not held surface water at any time when DWR was able to make the required physical measurements to derive this figure.

The SDID and PWUA have long conveyance systems consisting of unlined canals and ditches which incur substantial losses due to seepage and evaporation. While PWUA and SDID have canal lengths that are approximately the same, the PWUA canal has a 1-3/4 mile section of concrete lined ditch which decreases seepage losses for the system. The PWUA canal also has a smaller cross-sectional area thus decreasing the amount of seepage compared to the wider SDID ditch system. Additionally, SDID diverts substantially more water than PWUA allowing more water to be lost through evaporation and seepage through the course of an irrigation season.

The Bayless and Berkalew Company ditch has a high system loss compared to its short length of about two miles. This loss can be attributed to the nature of the silty-loam soils of the alluvium in which the canal is situated. This soil type allows rapid percolation of water back into the subflow zone of the San Pedro River.

Overall, there are some conclusions which may be drawn from the data presented in Table 3-10. There are only eighty-three acres supplied with enough surface water to meet total irrigation requirements in the San Pedro River watershed. All of this acreage is located along Aravaipa Creek, with fifty acres east of Aravaipa Canyon and the remaining twenty-five acres being found on the west side of the canyon. The rest of the acreage supplied with surface water does not receive enough to meet the gross irrigation requirement. Irrigators within PWUA and SDID do not have an adequate supply of surface water to meet the total irrigation demand and therefore pump groundwater to augment the available surface water component. Generally for these two water providers, surface water is unavailable or scarce during the irrigation season (May through October). During the winter months when consumptive use is typically at its lowest and surface water is available, it appears that SDID takes advantage of this winter water supply to build up the soil moisture profile. This practice of "soil banking" provides a partial contribution toward meeting the total crop demand in the early months of the growing season when surface water becomes scarce and with groundwater being more expensive to supply.

For a more detailed analysis of SDID and PWUA quantifications of use, see Chapter 5, Section 5.2 of this volume of the HSR. Table 3-11 describes all of the surface water diversion systems within the San Pedro River watershed. These diversions are described by the number of acres served, whether surface water is supplemented with well water, apparent first use date, and applicable watershed file report numbers.

The following sections discuss the remaining categories of cultural uses which are: water exports, municipal, mining, industrial/commercial, reservoirs, stockponds, and domestic uses.

WATER EXPORTS

Water is exported from the San Pedro River watershed for mining and municipal uses and is imported for other municipal uses and several irrigation uses.

The American Smelting and Refining Company (ASARCO) exports 1,860 acre-feet per year to its operations in Ray and Hayden and for use by the Town

TABLE 3-11

SUMMARY OF MEASURED AND UNMEASURED IRRIGATION DIVERSIONS AND SYSTEMS

LAND OWNER	DIVERSION NAME	ACRES SERVED	APPARENT FIRST USE DATE	REMARKS	WATERSHED FILE REPORT NUMBER
Anderson Development	East Ditch (Aravaipa Creek) West Ditch (Black Canyon Creek	199.0 199.0	1972 1972	Surface water is stored in two large reservoirs, and is supplemented by well pumpage.	115-10-BA-1 115-10-BA-1
Arizona Chapter Nature Conservancy	Claridge Ditch	46.1	1867	100 percent surface water supplied.	115-5-AC-4
Arizona Chapter Nature Conservancy	Instream pump on Aravaipa Creek (Wood Diversion)	15.0	1888	100 percent surface water supplied.	115-4-AAD-2
Arizona Chapter Nature Conservancy	Salazar-Tapia Ditch A.K.A. East Diversion #4	16.7	1867	100 percent surface water supplied.	115-5-AB-1
Arizona Chapter Nature Conservancy	Unnamed diversion from the Aravaipa Creek	26.4	1880	100 percent surface water supplied. Acreage is classified as discontinued irrigation.	115-5-AC-5 115-5-AC-10
Arizona Chapter Nature Conservancy	Unnamed diversion from the Aravaipa Creek	16.9	1880	100 percent surface water supplied. Acreage is classified as discontinued irrigation.	115-5-AC-5
Arizona Chapter Nature Conservancy	Westerfield Diversion	15.0	1888	100 percent surface water supplied.	115-4-AAD-2
ASARCO, Inc.	Instream pump on the San Pedro River	31.0	1900	Mixed source of supply. Estimate 95 percent of supply is furnished by groundwater. Acreage is classified as deficit.	114-1-CCD-1 114-1-CCD-3

TABLE 3-11 (cont'd)

LAND OWNER	DIVERSION NAME	ACRES SERVED	APPARENT FIRST USE DATE	REMARKS	WATERSHED FILE REPORT NUMBER
ASARCO, Inc.	Israel Spring	423.7	1873	Mixed source of supply. Estimate 90 percent of supply is furnished by groundwater. A portion of the acreage is classified as deficit irrigation.	114-4-BDA-1 114-4-BDA-4
ASARCO, INC.	Unnamed Diversion from the San Pedro River	4.7	1947	Mixed source of supply. Estimate 95 percent is supplied by groundwater.	114-1-CCD-1 114-1-CCD-3
Babocomari Ranch Company	Unnamed Diversion from the Babocomari River	31.3	1912	100 percent surface water supplied. Acreage is classified as deficit irrigation.	111-19-DAC-1
Bayless & Berkalew Company	Bayless Ditch	149.4	1879	Surface water is supplemented by pumpage from wells.	113-12-BD-4
Bayless & Berkalew Company	Markham Diversion Ditch on the San Pedro River	62.2	1906	Mixed source of supply. Estimate 90 percent of supply is furnished by groundwater.	113-12-BB-6 113-12-BD-4
Beatty, Thomas L. and Edith M.	Instream pump and Marshall Springs located on Miller Creek, tributary to the San Pedro River	5.0	1964	Mixed source of supply. Estimate that groundwater supplies 50 percent irrigation use. Spring and surface water commingled.	111-23-CAA-1
Cleveland, Robert L. Cleveland, Charles T.	Unnamed Spring and Big Tunnel Spring, tributary to the San Pedro River	0.8	1984	100 percent surface water supplied.	111-24-ACD-1
Cruz, Hector N.	Unnamed Spring, tributary to the San Pedro River	0.8	1935	100 percent surface water supplied. Acreage is classified as deficit irrigation.	112-14-DCA-1

TABLE 3-11 (cont'd)

LAND OWNER	DIVERSION NAME	ACRES SERVED	APPARENT FIRST USE DATE	REMARKS	WATERSHED FILE REPORT NUMBER
Douglas, Mark L. and Blanche A.	Instream pump on the Babocomari River	4.1	1918	Mixed source of supply.	111-19-BDD-1
Dreyfuss, Thomas C.	Unnamed Spring, tributary to the San Pedro River	4.2	1964	Mixed source of supply. Estimate 95 percent of supply is furnished by groundwater.	112-17-DBD-14
Dunn, Avis E. Loper, Joel E.	Big Tank Dam, tributary to the Big Tank Wash	23.2	1914	Mixed source of supply. Diversion is from a primary storage reservoir. Pumped well water also contributes to irrigation uses. Acreage is classified as deficit irrigation.	111-24-CBD-1
FS - Coronado	Unnamed Turkey Creek, tributary to Babocomari River. Instream pump on Turkey Creek	31.6	1970	Supplied by commingled surface and well water. Estimate over 50% of water supply is from groundwater.	111-22-ABC-1 111-22-ABC-2 111-22-ABC-3
Fry, Cecil	Unnamed Ramsey Creek, tributary to the San Pedro River	4.3	1907	Mixed water source. Pumped well water supplies irrigation. Surface water supplies small reservoir utilized for irrigation, stockwatering, recreation, and wildlife purposes.	111-23-BDCD-6 111-23-BDCA-9
Gay, John S., et al.	Unnamed Diversion, tributary to the San Pedro River	3.3	1986	Mixed source of supply. Surface water is stored in a small reservoir. Approximately 90 percent of supply is furnished by groundwater.	112-17-DBC-2
Gay, John S., et al.	Unnamed Diversion, tributary to the San Pedro River	0.4	1987	100 percent surface water supplied. Surface water stored in a small reservoir and diverted to acreage.	112-17-DBC-2

TABLE 3-11 (cont'd)

LAND OWNER	DIVERSION NAME	ACRES SERVED	APPARENT FIRST USE DATE	REMARKS	WATERSHED FILE REPORT NUMBER
Geldmacher, Donald E. and Beverly A.	Instream pump on Aravaipa Creek	0.7	1887	100 percent surface water supplied.	115-4-ADC-1
Guy, Lora J.	Flying H Spring	0.4	1985	100 percent surface water supplied.	111-23-DBC-36
Hendrickson, H. Thomas	Atchley Horse Camp Spring, tributary to the San Pedro River	0.4	1917	100 percent surface water supplied.	113-9-BA-1
Iser, Jerry and Vera	Instream pump on Aravaipa Creek	0.2	1985	100 percent surface water supplied.	115-4-ADB-3
Lackner & Son, Ltd.	Unnamed Diversion from the Four-Mile Creek, tributary to the Aravaipa Creek	31.3	1913	100 percent surface water supplied. Diversions from two springs and four-mile creek supply irrigation uses.	115-5-DB-1
Larsen, Mary Kathleen	Instream pumps on Aravaipa Creek	7.6	1890	Mixed source of supply.	115-4-ADA-1
Luebbermann, Henri A. and Susan E.	Instream pump on Aravaipa Creek	5.4	1899	Mixed source of supply.	115-4-ADA-2
Martinez, Cedric G. and Sally G.	Instream pump on Miller Creek	1.3	1978	100 percent surface water supplied.	111-23-DBB-27
Pomerene Water Users	Pomerene Canal	1,051.9	1912	Surface water supplied acreage is supplemented by groundwater pumpage from individually owned wells.	112-17-899
Pyeatt, Roland	Pyeatt Springs	3.4	1899	100 percent surface water supplied.	111-19-DDC-1
Richardson, Anthon G. and Barbara L.	Instream pump on Aravaipa Creek	1.3	1913	100 percent surface water supplied.	115-4-ADB-9

TABLE 3-11 (cont'd)

LAND OWNER	DIVERSION NAME	ACRES SERVED	APPARENT FIRST USE DATE	REMARKS	WATERSHED FILE REPORT NUMBER
Rubin, Joel W.	Unnamed Diversion from the Aravaipa Creek	1.7	1921	100 percent surface water supplied.	115-4-ADC-6
USDI-BLM Safford District	St. David Irrigation District Ditch	1,086.2	1881	Surface water supplied is supplemented by pumpage from two district wells and pumpage from individually owned wells.	112-17-88 112-17-DCD-1
Walker, Robert D.	Instream pump on the San Pedro River	0.3	1959	Mixed source of supply irrigation use less than 2.0 acres associated with a domestic use.	111-20-DDA-2
White, Jeptha O. and Peggy	Instream pump on Aravaipa Creek	6.8		100 percent surface water supplied.	115-4-ADB-1
Young, Lester and Thelma L.	Instream pumps on Aravaipa Creek	5.2		100 percent surface water supplied.	115-4-ADB-6 115-4-ADB-7 115-4-ADB-8 115-4-ADB-10

of Hayden municipal water system. The Arizona Water Company, Bisbee System, also exports approximately 962 acre-feet per year for municipal uses in the Town of Bisbee.

The Arizona Water Company, Oracle System, imports approximately 313 acre-feet per year for use by the Town of Oracle. Water users in the Cienega Creek area are also considered water importers. Groundwater pumping in this area imports water from the non-tributary Cienega Creek Groundwater Basin to the San Pedro River watershed. These irrigators pump about 262 acre-feet per year, but only 198 acre-feet is consumed. The rest is returned to the non-tributary aquifer.

Water exported from the watershed is 100 percent depleted from the hydrological system. Water imports only contribute a portion of the total volume transferred to the hydrologic system since most of the water is depleted by cultural uses. Of the 510 acre-feet per year that is imported, only 63 acre-feet is added to the hydrologic system.

MUNICIPAL USES

There are forty-four separate municipal systems and private water companies in the San Pedro River watershed. Fort Huachuca operates its own municipal water supply system which is described in Chapter 5, Section 5.4. The estimated total diversion by these systems (including Fort Huachuca) is 9,405 acre-feet per year of which 962 acre-feet is exported while 313 acre-feet is imported. This results in a net diversion of 8,130 acre-feet per year. The average delivery is 0.43 acre-feet per connection per year with a range from a high of 1.1 acre-feet to a low of 0.01 acre-feet per connection. The estimated return flow from municipal diversions is 1,620 acre-feet per year, resulting in an estimated depletion of 6,510 acre-feet per year. Forty-two of the municipal systems and water companies use groundwater (Zone 2) from wells as their source of supply. The City of Tombstone water system supplements its supply by springs. The Arizona Water Company - San Manuel System is supplied by wells located within Zone 1. The Huachuca City municipal system is supplied by wells located both within Zone 1 and Zone 2.

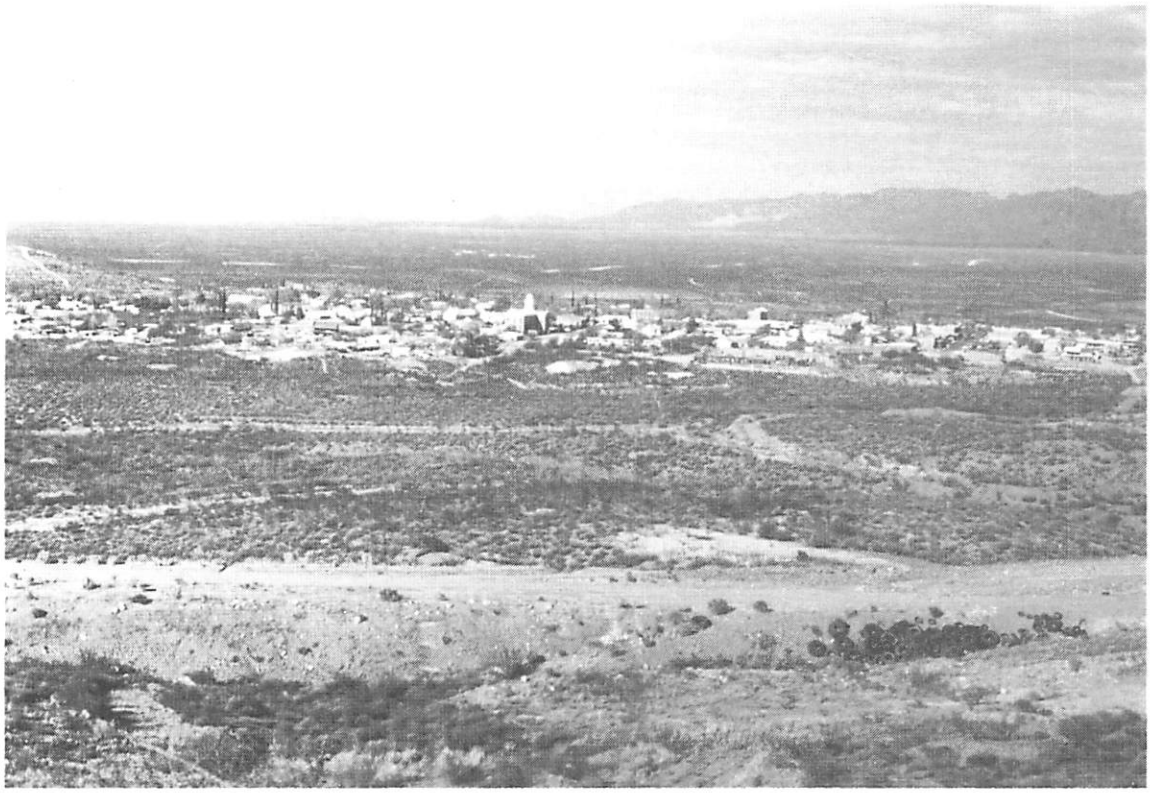


Figure 3-15. The City of Tombstone, with the Dragoon Mountains in the background, gets a portion of its municipal water supply from springs in the Huachuca Mountains which is transported nearly fifteen miles via a pipeline.

MINING USES

There is one large mining operation which uses water within the San Pedro River watershed. Magma Copper Company operates a mill and smelter near the community of San Manuel (refer to WFR #113-8-22). Water is obtained from eleven wells along the San Pedro River. Five of these wells are located within the brightline (Zone 1) while six of the wells are located within Zone 2. Water diverted from these wells is also used by the Town of San Manuel (refer to WFR #113-8-3). Water is also provided to the mine from the dewatering of shafts #1 and #5. These shafts are referred to as W13 and W14 by DWR and are located in Zone 3. The estimated diversion of water from the San Pedro River watershed by Magma is 23,000 acre-feet per year. The estimated return flow is 3,680 acre-feet per year and the estimated depletion is 19,320 acre-feet per year. Magma Copper Company is the single largest water user in the San Pedro River watershed. There are several smaller mining

operations that withdraw minor quantities of water. The largest of these, Oracle Ridge Mining, withdraws approximately 250 acre-feet per year from a dewatering shaft located in Zone 3.

INDUSTRIAL/COMMERCIAL USES

DWR has identified six industrial and two commercial water users within the San Pedro River watershed. The commercial water users are fish-rearing and agricultural facilities near the Town of Winkelman and in the Redington subwatershed. The industrial users are comprised of five sand and gravel operations and the Apache Nitrogen Products, Inc. which manufactures explosives and chemicals. Apache Nitrogen Products is the largest industrial user in the watershed. The commercial users, the Paul L. Sale Investment Company and Floyd Fish Farm, and one industrial user, the Clark Trucking Company, are supplied by wells located within Zone 1.

Figure 3-16. A sand and gravel operation, located in the Sierra Vista subwatershed, is supplied by pumped well water for industrial uses such as: washing of sand and gravel, dust control, and ready-mix concrete production.

The total estimated diversion for the industrial water use category is 911 acre-feet per year. The estimated return flow is 451 acre-feet per year and the estimated depletion is 460 acre-feet per year. The total estimated diversion for the commercial users is 260 acre-feet per year. The estimated return flow is 164 acre-feet per year and the estimated depletion is 96 acre-feet per year. These values are also included within the diversion, return flow, and depletions of reservoirs.

RESERVOIRS

There are 313 reservoirs, excluding stockponds, found in the watershed that have multiple purposes. Some common reservoir purposes are: regulation of irrigation supply, fish-rearing, wildlife, recreation, stockwatering, or flood control. Evaporation losses constitute the depletion due to reservoirs and total 720 acre-feet per year.

DWR investigations assign reservoirs to one of two categories: small reservoirs or primary storage reservoirs. Small reservoirs are those with capacities at the spillway crest of less than or equal to fifteen acre-feet. Primary storage are those which exceed fifteen acre-feet of capacity. As summarized in Table 3-12, there are 214 small reservoirs found within the San Pedro River watershed, all but nine of which are less than two acres in surface area at spillway crest elevation. There are sixteen primary storage reservoirs located within the watershed. These are also summarized in Table 3-12. The primary storage reservoirs total 106 surface area acres and 578 acre-feet at maximum controlled capacity.

STOCKPONDS

Stockwatering on rangeland within the San Pedro River watershed is provided by a number of different facilities as the physical circumstances permit and include stockponds, springs, water harvesting facilities, instream watering from intermittent and perennial streams, and from pumps and windmills. Of these various facilities, stockponds consume the overwhelming majority of the total stockwatering use. Nearly all of the water typically used by a stockpond is for seepage and evaporation with the actual amount consumed by the stock constituting a negligible amount. Table 3-12 shows that

TABLE 3-12

SUMMARY OF RESERVOIRS AND STOCKPONDS

TOTAL	SIERRA VISTA SUBWATERSHED (1)			BENSON SUBWATERSHED			REDINGTON SUBWATERSHED			WINKELMAN SUBWATERSHED			ARAVAIPA SUBWATERSHED			SAN PEDRO RIVER WATERSHED TOTALS		
	NO.	AREA (ACRES)	CAP. (AC-FT)	NO.	AREA (ACRES)	CAP. (AC-FT)	NO.	AREA (ACRES)	CAP. (AC-FT)	NO.	AREA (ACRES)	CAP. (AC-FT)	NO.	AREA (ACRES)	CAP. (AC-FT)	NO.	AREA (ACRES)	CAP. (AC-FT)
SMALL RESERVOIRS (SR)																		
< 2 acres measured	4	3.9	27.3	13	10.7	49.3	0	0.0	0.0	10	9.7	33.8	0	0.0	0.0	27	24.3	110.4
> 2 acres measured	1	3.7	14.7	1	2.7	10.0	0	0.0	0.0	7	27.4	67.3	0	0.0	0.0	9	33.8	92.0
Measured Total	5	7.6	42.0	14	13.4	59.3	0	0.0	0.0	17	37.1	101.1	0	0.0	0.0	36	58.1	202.4
Not Measured	18			121			22			1			16			178		
Total Number	23			135			22			18			16			214		
PRIMARY STORAGE RESERVOIRS (PS)																		
> 2 acres measured	6	33.5	268.9	4	14.3	82.1	4	15.9	109.0	1	7.4	51.3	1	35.0	66.6	16	106.1	577.9
Measured Total	6	33.5	268.9	4	14.3	82.1	4	15.9	109.0	1	7.4	51.3	1	35.0	66.6	16	106.1	577.9
Reservoirs Measured																		
SUBTOTAL	11	41.1	310.9	18	27.7	141.4	4	15.9	109.0	18	44.5	152.4	1	35.0	66.6	52	164.2	780.3
STOCKPONDS (SP)																		
< 2 acres measured	31	41.3	135.8	66	59.3	219.6	56	67.7	385.1	16	18.7	72.2	27	30.8	261.6	196	217.8	1,074.3
> 2 acres measured	40	176.3	700.1	33	144.0	572.6	32	96.2	708.1	7	19.9	93.4	14	76.7	264.3	126	513.1	2,338.5
Measured Total	71	217.6	692.2	99	203.3	792.2	88	163.9	1,093.2	23	38.6	165.6	41	107.5	525.9	322	730.9	3,412.8
Not Measured	709			271			284			48			240			1,552		
Total Number	780			370			372			71			281			1,874		
RESERVOIRS AND STOCKPONDS (2)																		
Total Measured	82	258.7	1,003.1	117	231.0	933.6	92	179.8	1,202.2	41	83.1	318.0	42	142.5	592.5	374	895.1	4,193.1
Total Not Measured	727			392			306			49			256			1,730		
Total Number	809			509			398			90			298			2,104		

(1) Includes reservoirs and stockponds within the Fort Huachuca military reservation.

(2) Does not include regulatory reservoirs or tailwater ponds.

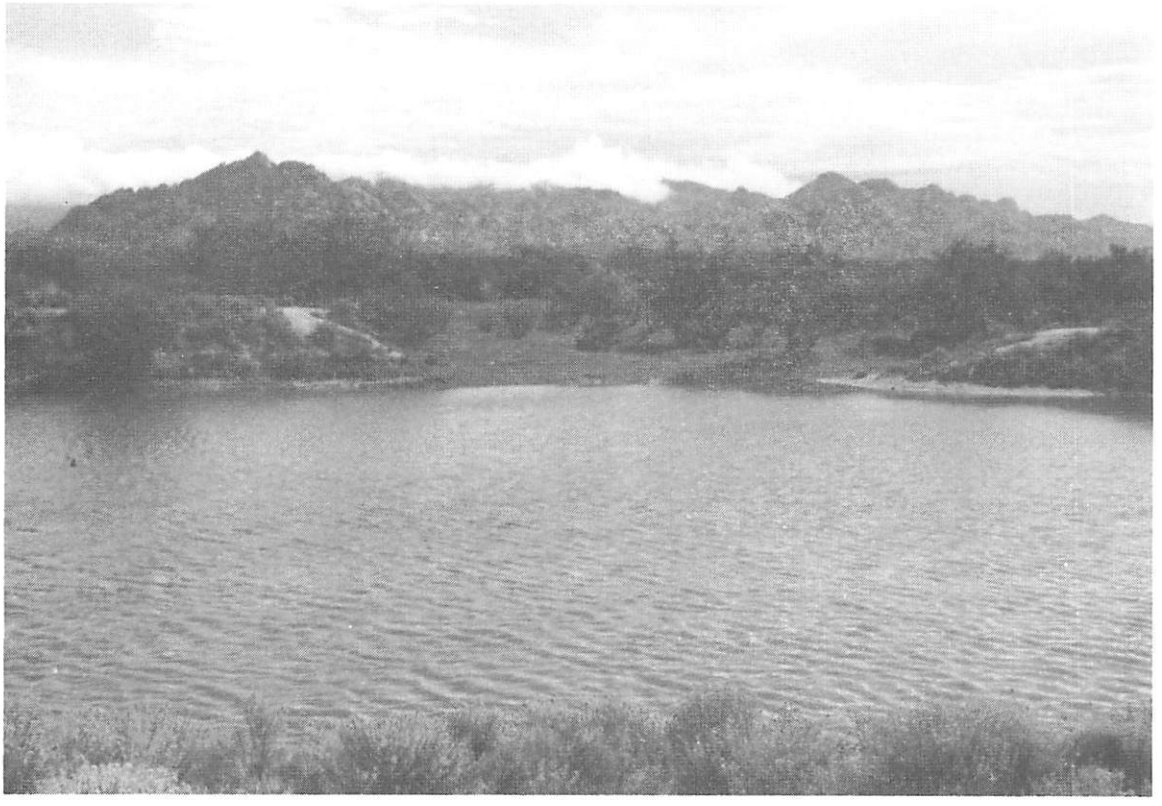


Figure 3-17. A stockpond located south of Interstate 10 in the Benson subwatershed. Stockponds in the San Pedro River watershed characteristically have greater water losses due to evaporation and seepage than due to consumption by livestock or wildlife.

DWR found 1,874 stockponds in the San Pedro River watershed, only 126 of which have surface areas at spillway crest exceeding two acres. Evaporation losses constitute a depletion for stockponds and is estimated at 3,870 acre-feet per year. The amount of water used by the other stockwatering facilities has not been determined but it is considered to be small.

DOMESTIC USES

DWR's investigations identified 2,599 separate self-supplied domestic uses that are not connected to a municipal supply system or private water company within the watershed.

There are 2,419 domestic uses supplied totally by groundwater (Zone 3 or Exempted Zone 2), 112 domestic uses supplied by Zone 1 and twenty-eight

Figure 3-18. A private property, located in Miller Canyon in the Huachuca Mountains, is supplied by surface water from a spring for domestic and stock uses, and for irrigation of a fruit tree orchard. However, the majority of self-supplied domestic uses in the San Pedro River watershed are supplied from individual wells.

supplied by springs. The estimated diversion for all domestic uses is 1,300 acre-feet per year, the estimated return flow is 250 acre-feet per year, and the estimated depletion is 1,050 acre-feet per year.

3.3 USES WITHIN MEXICO PORTION OF WATERSHED

The magnitude of water use taking place in the Mexico portion of the San Pedro River watershed is provided in order to compare with those within the United States portion of the watershed. While an international agreement dividing the water supply of the San Pedro River has not yet been reached with Mexico, the amount of water use occurring in Mexico is not expected to increase greatly in the future. If it did, however, the impact on downstream water users in the United States could be significant, particularly within the Sierra Vista and Benson subwatersheds where the inflow from Mexico constitutes a sizable percentage of their water supply.

Most of the information in this section has been obtained from an unpublished report by the International Boundary and Water Commission (1979).

Water within the Mexico portion of the San Pedro River watershed is used for irrigation, municipal, domestic, stockwatering, mining, and industrial purposes. These uses have not increased substantially in recent years. Small increases have occurred for municipal and stockwatering purposes.

IRRIGATION USES

There are approximately 5,100 acres developed for irrigation in the Mexico watershed area. Most of this land is used to grow pasture for cattle and much of it is supplied solely by surface water. Therefore, most of the agricultural land is concentrated along the lower reaches of the San Pedro River and along its various tributaries such as Las Nutrias, San Rafael, El Sauz, and El Alamo. Topographic maps published by the Mexican Government in 1975 at a scale of 1:500,000 show the general areas of developed land. An analysis of these maps reveals that agricultural lands are supplied with water from small reservoirs, ditch systems, and an occasional well.

Those lands that are solely dependent upon surface water as their supply would only be able to irrigate when that supply is available. Therefore, only part of the developed land shown on the Mexico maps could be irrigated on the average. The International Boundary and Water Commission publishes an annual bulletin (Western Water Bulletin) that contains the average annual acreage irrigated within the Mexico portion of the watershed. From 1970 to 1987, this amount has remained constant at 3,460 acres. Since most irrigation occurs

only when there is available surface water supply, the amount of water use is estimated to be a low 1.45 acre-feet per acre for a total use of 5,000 acre-feet per year. If irrigation practices in Mexico were assumed equivalent to those in the Sierra Vista subwatershed then the consumptive use from irrigation could be as high as 7,300 acre-feet per year given a consumptive use per acre of 2.1 acre-feet (weighted average for the Sierra Vista subwatershed).

MUNICIPAL AND DOMESTIC USES

There are only two cities of any size within the watershed in Mexico: Cananea and Naco. Otherwise the Mexico portion of the watershed is sparsely populated, having no towns or villages with a population of more than a few hundred. Cananea is a copper mining community with a population of about 30,000 that is located on the watershed divide between the San Pedro River and the Rio Sonora, with most of the city being within the latter watershed. Cananea's water supply is obtained from wells located in the floodplain of the San Pedro River about eleven miles northwest of the city. Its estimated annual use is 2,000 acre-feet. Naco is a small border town that has a population of about 5,000 and has an estimated annual use of 300 acre-feet. An additional 300 acre-feet per year is used by the rural population in the Mexican drainage area.

STOCKPOND AND RESERVOIR USES

The total number of stockponds and small reservoirs within the Mexico portion of the watershed is unknown. However, it is assumed that the number and size of impoundments per unit area in Mexico is the same as those in the Sierra Vista subwatershed. By applying the same methodology used within the Sierra Vista subwatershed to determine the water lost by evaporation from stockponds and small reservoirs, the estimated loss for this purpose is 1,000 acre-feet per year.

MINING AND INDUSTRIAL USES

The copper mine and mill at Cananea is one of the largest operations of its type in Mexico. Water is obtained from wells in both the Rio Sonora and San Pedro River watersheds. Return flow is into the Rio Sonora drainage, although spills into the San Pedro River watershed have occasionally occurred during large runoff events. Total water use from the San Pedro River watershed for the copper mine and mill is about 3,000 acre-feet per year. An additional 100 acre-feet per year is for industrial purposes used by a plant near Naco that produces lime for use in processing copper. No other mining or industrial uses exist within the Mexico portion of the watershed.

The estimated total depletion from the San Pedro River water supply by water uses in Mexico is 11,700 acre-feet per year and is summarized in Table 3-13.

TABLE 3-13

WATER DEPLETIONS IN MEXICO
(ACRE-FEET PER YEAR)

Irrigation	5,000
Municipal and Domestic	2,600
Stockponds and Reservoirs	1,000
Mining and Industrial	3,100
TOTAL	11,700

Source: International Boundary and Water Commission, 1979

3.4 USES WITHIN NON-TRIBUTARY GROUNDWATER BASINS

This section describes the water uses found in the non-tributary groundwater basin areas described in Chapter 2, Section 2.3. These two areas called Cienega Creek and San Rafael groundwater basins on Figure 2-2 are unique in that the surface water flow from these areas is tributary to the San Pedro River but the groundwater flow is tributary to adjacent watersheds and is not part of the San Pedro River hydrologic system. Therefore, any groundwater use within these areas would not constitute a depletion from groundwater tributary to the San Pedro River watershed but rather a depletion from the adjacent watershed. Figures 2-20 and 2-21 show the area covered by the Cienega Creek and San Rafael groundwater basins.

CIENEGA CREEK GROUNDWATER BASIN

The Cienega Creek groundwater basin area encompasses thirty-three square miles in the Sierra Vista subwatershed near the Town of Elgin (Figure 2-20). Surface water in the this area flows into the Babocomari River, a tributary to the San Pedro River. However, groundwater in this area exits the San Pedro River watershed and flows into the Cienega Creek groundwater basin which lies within the Upper Santa Cruz River watershed. Water uses in the Cienega Creek groundwater basin include: irrigation, domestic and stockwatering uses. These uses represent claims filed with DWR.

Irrigation uses in the Cienega Creek groundwater basin are composed of 147.2 acres of irrigated lands. Of this, 137.1 acres are vineyards, 7.5 acres are orchards, and 2.6 acres are composed of various crops. The vineyards and orchards are drip irrigated with 4.1 acres supplied primarily by groundwater and periodically supplemented by surface water pumped from the Babocomari River. The remaining 143.1 acres of cropland are supplied solely by groundwater.

The other water uses within the Cienega Creek groundwater basin are comprised of domestic and stockwatering uses. There are seventy-five domestic uses found within the area, all supplied by groundwater. The stockwatering uses consist of twenty-two stock wells pumping groundwater, one spring, two instream stockwatering uses, and fifty-four stockponds. Of the fifty-four stockponds, fifty-two are less than two surface acres and less than fifteen

acre-feet in capacity. The remaining two stockponds have a combined surface area of 9.4 acres and a combined capacity of 33.3 acre-feet.

SAN RAFAEL GROUNDWATER BASIN

The San Rafael groundwater basin comprises fifty-six square miles and is located in the Sierra Vista subwatershed south of the Canelo Hills and west of the Huachuca Mountains (Figure 2-21). Surface water in this area flows south of the International Border into the Mexico portion of the San Pedro River watershed. Groundwater in this area flows out of the San Pedro River watershed and into the San Rafael groundwater basin which lies within the Upper Santa Cruz River watershed. Water uses within the San Rafael groundwater basin area consists of domestic and stockwatering uses. No irrigation occurs in this area. Historically, there has been very little groundwater withdrawal from this area. Data gathered from the few long-term water level records that exist indicates that no significant water level changes have occurred (ADWR, 1984b).

A number of stockwatering use claims have been filed with DWR. These consist of twenty stock wells pumping groundwater, twenty-seven springs, and twenty-nine stockponds. DWR has determined that twenty-six of the stockponds are less than two surface acres and less than fifteen acre-feet in capacity. DWR surveyed three stockponds greater than two surface acres and determined that the three ponds have a combined surface area of 9.3 acres and a combined capacity of 41.3 acre-feet.

There are six domestic uses within this area that are supplied by groundwater.

3.5 SUMMARY AND CONCLUSIONS

The major conclusions regarding water uses within the San Pedro River watershed are provided below:

1. The estimated total diversions for all natural and cultural uses within the United States portion of the watershed is estimated to be 170,090 acre-feet per year. The estimated total depletion is 125,330 acre-feet per year. The estimated total depletion from the Mexico portion of the watershed is 11,700 acre-feet per year.

2. Domestic and municipal water uses are increasing along with the population in portions of the watershed, particularly in the Sierra Vista subwatershed.

3. Although the annual water supply within the San Pedro River watershed fluctuates depending upon yearly variations in available precipitation, water uses exhibit much less variation due to the dependability of supply provided by pumpage from wells.

4. Natural losses are estimated to be approximately 60,690 acre-feet. Evaporation from channel flows and alluvial soils is estimated to be 6,590 acre-feet per year or 11 percent. Losses from phreatophyte evapotranspiration is estimated to be 54,100 acre-feet per year or 89 percent of all natural losses.

5. The estimated total diversion for all cultural uses within the United States portion of the watershed is 109,400 acre-feet per year, while the estimated depletion is 64,600 acre-feet per year.

6. DWR identified about 20,842 acres developed for irrigation which have been irrigated at least once during the past ten years. Of these acres, approximately 3,320 acres are supplied at least partially by surface water diversions. The total surface water diverted for irrigation use is estimated at nearly 10,000 acre-feet.

7. Total diversion for irrigation uses is estimated to be 62,750 acre-feet per year and the estimated depletion is 32,470 acre-feet per year.

8. The total acreage irrigated solely by surface water is just under 230 acres. The total amount of acreage irrigated solely by wells

located within Zone 1 is about 7,230 acres. The total acreage irrigated solely by Zone 2 wells is approximately 7,430 acres.

9. ASARCO, Inc. exports nearly 1,900 acre-feet per year from the San Pedro River watershed to its facilities at Ray and Hayden located in the Upper Gila River watershed.

10. Total estimated diversions for municipal uses is about 9,410 acre-feet per year with a depletion estimated to be 6,510 acre-feet per year.

11. Magma Copper Company diverts over 23,000 acre-feet per year for its mining operation at San Manuel and is the largest single water user in the watershed.

12. Industrial/commercial users divert about 1,170 acre-feet per year. The estimated depletion for these uses is about 560 acre-feet per year.

13. DWR identified 313 reservoirs, other than stockponds, whose depletion due to evaporation losses is estimated to be 720 acre-feet per year, 260 acre-feet of which is considered a commercial depletion.

14. DWR found 1,891 stockponds in the San Pedro River watershed. The depletion due to stockpond evaporative losses is estimated to be 3,870 acre-feet per year or 4 percent of all cultural depletions.

15. There are 2,599 separate self-supplied domestic uses that are not connected to a municipal supply system or private water provider. DWR estimates the total depletions for these domestic uses is 1,050 acre-feet per year.

CHAPTER 4: HYDROLOGIC ANALYSIS

The previous two chapters examined the water sources and uses in the San Pedro River watershed independent of each other. Chapter 4 synthesizes the information presented in Chapters 2 and 3 and provides analysis of the interactions between supplies and uses within the watershed. The relationships between the surface and groundwater systems are addressed, followed by an examination of the effects of both natural and cultural uses on the hydrologic system.

Transmission losses and gains along the San Pedro River and Aravaipa Creek and the water usage aspect of crop irrigation versus natural phreatophytes is discussed. Classification of the categories of water withdrawn from wells is identified and discussed and uses within each category are quantified. A water budget analysis and an estimate of undepleted streamflows are presented. Finally, the analysis presents the Arizona Department of Water Resources' (DWR) conclusions regarding the hydrologic system of the San Pedro River.

4.1 INTERACTION BETWEEN GROUNDWATER AND SURFACE WATER SYSTEMS

The purpose of this section is to bring together the information on groundwater and surface water presented in Chapter 2 and to describe their general interrelationships. Most of the dynamic interaction between surface water and groundwater (excluding mountain front and minor tributary channel recharge) occurs in a relatively narrow strip of land bordering the San Pedro River and its largest tributaries: Aravaipa Creek and the Babocomari River. This area generally conforms to the floodplain of these streams and is often referred to as the younger alluvium (inner valley). A conceptual illustration of the younger alluvium and the interrelationship between the surface water system and the two groundwater aquifer systems was shown on Figure 2-8. The younger alluvium is also where most of the cultural and natural uses take place in the San Pedro River watershed.

Figure 4-1. The younger alluvium is the focal point for groundwater and surface water interaction. High streamflows can recharge alluvial voids created by cultural or natural uses such as phreatophytes shown here on the San Pedro River.

Streams of the San Pedro River watershed fall into one of three categories: perennial, intermittent, or ephemeral. The type of stream is indicative of the extent of the groundwater/surface water interactions taking place. Many streams in Arizona have shifted from perennial to intermittent or ephemeral since groundwater development began. This indicates that pumpage has altered the aquifer/stream relationship. A discussion of the effects of cultural uses on the hydrologic system appears in Section 4.3 of this chapter.

Perennial streams discharge water continuously throughout the year. Their source of supply is normally comprised of both direct runoff from precipitation events or snowmelt and baseflow derived from the discharge of groundwater into the stream in the form of springs or seepage through the bed and banks of the stream. Seepage into the stream from the adjacent floodplain aquifer occurs when the water table is at or above the water level in the stream. The baseflow water the stream receives from the floodplain aquifer during these times initially comes from the regional aquifer system along the

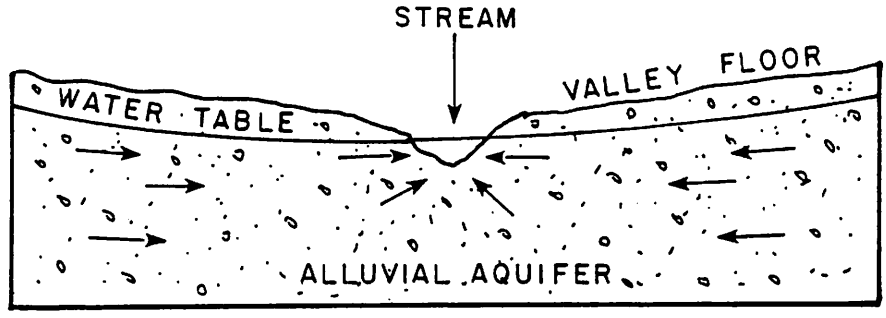
sides and margins of the valley. This water from the regional aquifer is the source of the stream's baseflow. It moves slowly downgradient through the regional aquifer from the mountain fronts to the inner valley. At its natural rate of flow, groundwater recharged far from the river may take many years to discharge at the river. Eventually the groundwater reaches the inner valley area and is discharged into the floodplain aquifer. In cases where the floodplain aquifer is already fully saturated, groundwater discharges to the floodplain aquifer from the regional aquifer are manifested as flowing water in the channel. In certain areas, springs may also discharge groundwater directly to the river.

Under dry conditions or when natural and cultural uses of water are high, the floodplain aquifer water table may fall below the water level in the stream. During these times, the direction of seepage reverses and the stream begins to lose water to the groundwater system. It is not uncommon for a perennial stream flowing under baseflow conditions to have both gaining and losing reaches, as shown by Figure 4-2 (A) and (B). The gaining reaches represent areas where the amount of groundwater discharging into the stream is greater than natural losses and cultural diversions. Losing reaches are the areas where natural losses and cultural diversions are greater than groundwater discharge entering the stream. Where losing reaches are long enough to consume all of the baseflow, perennial stream conditions cease.

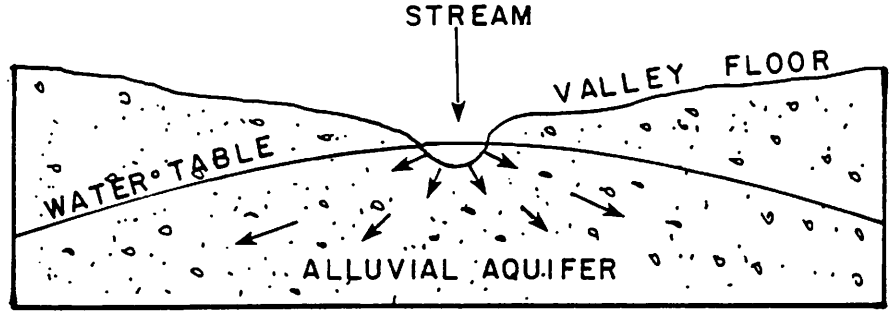
Intermittent streams discharge water continuously for long periods of time, but not continuously throughout the year. They normally flow seasonally. For example, an intermittent stream may flow continuously all winter, every winter, but never flow continuously during the summer. During the times when baseflow is maintained, groundwater is often contributing to the stream. During periods of discontinuous streamflow, natural and/or cultural losses may be greater than the contribution from groundwater, resulting in a losing stream or the amount of groundwater discharge itself may have decreased. Figure 4-3 (A) shows a typical cycle for intermittent streams interconnected with the floodplain aquifer. During periods when there is no baseflow, intermittent streams may retain an active groundwater subflow component where the water table lies only a short distance below the streambed. Under these conditions, vigorous habitats of riparian vegetation are often maintained. If the dry period is extensive, the aquifer below the river will continue to be depleted and the water table will fall as shown in

PERENNIAL STREAM

A. GAINING REACH (PERENNIAL STREAM)



B. LOSING REACH (PERENNIAL STREAM)



C. LOSING REACH (BECOMING INTERMITTENT or EPHEMERAL)

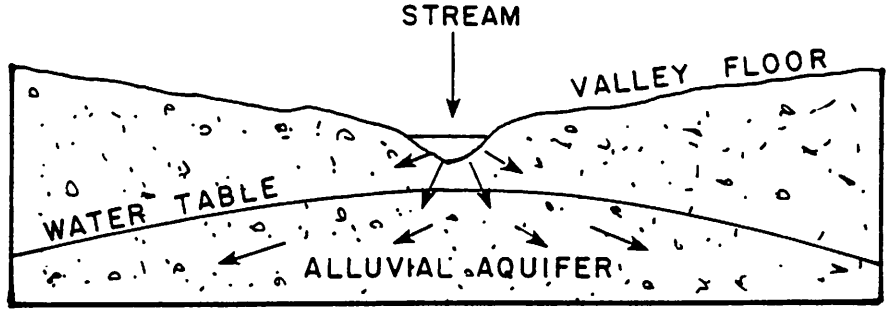
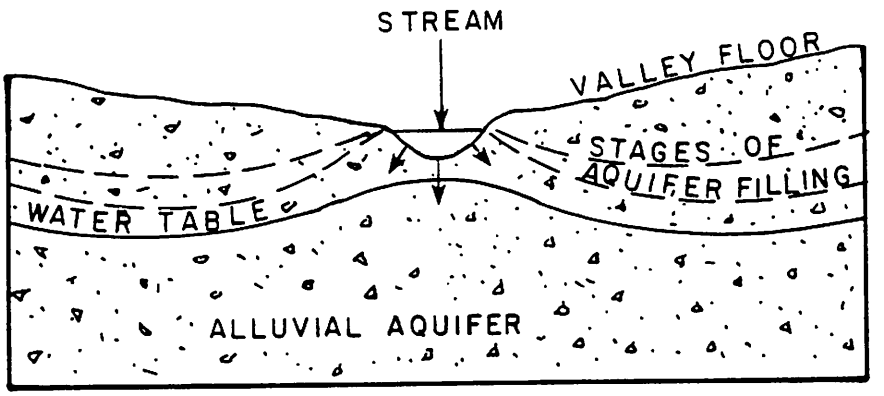


Figure 4-2. Perennial stream showing examples of gaining and losing reaches

INTERMITTENT STREAM

A. FLOWING REACH



B. DRY REACH

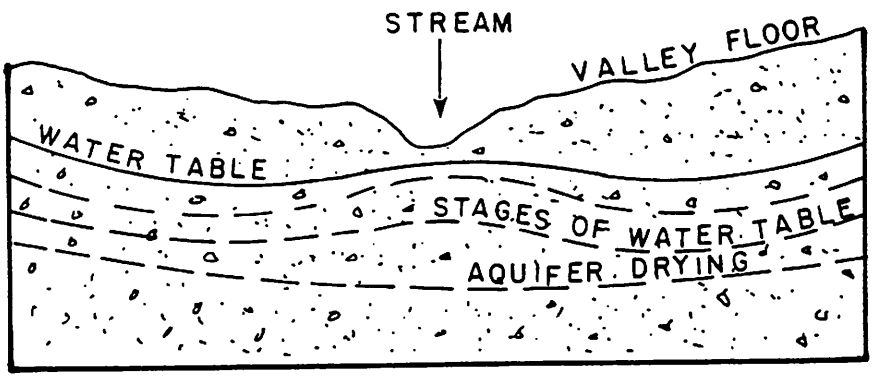


Figure 4-3. Intermittent stream showing examples of water table fluctuations within flowing and dry reaches

Figure 4-3 (B). This will continue until it is refilled from surface water recharge or until natural and cultural uses become less than the natural groundwater recharge from the regional aquifer.

Under both perennial and intermittent streamflow conditions, the surface water system may recharge the floodplain aquifer when there is space in the floodplain alluvium to store additional water (Figure 4-2 (B) and (C) and Figure 4-3). This occurs after dry seasons, when phreatophytes and wells have removed enough water from the floodplain alluvium to create a significant unsaturated area. Any high surface water flows will recharge the available space within the floodplain aquifer. Flow in the stream, usually due to periodic flood events, rapidly saturates the floodplain alluvium and refills the available storage space. After the high flow season, the river level falls leaving saturated portions of the floodplain above the lower river level. The water in the floodplain alluvium then drains back to the river at a low rate helping to sustain river flow. Under intermittent conditions this may sustain river flows for a few weeks or even months.

Groundwater is also transferred to the floodplain aquifer and the surface water system from the regional aquifer by the influence of shallow bedrock. Shallow bedrock such as near Charleston and northwest of Cascabel (Figure 2-2) forces water in the regional aquifer upward into the floodplain aquifer and into the San Pedro River resulting in perennial stream reaches within these two areas.

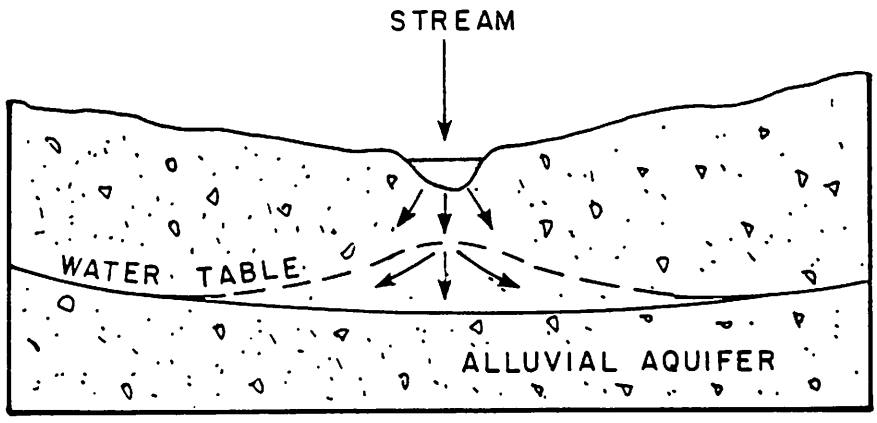
Another mechanism by which groundwater may discharge to the inner valley is by upward leakage from the confined portions of the regional aquifer. In several reaches of the San Pedro River the older alluvium is under confined conditions adjacent to and underlying the inner valley (Figure 2-4). The water in a confined aquifer is under pressure that is greater than atmospheric pressure. When penetrated by a well, the pressure forces water in the well to rise above the level at which it is first encountered. This would be an artesian well. A flowing artesian well is created when the pressure is high enough to force the water level above the land surface (Figure 2-5). There are many examples of flowing artesian wells in the Benson - St. David area. Even when wells are not present, the difference in pressure between the floodplain alluvium and the underlying confined aquifer may allow groundwater

to leak upward into the floodplain aquifer through "breaks" in the confining layers and be discharged to the surface water system (Roeske and Werrell, 1973).

Ephemeral streams discharge water only in response to precipitation events or snowmelt and do not have a baseflow component at any time of the year. Consequently, they flow only sporadically. Figure 4-4 illustrates the relationship between ephemeral streams and underlying aquifers. Ephemeral stream reaches are always losing streams over their entire length, continuously discharging water to the groundwater system when flowing over alluvium.

EPHEMERAL STREAM

A. FLOWING REACH



B. DRY REACH

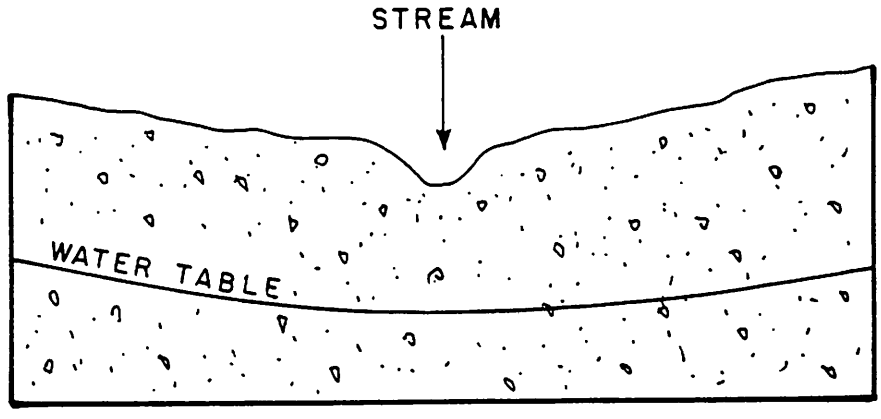


Figure 4-4. Ephemeral stream showing water table fluctuations within flowing and dry reaches

4.2 EFFECTS OF NATURAL USES ON THE HYDROLOGIC SYSTEM

As described in Chapter 3, Section 3.1, the two major components of natural uses from the San Pedro River's hydrologic system are evaporation from bare soils and water flowing in the streams and evapotranspiration from riparian vegetation. These natural depletions to the hydrologic system directly impact the amount of water delivered to the Gila River.

CHANNEL AND BARE SOIL EVAPORATION

Channel evaporation losses occur from the free water surface where there is surface flow. The potential for this loss can be viewed as being the same as from a shallow lake with a surface area equal to the accumulated area of channel occupied by surface water. Of greater importance than the direct evaporation of surface flows is the evaporation of water flowing beneath the surface of dry portions of the channels. These losses result in high streamflow attenuation for the first few runoff events after the dry season. The losses are due to the infiltration of streamflow replacing the water evaporated from the alluvium. As a consequence, runoff events during the height of the summer runoff season tend to traverse the channel with less transmission loss than do the first few events of the season.

Direct evaporation from the perennial and flowing intermittent reaches of the main stem and the major tributaries of the San Pedro River System average approximately 880 acre-feet per year. Evaporation from the dry portions of the streambeds of the active channels of the mainstem and major tributaries averages 5,710 acre-feet annually.

PHREATOPHYTES

Phreatophytes are plants that draw water directly from groundwater sources. Within the San Pedro River watershed, these plants make up the riparian communities found along the San Pedro River and its tributaries. Within the water hungry arid southwest, phreatophytes have historically been a target for watershed management practices and economic development. With little regard for any beneficial uses phreatophytes may provide, riparian communities have been greatly reduced in their areal extent over the years.

Examples of these reductions are the conversion of phreatophyte covered land to agricultural land and the lowering of water tables below that which is required for phreatophyte survival as a result of cultural activities.

As well as the obvious recreational and wildlife benefits, riparian communities provide a number of hydrologic and watershed values. They provide channel bank stability resulting in a form of natural erosion protection. Large phreatophyte communities can improve downstream water quality and provide downstream flood control by spreading sediment laden flood flows out over a larger area, slowing these flows down, increasing infiltration, and increasing deposition of sediments. The increased infiltration results in a slower release of the original flood flows back to the surface water system.

However, phreatophytes' consumptive use of water is high. Dense stands of phreatophytes can dewater streams by inducing the flow of water in the alluvium toward the vegetation. During peak phreatophyte water usage, a reversal of the hydraulic gradient can occur in the alluvium. The stands of phreatophytes act much like a series of small pumping wells. As water flowing beneath the streams flows toward the vegetative stands to meet the plants' transpiration needs, surface water infiltrates into the alluvium and away from the stream to compensate for the amount of water being used. In areas of nonperennial flow, large infiltration rates will occur from the initial flows following dry periods, replenishing the water stored in the alluvium used from the aquifer by both phreatophyte transpiration and alluvial soil evaporation, as discussed previously. Although some phreatophytes may be withdrawing water directly from the regional aquifer, most are believed to derive their water requirements from surface water flows and alluvial aquifers in direct hydraulic connection with surface streams. Figure 4-5 is a schematic showing the potential affect that transpiring phreatophytes have on the groundwater system.

Much of the research on phreatophytes has focused on water salvage, that is, how much water could be saved by removing dense phreatophyte growth from the floodplains of river systems (Culler et al., 1982, for example). Short-term increases in flows are possible with phreatophyte eradication. However, replacement vegetation must be established in order to eliminate the unnatural condition of a barren floodplain and provide channel stability. Much of the irrigated agriculture in the San Pedro River watershed is in areas cleared of their original phreatophyte growth. Typically, these cultural uses require

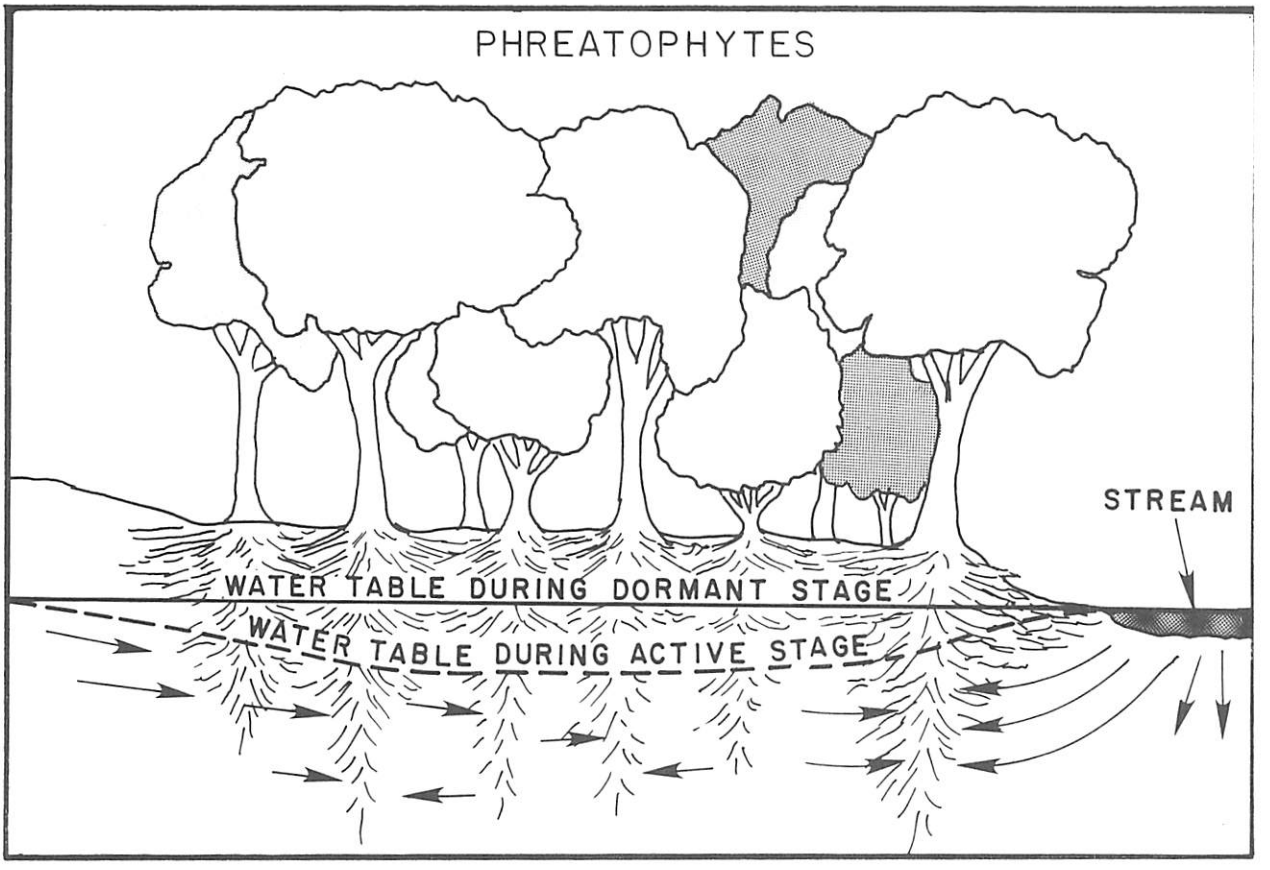


Figure 4-5. Schematic showing the potential effect that phreatophytes have on the groundwater system.

less water than dense stands of phreatophytes and may result in a potential savings to the surface water system. A more detailed discussion of phreatophyte salvage is contained in Section 4.5 of this chapter.

4.3 EFFECTS OF CULTURAL USES ON THE HYDROLOGIC SYSTEM

The effects of cultural uses on the hydrologic system depend on the location of the use within the system, or proximity to the San Pedro River, and the nature of the withdrawal, either groundwater or surface water. Therefore, this section is divided into five subsections which are: 1) the general effect of wells, 2) remote groundwater uses, 3) tributary groundwater uses, 4) tributary surface water uses, and 5) mainstream water uses.

EFFECT OF WELLS ON THE HYDROLOGIC SYSTEM

From a technical perspective, when a well is pumped, water is initially removed from aquifer storage in the vicinity of the well. This creates a cone of depression in the water table around the well which, in turn, causes groundwater to move toward the well. The areal extent and depth of the cone of depression will vary with the transmissivity and storage coefficient of the aquifer penetrated, the pumping rate, and the total time of pumping. If the well is pumped for a sufficiently long time, the cone of depression may expand outward to intercept the recharge or discharge area for the aquifer. Therefore, increased recharge may be induced or the natural discharge may be reduced by the quantity of water necessary to continuously supply the well.

Cones of depression surrounding single wells have the potential to impact other nearby groundwater users. Ordinarily, the first users to experience the negative effects of excessive pumping are the small individual domestic users who typically have the most shallow wells. Figure 4-6 (A) is a schematic showing a generalized example of a deeper well impacting a shallow well. When several wells are located in close proximity, coalescing cones of depression can form regional declines in groundwater levels as shown in Figure 4-6 (B). In Figure 4-6 (A), production from the small domestic well is greatly reduced while in part B the domestic well has become completely dry.

If a well is located relatively close to a stream and is in direct hydraulic connection with the stream, pumping of that well may interfere with the stream in one of two ways. Direct interference between a well and a stream occurs when the cone of depression of the pumped well intercepts the streambed and induces surface water to move away from the stream toward the

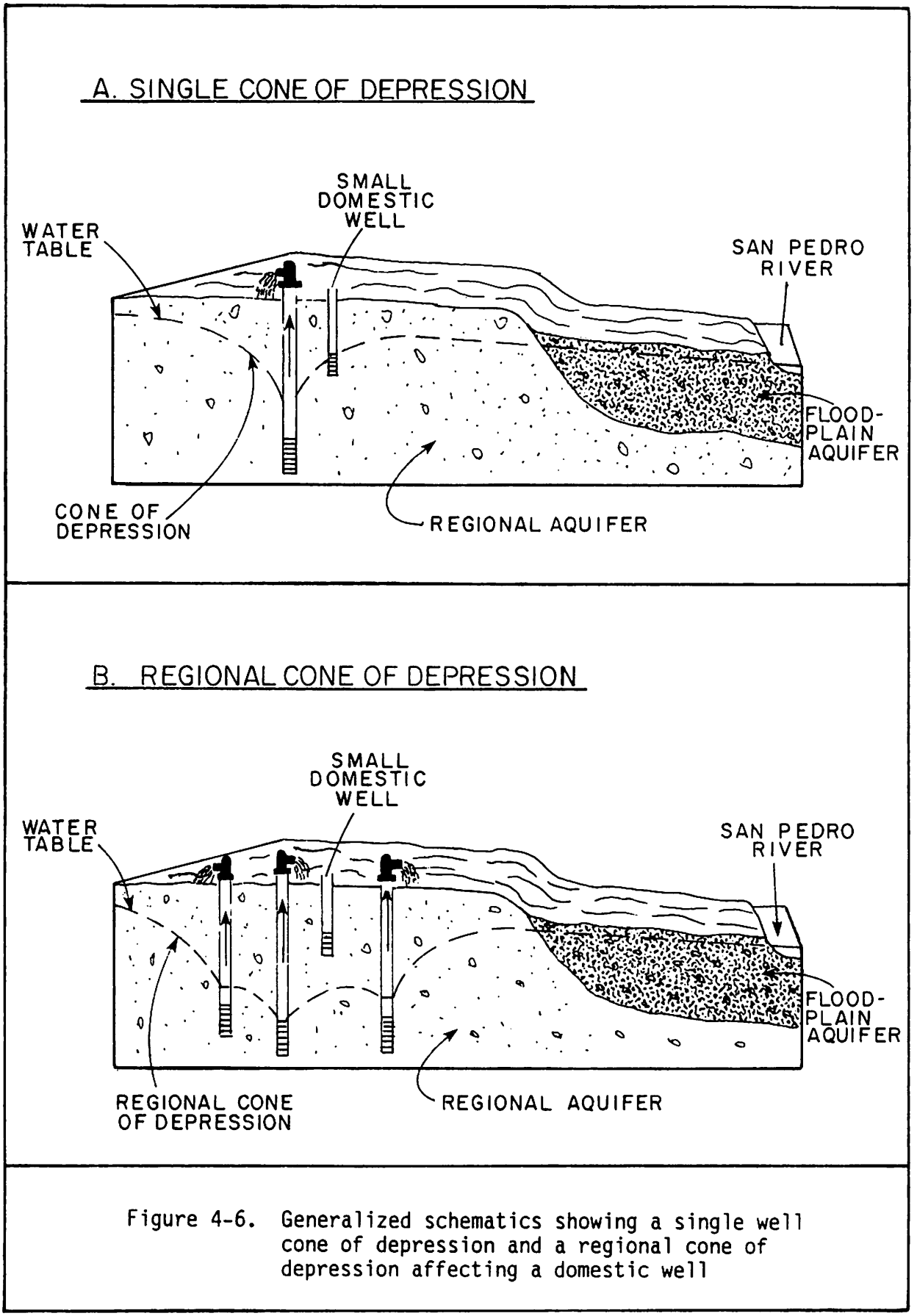


Figure 4-6. Generalized schematics showing a single well cone of depression and a regional cone of depression affecting a domestic well

well as shown in Figure 4-7 (A). Indirect interference occurs when the cone of depression of the pumped well does not intercept the stream, but the natural hydraulic gradient toward the stream is reduced, thereby reducing the amount of groundwater discharged to the stream as shown in Figure 4-7 (B).

The effects of a pumping well are often delayed until long after pumping begins, sometimes not reaching the stream until after pumping has ceased. Figure 4-8 (A) shows how delayed indirect interference may affect a stream. After pumping has ceased, the effect of the withdrawal reduces the amount of water discharged from the aquifer to the stream. Even for direct interference circumstances, it takes a period of time for the effect of an expanding cone of depression to be felt at the streambed. Figure 4-8 (B) shows an example of these delayed effects. In this case, the maximum rate of streamflow interception occurred after the well ceased pumping and continued to deplete the stream for a long period of time thereafter. For certain streams such as the San Pedro River, both direct and indirect interference can occur over the same stream reach.

The effect of a pumping well on surface water flow, on the floodplain aquifer, and on the regional aquifer depends on the location and depth of the well, the hydrogeologic conditions of the aquifer near the well, the well discharge rate, and the duration of pumping. Figure 4-9 shows a generalized schematic of several wells, their relationship to the stream, floodplain and regional aquifers, and how they may affect groundwater and surface water conditions given different pumping scenarios.

Wells located in the younger alluvium may draw water either directly from the floodplain aquifer or the underlying regional aquifer (Figure 4-9, Wells A, B, and C). Pumping wells whose casings are perforated in the floodplain aquifer can cause water levels in the aquifer to drawdown (Figure 4-9, Well A). As the cone of depression becomes larger with increased pumping time, it may reach the streambed. If water is present in the stream at the time of pumping, surface water will be diverted from the stream by the well. When there is no surface water in the vicinity of the well, the cone of depression continues to grow in the floodplain alluvium. The cone may eventually reach the contact zone between the floodplain alluvium and the regional aquifer and induce increased flow from the basin fill to the younger alluvium by increasing the hydraulic gradient. The floodplain aquifer of the San Pedro River watershed generally transmits water more readily and stores more water

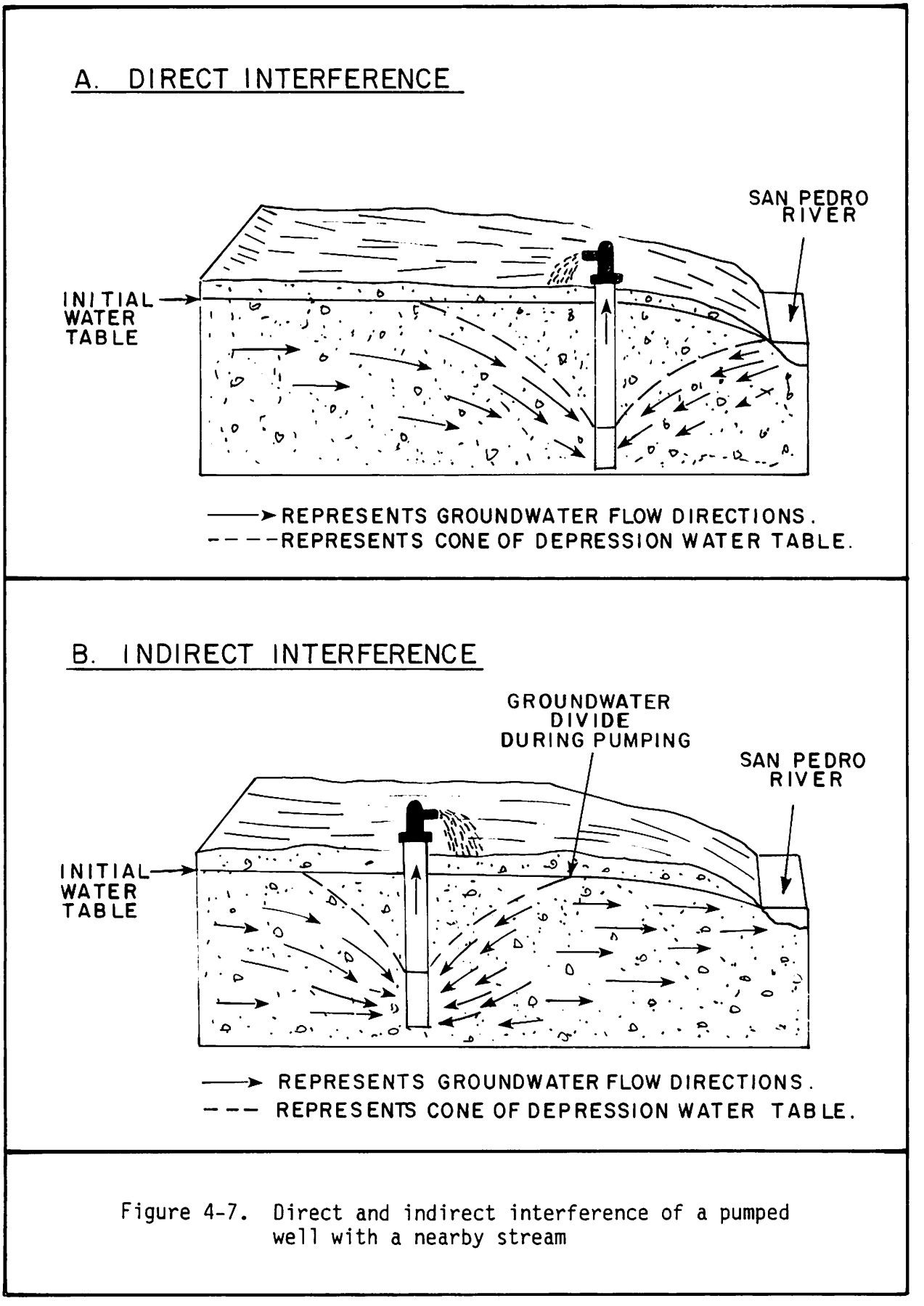
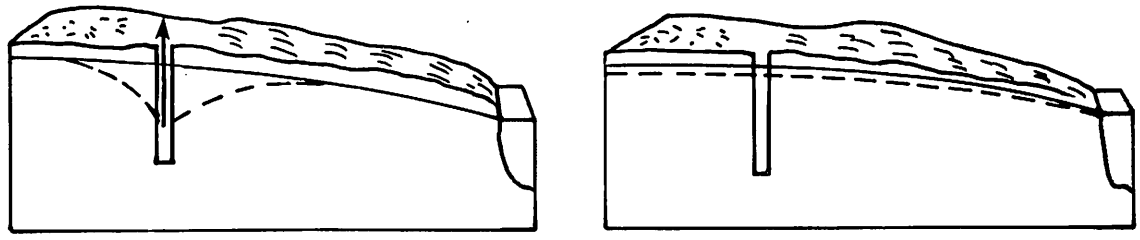


Figure 4-7. Direct and indirect interference of a pumped well with a nearby stream

A DELAYED INDIRECT INTERFERENCE, SHOWING NO INTERFERENCE WHILE PUMPING (a) AND INTERFERENCE AFTER PUMPING STOPS (b). SOLID LINE INDICATES THE POSITION OF THE WATER TABLE PRIOR TO PUMPING.



B EXAMPLE OF DELAYED EFFECTS OF WELL PUMPING 35 DAYS. (FROM C.T. JENKIN, 1968.)

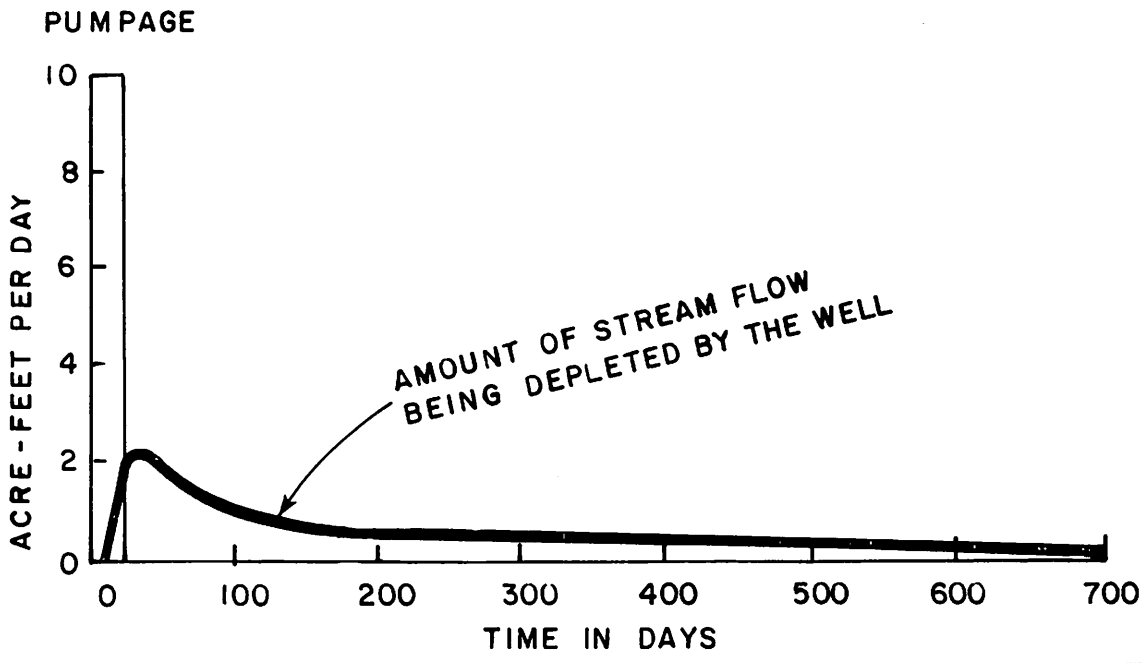


Figure 4-8. Delayed interference of a pumped well to the stream system

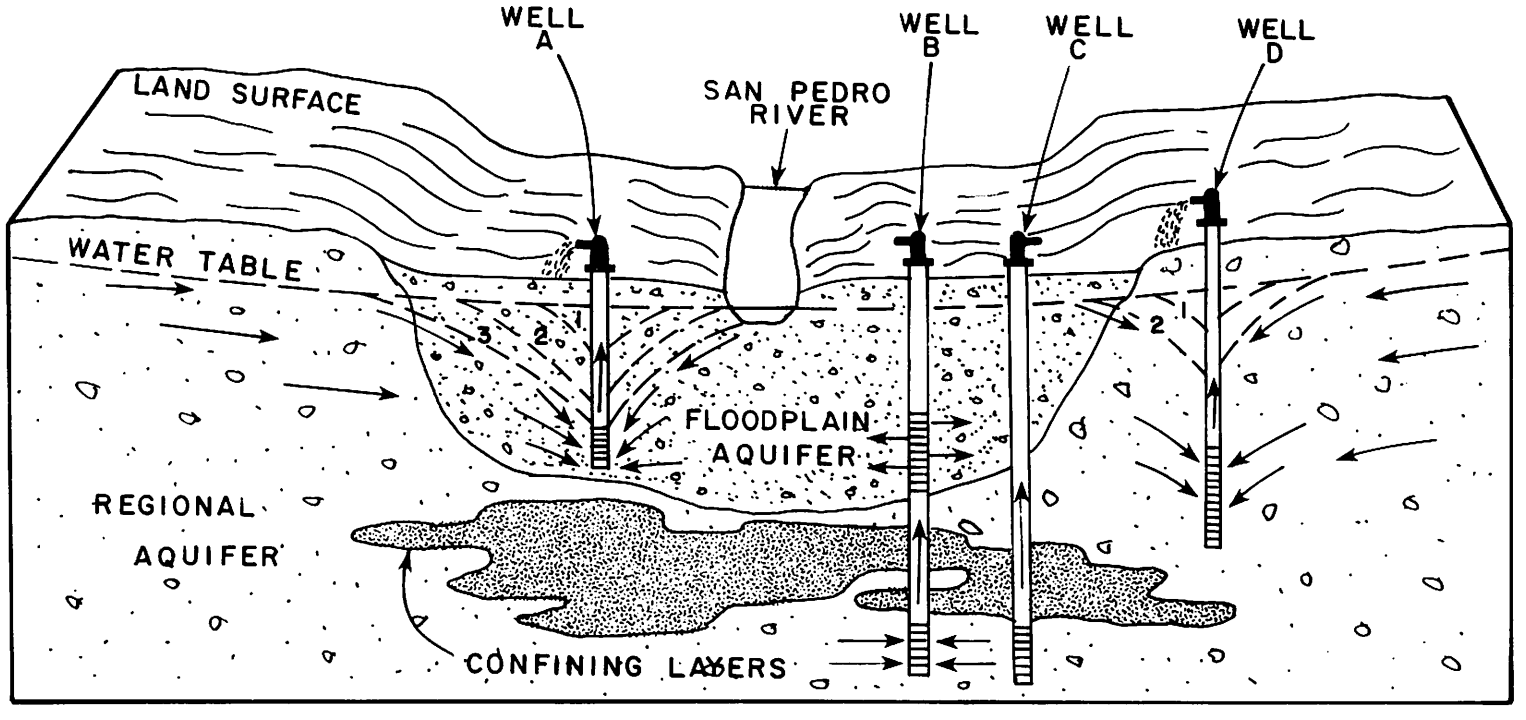


Figure 4-9. Generalized relationship of several wells on surface and groundwater systems

per unit volume than the regional aquifer. Consequently, the relative amount of water pumped from the regional aquifer is small from wells perforated in the younger alluvium unless the alluvial aquifer has been largely depleted. Some wells may actually withdraw water from all three available sources in the watershed: streamflow, the floodplain aquifer, and the regional aquifer (Figure 4-9, Well A, Time 3).

Deeper wells in the valley's center may penetrate the clay layers that confine the underlying regional aquifer (Figure 4-9, Wells B and C). These deeper wells may be perforated in both the floodplain aquifer and the deeper basin fill aquifer such as shown in Figure 4-9, Well B. These wells can result in leakage between the confined portions of the regional aquifer and the floodplain aquifer. This can result in local declines in artesian head in the confined regional aquifer. Wells that are completed only in the deeper regional aquifer (Figure 4-8, Well C) should only be withdrawing water from the regional aquifer. However, if the well is poorly completed and the seal between the regional aquifer and the overlying floodplain aquifer has not been utilized or has failed, then water under artesian pressure could travel upwards into the floodplain aquifer.

Wells located in the basin fill outside the floodplain aquifer withdraw water primarily from the regional aquifer (Figure 4-9, Well D). The cones of depression created by pumping these wells may intercept the younger alluvium and withdraw water directly from the floodplain aquifer. The flow rate from the regional aquifer to the floodplain aquifer may be lessened by the flattening of the hydraulic gradient by these withdrawals, slowing the velocity of groundwater movement in the regional aquifer. Water may also be induced to flow from the floodplain aquifer into the regional aquifer if the head in the regional aquifer is lowered to a level below the head in the floodplain aquifer (Figure 4-9, Well D, Time 2). This could eventually lessen streamflow as infiltration into the alluvial aquifer increases to replace the water withdrawn from storage.

Wells located in the regional aquifer some distance away from the valley centers or wells near the valley centers that operate only for short periods of time, may have no direct measurable influence on the floodplain aquifer or the surface water system. The distance of the well from the younger alluvium, the relative elevation of the water levels in the regional aquifer and the floodplain aquifer, the hydraulic properties of the groundwater system, and

the pumping rate and duration usually are such that the cones of depression from these wells do not reach the younger alluvium. Even in such cases, however, the well is pumping groundwater that may have eventually reached the younger alluvium. Large amounts of regional aquifer pumping will eventually have an effect on streamflow. A prime example of this is in the Tucson area where high rates of groundwater withdrawal over many years have lowered the water table far below the elevation of the bed of the Santa Cruz River, turning this formerly perennial river, with its associated stands of riparian vegetation, into an ephemeral, essentially barren stream channel.

REMOTE GROUNDWATER USES

Remote groundwater uses are withdrawals from hard rock aquifers and non-tributary alluvial aquifers. These withdrawals occur in areas so far removed from the San Pedro River, the Babocomari River, or Aravaipa Creek, or have such limited hydraulic connection with the main regional aquifer that their effect on groundwater levels in the main regional aquifer or upon the surface water system is negligible. These uses occur in the hard rock areas of the mountain ranges of the watershed. They also include the Allen Flat groundwater basin and other alluvial aquifers hydrologically separated from the valley floor by hard rock groundwater divides. Groundwater in these areas is considered to be non-tributary to a surface water supply. Further information on these non-tributary groundwater aquifers is presented in Section 4.6 of this chapter.

TRIBUTARY GROUNDWATER USES

Tributary groundwater uses are groundwater withdrawals from areas of the regional aquifer that have a direct hydraulic connection to, and are discharging groundwater to, the two principal inner valleys: the San Pedro River and Aravaipa Creek valleys. The Babocomari River valley is assumed to be an extension of the San Pedro River valley. The effect of withdrawals of tributary groundwater may be very small as with a domestic well. In areas where there are major withdrawals occurring, the cones of depression from many wells may coalesce into a much larger regional cone of depression, such as the

one in the Sierra Vista area which produces a significant effect. The water flowing into these pumping wells may be from up to three distinct sources.

First, water could be derived from groundwater flow in the regional aquifer that is traveling toward the younger alluvium. Small isolated wells which experience little or no net change in depth to groundwater from year to year are probably obtaining their supply from this source. Their affect on the hydrologic system will be to eventually reduce the discharge of groundwater to the younger alluvium. Depending upon the distance of the wells from the younger alluvium, it may take only several years of use or it may take centuries of pumping before these withdrawals result in a decreased water supply in the younger alluvium.

The second possible source of water for tributary groundwater uses is water in groundwater storage. In the regional Sierra Vista cone of depression, groundwater levels are currently declining at a rate of about 1.3 feet per year and are projected to increase to about five feet per year by the year 2000 (Putman et al., 1988). Many thousands of acre-feet of groundwater have already been removed from storage, creating an overdraft condition. As pumping increases to meet the projected increased demand associated with the area growth, the rate of groundwater overdraft may also increase. In areas of the watershed outside of the Sierra Vista area, such as in the area of San Manuel, further analysis is needed to identify any significant removals from groundwater storage.

The third potential source of water for tributary groundwater uses is surface water and floodplain aquifer storage from the younger alluvium. If a cone of depression in the regional aquifer expands far enough over time to extend to the streambed in the younger alluvium, water will be withdrawn from the alluvium, inducing the infiltration of streamflow into the channel material which will then flow toward the center of the cone of depression. The Sierra Vista cone of depression is expanding toward the San Pedro River. Groundwater modeling studies indicate that with projected future demand, the cone may eventually intercept the river (Putman et al., 1988). If and when this occurs, the current baseflow in the stream in the vicinity of Charleston could be significantly reduced or eliminated, impacting the San Pedro Riparian National Conservation Area (SPRNCA). (See Chapter 6, Section 6.3 for a further analysis of the projected impact of the Sierra Vista cone of depression on intercepting streamflow from the San Pedro River.)

TRIBUTARY SURFACE WATER USES

Tributary surface water uses are surface water withdrawals from small springs, washes, or minor streams in the watershed. These withdrawals are predominantly for stockwatering purposes and are typically either developed springs or stockponds. There are a few isolated irrigation diversions from streams other than the San Pedro River and Aravaipa Creek mainstreams. The City of Tombstone diverts water for municipal purposes from springs in the Huachuca Mountains. Water is piped across the San Pedro River valley to a reservoir situated on a hilltop above the city. Fort Huachuca also diverts water from springs in the Huachuca Mountains for use on the Fort.

The effect of any of these types of withdrawals on the hydrologic system depends upon the magnitude of runoff in the tributary stream and whether runoff is generally occurring watershed-wide at the time of the withdrawal. The effects of these withdrawals will differ depending on whether it is a wet year or a dry year. The distance of the diversion from the downstream point of interest is also an important factor. Stockponds, for example, typically fill during the localized, high intensity storms of the summer monsoons. This runoff generally does not occur watershed-wide. The runoff in the small tributaries on which these ponds are located often would not have reached the main channels. Many of these ponds impound flows which would have, in part, only reached the San Pedro River as subflow in the alluvium. Also much of the tributary flows resulting from storm events may not reach the San Pedro River as subflow but rather would be lost to evaporation. Impounding the water in stockponds may actually enhance infiltration and increase recharge of water that otherwise might have been lost.

With an annual precipitation averaging approximately fifteen inches and exceeding thirty inches on the highest mountain peaks, the San Pedro River watershed cannot be characterized as a strictly desert watershed. It is, nonetheless, an inefficient producer of streamflow. Only about 1.6 percent of the 3,500,000 acre-feet of precipitation that falls on the watershed during an average year leaves the watershed as streamflow. A significant portion of the total runoff produced by the watershed is used by the major natural and cultural uses occurring within the younger alluvium of the inner valley (Plates 2 through 10). Some streamflow is now being reduced by pumpage from the floodplain and regional aquifers. Much of the precipitation originated

runoff is lost to natural and cultural uses on the many small tributary washes and streams in the watershed before reaching the mainstream of the San Pedro River.

When there is a high runoff event or when runoff is occurring and accumulating over much of the watershed, natural use losses, while being maximized, normally become a smaller percentage of the total runoff. On these rare occasions, runoff can continue for long distances, occasionally traversing the entire length of the watershed. The more typical isolated runoff events on the small tributaries, however, are normally quickly depleted by natural uses and transmission losses. Therefore, cultural uses of the small isolated runoff events frequently involve water which would not have continued very far downstream before infiltrating or evapotranspiring.

Perhaps the most important factor in determining the average annual impact of tributary surface water uses on downstream water availability is the intervening travel distance. As the distance between an upstream point of diversion and a downstream point of interest becomes greater, continuity of surface flow between the two points becomes less frequent especially during low flow periods. Because of the effect of transmission losses, surface water supplies and uses are more closely related within subwatersheds than they are across the entire watershed. For example, tributary surface water uses within the Winkelman and Aravaipa subwatersheds have a more immediate and substantial effect in reducing the contributions of the San Pedro River to the Gila River than those occurring within the Benson and Sierra Vista subwatersheds.

MAINSTREAM WATER USES

Mainstream water uses are groundwater and surface water withdrawals from the aquifers or streams of the inner valleys of the San Pedro River and Aravaipa Creek. These withdrawals are made by direct surface water diversions from diversion dams or instream pumps and by pumping groundwater from the floodplain aquifer. The effect of these withdrawals on the hydrologic system is more predictable than the effect of cultural uses on the hydrologic system outside of the younger alluvium. In the younger alluvium, all depletions due to mainstream withdrawals result in an equal reduction in surface flow near the location of use. These reductions occur either immediately, as with surface water diversions or when cones of depressions from wells intersect

streams within a relatively short period of time, as flows following groundwater withdrawals infiltrate into the alluvium to replace pumped water.

The floodplain aquifers of the San Pedro River, Babocomari River, and Aravaipa Creek are integrated hydrologic systems in which groundwater and surface water are basically interchangeable. The younger alluvium is, in essence, the watershed drain into which flows all the water produced by precipitation in the watershed that is not used by natural or cultural uses. The amount of water left after consumptive uses, as reflected by the discharge of the San Pedro River at its mouth, is currently about 34 percent of the combined volume of cultural and natural uses in the watershed. If the climate remains relatively stable, streamflow discharging from the watershed will likely decrease as the impacts from cultural uses of tributary groundwater accumulated over the last century manifest themselves toward the younger alluvium.

If streamflow were to become smaller and less frequent, the San Pedro River would become an ephemeral stream in certain reaches where it has historically been perennial or intermittent. This may cause groundwater levels in the alluvium to be permanently lowered, resulting in the loss of some riparian vegetation. As depletions increase, groundwater levels in the inner valleys will be restored to the streambed level less frequently. Eventually, as groundwater overdraft begins below the younger alluvium, the groundwater levels may lose contact with the stream level altogether. Where and when this situation occurs, the stream will continue to discharge water that is not diverted or infiltrated to meet the cultural or natural demands. However, the frequency of flow will be less and will consist mostly of rapidly rising and falling ephemeral discharges resulting only from precipitation events. In the worst case scenario, portions of the San Pedro River may eventually become similar to the Santa Cruz River near Tucson where regional groundwater tables are no longer in contact with the stream alluvium and virtually all of the notable native riparian vegetation has been dewatered and destroyed.

4.4 EFFECTS OF TRANSMISSION LOSSES AND GAINS

Transmission losses or gains are depletions or additions to streamflow in a stream reach and are generally seasonal. Streamflow in a channel reach may be depleted by channel evaporation, phreatophyte use, recharge to the aquifer, pumping, or direct diversion. Streamflow may increase in a channel reach as a result of storm runoff, groundwater discharge to the stream in that reach, cessation of cultural uses such as pumping, or seasonal reductions in phreatophyte use. The mechanisms depleting and augmenting streamflow often take place simultaneously making the measured gain or loss in flow the net sum of the processes.

MAINSTEM SAN PEDRO RIVER

During the growing season, the mechanisms that deplete the streamflow of the San Pedro River are greater than those that augment it in all reaches except from Hereford to Charleston where the stream gains in baseflow during all seasons. As a consequence, most of the length of the San Pedro River does not sustain baseflow during the early summer months before the summer rainy season begins. During the winter season, the situation reverses and the augmentation mechanisms are greater in nearly all reaches. Streamflow normally resumes over most of the length of the stream beginning in November or December and generally lasts until March or April. Although cultural uses contribute to the streamflow depletion mechanisms, the same seasonal pattern of transmission losses and gains would exist in the absence of cultural uses due to the magnitude of the riparian natural uses that are occurring along the San Pedro River. However, in the absence of cultural uses the period of baseflow would be longer and at a higher discharge in the intermittent reaches of the San Pedro River.

Factors Affecting Transmission Losses During the Summer Season

One of the effects that transmission losses have on the hydrologic system is to create a discontinuous surface flow during the growing season. As a result, depletions of surface water in the upper areas of the watershed have less immediate effect on the availability of surface water in the lower areas of the watershed or on the discharge to the Gila River. All of the baseflow and minor flood flows originating in the upper areas are lost to the depletion

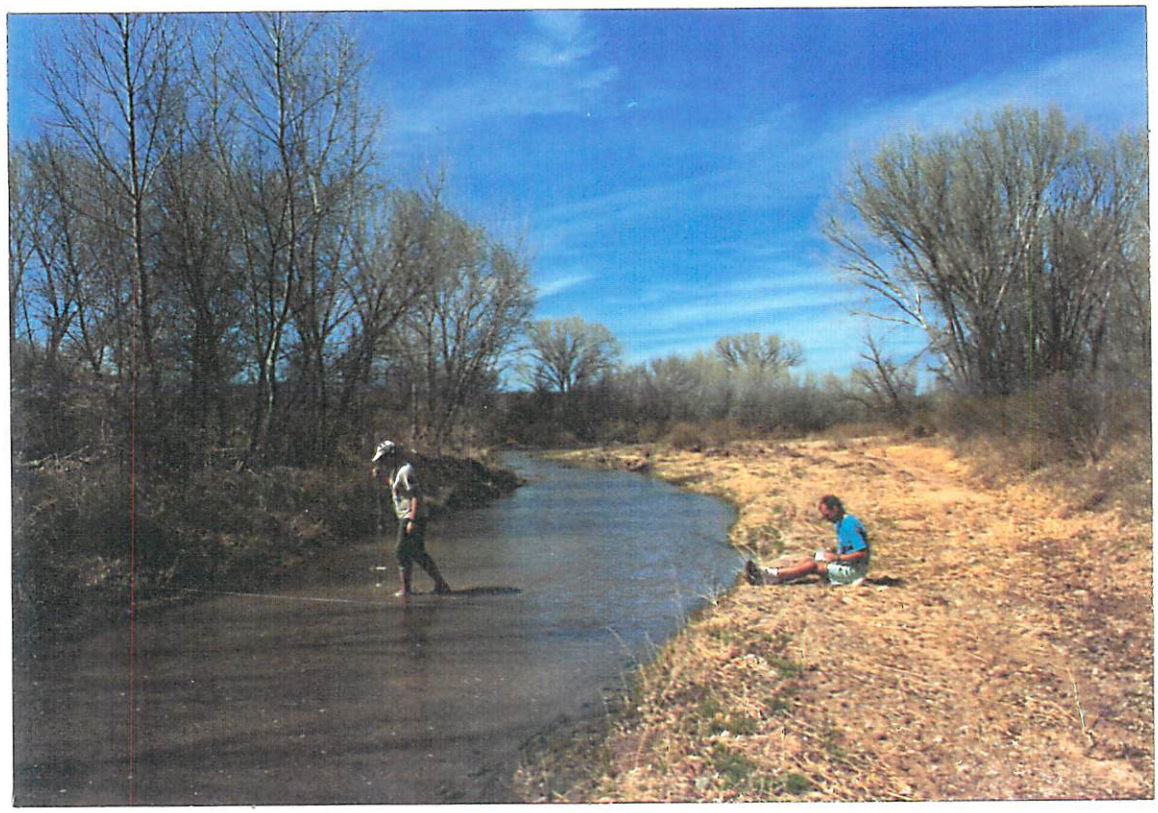


Figure 4-10. Stream gaging at various points along the San Pedro River can help determine the magnitude of transmission losses and gains to the surface water system.

Figure 4-11. During parts of the year and/or during dry periods, transmission losses along the San Pedro River are able to capture all streamflow. Shown here in the foreground is the San Pedro River looking north toward the confluence with the Gila River which can be seen flowing in the center of the photo.

mechanisms before the stream can reach lower areas. When baseflow occurs in the lower watershed stream reaches, it is due more to tributary surface water and groundwater discharge in the lower reaches rather than to the conveyance of upstream baseflow to the lower watershed stream reaches. During most years, only prolonged high winter flows and significant summer flood flows are able to pass through the gauntlet of transmission losses and appear in the lower reaches of the stream or discharge to the Gila River.

Tables 4-1 through 4-5 illustrate this effect. There are United States Geological Survey (USGS) stream gaging records for the San Pedro River at the Palominas, Tombstone, Benson, Redington, and Winkelman gages during the 1971 water year. Referring to Table 4-1, on July 24 the Palominas gage recorded a significant runoff event entering the United States from Mexico. From an examination of the downstream gage records, it appears that the storm producing the runoff event was confined to Mexico and did not produce high runoff in the United States. The bottom of Table 4-1 shows that two distinct peak flows occurred on July 24. A peak discharge of 2,720 cubic feet per second (cfs) was recorded at 5:00 a.m. and a second peak of 3,720 cfs was recorded at 8:30 p.m. The total discharge for July 24 and 25 was the sum of the two daily average discharge flows or 1,540 cfs-days (cfs-days is a measure of volume of water; an example is 10 cfs continuous flow over 3 days time is 30 cfs-days).

Following the event downstream, the Tombstone gage (Table 4-2) shows the effect of travel time with more of the discharge appearing later on the 25th. However, the total discharge for the two days has decreased to 1,416 cfs-days. Moving downstream to the Benson gage (Table 4-3) most of the discharge occurred on the 25th and totaled 1,140 cfs-days or about 75 percent of the total at Palominas. The next downstream gage at Redington (Table 4-4) indicates dramatic transmission losses with only 687 cfs-days total. Finally, at the Winkelman gage (Table 4-5) located one mile upstream from the mouth of the San Pedro River, 525 cfs-days were recorded on the 25th and 26th or about a third of the runoff that entered the United States from Mexico.

TABLE 4-1
SAN PEDRO RIVER DISCHARGE DATA (1971) - PALOMINAS
DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1971

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	7.1	.60	0	3.3	2.3	4.4	.20	.10	0	0	67	36
2	5.1	.70	0	3.3	2.3	3.5	.10	.10	.10	0	32	393
3	3.8	.70	.10	2.8	2.3	3.8	.10	.10	0	0	32	56
4	2.5	.60	.20	1.7	1.6	4.4	.10	0	0	0	57	47
5	1.4	.80	.30	1.4	1.9	4.4	.10	0	0	6.3	45	44
6	1.0	1.0	.20	1.5	1.9	3.5	.10	0	0	0	14	42
7	.70	1.1	.40	1.5	1.9	3.3	.10	0	0	0	8.6	40
8	.60	1.4	.20	1.5	1.7	3.0	.10	0	0	0	5.8	67
9	.60	1.6	.40	1.5	1.9	2.8	.20	0	0	0	32	54
10	.50	1.6	1.2	1.5	1.2	2.3	.50	.10	1.0	0	519	46
11	.50	1.7	1.4	1.7	1.2	2.3	.30	.10	1.0	0	2,140	44
12	.30	1.7	1.4	1.7	1.0	2.1	.10	.20	1.0	0	391	38
13	.40	1.6	1.1	1.7	1.1	1.9	.10	.50	0	0	1,680	35
14	.30	.60	1.6	1.4	1.2	1.4	0	.10	0	0	346	33
15	.20	.50	2.8	1.1	.70	2.1	0	.20	0	0	1,090	30
16	.20	.60	2.8	1.1	.60	2.3	.10	0	0	82	236	26
17	.20	.50	3.0	1.6	.70	2.1	0	.20	0	49	113	28
18	.10	.30	3.5	1.6	1.9	2.1	0	.10	0	27	199	151
19	.20	.10	3.5	1.2	2.5	2.1	0	.10	0	4.9	892	334
20	.20	.10	4.7	1.4	2.8	.80	0	.10	0	.70	1,980	30
21	.20	.10	5.1	.80	2.8	.30	0	.10	0	289	1,010	20
22	.20	.10	3.5	1.0	3.3	.30	0	0	0	206	400	10
23	.20	0	4.7	1.4	3.0	.20	0	0	0	22	250	10
24	.20	0	5.4	1.1	3.8	.20	0	.10	7.3	1,300	395	9.6
25	.20	0	3.3	1.1	4.1	.70	0	.30	0	240	102	12
26	.30	0	3.0	1.1	4.1	.60	0	.20	0	20	40	8.6
27	.20	0	5.1	1.1	4.1	.60	0	.30	0	16	40	8.6
28	.40	0	3.8	1.0	4.1	.50	.10	.60	0	48	40	5.0
29	.60	0	3.3	1.0	----	.20	0	.70	0	662	185	9.6
30	.60	0	3.0	1.2	----	.20	0	.70	0	502	62	12
31	.60	----	3.0	1.9	----	.20	----	0	----	584	74	----
TOTAL	29.60	18.00	72.00	47.20	62.00	58.60	2.30	5.00	10.40	4,058.90	12,477.4	1,679.4
MEAN	.95	.60	2.32	1.52	2.21	1.89	.077	.16	.35	131	402	56.0
MAX	7.1	1.7	5.4	3.3	4.1	4.4	.50	.70	7.3	1,300	2,140	393
MIN	.10	0	0	.80	.60	.20	0	0	0	0	0	5.0
AC-FT	59	36	143	94	123	116	4.6	9.9	21	8,050	24,750	3,330

CAL YR 1970 TOTAL 7,932.10 MEAN 21.7 MAX 1,850 MIN 0 AC-FT 15,730
WTR YR 1971 TOTAL 18,520.80 MEAN 50.7 MAX 2,140 MIN 0 AC-FT 36,740

PEAK DISCHARGE (BASE, 2,400 CFS)

DATE	TIME	G.H.	DISCHARGE	DATE	TIME	G.H.	DISCHARGE
7-24	0500	7.65	2,720	8-11	0830	10.86	6,380
7-24	2030	8.67	3,720	8-13	0930	8.25	3,290
7-29	0500	7.63	2,700	8-15	0130	9.35	4,460
7-30	2200	9.15	4,240	8-20	0300	8.10	3,140
8-10	1930	8.05	3,090				

NOTE. - - Doubtful or no gage-height record August 21 to September 30.

TABLE 4-2

SAN PEDRO RIVER DISCHARGE DATA (1971) - TOMBSTONE
DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1971

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	9.3	7.7	11	17	14	29	14	7.1	2.2	0	109	82
2	7.0	7.7	12	19	15	33	12	7.6	2.0	0	63	514
3	5.0	8.5	12	17	14	30	14	7.5	2.0	0	50	268
4	5.0	9.4	11	20	11	29	12	7.5	2.0	0	174	46
5	5.0	8.6	10	13	17	26	12	7.0	1.5	0	56	38
6	5.0	8.9	9.5	15	22	25	13	7.0	1.0	0	58	23
7	4.9	8.2	11	25	18	25	13	7.0	1.0	0	46	17
8	4.2	8.6	10	34	20	27	15	7.0	1.0	0	43	58
9	3.7	11	9.8	19	21	27	14	6.5	1.2	0	44	82
10	4.1	11	10	15	19	29	13	6.5	1.0	0	1,110	43
11	5.6	12	8.9	14	23	24	13	6.5	1.0	0	1,880	32
12	5.4	9.7	9.7	14	22	19	12	6.5	1.0	0	432	26
13	4.9	9.4	12	12	25	22	11	6.0	.44	0	1,360	21
14	5.0	8.4	11	12	21	22	12	6.0	.30	0	270	23
15	4.9	8.1	12	13	26	18	11	6.0	.13	0	832	21
16	5.1	7.2	14	13	29	22	9.5	6.0	0	121	68	14
17	5.3	8.3	13	12	26	20	12	5.7	0	90	61	11
18	5.4	9.0	14	14	29	19	10	5.2	0	50	298	67
19	6.0	9.2	15	14	19	21	9.7	5.7	0	135	871	114
20	5.7	11	15	14	29	22	10	5.7	0	9.3	1,520	76
21	5.4	11	13	13	31	18	9.1	5.2	0	19	424	46
22	5.0	11	11	14	27	17	11	4.4	0	354	135	36
23	5.4	12	14	12	32	16	8.2	4.4	0	112	103	30
24	6.3	12	15	13	33	15	8.9	3.9	0	851	185	26
25	6.1	12	16	13	29	15	8.2	3.4	.04	565	292	24
26	6.5	13	16	14	27	16	9.3	2.2	0	91	85	19
27	6.4	13	19	14	34	15	8.1	2.5	0	65	73	17
28	6.7	14	21	16	33	14	7.4	2.5	0	56	138	16
29	6.9	11	18	14	----	15	8.3	2.2	0	782	61	46
30	7.6	12	16	13	----	14	7.5	2.2	0	134	125	43
31	8.2	----	15	13	----	15	----	2.2	----	970	88	----
TOTAL	177.0	302.9	404.9	475	666	659	328.2	165.1	17.81	4,404.3	11,054	1,879
MEAN	5.71	10.1	13.1	15.3	23.8	21.3	10.9	5.33	.59	142	357	62.6
MAX	9.3	14	21	34	34	33	15	7.6	2.2	970	1,880	514
MIN	3.7	7.2	8.9	12	11	14	7.4	2.2	0	0	43	11
AC-FT	351	601	803	942	1,320	1,310	651	327	35	8,740	21,930	3,730

CAL YR 1970 TOTAL 15,227.60 MEAN 41.7 MAX 1,610 MIN 0 AC-FT 30,200
WTR YR 1971 TOTAL 20,533.21 MEAN 56.3 MAX 1,880 MIN 0 AC-FT 40,730

PEAK DISCHARGE (BASE, 3,000 CFS)

DATE	TIME	G.H.	DISCHARGE	DATE	TIME	G.H.	DISCHARGE
8-10	2130	8.00	9,220	8-19	0115	5.68	3,690
8-13	0015	7.46	7,600	9-02	2345	6.39	5,280
8-15	0815	5.83	4,020				

TABLE 4-3

SAN PEDRO RIVER DISCHARGE DATA (1971) - BENSON
DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1971

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	22									0	192	44
2	28									0	59	66
3	0									0	715	585
4	0									0	373	96
5	0									0	63	42
6	0									0	4.1	16
7	0									0	0	5.0
8	0									0	0	85
9	0									0	0	64
10	0									0	3.6	31
11	0									0	3,080	20
12	0									0	732	12
13	0									0	1,790	5.3
14	0									0	993	.60
										0	1,670	0
16	0									0	320	0
17	0									54	142	274
18	0									25	92	163
19	0									96	1,300	101
20	0									12	2,660	124
21	0									.60	1,220	45
22	0									107	355	15
23	0									102	170	5.0
24	0									559	106	0
25	0									581	464	0
26	0									108	123	0
27	0									50	60	0
28	0									103	225	0
29	0				---					336	164	0
30	0				---					421	44	80
31	0	---			---		---		---	529	86	----
TOTAL	50	0	0	0	0	0	0	0	0	3,083.60	17,205.7	1,878.90
MEAN	1.61	0	0	0	0	0	0	0	0	99.5	555	62.6
MAX	28	0	0	0	0	0	0	0	0	581	3,080	585
MIN	0	0	0	0	0	0	0	0	0	0	0	0
AC-FT	99	0	0	0	0	0	0	0	0	6,120	34,130	3,730

CAL YR 1970 TOTAL 15,215.00 MEAN 41.7 MAX 1,650 MIN 0 AC-FT 30,180
WTR YR 1971 TOTAL 22,218.20 MEAN 60.9 MAX 3,080 MIN 0 AC-FT 44,070

PEAK DISCHARGE (BASE, 3,000 CFS)

DATE	TIME	G.H.	DISCHARGE	DATE	TIME	G.H.	DISCHARGE
8-03	2230	9.14	7,130	8-15	0100	6.82	4,630
8-11	0630	9.34	7,390	8-15	1400	5.90	3,390
8-11	2030	6.31	3,970	8-19	2400	8.29	6,240
8-13	1300	7.12	4,970	8-20	2300	7.80	5,700

TABLE 4-4

SAN PEDRO RIVER DISCHARGE DATA (1971) - REDINGTON
DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1971

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	.80	.50	.60	1.1	.40	.80	.20			0	302	42
2	25	.50	.60	1.4	.50	1.8	.30			0	100	40
3	4.0	.60	.60	1.8	.20	.80	.30			0	50	419
4	2.5	.40	.60	1.1	.90	.60	.30			0	878	110
5	2.0	.30	.70	1.1	.50	.60	.20			0	41	50
6	1.5	.20	.60	1.1	.20	.60	.20			0	12	20
7	1.1	.40	.60	1.1	0	.60	.10			0	4.0	10
8	1.2	.60	.70	1.1	.30	.60	.10			0	2.0	20
9	1.4	.70	.80	1.1	.20	.60	.10			0	1.7	99
10	1.4	.70	.80	1.1	0	.60	.10			0	1.5	5.0
11	1.2	.80	1.1	1.1	.20	.50	.10			0	2,290	5.0
12	1.4	.70	1.0	1.1	.20	.50	.10			0	835	3.0
13	1.2	.70	1.0	1.1	.20	.40	.10			0	1,160	2.4
14	1.1	.80	.80	1.1	.10	.40	.10			0	1,060	2.4
15	.80	1.0	.80	1.1	.10	.40	.30			0	1,290	2.4
16	.70	1.0	.80	1.1	.10	.40	.10			0	472	1.4
17	.60	.80	.80	1.1	.30	.40	.10			28	149	25
18	.50	1.0	1.0	1.1	.30	.40	.20			26	80	303
19	.40	1.0	1.0	.60	.50	.40	.30			93	924	117
20	.20	1.0	1.0	.50	1.4	.40	.30			5.0	2,180	54
21	.20	.80	1.0	.50	1.2	.40	.10			2.0	1,970	20
22	.10	.80	1.1	.50	1.1	.40	.10			1.1	485	10
23	.30	1.0	1.1	.50	1.0	.40	.10			116	170	5.0
24	.20	1.0	1.1	.60	.80	.30	.10			176	245	5.0
25	.10	1.1	1.1	.60	.80	.30	.10			511	314	2.0
26	.30	1.0	1.1	.50	.70	.10	0			88	148	2.0
27	.30	.70	1.2	.40	1.0	.10	0			24	82	2.0
28	.60	.50	1.2	.40	1.1	.20	0			29	143	1.0
29	.50	.50	1.1	.50	----	.20	0			75	90	1.0
30	.60	.60	1.1	.50	----	.50	----			601	113	5.0
31	.40	----	1.1	.50	----	.20	----			394	62	----
TOTAL	52.60	21.70	28.10	27.40	14.30	14.90	4.10	0	0	2,169.1	15,654.	21,383.6
MEAN	1.70	.72	.91	.88	.51	.48	.14	0	0	70.0	505	46.1
MAX	25	1.1	1.2	1.8	1.4	1.8	.30	0	0	601	2,290	419
MIN	.10	.20	.60	.40	0	.10	0	0	0	0	1.5	1.0
AC-FT	104	43	56	54	28	30	8.1	0	0	4,300	31,050	2,740

CAL YR 1970 TOTAL 14,392.60 MEAN 39.4 MAX 1,450 MIN 0 AC-FT 28,550
WTR YR 1971 TOTAL 19,370.00 MEAN 53.1 MAX 2,290 MIN 0 AC-FT 38,420

PEAK DISCHARGE (BASE, 3,000 CFS)

DATE	TIME	G.H.	DISCHARGE	DATE	TIME	G.H.	DISCHARGE
8-4	0230	14.16	7,280	8-15	0400	12.45	3,080
8-11	1000	14.80	8,600	8-20	0400	14.27	7,310
8-13	0930	13.15	4,450	8-21	0230	14.15	6,950

TABLE 4-5

SAN PEDRO RIVER DISCHARGE DATA (1971) - WINKELMAN
DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1970 TO SEPTEMBER 1971

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	0	.40	10	3.0	5.5	.70			0	389	121
2	1.7	0	.40	10	4.4	4.4	1.1			0	58	23
3	130	0	.40	10	4.4	4.9	.60			0	8.2	63
4	54	0	.40	9.0	5.5	5.5	.60			0	362	222
5	.40	0	.60	6.8	6.1	4.9	1.9			0	60	44
6	1.1	0	.40	6.1	6.1	4.4	1.3			0	13	12
7	.10	0	.60	6.8	5.5	3.9	1.3			0	13	3.9
8	0	0	.60	7.5	4.9	3.0	1.3			0	5.5	232
9	0	0	1.1	7.5	4.9	2.2	.60			0	22	434
10	0	0	1.1	6.1	4.9	1.9	.40			0	6.8	28
11	.10	0	1.3	7.5	4.9	1.6	.30			0	1,080	19
12	0	0	1.3	7.5	4.4	1.6	.20			0	1,270	10
13	0	0	1.9	7.5	4.4	1.6	.40			0	865	5.5
14	0	0	1.9	8.2	3.0	1.3	0			0	937	4.4
15	0	0	3.4	6.1	3.0	2.2	.60			0	1,020	1.9
16	0	0	3.9	3.9	2.6	2.6	.30			0	764	.90
17	0	0	4.9	3.0	2.2	2.2	.10			0	452	.30
18	0	0	4.9	2.2	3.0	2.2	0			0	878	.10
19	0	0	5.5	1.6	3.9	2.6	.20			91	1,900	60
20	0	0	6.1	1.3	3.9	3.9	.30			65	2,230	51
21	0	0	7.5	1.1	3.9	4.4	.40			3.4	2,590	51
22	0	.40	9.0	1.1	3.9	3.9	.20			.20	2,070	18
23	0	0	9.0	.90	3.9	3.4	.20			.90	218	11
24	0	0	8.2	.90	3.9	3.0	0			47	144	9.0
25	0	.10	9.0	1.3	3.9	1.6	0			306	154	4.9
26	0	.10	11	1.6	3.9	1.1	0			219	240	2.2
27	0	.10	12	2.2	4.4	1.3	.10			37	66	1.6
28	0	.10	12	2.2	4.9	1.1	.10			36	172	.40
29	0	.20	12	2.6	----	1.1	0			35	84	411
30	0	.40	12	3.0	----	1.1	0			366	51	370
31	0	----	11	3.0	----	.90	----			128	39	----
TOTAL	187.40	1.40	153.80	148.50	117.7	85.30	13.20	0	0	1,344.50	18,161.5	2,215.10
MEAN	6.05	.047	4.96	4.79	4.20	2.75	.44	0	0	43.0	586	73.8
MAX	130	.40	12	10	6.1	5.5	1.9	0	0	366	2,590	434
MIN	0	0	.40	.90	2.2	.90	0	0	0	0	5.5	.10
AC-FT	372	2.8	305	295	233	169	26	0	0	2,650	36,020	4,390

CAL YR 1970 TOTAL 12,927.50 MEAN 35.4 MAX 2,080 MIN 0 AC-FT 25,640
WTR YR 1971 TOTAL 22,418.40 MEAN 61.4 MAX 2,590 MIN 0 AC-FT 44,470

PEAK DISCHARGE (BASE, 4,000 CFS)

DATE	TIME	G.H.	DISCHARGE	DATE	TIME	G.H.	DISCHARGE
8-11	2200	8.80	4,430	8-19	2200	9.00	5,240
8-18	0230	9.07	5,450	8-20	1400	9.29	6,110
8-19	0630	10.55	10,500	8-22	0500	9.39	6,400

Factors Affecting Transmission Losses During the Winter Season

During the winter months, the effects of transmission losses can also be significant in the reaches where significant depletions occur during the growing season. It may take most of the winter to restore the floodplain aquifer to the point where continuous surface flows can resume. In drier years the aquifer may not be fully recharged and continuous flow through the reach may not occur during the winter. Tables 4-6 and 4-7 are stream gaging records for the Tombstone and Benson gages during the 1973 water year, a heavy runoff year during the winter months. Notice the differences in discharge between the upstream Tombstone gage and downstream Benson gage during December through February. Although the St. David and Pomerene ditches divert flow between these two gages with a combined maximum capacity of 44 cfs, crop uses are low at that time of the year and most of the applied water is returned to the hydrologic system as excess irrigation, deep percolation, or return flow. Likewise, phreatophyte uses are small during these months. Nevertheless, since the flow at the Benson gage is zero for much of these months, the floodplain aquifer is able to absorb all of the excess supply entering the reach plus any tributary flows entering between the two gages. When the discharge at Tombstone increased substantially on February 22, the Benson gage began to record runoff which continued until March 31. Note the difference in flow between the gages in late March when natural and cultural uses began increasing in the reach. The Tombstone gage was still recording over 40 cfs when the flow at the Benson gage had rapidly decayed to zero.

Long-term Average Annual Effects

The net effect of transmission losses and gains for the inner valley of the San Pedro River for annual and seasonal streamflows are shown in Figure 4-12. This figure indicates how much of the annual and seasonal discharge passing an upstream point will theoretically appear at a downstream point. It is important to note that during the wintertime almost all of the transmission losses occur by the time flow reaches the Benson gage as illustrated by the discussion in the previous paragraph. Summertime (as compared to wintertime) transmission losses occur throughout the entire San Pedro River reach as shown in Figure 4-12. The actual percentage of stream depletions on an annual and seasonal basis for each subwatershed is given in Table 4-8. The results given in this table were based on the most recent twenty year period of record for

TABLE 4-6

SAN PEDRO RIVER DISCHARGE DATA (1973) - TOMBSTONE
DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	8.5	17	20	21	29	43	34	16	2.0	0	10	1.6
2	7.4	17	20	23	31	41	36	17	2.2	0	45	.51
3	8.5	17	17	19	33	31	41	17	1.5	0	9.3	0
4	30	19	17	22	33	29	34	16	.39	0	7.8	0
5	95	19	19	25	32	31	28	17	0	0	4.5	0
6	92	17	19	26	31	30	28	17	0	0	3.4	0
7	56	17	17	26	30	33	28	13	0	75	2.5	0
8	46	16	20	28	30	34	26	13	0	28	1.0	0
9	43	16	20	24	30	35	23	13	0	3.5	.04	0
10	43	16	20	22	30	32	21	12	0	9.4	0	0
11	41	16	19	24	27	29	19	12	0	.97	158	0
12	38	17	20	19	27	32	16	9.7	1.5	84	27	0
13	38	16	20	21	28	41	16	9.5	4.0	43	10	0
14	34	17	22	24	31	65	16	10	2.8	197	4.5	0
15	32	17	26	25	31	224	17	8.5	.93	374	3.0	0
16	36	19	21	28	31	220	17	10	0	167	1.6	0
17	36	25	21	26	31	148	19	18	0	75	.57	0
18	121	24	20	24	32	110	19	31	0	25	0	0
19	554	23	18	22	30	95	17	19	0	10	0	0
20	256	21	20	26	27	99	13	11	0	5.0	0	0
21	157	18	21	28	40	95	13	6.7	0	5.0	51	.43
22	51	17	22	24	337	67	16	6.7	0	5.0	43	.02
23	34	22	21	23	394	64	16	6.1	0	5.0	46	0
24	25	19	20	26	212	58	11	4.5	0	2.0	15	0
25	23	19	19	25	117	53	.7	4.6	0	2.0	.36	0
26	19	21	17	27	70	46	13	4.0	0	2.0	0	0
27	21	19	17	28	54	51	16	2.4	0	125	0	0
28	17	17	19	28	51	48	16	2.1	0	20	0	0
29	19	21	19	25	----	46	14	1.7	0	143	0	0
30	21	22	21	27	----	43	13	1.6	0	50	8.6	0
31	17	----	23	34	----	41	---	1.6	---	15	4.1	---
TOTAL	2,019.4	561	615	770	1,879	2,014	605.7	331.7	15.32	1,566.9	456.27	2.56
MEAN	65.1	18.1	19.8	24.8	67.1	65.0	20.2	10.7	.51	50.5	14.7	.085
MAX	554	25	26	34	394	224	41	31	4.0	374	158	1.6
MIN	7.4	16	17	19	27	29	9.7	1.6	0	0	0	0
AC-FT	4,010	1,110	1,220	1,530	3,730	3,990	1,200	658	30	3,110	905	5.1

CAL YR 1972 TOTAL 13,510.60 MEAN 36.9 MAX 1,480 MIN 0 AC-FT 26,800
WTR YR 1973 TOTAL 10,836.85 MEAN 29.7 MAX 554 MIN 0 AC-FT 21,490

PEAK DISCHARGE (BASE, 3,000 CFS). -- No peak above base.

TABLE 4-7

SAN PEDRO RIVER DISCHARGE DATA (1973) - BENSON
DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1972 TO SEPTEMBER 1973

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	0	15	15	0	0	39				0	9.5	
2	0	15	15	0	0	37				0	1.4	
3	0	15	15	0	0	33				0	3.9	
4	20	15	13	0	0	31				0	1.0	
5	19	15	13	0	0	29				0	.50	
6	85	15	12	0	0	31				0	0	
7	24	15	12	0	0	33				0	0	
8	8.2	15	12	0	0	25				0	0	
9	5.3	15	10	2.1	0	22				0	0	
10	3.1	15	9.5	0	0	20				5.4	0	
11	2.2	15	8.2	0	0	20				131	2.8	
12	1.9	15	9.5	0	0	20				11	18	
13	1.0	15	9.5	0	0	37				2.8	5.0	
14	1.0	15	5.3	0	0	44				116	2.0	
15	.50	20	5.3	0	0	63				355	1.0	
16	.50	30	5.8	0	0	196				489	0	
17	2.8	44	6.4	0	0	159				147	0	
18	148	36	5.8	0	0	103				40	0	
19	884	36	2.8	0	0	75				35	0	
20	307	36	5.3	0	0	64				30	0	
21	192	36	3.9	0	3.7	69				25	0	
22	129	40	2.2	0	394	71				20	12	
23	90	39	.80	0	441	56				15	5.0	
24	69	35	.50	0	208	30				10	1.0	
25	45	30	0	0	108	34				10	0	
26	44	25	0	0	71	36				5.0	0	
27	30	20	.50	0	56	33				5.0	0	
28	25	15	2.1	0	45	15				5.0	0	
29	20	15	0	0	----	5.3				5.0	0	
30	20	15	0	0	----	1.6				50	0	
31	15	----	0	0	----	.20				21	0	
TOTAL	2,192.50	682	200.40	2.1	1,326.7	1,432.10	0	0	0	1,533.2	63.10	0
MEAN	70.7	22.7	6.46	.068	47.4	46.2	0	0	0	49.5	2.04	0
MAX	884	44	15	2.1	441	196	0	0	0	489	18	0
MIN	0	15	0	0	0	.20	0	0	0	0	0	0
AC-FT	4,350	1,350	397	4.2	2,630	2,840	0	0	0	3,040	125	0

CAL YR 1972 TOTAL 14,645.60 MEAN 40.0 MAX 2,430 MIN 0 AC-FT 29,050
WTR YR 1973 TOTAL 7,432.10 MEAN 20.4 MAX 884 MIN 0 AC-FT 14,740

PEAK DISCHARGE (BASE, 3,000 CFS). -- NO PEAK ABOVE BASE.

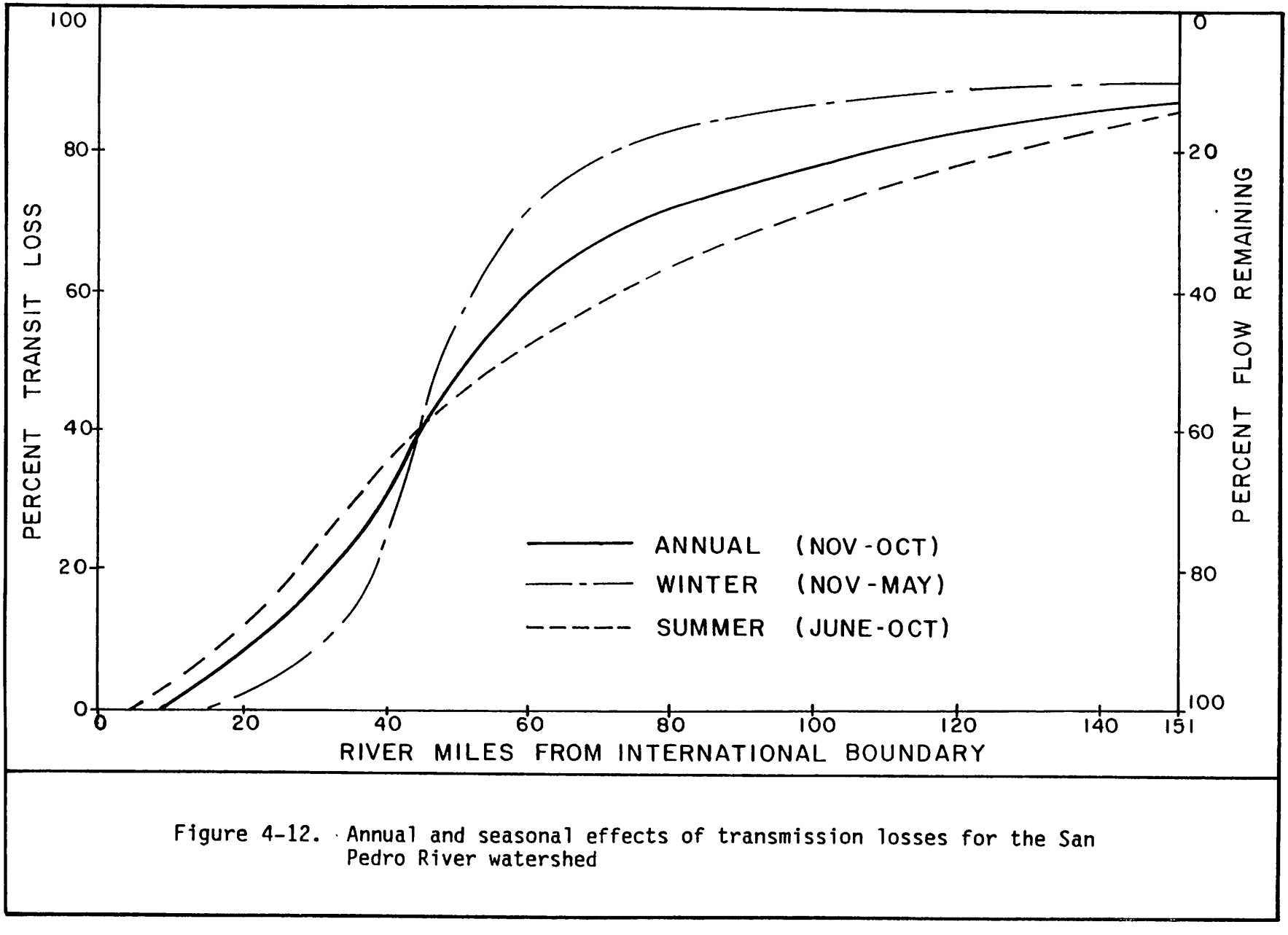


Figure 4-12. Annual and seasonal effects of transmission losses for the San Pedro River watershed

each gage analyzed. This was typically for the period of 1968 through 1987. Regression analysis was used to fill in missing data. Work sheets showing these analyses are available from DWR. Table 4-8 shows that on an annual basis, of the water entering the United States from Mexico, 100 percent reaches the Sierra Vista subwatershed, 31 percent reaches the Redington subwatershed, and only 13 percent reaches the watershed outlet. Beginning with the Sierra Vista subwatershed of the Mexico water that reaches the Benson subwatershed, only 45 percent reaches the Redington subwatershed, and only 19 percent reaches the watershed outlet. For each subsequent subwatershed, the percent of Mexico water remaining was normalized to 100 percent of the inflow to the next subwatershed, thereby illustrating the losses of Mexico water from one subwatershed to the next. Only the inflow from Mexico illustrates the transmission losses through the entire reach of the San Pedro River system. As illustrated in Figure 4-12, 87 percent of the inflow to the United States from Mexico is lost to cultural and natural uses before reaching the confluence with the Gila River.

TABLE 4-8

NORMAL PERCENT OF WATER VOLUMES REACHING DOWNSTREAM SUBWATERSHEDS ON AN ANNUAL AND SEASONAL BASIS

SUBAREAS OF WATER USE	SIERRA VISTA	BENSON	REDINGTON	WINKELMAN	OUTFLOW
Annual					
Inflow from:					
Mexico	100	69	31	17	13
Sierra Vista		100	45	25	19
Benson			100	55	42
Redington				100	76
Winkelman					100
Winter					
Inflow from:					
Mexico	100	76	18	11	10
Sierra Vista		100	24	9	8
Benson			100	61	55
Redington				100	91
Winkelman					100
Summer					
Inflow from:					
Mexico	100	65	38	20	15
Sierra Vista		100	58	31	23
Benson			100	53	40
Redington				100	75
Winkelman					100

Impacts of Withdrawals from Indirect Interference Areas

Factors that may affect transmission gains and losses in the future include impacts of withdrawals from indirect interference areas. Indirect interference areas are defined as areas where groundwater withdrawals are currently depleting water from storage and intercepting mountain front recharge. The major area of indirect interference is the cone of depression around the Sierra Vista - Fort Huachuca area. At the present time, there are no impacts direct to the surface water system due to these groundwater withdrawals. Future withdrawals have the potential to directly impact the surface water system if the cone of depression intersects the surface flows of the San Pedro River. It is not known if or when this will occur; however, groundwater gains to the San Pedro River in the reach between Palominas and Charleston, and Charleston and the mouth of the Babocomari River have been estimated to decrease from 4.2 cfs and 1.2 cfs, 1985 conditions, to approximately 3.7 and 0.9 cfs, respectively, in the year 2000 (Putman et al., 1988). This indicates that due to indirect interference there may be an impact to the surface water system over time which may affect the transmission losses and gains along the San Pedro River. For additional information refer to Chapter 6, Section 6.3 regarding the significant diminishment to the SPRNCA.

ARAVAIPA CREEK

The Aravaipa Creek subwatershed includes approximately twenty-two miles of perennial flow in Aravaipa Creek. The perennial reach of Aravaipa Creek has been noted to start within the North ½, Section 35, Township 6 South, Range 19 East (Ellingson, 1980) and continues to flow through the Galiuro Mountains in Aravaipa Canyon. This flow is attributed to groundwater within the younger alluvium surfacing due to hard rock constrictions at the entrance of the canyon. Surface water flows exit the canyon through the western side of the Galiuro Mountains. Surface water flows then begin to infiltrate into the younger alluvium and continue to move downgradient as subflow into the Winkelman subwatershed. Only during significant storm events do surface flows in Aravaipa Creek reach the San Pedro River.

Factors Affecting Transmission Losses

The major factors that affect transmission losses in the Aravaipa subwatershed include phreatophyte evapotranspiration, surface water diversions, and seasonal reduction of available precipitation that is expressed as mountain front recharge to the stream. On a seasonal basis, these factors would probably have a greater impact in the summer when there is less precipitation, more irrigation diversions, and more consumptive use due to phreatophyte growth (Ellingson, 1980). This would result in less available discharge to the stream from the regional aquifer and begin a depletion of the water in storage in the younger alluvium. This situation will begin to reverse itself beginning with the summer rainy season when additional precipitation will begin to recharge the groundwater system in this area. Augmentation of the streamflow within the Aravaipa subwatershed will continue to increase through the winter season as consumptive uses diminish due to a decrease in both surface water diversions and phreatophyte evapotranspiration.

Transmission losses for Aravaipa Creek through Aravaipa Canyon are dependent on the occurrence and storage capacity of the younger alluvium. Where the younger alluvium is present within Aravaipa Canyon, surface water infiltrates and streamflow is reduced. Where there is little or no younger alluvium within the canyon, bedrock would force subflow to the surface and create additional streamflow. Other factors that may influence transmission losses or gains of streamflow within the canyon include additional surface water contributions from side canyons or consumptive uses due to phreatophytes within the canyon.

4.5 RIPARIAN SALVAGE

Prior to cultural development in the San Pedro River watershed, riparian vegetation occupied the floodplains of the principal streams. Most of the irrigated lands that have since been put into cultivation also occupy those same floodplains, and in many instances the irrigated lands were developed by removing the naturally occurring riparian vegetation. A large percentage of the cleared vegetation were trees and grasses known as phreatophytes, or plants which can obtain their water requirements directly from an underlying aquifer. They are thus able to utilize significant amounts of water. In fact, sometimes the lands cleared of phreatophytes and put into cultivation use less water per acre than was being used by the phreatophytes under natural conditions. However, in all cases where phreatophytic riparian vegetation has been cleared to make way for irrigated agriculture, the amount of water that was being used by the removed natural vegetation has been eliminated. Thus as

Figure 4-13. If given the opportunity, phreatophytic vegetation will re-establish itself within cleared land within the inner valley. As shown here, an abandoned pasture (discontinued irrigation) is quickly replaced by tamarisk and mesquite near Winkelman.

a consequence of initiating a cultural use, natural uses have been reduced. This effect is referred to in this report as "riparian salvage."

Quantifying riparian salvage requires a prediction of the extent and type of natural vegetation that would most likely have been present in the absence of the currently developed irrigated lands. The predictive technique employed for this analysis was based on an assumption that phreatophytes could occupy lands currently cultivated to the density and composition found on adjacent, uncleared land. The methodology is explained in APPENDIX D.

The area of riparian displacement for six primary vegetation classes was estimated for the watershed by subwatershed. About 2,900 acres are predicted to have been displaced in the watershed by currently irrigated land, and about 2,100 acres of this total is determined to have formerly been occupied by dense or medium dense mesquite. This comprises about 18 percent of the current irrigated area and 14 percent of the present total riparian area.

The amount of water use associated within the areas of displacement was estimated next. As defined above, the total riparian salvage in the San Pedro River watershed is calculated to be 7,630 acre-feet per year under current irrigation development conditions. The annual average consumptive use for the displaced vegetation is calculated to be 3.05 acre-feet per acre. The displacing irrigation, based on the irrigation consumptive use quantification described in Chapter 3, has a lower annual watershed average consumptive use of 2.42 acre-feet per acre.

This analysis indicates that the net effect on the hydrologic system due to all irrigation uses in the San Pedro River watershed is not the apparent total annual consumptive use of 32,470 acre-feet as reported in Chapter 3, Section 3.2, but rather must be reduced by the total riparian salvage of approximately 7,630 acre-feet. The net effect on the hydrologic system due to irrigation uses is therefore 24,840 acre-feet per year.

4.6 CLASSIFICATION OF WELLS PURSUANT TO COURT ORDER

On September 9, 1988, the Court entered a comprehensive order regarding the relationship between groundwater and surface water in the Gila River General Adjudication. The order addresses legal issues brought before the Court under both state and federal water law. It also directs DWR to classify wells reported in its HSRs according to the category of water being withdrawn. There are three categories identified by the order: 1) wells withdrawing appropriable subflow, 2) wells whose withdrawals significantly diminish federal reserved rights, and 3) wells whose withdrawals do not significantly affect appropriators under state law or significantly diminish water available to a federal reservation.

DWR's first step in implementing these provisions of the order was to delineate distinct hydrologic areas within the San Pedro River watershed that apply to each of the above three categories. These three hydrologic areas are referred to in this report as Zone 1, Zone 2, and Zone 3, respectively. The next step in implementing the order involves assigning each of the wells identified and reported in the HSR to one of the three zones. This section of Chapter 4 describes the technical methodology that was utilized to delineate Zones 1, 2, and 3, displays or references maps which show the areas encompassed, and describes the method by which wells are assigned to each zone. Figure 4-14 and Plate 1 show the San Pedro River watershed with the delineated three zones of water use as determined by DWR.

The association between the three delineated zones of groundwater use is depicted on Figure 4-15. This figure displays a three-dimensional diagram of a cross section of the San Pedro River valley. Shown are the relationships of the three zones depicting well classification, the two major aquifers (regional and floodplain), tributary groundwater, and a non-tributary alluvial aquifer. The remaining portion of this section describes how the three groundwater zones were delineated by DWR in accordance with the 1988 Court order.

ZONE 1 USES

The Court's order of September 9, 1988, directed DWR to determine the boundary within which wells are presumed, for purposes of the HSR, to be

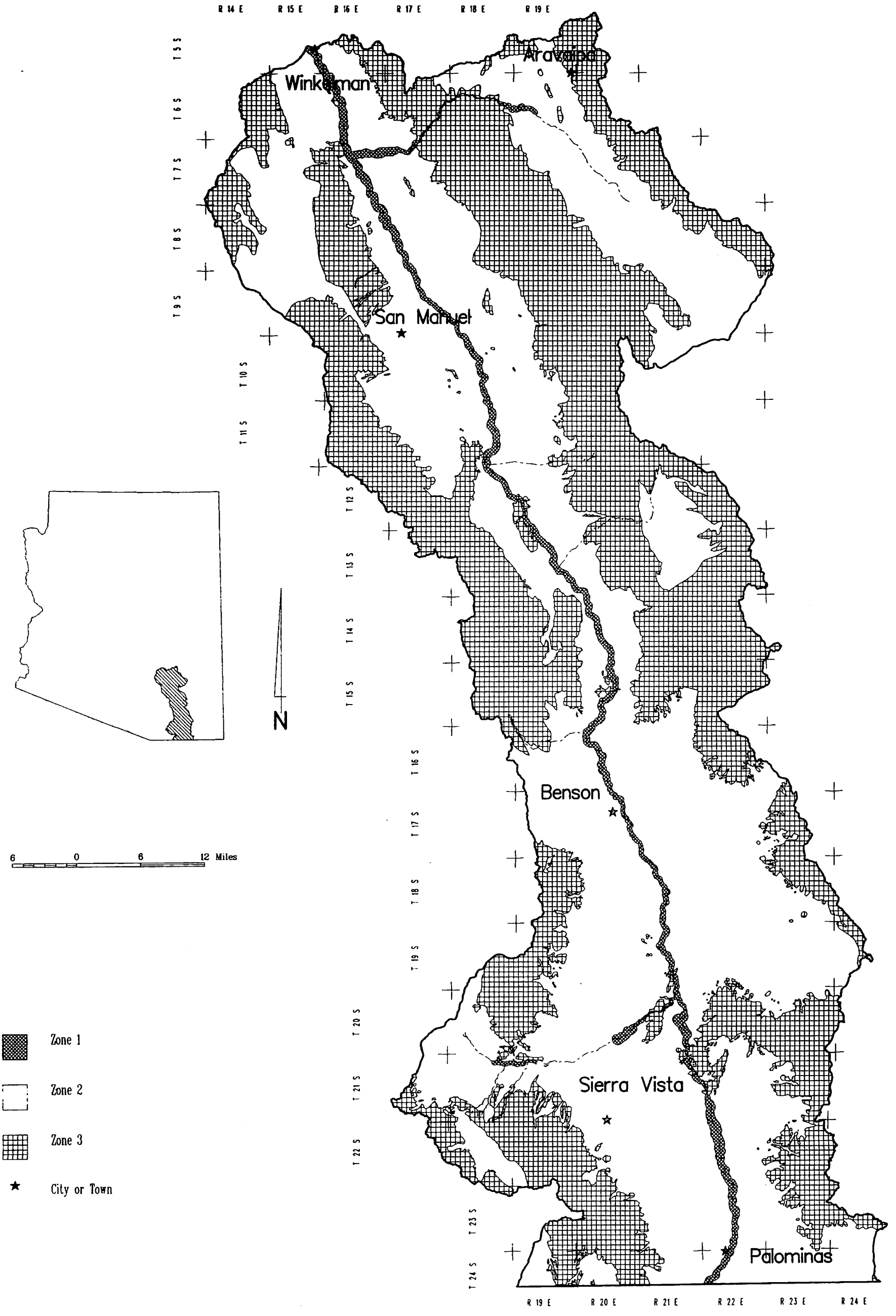


Figure 4-14. Delineation of the three groundwater zones

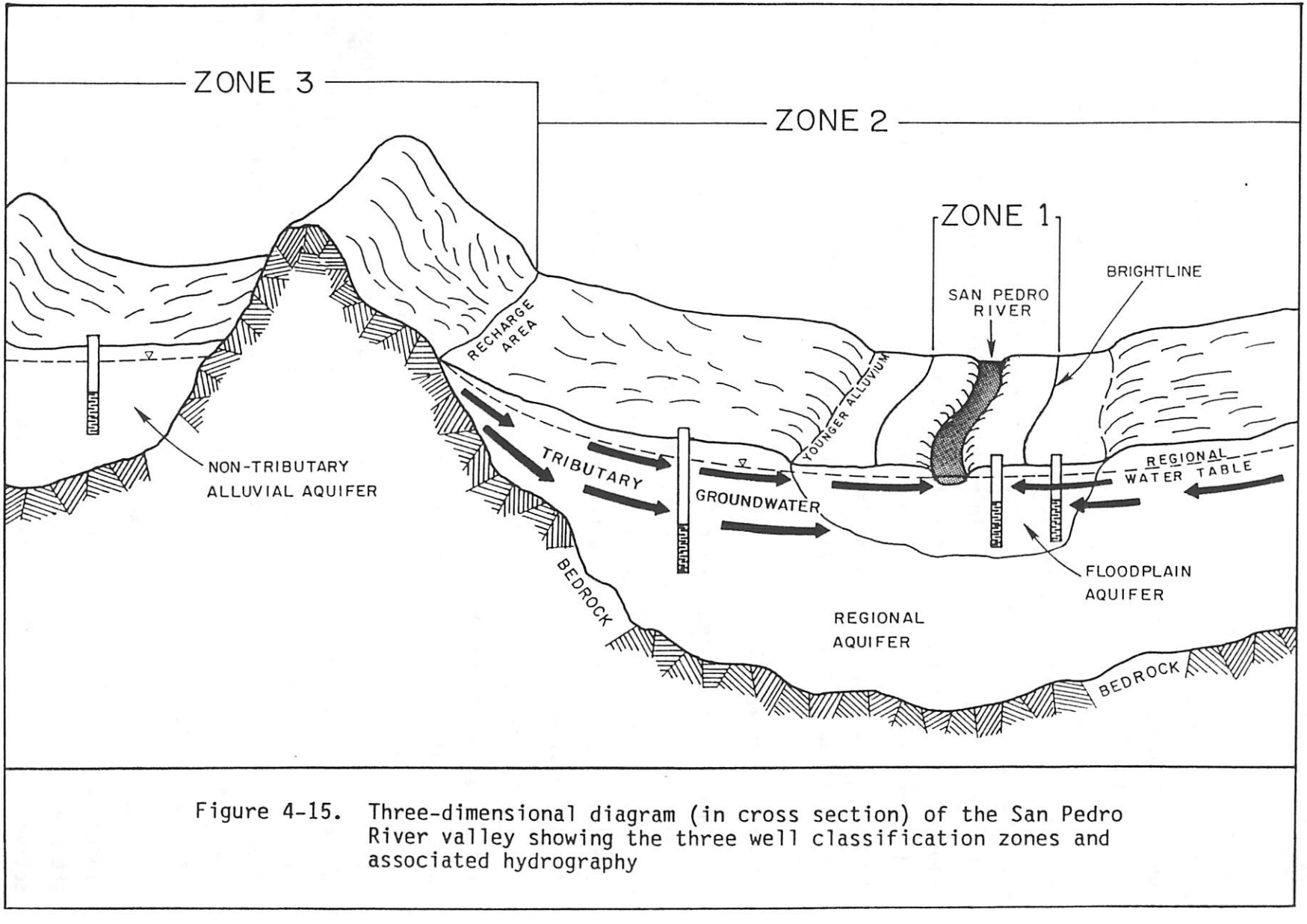


Figure 4-15. Three-dimensional diagram (in cross section) of the San Pedro River valley showing the three well classification zones and associated hydrography

pumping appropriable streamflow. The technical test for delineating this boundary is ". . . as to wells located in or close to that younger alluvium, the volume of stream depletion would reach 50% or more of the total volume pumped . . ." and the ". . . period of withdrawal is equivalent to 90 days of continuous pumping." DWR's interpretation of this provision is that it requires the Department to delineate a "brightline" on both sides of the stream within which wells would be classified as withdrawing Zone 1 water. The "brightline" itself represents the distance outward from the stream bank where 50 percent of the volume of water pumped from a well would be expected to be derived from streamflow diminishment after 90 days of continuous pumpage. DWR refers to the area between the "brightlines" as Zone 1. This section describes the methodology which DWR employed to delineate the "brightline" and identify water uses withdrawing Zone 1 groundwater. APPENDIX E furnishes additional information on the developed methodology.

Delineation of Zone 1

There are two primary hydrologic principles involved in developing a "brightline": 1) stream conditions under which groundwater and surface water interrelationships occur (Section 4.1) and 2) the technical theory and formulas to calculate the amount of diminishment of streamflow due to pumpage from a nearby well.

From a technical perspective, a well can only pump streamflow if there is at least an occasional hydraulic connection between the surface stream and the adjacent aquifer. The extent of this stream/aquifer connection can be predicted on the basis of whether the stream involved is perennial, intermittent, or ephemeral. Perennial streams flow all the time and their base or low flows are maintained by the discharge of water from an aquifer into a stream (Figure 4-2). A groundwater and surface water connection occurs under these circumstances and hydrologic principles would predict that pumpage from a nearby well would have the potential to reduce the quantity of surface water in the stream.

Intermittent streams flow seasonally and may also seasonally establish hydraulically continuous groundwater/surface water interrelationships. During the dry season, the water table may recede below the streambed, severing an active groundwater/surface water connection (Figure 4-3 (B)) so that pumpage from a nearby well would not reduce the amount of water that might

occasionally be flowing in the stream during the dry season. But during the wet season as streamflow begins to occur continuously, the groundwater level rises from streamflow infiltration below the streambed until hydraulic continuity is once again established (Figure 4-3 (A)) and the potential exists to reduce streamflow from pumpage in a nearby well.

Ephemeral streams never maintain a baseflow and never have an active groundwater/surface water connection (Figure 4-4). Therefore, subflow is never associated with ephemeral stream conditions, may occur seasonally with intermittent streams, and generally occurs with perennial streams when flowing over alluvial material.

The "brightline" analysis therefore requires: 1) that DWR identify all perennial stream reaches in the San Pedro River watershed, 2) that DWR identify all intermittent streams that consistently establish seasonal groundwater/surface water connections, and 3) that the season for such intermittent connections is sufficiently long to meet the Court's technical test for subflow. In recognition that the test is to be based upon 90 days of continuous pumping, streamflow records were analyzed to ascertain whether continuous flow for 90 days occurs seasonally. Also since intermittent flow in some places can occur in losing reaches where the aquifer is considerably below the stream and an active connection is not established seasonally, it is necessary to determine that there are shallow water levels in the aquifer associated with the intermittent streams.

The "brightline" analysis was applied to perennial stream reaches and intermittent stream reaches that have continuous flow for at least 90 days and that have relatively shallow groundwater levels (less than 20 feet to water). It is assumed that these shallow water levels allow a quick hydraulic reconnection between the groundwater and surface water systems during the minimum 90 day flow period.

The San Pedro River was identified as meeting the above criteria and a "brightline" was established for its entire length. However, only portions of the Babocomari River and Aravaipa Creek were found to meet the above criteria and therefore, the "brightline" determination was applied only to these locations. Figure 4-14 shows the general locations that the "brightline" concept was applied to on the San Pedro River and its two major tributaries.

Figure 4-16. Zone 1 was developed for all perennial reaches of the San Pedro River, Babocomari River, and Aravaipa Creek. Shown here is the beginning of perennial flow on Aravaipa Creek, upstream (east) of Aravaipa Canyon near the Cobre Ranch.

The second hydrologic principle is the manner by which water can be intercepted from a stream by a nearby well and the technical means for measuring the amount of interference.

When water is pumped from a well, it establishes a cone of depression around the well by removing water from the aquifer in the vicinity of the well. As more water is pumped, the cone of depression deepens and a gradient in the water table is established toward the well. The cone of depression continues to reach even further outward from the well as long as pumpage continues (and may even continue for a period of time after pumping stops). When the cone of depression reaches a stream, water in the aquifer below the stream begins to flow toward the well in response to the induced hydraulic gradient. As this occurs, space that would otherwise be created in the aquifer below the stream is filled by the downward infiltration of surface water through its permeable streambed. This assumes that the aquifer is in

direct hydraulic connection with the stream. Figure 4-17 illustrates this phenomenon which can be mathematically predicted.

In 1941, C.V. Theis extended his groundwater movement formula to the problem of streamflow interception from nearby groundwater pumpage. Theis' formula states that the:

EQUATION 4-1

$$\text{Percentage of stream depletion} = \frac{2}{\pi}\int_0^{\pi/2} e^{-1.87\frac{a^2 S}{t T}} \sec^2 u \, du$$

The variables in this determination are the distance of the well from the stream (a), the time of continuous pumping (t), and the aquifer parameters of both storage coefficient (S) and transmissivity (T). Storage coefficient of an aquifer is "the volume of water the aquifer releases from or takes into storage per unit of surface area of the aquifer per unit decline or rise in head" (Walton, 1979). While storage coefficient is the measure of an aquifer's ability to store water, transmissivity is the measure of an aquifer's ability to transmit water through it. An example is how fast groundwater can move toward a pumping well.

In 1968, C.T. Jenkins developed a series of curves and tables for solving the Theis equation for stream depletion calculations. Jenkins' work resulted in the following relationship.

EQUATION 4-2

$$\text{Percentage of stream depletion} = \frac{t}{sdf} = \frac{t\,T}{a^2\,S}$$

Where:

sdf = Jenkins' stream depletion factor
a = distance from well to stream (feet)
t = duration of pumping (days)
S = specific yield (percentage)
T = transmissivity (square feet per day)

For the problem of developing the "brightline" pursuant to the Court's order, the percentage of stream depletion is already known. The order sets it

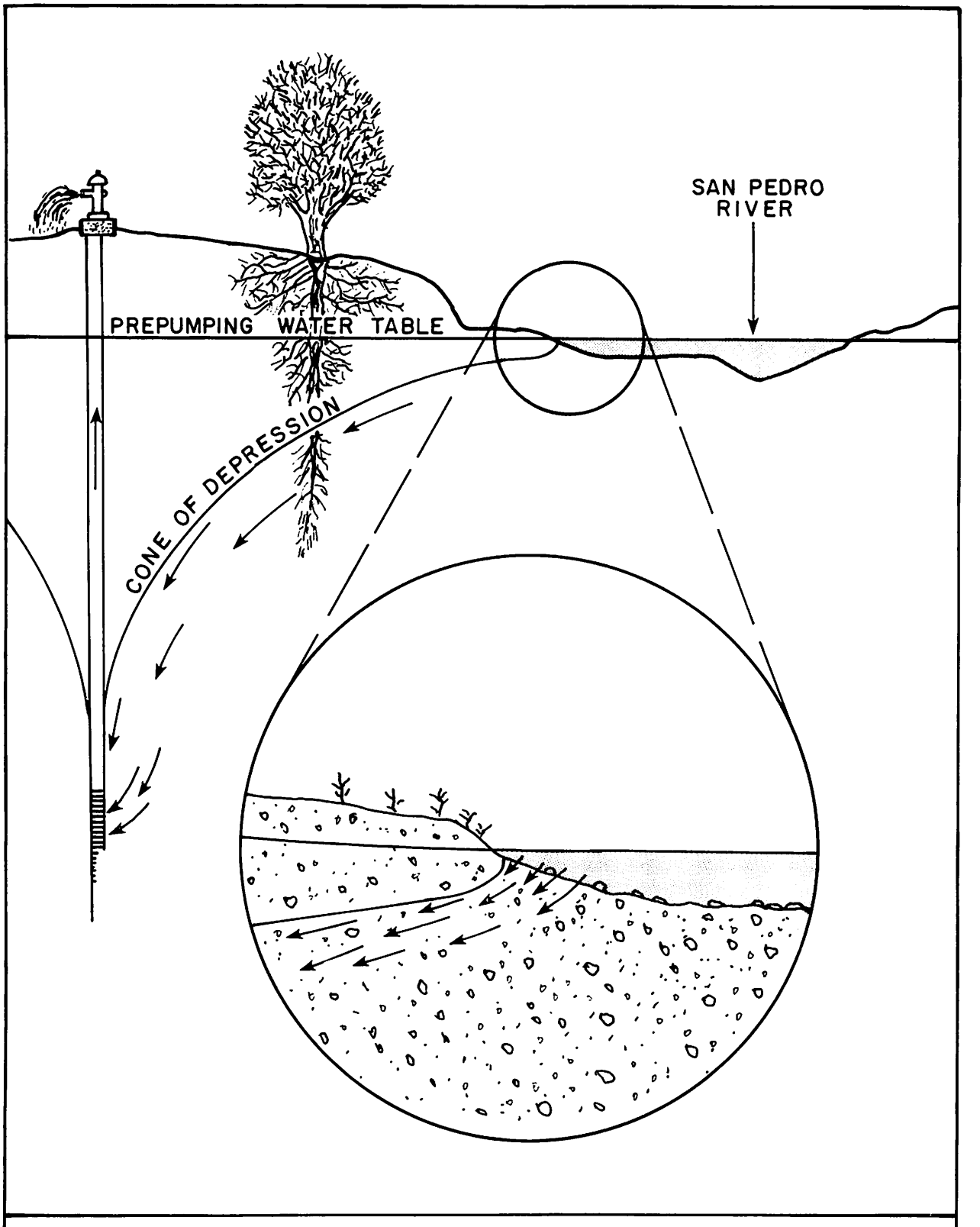


Figure 4-17. Generalized diagram showing the effect that a pumping well has on a stream

at 50 percent. Also known is the duration of pumpage, time (t), which is 90 days. The distance (a) from the well to the stream is the unknown variable for which we are trying to solve.

By utilizing Jenkins' (1968) analysis, a 50 percent stream depletion results in a stream depletion factor value of 3.043 (dimensionless). A graphical representation of this relationship is shown on Figure 4-18. Therefore, given the

relationship $\frac{t}{sdf_{50}} = 3.043$ and a pumping time of 90 days,

$sdf_{50/90} = 29.58.$

Equation 4-2 can now be solved for the desired unknown value of "a", distance from the well to the stream. This results in the following relationship:

EQUATION 4-3

$$a = \sqrt{\frac{29.58\ T}{S}}$$

The resulting value of "a" from Equation 4-3 is defined as the distance from the well to the stream at which point 50 percent of the cumulative volume of pumpage is streamflow after 90 days of continuous pumpage. This "a" value can also be viewed as the distance out from the stream that marks the location of the "brightline." Any well located inside this "brightline" or between the stream and the "a" distance from the stream, when pumped for 90 days, would be, as predicted from the Theis formula, pumping at least 50 percent of its water from the stream.

Before the "brightline" or "a" values along the stream can be calculated, it is necessary to estimate the floodplain aquifer parameters of transmissivity and storage coefficient. In the San Pedro River watershed, transmissivity and storage coefficient data for the floodplain aquifer was obtained from several different sources: 1) actual aquifer tests, 2) USGS

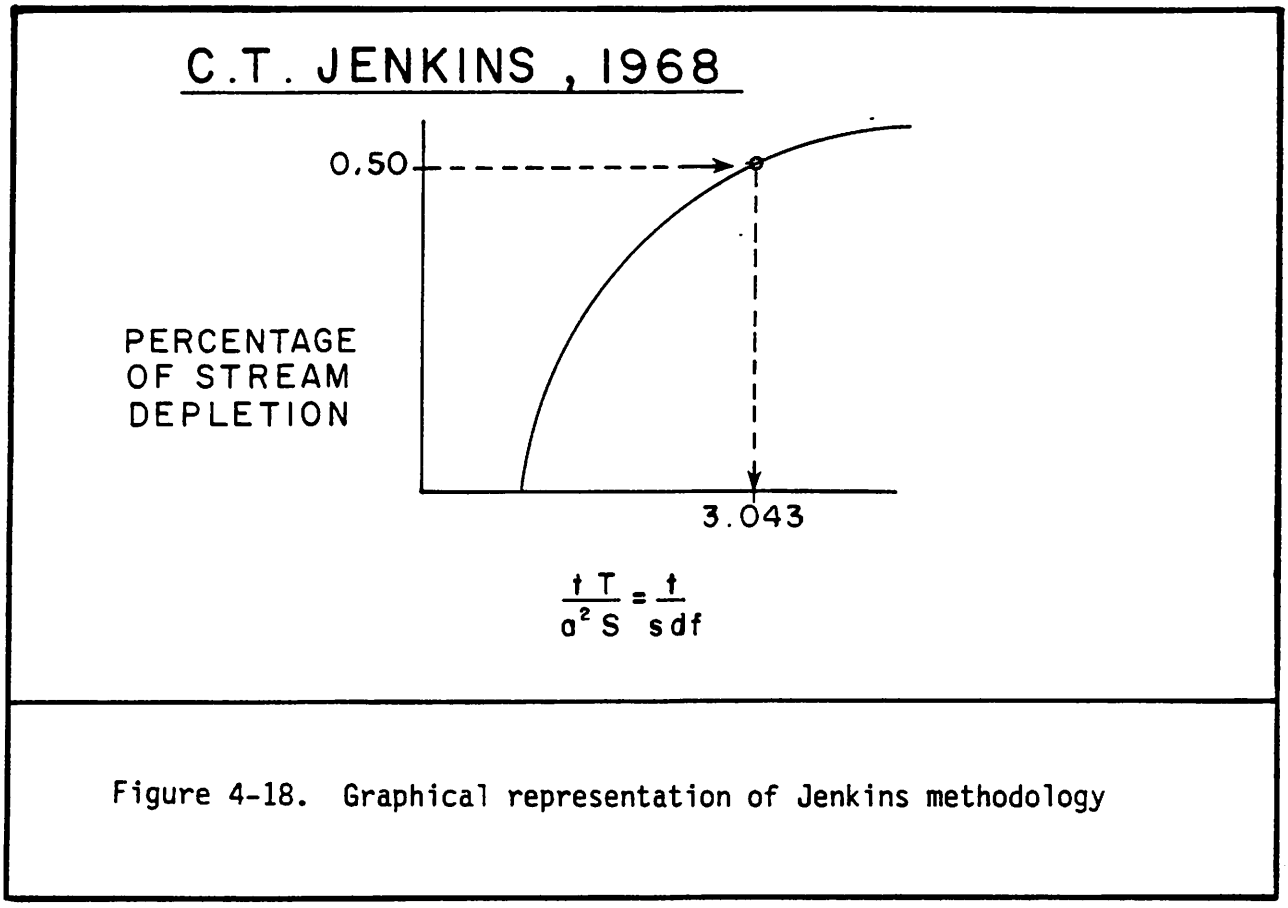


Figure 4-18. Graphical representation of Jenkins methodology

report: Hydrologic Analysis of the Upper San Pedro River Basin from the Mexico - United States International Boundary to Fairbank, Arizona, Open File Report 82-752, 3) DWR's Driller's Log Program, and 4) water well completion reports. The reliability of these parameters decreases in the same order as the source, with the aquifer tests giving the most reliable estimate of transmissivity and storage coefficient and the water well completion reports the least reliable.

The available transmissivity and storage coefficient values for the floodplain aquifer along the San Pedro River, Babocomari River, and Aravaipa Creek were averaged according to either a geographic stream reach, Township and Range, confining clay units under the stream, or node(s) within the USGS model area of the Upper San Pedro River (Freethey, 1982). Figure 4-19 shows the areas where averaging of transmissivity and storage coefficient values was

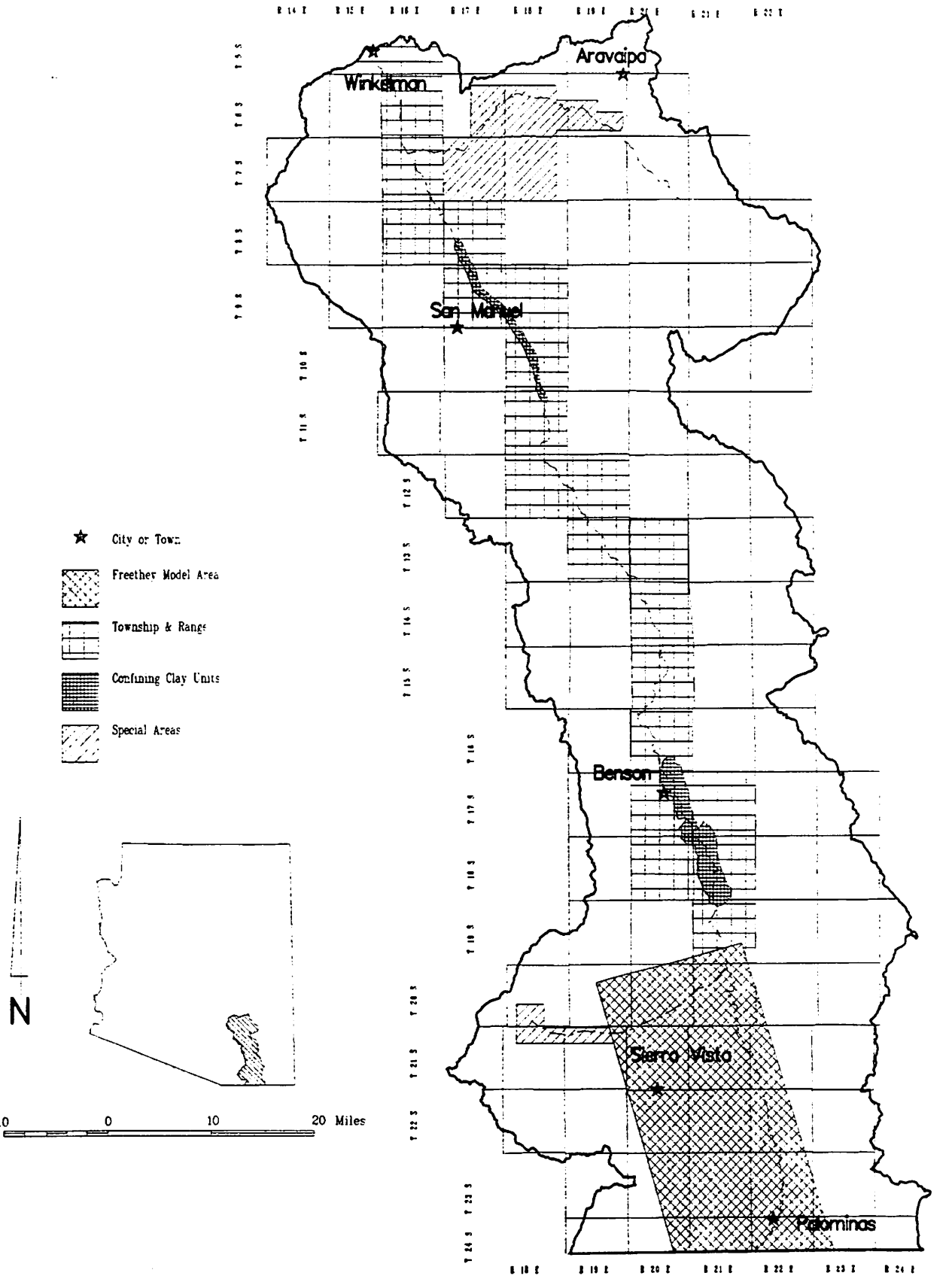


Figure 4-19. Areas of delineation for transmissivity and storage coefficient values for "brightline" determinations

performed. DWR estimated average transmissivity and storage coefficient values for fifty separate areas. Within each of these fifty areas, available transmissivity and storage coefficient values were evaluated, Equation 4-3 was applied, and corresponding "a" values determined. Example 4-1 gives the results of Equation 4-3 for Township 14 South, Range 20 East given average transmissivity and storage coefficient values.

EXAMPLE 4-1

T = 9632 square feet per day
S = 16.9 percent
Utilizing Equation 4-3 results in an
a = 1298 feet

DWR made fifty separate calculations using the Jenkins formula (Equation 4-3) along the stream reaches identified on Figure 4-19 and in the manner illustrated by Example 4-1. Further details, values of transmissivity and storage coefficient, and results of the fifty calculations are provided in APPENDIX E along with maps and tables that allow the determination of the appropriate "a" value utilized for any location within the "brightline" zone.

At this point there are still two more tasks involved in delineating the "brightlines" and one more involved in implementing the Court's order with regard to subflow pumpage. First, the stream channel bank, which is the point from where the "a" value distance will extend outward, must be determined. In many places, the San Pedro River and Aravaipa Creek have channels that shift from side to side with moderate to high flow events within "principal" or active flood channel boundaries. To form the "brightline" zone, these principal channel boundaries are the starting point from which the "a" value distances are extended out from. Existing data from quadrangle maps and other available sources were considered inadequate for this task, and so the principal channel boundaries were delineated by DWR from 1984-1986 aerial photography. This photograhy represents general channel conditions following the most recent 1983 flood.

The San Pedro River system which is generally represented by a meandering channel is continuously shifting in an attempt to reach some unobtainable equilibrium between the forces working within the system. Low flow active channels work their way back and forth across a larger defined principal channel and given time, can cut away at the channel banks on the outside of

meanders. Furthermore, large changes to the physical characteristics of the river can occur rapidly during flood flows when the cutting force of larger volumes of water with large amounts of sediment load can quickly alter a channel's dimensions. These changes, whether they happen slowly from normal flows or quickly from extreme flood flows, may result in the movement of the principal channel boundary outward in places. It should be noted that the "brightline" concept does not take into account these types of changes to the channel, but rather assumes a stationary channel bank. However, the concept does account for most shifts in the low flow active channel by utilizing the principal channel boundary as its reference point for applying the brightline "a" value.

Secondly, hard rock outcroppings in the vicinity of the younger alluvium were identified using Roeske and Werrell (1973) and aerial photography and the "brightline" adjusted to account for the effect the hard rock has on the "a" values and potential for streamflow interception. The adjustment consists of the exclusion of any hard rock area from being representative of Zone 1.

The Court has accepted that the potential withdrawal of subflow exists in and near the younger alluvium provided pumpage would meet the "50 percent/90 day" test. In order to meet the potential requirements of the Court with regard to consideration of the younger alluvium, DWR delineated its boundary using stereoscopic aerial photography interpretation. The shallow alluvium within small side tributary ephemeral washes of the mainstem portions of the river system were excluded. This results in the delineation of the floodplain aquifer as shown in Figure 2-3 and Plates 1 through 10.

These preliminary geographic tasks allowed DWR to construct a map showing the surface relationships between the principal channel boundary, floodplain aquifer, regional aquifer, and hard rock outcroppings. Figure 4-20 (A) shows these relationships in a generalized way.

The final task in developing the "brightline" is to actually draw the line. That task is done by DWR's computerized Geographic Information System. The calculated "a" values are assigned to their proper location along the stream reaches (Figure 4-19), and this information is entered into the computer. A buffering procedure accurately plots a line out from the principal channel boundary that is at a distance equal to the calculated "a" value. This procedure is explained further in APPENDIX E.

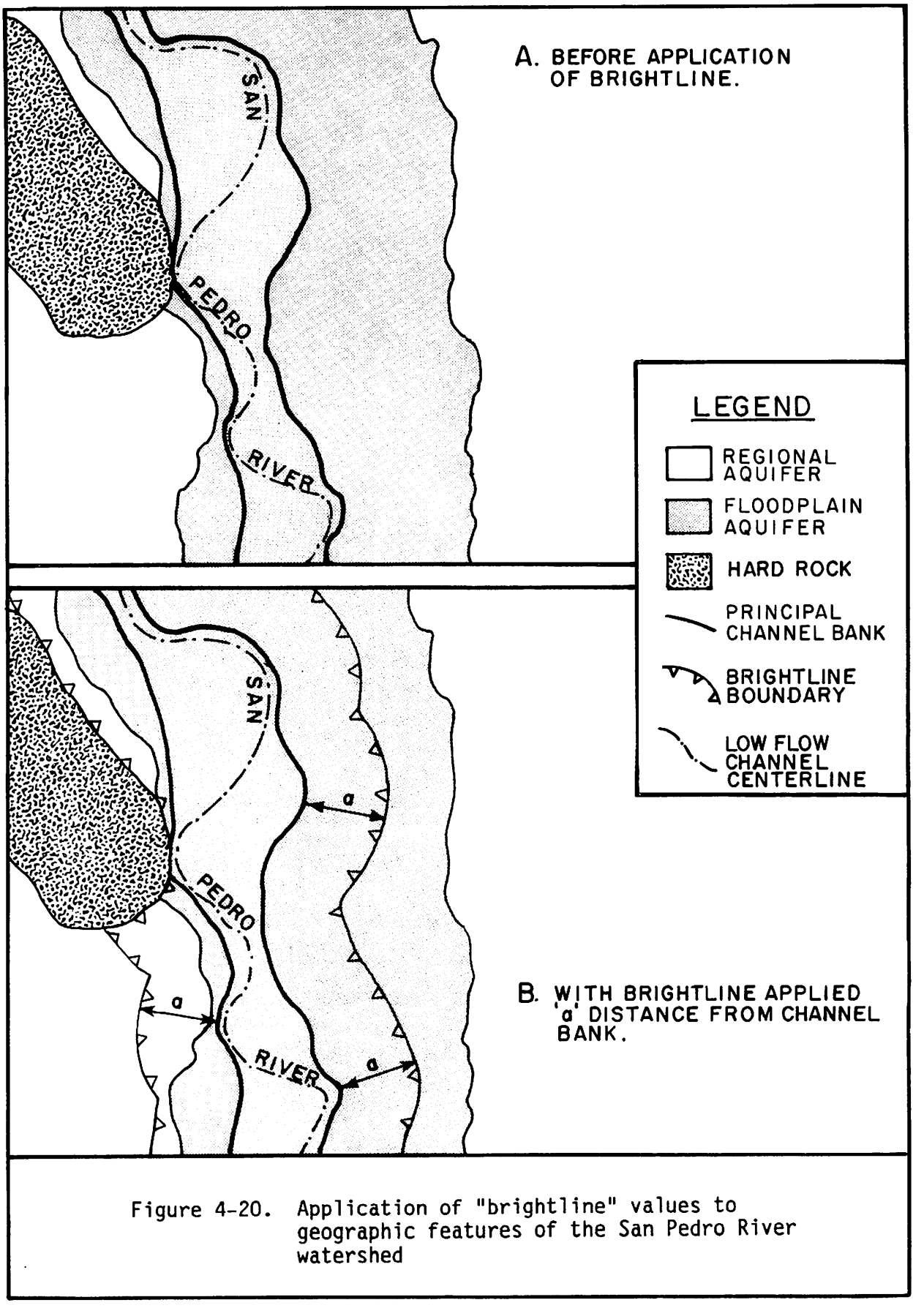


Figure 4-20. Application of "brightline" values to geographic features of the San Pedro River watershed

The result of the above procedures is a map showing the "brightline" as shown on Figure 4-20 (B). The Zone 1 boundary is delineated "a" distance outward from the principal channel bank except where hard rock exposures are encountered. In these cases, the "brightline" only extends out from the channel bank until it meets the hard rock. It is assumed that the hard rock acts as an impermeable boundary to the flow of groundwater within these areas. At this time, no other adjustment has been made to the "brightline" in association to the hard rock outcroppings. For development of the "brightline," at this time it is assumed that any boundary effects of the hard rock outcropping are insignificant.

As shown on Figure 4-20 (B), it is possible for the "brightline" to extend out beyond the floodplain aquifer (younger alluvial) boundary into the basin fill. The extension of the "brightline" out into the basin fill without any adjustment to the "a" value assumes that the aquifer parameters (transmissivity and storage coefficient values) of the regional aquifer are the same as those of the adjacent floodplain aquifer. This assumption is made for the purpose of "brightline" placement for this report. It is realized that over the entire area of the San Pedro River watershed, the regional and floodplain aquifer hydraulic parameters differ, with the floodplain aquifer being more permeable to the flow of groundwater than the regional aquifer. At this time, however, for the purpose of making adjustments to the "brightline" it is impossible to determine any local differences in aquifer parameters between the floodplain aquifer and the adjacent regional aquifer.

A series of nine maps (Plates 2 through 10) show the Zone 1 area on USGS 15 minute quadrangle maps at a scale of 1:62,500. The entire extent of Zone 1 as delineated within the San Pedro River watershed is given on Figure 4-14 and Plate 1. These maps also show the location of the floodplain aquifer and hard rock outcrops that intercept the "brightline" in certain locations. The Zone 1 boundaries ("brightlines") are also shown on the subregion water use maps in Volume 9. An example of what appears on a subregion water use map is given in Figure 4-21. Additional information on the above methodologies is provided in APPENDIX E of this volume.

The reliability of the "brightline" delineation is dependent upon the accuracy with which the aquifer parameters transmissivity and storage coefficient are known and the extent to which the idealized assumptions required by the analytic estimation technique (Jenkins formula) are

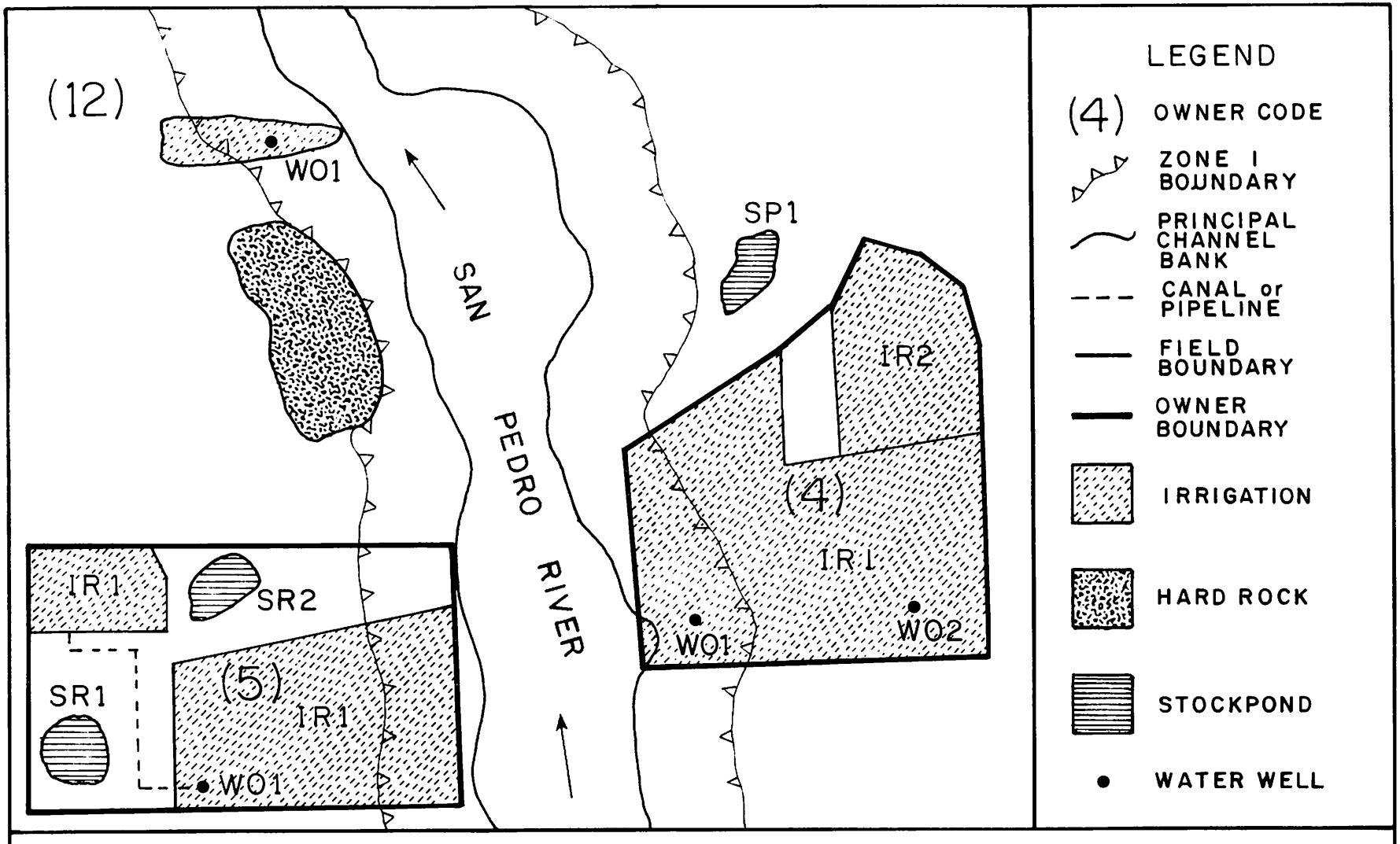


Figure 4-21. Generalized example of a water use map with the Zone 1 boundary

compromised by real world conditions found along the San Pedro River, Babocomari River, and Aravaipa Creek. By comparison the younger alluvium and corresponding floodplain aquifer have been delineated on the basis of geologic features observable from above ground, and therefore, the factors involved in its delineation are probably known with greater reliability than those required for the "brightline" delineation.

An examination of Plate 1 shows that the boundaries of the younger alluvium (floodplain aquifer) and the 50 percent/90 day "brightline" coincide closely over most of the delineated length of the San Pedro River, Babocomari River, and Aravaipa Creek. The principal exceptions occur in the St. David - Pomerene and Palominas areas. In these locations the boundaries of the younger alluvium extend a much greater distance outward from the San Pedro River than does the 50 percent/90 day "brightline."

Method of Reporting Zone 1 Uses

All identified Zone 1 diversions and the uses they supply are reported in the watershed file reports (WFR) in Volumes 3 through 6. Data furnished in these volumes is presented in the standard WFR format utilized in this and the Little Colorado River General Adjudication and consists of all applicable filings and decrees, diversions, reservoirs, summary of potential water rights (PWR), quantity of use determination, and any necessary explanations. All WFRs whose potential water rights are supplied wholly or partially by surface water or Zone 1 water are included in Volumes 3 through 6. Table 4-9 gives an example of a WFR that may appear in these volumes. The "Diversions" section of the WFR identifies those wells located within the "brightline" zone by reporting "GROUNDWATER: ZONE 1 OF THE SAN PEDRO RIVER" under the water source and classification column. The subregion water use maps in Volume 9 show the locations of groundwater wells in relationship to the "brightlines." Figure 4-21, a generalized example of a water use map found in Volume 9, shows that Claimant (4) has a water well W01 that is located within Zone 1 while water well W02 is outside the "brightline" within Zone 2 that is discussed in the next section.

TABLE 4-9

EXAMPLE OF WATERSHED FILE REPORT SHOWING WATER SOURCES AND CLASSIFICATIONS (VOLUMES 3-6)

LAND OWNER	WATERSHED FILE REPORT NUMBER
DOE, JOHN	111-23-XXXX-006

APPLICABLE FILINGS AND DECREES

CLEARLY STATED INFORMATION FROM FILINGS AND DECREES

FILING NO.	FILING STATUS	USES	QUANTITY IN AFA	USE LOCATION SECTION	USE LOCATION TWNP	USE LOCATION RNGE	CLAIM DATE	DIVERSION LOCATION SECTION	DIVERSION LOCATION TWNP	DIVERSION LOCATION RNGE
36-2000000		IRRIGATION	1,000.00	SE30	230S	210E	1930	SESE30	230S	210E
39-0000100		IRRIGATION	700.00	SE30	230S	210E	1930	SWSW31	230S	210E
39-0000101		DOMESTIC	100.00	SE36	230S	210E	1942	SESE36	230S	210E

DWR ANALYSIS OF FILINGS AND DECREES

FILING NO.	USES CLAIMED OR REFERENCED	USES FOUND BY DWR	APPLIES TO DIVERSIONS	APPLIES TO PWR NUMBERS
36-2000000	IRRIGATION	IRRIGATION	D01,W01	IR001
39-0000100	IRRIGATION	IRRIGATION	D01	IR001
39-0000101	DOMESTIC	DOMESTIC	W03	DM001

DIVERSIONS

DIV #	LOCATION SECTION	LOCATION TWNP	LOCATION RNGE	DIVERSION NAME	WATER SOURCE AND CLASSIFICATION
D01	SWSWSW31	230S	210E	MANY FARMS I.D. DITCH	SURFACE WATER: SAN PEDRO RIVER
W01	NESESE30	230S	210E	UNNAMED	GROUNDWATER: ZONE 1 OF THE SAN PEDRO RIVER
W02	NWSESE36	230S	210E	UNNAMED	GROUNDWATER: ZONE 2
W03	NESESE36	230S	210E	UNNAMED	GROUNDWATER: CATALOGUED

USES

PWR #	LOCATION SECTION	LOCATION TWNP	LOCATION RNGE	SUPPLIED BY DIVERSIONS	WATER SOURCES	PHOTO DATE	SOURCE CHANGE	FACILITY NAME
DM001	NENENE30	230S	210E	W03	GROUNDWATER: CATALOGUED		NO	
IR001	SE30	230S	210E	D01,W01,W02	SURFACE WATER GROUNDWATER: ZONE 1 GROUNDWATER: ZONE 2	1935	NO NO	

PWR SUMMARY

PWR #	APPLICABLE ADJ FILINGS	APPLICABLE PRE FILINGS	*APPARENT FIRST USE DATE* DATE	*APPARENT FIRST USE DATE* BASIS FOR DATE	WATER SOURCES AND CLASSIFICATIONS
DM001	39-0000101	NONE			GROUNDWATER: CATALOGUED
IR001	39-0000100	36-2000000	1930	36-2000000	SURFACE WATER: SAN PEDRO RIVER GROUNDWATER: ZONE 1 OF THE SAN PEDRO RIVER GROUNDWATER: ZONE 2
SP001	NONE	38-0000900	1950	38-0000900	SURFACE WATER: SAN PEDRO RIVER

QUANTITIES OF USE

PWR #	QUANTIFICATION TYPE	ACRES	CROP TYPE	EFF	WATER DUTY	ESTIMATED VOLUME	REMARKS
DM001							SEE VOLUME 1 - GENERAL ASSESSMENT
IR001	MAX. OBSERVED	130.0	PERM. PSTR.	35%	6.0 AF/AC	780.0 AFA	
	REGIONAL	135.0	AVE. CROP	50%	5.4 AF/AC	729.0 AFA	
	MAX. POTENTIAL	135.0	ALFALFA	35%	6.5 AF/AC	877.5 AFA	

EXPLANATION

DIVERSIONS

D1 - DIVERSION FROM THE SAN PEDRO RIVER INTO THE MANY FARMS IRRIGATION DISTRICT DITCH.
W1 & W2 - WELLS PROVIDE WATER FOR IRRIGATION USES.
W3 - CATALOGUED WELL PROVIDES WATER FOR DOMESTIC USES.

USES AND RESERVOIRS

DM1 - DOMESTIC USE.
IR1 - IRRIGATED PASTURE.

ZONE 2 USES

The Court's order of September 9, 1988, also directed DWR to ". . . determine all stream users or diversions of either surface water or groundwater which significantly affect those sources reasonably available on, at, or near the federal parcel . . . ." This complex requirement, as interpreted by DWR, contains three technical components:

1) The determination of upstream surface water users who diminish the supply of surface water available to meet downstream federal reserved rights.

2) The determination of users who pump from wells whose withdrawals may potentially diminish the supply of groundwater available to meet the federal reserved rights on a reservation.

3) The determination of upstream users who pump from wells whose withdrawals may potentially diminish the supply of surface water available to meet downstream federal reserved rights.

The methodology which DWR employed to meet each of these three components of the directive are described below.

Surface Water Users Who Diminish Surface Water Supply

DWR, as part of its normal HSR investigation process, identifies all surface water uses occurring in each watershed. Each of these uses are assigned a potential water right and an estimated quantity of use is reported for most types of uses. More importantly, in the context of assessing the potential effects of these uses on possible downstream federal reserved rights, the water budget analysis in Section 4.7 contains an evaluation of the combined effect of surface water uses on the surface water outflow from the watershed. This evaluation lists the average annual use of water in each subwatershed, the average annual surface water outflow from each subwatershed, and the undepleted flow at each of these locations. This chapter also includes an analysis of the effect of transmission losses on downstream availability. DWR believes that these determinations provide the means to identify upstream surface water users who diminish surface water available to meet downstream federal reserved rights and the means to establish the quantity of the diminishment.

Well Users Who Diminish Groundwater Supply

This component of the Court's directive to DWR apparently requires DWR to evaluate the potential affect of pumpage by well users outside a federal reservation on the groundwater supply on the reservation. DWR is including this analysis in the HSR for each reservation where it appears that the groundwater supply is or has been susceptible of being significantly affected by pumpage from outside the reservation. For the San Pedro River watershed, the Fort Huachuca Military Reservation and the BLM's SPRNCA are the only reservations identified as being in this category. Analyses are included in the reports on the Fort and SPRNCA appearing in Chapters 5 and 6 of this volume of the HSR.

Well Users Who Diminish Surface Water Supply

While the Court's directive for the determination of subflow in the HSR was technically specific with the 50 percent/90 day test, this directive for the identification of well users who significantly diminish the surface water supply available to meet a downstream federal reserved right imposes a more general technical requirement for DWR. Previous sections of this chapter have discussed the concepts involved in groundwater/surface water interrelationships such as the relationship between aquifers and stream types, the dynamics of pumping wells, and how cones of depression can expand to intercept and divert surface water from alluvial streambeds, and the concepts of direct and indirect interference from pumped wells. These discussions show how water pumped from a well can be derived from aquifer storage depletion, from capturing sources of groundwater recharge, from capturing streamflow, or from combinations of these three sources. The percentage of water pumped that is captured from streamflow depends upon the distance of the well from the stream, the characteristics of the aquifer across the intervening distance, and the duration of pumpage. The duration of pumpage introduces the factor of time that makes it difficult to clearly distinguish between those well users that diminish streamflow and those that do not. With a further increase in the period of time set for the standard, more well users would be encompassed. These numerous factors affecting groundwater/surface water relationships present a large array of uncertainties as well as possible standards for determining the diminishment to downstream federal reserved rights.

Since the time and interference factors were not defined in this directive as they were in the appropriable subflow provision of the Court's order, DWR concluded that it could provide the most useful information to the Court by identifying all well users who have the potential to diminish streamflow. This assessment can be made without making assumptions regarding the complexities described above, such as time/interference thresholds or aquifer parameters. It also permits more definitive quantifications of current diminishment as well as future potential diminishment than could be determined from utilizing a time/interference standard.

Simply stated, wells which have the potential to diminish streamflow are those which withdraw water from tributary groundwater aquifers. Tributary groundwater aquifers, which have been defined and discussed previously in this chapter, are aquifers in direct hydraulic connection with a stream or have a hydraulic connection with another aquifer which is in hydraulic connection with a stream. Groundwater that has been recharged into a tributary aquifer and is flowing downgradient within the aquifer is in transit toward a surface stream and will eventually discharge into the stream and constitutes a part of the surface water supply, if not withdrawn from a well first. All appropriable subflow occurs in tributary aquifers. However, tributary aquifers normally extend much greater distances outward from the stream they supply than the distance of the "brightline," established by the 50 percent/90 day criteria. Wells which have the potential to diminish streamflow include those within the "brightlines," or Zone 1, and also those further from the stream between the "brightlines" and the headwaters of the tributary aquifer. This second area is referred to in this report as Zone 2.

In summary then, DWR has concluded that it can most effectively meet the Court's request to ". . . determine all . . . diversions of . . . groundwater which significantly affect those (surface water) sources reasonably available on, at, or near the federal parcel . . ." by identifying all well users who have the potential to diminish streamflow. Well users who have the potential to reduce streamflow are all those identified as withdrawing from Zone 1 plus all those identifed as withdrawing from Zone 2.

Delineation of Wells in Zone 2

In the San Pedro River watershed, Zone 1 generally occurs within the floodplain aquifer composed of the younger alluvium while Zone 2 generally

extends across the regional aquifer comprised of the older alluvium. More specifically, Zone 2 extends from the "brightlines" to the beginning edge of the regional aquifer on both sides of the San Pedro River, Aravaipa Creek, and the Babocomari River. The beginning edge of the regional aquifer is where the aquifer encounters the hard rock of the surrounding mountains or transitions to isolated non-tributary aquifers within the watershed. These non-tributary aquifers are described under Zone 3 Uses.

The entire extent of Zone 2 is shown on Figure 4-14 and Plate 1. Plates 2 through 10 show the delineation of Zone 2 as it relates to Zone 1.

Method of Reporting Wells in Zone 2

Wells located within Zone 2 are listed in Volume 7, Zone 2 Well Reports, with several exceptions. In addition to the directive of the Court quoted previously as the reason for establishing Zone 2, the order also specified that DWR should ". . . exclude each domestic and stockwatering well and irrigation well irrigating no more than two acres . . ." from its determination of wells which may potentially diminish the water supply available to meet federal reserved rights. In compliance with this provision, these uses that are supplied totally by wells located within Zone 2 are, nevertheless, not reported as Zone 2 Well Reports in Volume 7 of this HSR. Instead, wells supplying the above uses described in the order are listed in Volume 8 of this HSR, Catalogued Wells, even though the wells are physically located within and withdrawing water from Zone 2.

Table 4-10 shows an example of a report from the Zone 2 Well Reports volume (Volume 7). Within this volume is a listing of all land owners that pump groundwater within Zone 2 for municipal, mining, industrial, or irrigation of land greater than two acres in size. Also listed are the wells, water use, acres irrigated, and the apparent annual volume of water used.

ZONE 3 USES

The Court's final directive regarding the classification of wells is that "All other groundwater sources, not involving federal claims, shall be catalogued and their data determined . . ." The DWR's interpretation of this provision is that it should include in its HSRs a separate listing of all

TABLE 4-10

EXAMPLE OF ZONE 2 WELL REPORT (VOLUME 7)

LAND OWNER	FILE REPORT NUMBER
DOE, JOHN	111-23-XXXX-006

		WELL LOCATION				
WELLS	WELL NAMES	SECTION	TWNP	RNGE	WATER USES SERVED	REMARKS
W02	UNNAMED	NWSESE36	230S	210E	IR001	

	WATER USE LOCATION			** APPARENT FIRST USE **		APPAR. ANNUAL	ACRES
WATER USE NUMBER	SECTION	TWNP	RNGE	DATE	BASIS FOR DATE	VOLUME USED	IRRIGATED
IR001	SE31	230S	210E	1930	36-2000000	128.4 AFA	135.0

APPLICABLE STATEMENTS OF CLAIMANT	APPLIES TO: WELLS	APPLIES TO: WATER USES
39-0000101		IR001

EXPLANATION

THE APPARENT ANNUAL VOLUME FOR IR001 IS PARTIALLY SUPPLIED BY SURFACE WATER AND ZONE 1 GROUNDWATER.
W2 - WELL PROVIDES WATER FOR IRRIGATION USES.
IR1 - IRRIGATED PASTURE.

wells (and their associated data) that it finds during the course of its investigations that are not withdrawing water classified as Zone 1 or Zone 2. These wells will include those supplying the small uses excluded by the order from inclusion in the wells of Zone 2 and also wells located in groundwater basins that are not hydrologically related to a surface water stream. This last category includes non-tributary alluvial aquifers and the limited waterbearing hard rock areas. These areas are referred to in this report as Zone 3.

The Zone 3 area is limited to locations comprised of non-tributary alluvial aquifers and generally nonwaterbearing hard rock. These areas are shown on Figure 4-22. The term non-tributary indicates that the aquifers do not constitute a source of surface water, in that significant quantities of groundwater are not flowing through the aquifer toward a surface water stream. Pumpage from these aquifers cannot produce direct interference with streamflow. The amount of indirect interference that can result from pumpage

from non-tributary aquifers is either zero where groundwater levels are far below the adjacent streambeds or the amount of indirect interference is limited by hydraulic constraints in the aquifer to a relatively small amount.

Delineation of Zone 3

The non-tributary alluvial aquifers delineated on Figure 4-22 are isolated groundwater basins that have only limited hydraulic connections with other aquifers. None of the non-tributary alluvial aquifers are adjacent to perennial or intermittent streams. Figure 4-23 shows a typical aerial and cross-sectional view of one of these aquifers. Commonly, they are surrounded by hard rock hills or mountains and have relatively narrow connections with other groundwater basins. The amount of groundwater which discharges from the non-tributary groundwater basin into another groundwater basin is relatively small (less than 500 acre-feet per year), and streams that drain the non-tributary groundwater basin are ephemeral in character. Small tributary groundwater basins that have perennial surface streams flowing from them do not qualify as non-tributary alluvial aquifers.

In looking at the Line A-B in the cross-sectional view of the bottom of Figure 4-23, the aquifer is usually shallow where the transition occurs between basins (point B). If pumpage commences in the non-tributary aquifer and the water table declines only slightly at point B, the groundwater outflow from the non-tributary groundwater basin would cease. When that occurs, continued or increased pumpage will not further decrease basin outflow since it would have already reached zero. Therefore, groundwater pumpage from the non-tributary alluvial aquifer can only reduce the supply going to an adjacent aquifer and ultimately to a stream by the amount of predevelopment basin outflow. Only aquifers that fall within this general description and have less than 500 acre-feet per year of natural basin outflow as underflow have been delineated as non-tributary alluvial aquifers. Three main non-tributary alluvial aquifers have been identified by DWR. Their locations are shown on Figure 4-22. They are in the areas of Tombstone, Elgin, and southeast of Cascabel (southern portion of Allen Flat). These aquifers are located in remote areas of the San Pedro River system and most have undergone limited groundwater development.

For the purpose of this report, the generally nonwaterbearing hard rock consists of consolidated to semi-consolidated sedimentary rocks and the older

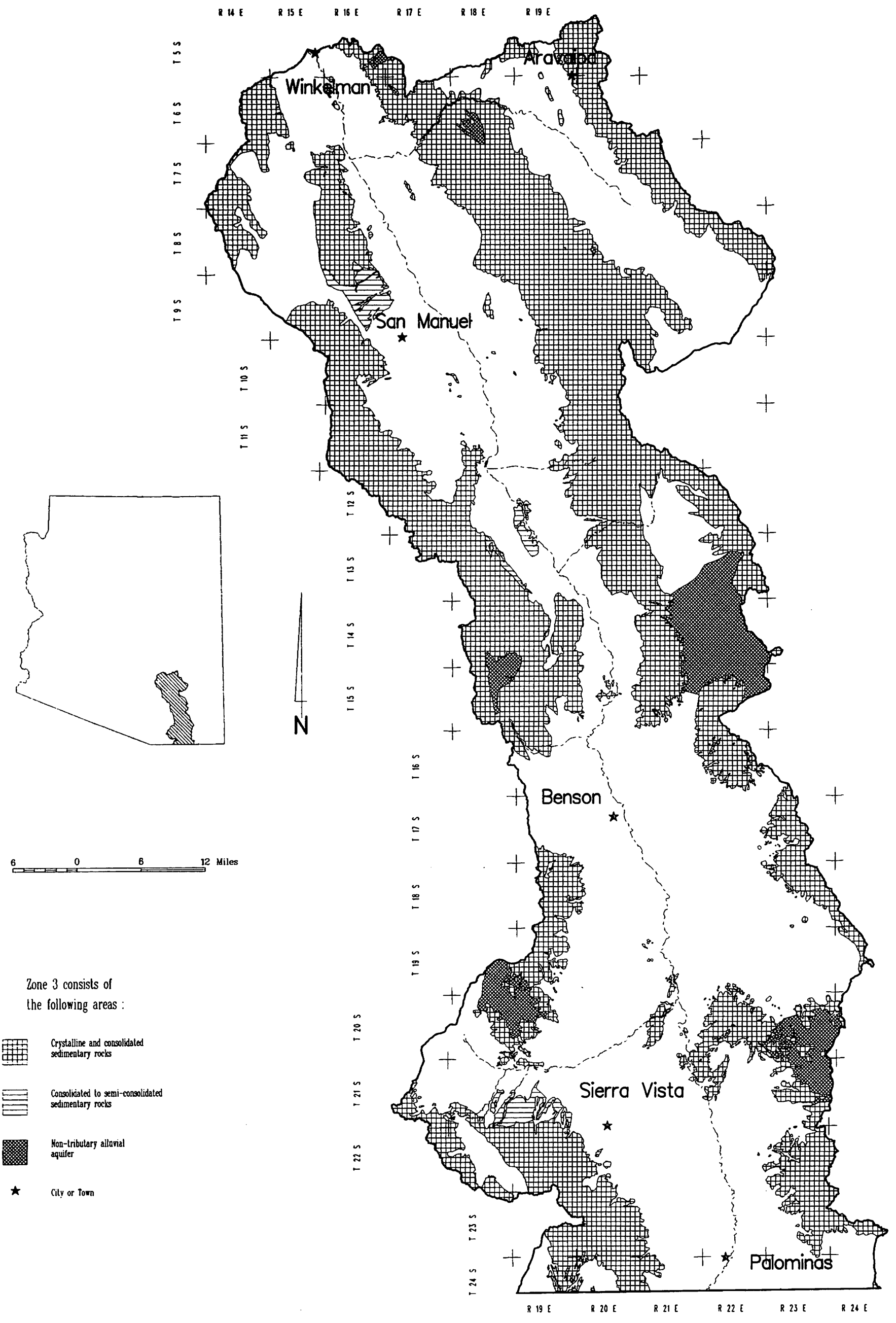


Figure 4-22. Zone 3 delineation of catalogued groundwater users

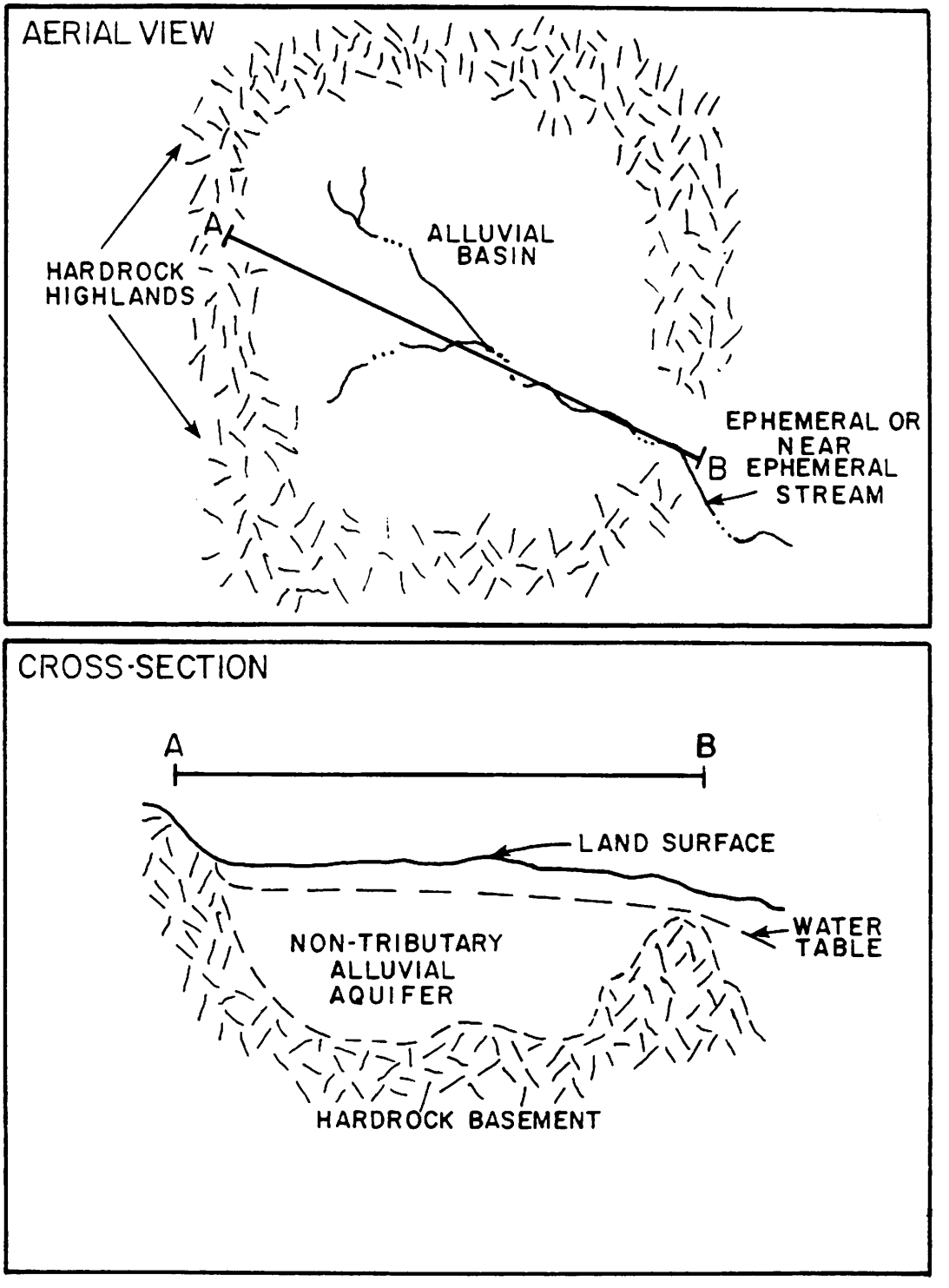


Figure 4-23. Typical areal and cross-sectional view of a non-tributary alluvial aquifer

crystalline and consolidated sedimentary rocks of the mountains. As stated in Chapter 2, groundwater is found in these units under local conditions and in small quantities. Regional characteristics of generalized flow directions and general availability of groundwater do not exist. This designation is, therefore, primarily an identification of areas within the San Pedro River system where significant aquifers do not occur. The extent of surface exposures of these units shown on Figure 4-22 was taken from Roeske and Werrell, 1973; Drewes, 1980; Cooper et al., 1959; Wilson and Moore, 1958; and Wilson et al., 1969.

Plates 2 through 10 show portions of Zone 3 as it relates to Zone 1 while Figures 4-14 and 4-22 show the entire extent of Zone 3 as delineated in the San Pedro River watershed.

Method of Reporting Wells in Zone 3

The Court's order of September 9, 1988 directed DWR to catalogue and determine available data on all groundwater sources that do not potentially affect federal claims or withdraw appropriable subflow. DWR's interpretation of this provision is to tabulate and report available data on all identified groundwater users that fall into Zone 3 as defined above.

The tabulation of all identified Zone 3 groundwater users as well as the small users defined in the Court's order who withdraw from Zone 2 is found in Volume 8 of this HSR. Data furnished in this volume consists of well location by section, township, and range; owner's name; apparent date of first use; claimed quantity; source of data; and type of use. Table 4-11 gives an example of the data furnished in Volume 8.

TABLE 4-11

EXAMPLE CATALOGUED WELL REPORT (VOLUME 8)

	WELL LOCATION			CLAIMED	CLAIMED		
WELL OWNERS NAME	SECTION	TWNP	RNGE	DATE	QUANTITY	DATA SOURCE	TYPE
ADAMS, B.B.	SESESE36	140E	200E	1962	9.00 GPM	55-1000000	DOMESTIC WELL
BAKER, C.C.	NENENE01	141S	200E	1983		55-2000000	DOM/STK WELL
CHARLES, D.D.	NWNWNW01	141S	200E	1956		55-3000000	STOCK WELL
JOHNSON, E.E.	SWSWSW36	140S	200E	1970	1.00 AFA	111-23-AAA-100	AI FILING 39-1000104
JONES, A.D.	NWNWNW36	140S	200E			111-23-ADA-009	AI PLACE OF USE DM002
SMITH, J.E.	NENENE36	140S	200E			111-23-ADD-006	AI DIVERSION W03

4.7 WATER BUDGET ANALYSIS

Water budgets are a hydrologic balance sheet used to account for the amount of water supply available, the amount that is used, and the amount that is remaining to flow to another area. On the balance sheet these supply, use, and outflow categories are separated into their component parts. When all of the component parts are properly accounted for, the water budget becomes a conceptual model of the watershed's hydrologic system. Such a model provides the means to analyze the effect that one component has on another, such as the effect that certain cultural uses have on watershed or subwatershed outflows.

This section provides a current condition budget for the San Pedro River watershed and its five designated subwatersheds in the United States and for the contributing drainage area in Mexico. This budget shows the supplies, uses, outflows, and groundwater overdraft that is currently occurring in the watershed under 1990 development conditions. An undepleted flow water budget is also included that shows the extent of the water supply that would exist within and discharge from the San Pedro River watershed if there were no cultural uses occurring.

CURRENT CONDITION WATER BUDGET

The estimated values for the inflow, water use, and outflow components for each subwatershed are listed in Table 4-12. APPENDIX F provides a description of the procedures used and assumptions made for each of the water budget terms. Figures 4-24, 4-25, and 4-26 provide three-dimensional diagrams of each subwatershed and the Mexico portion of the San Pedro River watershed. These schematics show the relationships of all water budget components as estimated by DWR and presented in Table 4-12.

The supply portion of this budget lists the components that contribute to the water supply within each subwatershed. The contributing components include surface water and groundwater inflow from the upstream subwatershed, tributary inflow produced within each subwatershed, and groundwater recharged within each subwatershed. The water use section of the budget lists the cultural and natural depletions occurring within each subwatershed and in Mexico. The surplus section denotes outflows from the system and estimated changes in storage.

TABLE 4-12

WATER BUDGET ANALYSIS OF THE SAN PEDRO RIVER WATERSHED
1990 DEVELOPMENT CONDITIONS
(ACRE-FEET PER YEAR) (1)

	MEXICO	SIERRA VISTA	BENSON	REDINGTON	WINKELMAN	ARAVAIPA	TOTAL (2)
SUPPLY (+)							
SW Inflow	-	23,420	39,200	25,500	32,100	0	23,420 (3)
GW Inflow	-	3,000	0	120	150	0	3,000 (4)
Tributary SW	35,900	17,300	11,800	15,710	34,070 (5)	1,500	78,880 (6)
GW Recharge	- (7)	13,860	11,760	20,350	9,650	-	55,620 (8)
Imports	-	200 (9)	0	310 (10)	0	0	510
Exports	-	-960 (11)	0	0	-1,860 (12)	0	-2,820
TOTAL	35,900	56,820	62,760	61,990	74,110	1,500	158,610 (13)
WATER USE (-)							
Cultural							
Irrigation	5,000	4,590	14,230	8,480	3,360	1,810	30,660
Domestic	300	460	260	130	170	30	1,020
Municipal	2,300	4,530	750	1,220 (14)	10	0	6,510
Stockpond	1,000	1,460	870	780	160	600	3,270
Reservoirs	-	160	270	80	110	100	620
Mining	3,000	-	0	19,560	0	0	19,560
Industrial	100	50	380	30	0	0	460
TOTAL	11,700	11,250	16,760	30,280	3,810	2,540	62,100
Natural							
Channel Evap	-	950	770	2,220	1,680	970	5,620
Phreatophytes	-	14,450	17,690	13,400	7,060	1,500	52,600
TOTAL	11,700	15,400	18,460	15,620	8,740	2,470	58,220
TOTAL USE		26,650	35,220	45,900	12,550	5,010	120,320 (15)
SURPLUS (=)							
GW Outflow	900	0	120	150	1,570	800	1,570 (16)
SW Outflow	23,420	39,200	25,500	32,100	56,540 (17)	27,559 (18)	56,540 (19)
Change in storage	-120	-9,030	1,920	-16,160	3,450	-	-19,820 (20)

See continuation table for explanation of footnotes.

TABLE 4-12 (cont'd)

WATER BUDGET ANALYSIS OF THE SAN PEDRO RIVER WATERSHED
1990 DEVELOPMENT CONDITIONS

(1) All values are rounded to the nearest tens, however, this should not be construed to mean that the computed values are accurate to this degree.
(2) Totals include inflow from Mexico but do not include supplies or uses.
(3) Includes only surface water outflow from Mexico accounted for at the Palominas gage, 09470500 San Pedro River at Palominas, Arizona.
(4) Includes only groundwater entering the watershed from Mexico.
(5) Tributary surface water includes Aravaipa subwatershed tributary surface water.
(6) Total includes tributary surface water from Sierra Vista, Benson, Redington, and Winkelman.
(7) - means no data available or not estimated.
(8) Total includes groundwater recharge from Sierra Vista, Benson, Redington, and Winkelman subwatersheds.
(9) Groundwater pumped from Cienega Creek groundwater basin and used for irrigation within the San Pedro River watershed.
(10) Groundwater imported to Oracle.
(11) Groundwater exported to Bisbee.
(12) Groundwater exported by ASARCO.
(13) Summation of all above values of supplies including imports and exports.
(14) Includes municipal use of imported water to Oracle.
(15) Total includes all cultural and natural uses for the Sierra Vista, Benson, Redington, and Winkelman subwatersheds.
(16) Total groundwater outflow is the outflow at Winkelman.
(17) Surface water flows from the Aravaipa subwatershed are accounted for with surface water outflow from the Winkelman subwatershed.
(18) Aravaipa uses and tributary SW are accounted for at the Aravaipa gage, 0947300 Aravaipa Creek near Mammoth, Arizona, not included in total water use because it is accounted for at the Winkelman gage.
(19) Total surface water outflow is the outflow at Winkelman.
(20) Total change in storage = supply - total uses - groundwater out - surface water out.
Negative values are assumed to indicate groundwater overdraft.

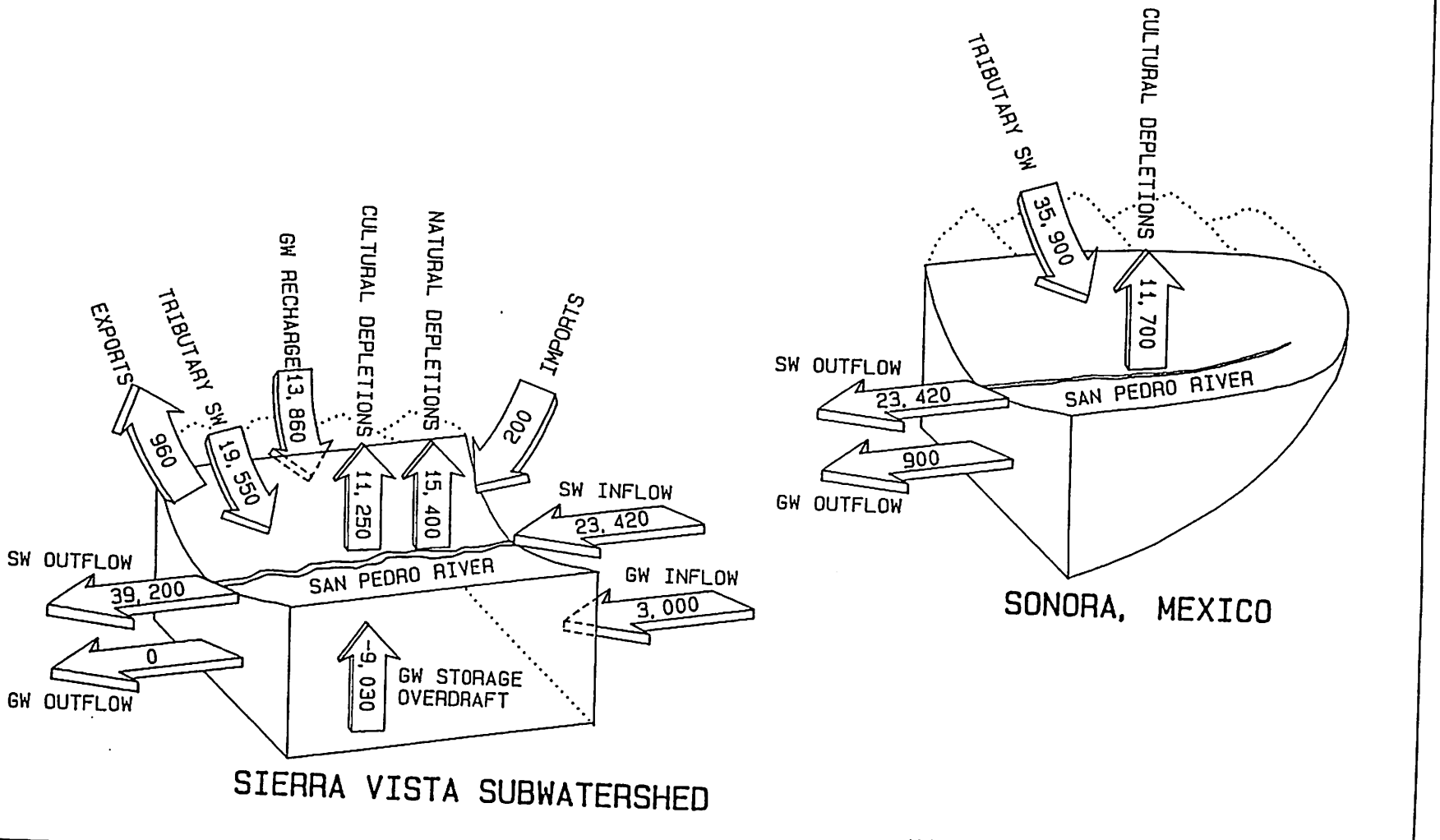


Figure 4-24. Schematic of the water budget components as they relate to the Mexico and Sierra Vista subwatershed portions of the San Pedro River watershed

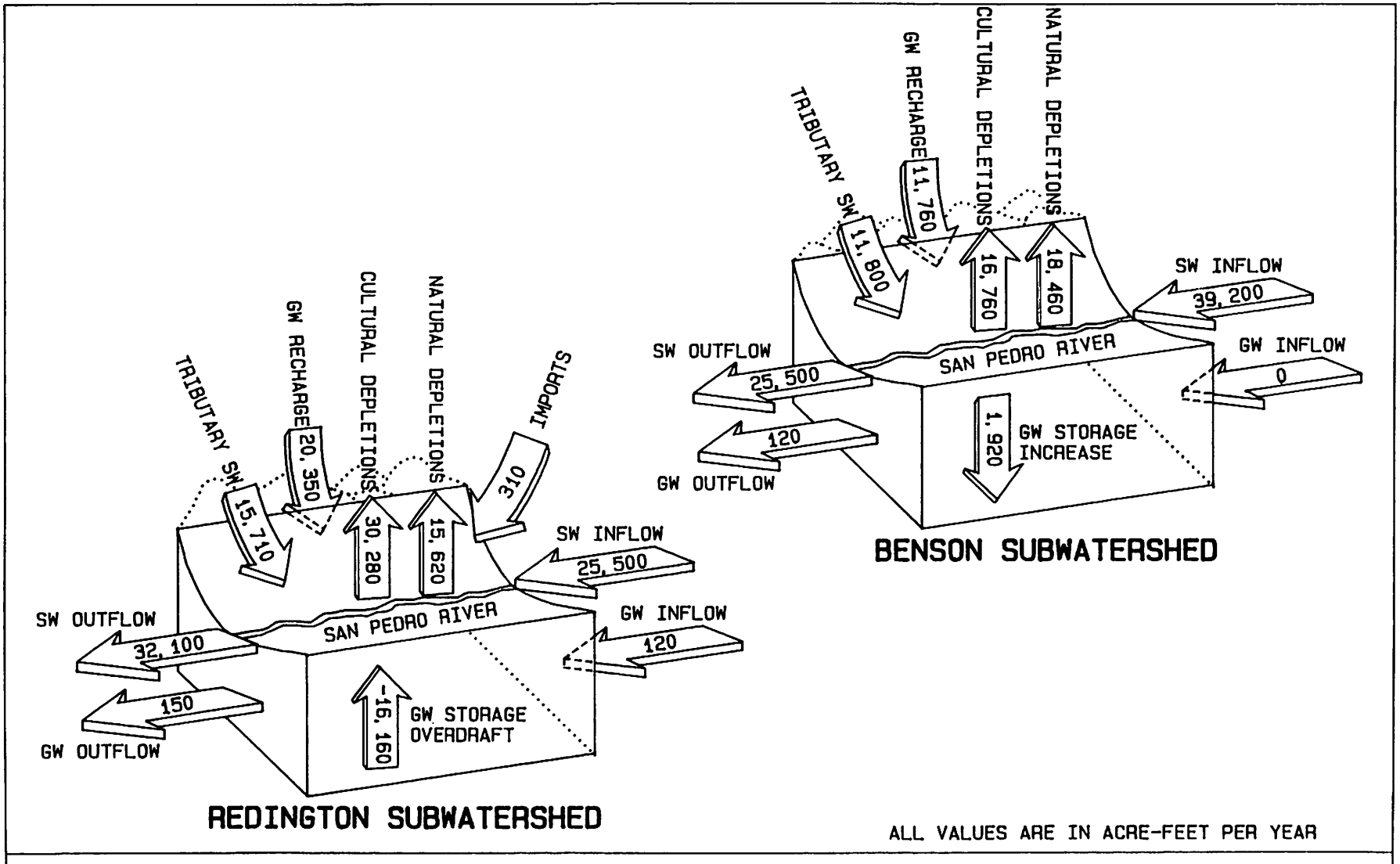


Figure 4-25. Schematic of the water budget components as they relate to the Benson and Redington subwatersheds of the San Pedro River watershed

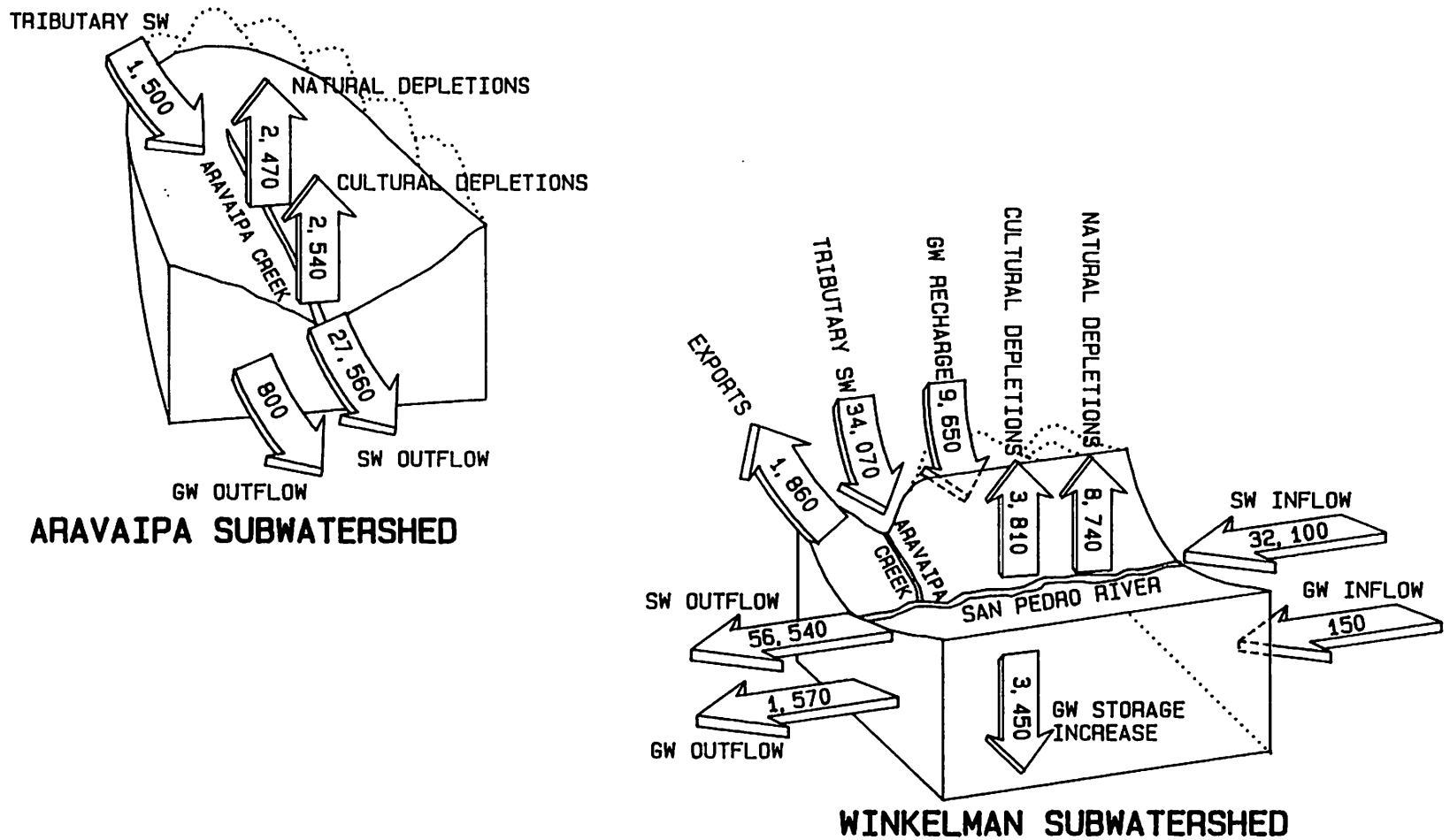


Figure 4-26. Schematic of the water budget components as they relate to the Aravaipa and Winkelman subwatersheds of the San Pedro River watershed

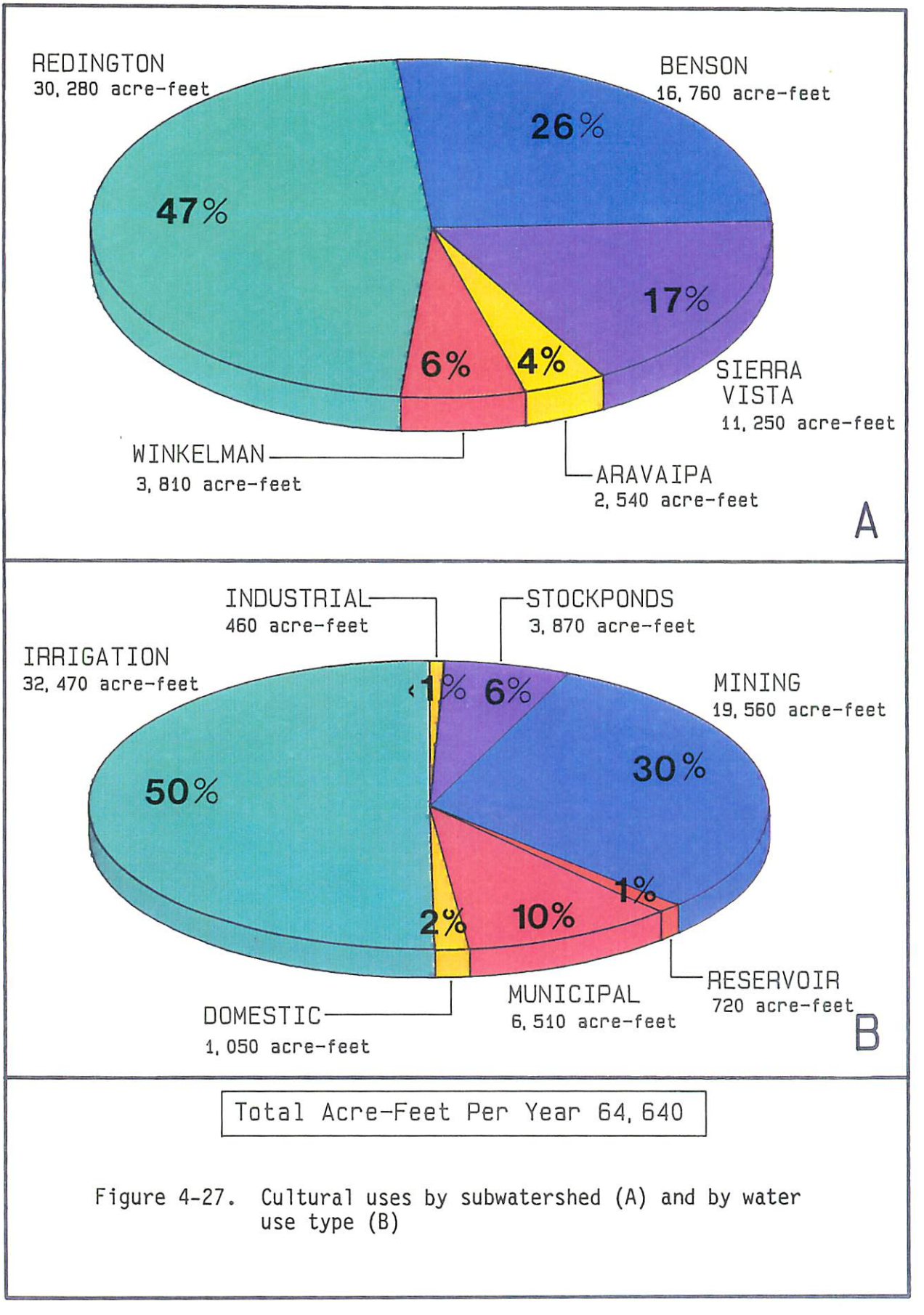
Average annual surface water inflows and outflows to each subwatershed were derived from USGS stream gage records for the period of record from 1968 to 1988. Synthetic streamflows were calculated for gages with an insufficient period of record but which had a high degree of correlation with an adjacent gage. The amount of tributary inflow attributed to each subwatershed was estimated using an equation developed by Moosburner (1970) which relates discharge to drainage area and average annual precipitation.

Recharge to the groundwater system occurs near the basin margins where surface water runoff flows from the mountain fronts onto the alluvium and is subsequently recharged to the regional aquifer. Values for groundwater recharge for each subwatershed were based on analysis of previous investigations performed by the USGS. The amount of groundwater inflow from Mexico into the United States portion of the watershed used in the budget was based on estimates reported by Heindl (1952) and derived by a flow net analysis (ADWR, 1990f).

The total amount of water consumptively used by cultural and natural uses reduces the total available water supply. These depletions affect both the surface water and groundwater supplies. Estimated water use data was obtained for 1990 development conditions. For a complete description of natural and cultural water use occurring in the watershed refer to Chapter 3. APPENDICES B, C, and F describe the procedures used and assumptions made for the water budget analysis.

Cultural water use exceeds natural water use in the Sierra Vista and Redington subwatersheds, the reverse situation occurs in the Winkelman subwatershed, and cultural and natural uses are nearly equal in the Benson and Aravaipa subwatersheds. For the watershed as a whole (including the Aravaipa subwatershed), cultural uses exceed natural depletion by 3,950 acre-feet. Figure 4-27 presents a comparison of cultural uses by subwatershed and by use category. The highest cultural use is occurring in the Redington subwatershed (47 percent) and the least within the Aravaipa subwatershed (4 percent) as shown in Figure 4-27 (A). Irrigation use (Figure 4-27 (B)) represents 50 percent of all cultural uses within the San Pedro River watershed followed by mining at 30 percent.

The results from the budget show a change in storage of minus 9,030 acre-feet in the Sierra Vista subwatershed. This overdraft is the result of



Total Acre-Feet Per Year 64, 640

Figure 4-27. Cultural uses by subwatershed (A) and by water use type (B)

both municipal groundwater pumping in the Sierra Vista - Fort Huachuca area and pumpage to supply irrigation uses located near the San Pedro River. Although about 1,900 acres of irrigation are no longer being actively irrigated each year by BLM within the national riparian area, substantial withdrawals for irrigation use remain. Some of this pumpage may be supplied from overdraft of the regional aquifer as indicated by the current groundwater decline in the regional aquifer of 0.5 to 1.0 feet per year (Putman et al., 1988).

A negative change in storage of -16,160 acre-feet is estimated to be occurring in the Redington subwatershed. This is a result of estimated groundwater withdrawals for mining and irrigation activities within the subwatershed. The effects of the groundwater pumpage due to the mining activities in the Redington subwatershed are not apparent in the groundwater contour map of the lower San Pedro River watershed as presented in Figure 2-6. Unlike the evidence provided by the water level contour map of the upper San Pedro River watershed in the vicinity of Sierra Vista, Figure 2-7, there is not much direct evidence to support this change in storage value for the Redington subwatershed. Additional unit specific water level information should be collected to determine the impacts of these withdrawals on the system.

The average annual surface water outflow to the Gila River from the San Pedro River watershed is 56,540 acre-feet per year. This equates to approximately 36 percent of the total available water supply within the United States portion of the watershed. The remaining 64 percent is consumptively used by cultural and natural depletions.

UNDEPLETED FLOW ANALYSIS

Undepleted flow is the average annual streamflow in a watershed without the affects of diminishment by cultural depletions. In other words, undepleted flow is an estimate of the surface flow if all current condition cultural depletions were "turned off." Undepleted flow should not be confused with predevelopment or virgin flow which is the streamflow that existed on the San Pedro River prior to cultural interference. Within the San Pedro River watershed, no stream gaging records exist prior to cultural interference making it difficult to derive flows under predevelopment or virgin conditions.

An estimate of the undepleted flow for the United States portion of the San Pedro River was derived by determining the average annual streamflow and groundwater inflow entering the watershed at the International Boundary, adding contributions to streamflow occurring within the United States and groundwater recharge and subtracting natural depletions and riparian salvage. This estimate requires an assumption that groundwater inflow, surface water inflow, tributary inflow, and groundwater recharge represent undepleted conditions and are unaffected by cultural development.

The average annual streamflow entering the watershed from Mexico was calculated from streamflow data at the Palominas stream gage provided by the USGS from 1968 through 1981 and the International Boundary and Water Commission from 1982 through 1989.

It is assumed that natural consumptive uses, channel evaporation, and riparian salvage would increase by 12 percent over current conditions due to the availability of additional water.

The sum of the total streamflow minus natural consumptive uses and riparian salvage for each subwatershed results in the undepleted flow for the subwatershed. The estimated outflow for an upstream subwatershed is the inflow to the downstream subwatershed. This procedure was repeated for each subwatershed along the San Pedro River. Table 4-13 illustrates the results of the undepleted flow analysis.

Table 4-13 shows that an estimated 89,260 acre-feet of surface water and subflow would be discharged from the watershed outlet annually under undepleted conditions. This value is about 32,720 acre-feet greater than the current condition average annual surface water outflow at Winkelman of 56,540 acre-feet (see Table 4-12, Current Conditions Budget). The reason why the difference between undepleted flow and current condition outflow is much less than the sum of cultural uses (64,640 acre-feet per year including Aravaipa Creek) is because natural uses increase for undepleted flow conditions and because groundwater overdraft supplies approximately 19,200 acre-feet of the total cultural use. Thus, about 58 percent of the total cultural use results in a reduction in watershed outflow. Stated another way, for every ten acre-feet of water consumptively used in the San Pedro River watershed, on average the outflow of the stream into the Gila River is being reduced by six acre-feet.

TABLE 4-13

SAN PEDRO RIVER UNDEPLETED FLOW ANALYSIS

	SUBWATERSHEDS			
	SIERRA VISTA	BENSON	REDINGTON	WINKELMAN
SUPPLY				
Groundwater Inflow	3,000			
Surface Water Inflow (1)	23,420	38,683	38,848	55,915
Tributary Inflow (2)	17,300	11,800	15,710	34,070
Groundwater Recharge (3)	13,860	11,760	20,350	9,650
Imports	200 (4)	0	310 (5)	0
NET	57,780	62,243	75,218	99,635
USE				
Natural Use (6)	17,248	20,675	17,494	9,789
Riparian Salvage	1,849	2,720	1,809	1,170
NET	19,097	23,395	19,303	10,963
TOTAL (AF/YR)	38,683	38,848	55,915	88,672

(1) Surface water inflow to the United States portion of the watershed determined from USGS stream gage at Palominas for the period of record from 1968-1988. Assumes surface water supplies from Mexico represent undepleted conditions.

(2) Inflow of tributary surface water which contributes to streamflow of the San Pedro River. Tributary inflow consists of ephemeral streamflow from storm water runoff.

(3) The amount of mountain front recharge that is discharged to the San Pedro River as groundwater seepage from the regional aquifer.

(4) Groundwater pumped from Cienega Creek groundwater basin and used for irrigation within the San Pedro River watershed.

(5) Groundwater imported to Oracle for municipal use.

(6) Natural use values were adjusted upward 12 percent from the water budget due to the additional water available under undepleted flow conditions which would result in increased consumptive use.

4.8 SUMMARY AND CONCLUSIONS

The major technical conclusions regarding the hydrologic system in the San Pedro River watershed are summarized below:

1. Most of the dynamic interaction between surface water and groundwater (excluding mountain front and minor tributary channel recharge) occurs in a relatively narrow strip of land which conforms to the younger alluvium and that borders the San Pedro River, Babocomari River, and Aravaipa Creek. The younger alluvium is also where most of the natural and cultural uses take place within the San Pedro River watershed.

2. The San Pedro River receives its water supply from direct precipitation and snowmelt runoff (higher flows) and baseflow derived from groundwater discharges to the stream (low flows).

3. Under both perennial and intermittent conditions, the San Pedro River may recharge the floodplain aquifer when there is space in the floodplain alluvium created by natural or cultural withdrawals.

4. Some of the perennial streamflow within the watershed is a result of groundwater being forced to the floodplain aquifer and the surface water system from the regional aquifer by the influence of shallow bedrock.

5. Natural uses occurring in the San Pedro River watershed (including the Aravaipa subwatershed) consist of direct evaporation from flowing reaches (880 acre-feet per year), evaporation from channel soils (5,710 acre-feet per year), and phreatophyte evapotranspiration (54,100 acre-feet per year).

6. Cultural depletions impact the hydrologic system by lowering groundwater levels in the regional and floodplain aquifers and/or by directly reducing streamflow in channels. The removal of groundwater may directly or indirectly interfere with streamflow. Direct interference occurs when a cone of depression of a pumped well(s) intercepts the streambed and induces surface water to move away from the stream. Indirect interference occurs when the cone of

depression does not intercept the stream, but reduces the amount of groundwater discharged to the stream by intercepting groundwater flows.

7. Tributary groundwater uses are groundwater withdrawals from areas of the regional aquifer that have a direct hydraulic connection to the floodplain aquifer of the younger alluvium. These uses remove groundwater in storage from both the regional and floodplain aquifers or intercept groundwater flowing toward the younger alluvium.

8. The impacts of some cultural or groundwater withdrawals have not yet affected or reduced the surface water supply in the inner valleys, but are impacts in transit toward the younger alluvium that will eventually reach the younger alluvium. As more of these impacts arrive at the younger alluvium, their cumulative effect can be expected to further reduce the surface water supply.

9. Because of intervening travel distance, tributary surface water uses within the Winkleman and Aravaipa subwatershed have more effect in reducing the contributions of the San Pedro River to the Gila River during periods of low surface water flow than those occurring within the Benson and Sierra Vista subwatersheds.

10. The floodplain aquifers of the San Pedro River, Babocomari River, and Aravaipa Creek are integrated hydrologic systems in which groundwater and surface water are basically interchangeable.

11. During most years, only prolonged high water flows and significant summer flood flows are able to pass the gauntlet of transmission losses and appear in the lower reaches of the San Pedro River or be discharged to the Gila River.

12. During the summer, all baseflow and minor flood flows originating in the upper areas are lost to the depletion mechanism before reaching the lower areas. Winter is a period of restoration when transmission losses are reduced and the surface flows are restoring the floodplain aquifer from effects of the previous growing season.

13. Transmission losses (cultural and natural uses) deplete approximately 87 percent of the inflow to the United States from Mexico. Only 13 percent reaches the confluence with the Gila River.

14. The amount of water that precultural phreatophytic riparian vegetation was using has been eliminated by removal of this vegetation in conversion to agricultural land. Thus as a consequence of initiating a cultural use, natural uses have been reduced. This effect is referred to as "riparian salvage."

15. An estimated 2,900 acres of riparian displacement has occurred within the watershed. The total riparian salvage is calculated to be 7,630 acre-feet per year. The net effect to the hydrologic system due to all irrigation uses in the San Pedro River watershed is not the apparent total annual consumptive use of 32,470 acre-feet but rather must be reduced by the total riparian salvage of 7,630 acre-feet. Therefore, the net effect on the hydrologic system due to irrigation uses is 24,840 acre-feet per year.

16. Pursuant to Court order, DWR has classified wells reported in its HSR according to the category of water being withdrawn as: 1) Zone 1 wells which have the potential to withdraw appropriable subflow, 2) Zone 2 wells whose withdrawals have the potential to significantly diminish federal reserved rights, and 3) Zone 3 wells whose withdrawals may not significantly affect appropriators under state law or may not significantly diminish water available to a federal reservation. The entire San Pedro River watershed has been subdivided into these three zones representing these three categories of wells.

17. Zone 1 is an area on either side of the major stream channels that is defined by an analytical relationship (Jenkins, 1968). This relationship defines the distance on either side of the stream's bank within which a well would have derived 50 percent of its volume of pumpage from the surface flow in the stream after 90 days of continuous pumpage.

18. Zone 2 is the area that extends from the "brightlines" of Zone 1 to the beginning edge of the regional aquifer on both sides of the San Pedro River, Aravaipa Creek, and the Babocomari River. The

beginning edge of the regional aquifer is where the aquifer encounters the hard rock of the surrounding mountains or transitions to isolated non-tributary aquifers. The Zone 2 region is comprised of tributary groundwater aquifers that are in direct hydraulic connection with a stream or have a hydraulic connection with another aquifer which is in hydraulic connection with a stream.

19. Zone 3 is represented by the areas of the watershed where significant aquifers do not occur such as the nonwaterbearing hard rock of the mountains and isolated non-tributary alluvial aquifers.

20. A current condition water budget analysis of the San Pedro River watershed shows a total supply into the mainstem of the San Pedro River watershed of 159,200 acre-feet per year, a water use (natural and cultural) of 120,320 acre-feet per year, and a groundwater and surface water outflow of 58,110 acre-feet per year. This excludes the Aravaipa subwatershed.

21. Annual cultural depletions for the entire watershed (including the Aravaipa subwatershed) equal 64,640 acre-feet or 52 percent of all depletions. Irrigation represents 50 percent and mining 30 percent of the total cultural depletions. The Redington subwatershed has the largest cultural depletion (30,280 acre-feet per year) with 65 percent occurring within the mining category. The Benson subwatershed is the second largest user with 16,760 acre-feet per year of which 85 percent is used for irrigation. The Benson subwatershed has the largest irrigation use. The Sierra Vista subwatershed is the third largest user with 11,250 acre-feet per year, however, it is the largest user in the category of municipal use (4,530 acre-feet per year).

22. Natural uses within the mainstem San Pedro River watershed total 58,220 acre-feet per year with phreatophytes consuming 90 percent of the total. An additional 2,470 acre-feet of natural uses occurs within the Aravaipa subwatershed.

23. Cultural water use exceeds natural water use in the Redington subwatershed, the reverse situation occurs in the Sierra Vista, Benson, and Winkelman subwatersheds, and cultural and natural uses

are nearly equal in the Aravaipa subwatershed. Cultural uses exceed natural depletions by 3,950 acre-feet per year for the watershed as a whole.

24. A negative change in storage of -9,030 acre-feet is occurring in the Sierra Vista subwatershed as a result of municipal groundwater pumping in the Sierra Vista - Fort Huachuca area and pumpage to supply irrigation uses located near the San Pedro River. The Redington subwatershed is also showing a negative change in storage of -16,160 acre-feet, mainly as a result of groundwater withdrawals for mining and irrigation operations.

25. An average of 36 percent of the total available water supply within the United States portion of the San Pedro River watershed or 56,540 acre-feet per year of surface water outflow to the Gila River. The remaining 64 percent is consumptively used by cultural and natural depletions.

26. The estimated average streamflow leaving the San Pedro River watershed under undepleted flow conditions is 89,262 acre-feet per year. This value is about 31,720 acre-feet greater than the current condition average annual outflow at Winkelman of 56,540 acre-feet.

CHAPTER 5: MAJOR USERS REPORTS

This chapter presents information on major water users and claims located in the San Pedro River watershed and investigated by the Arizona Department of Water Resources (DWR). Major water users include municipal and irrigation water providers, commercial/industrial water users, and non-Indian federal claims. Forty-three municipal reports, two irrigation water provider reports, one private party diversion report, a report for surface water diversions along Aravaipa Creek, thirteen industrial and mining user reports, and six non-Indian federal reports are included in this chapter. The discussions include the history, water use characteristics and facilities, and past water usage of each provider/user. The purpose of these reports is to provide additional pertinent information about each major user not contained in the watershed file reports (WFRs).

5.1 MUNICIPAL WATER PROVIDERS

This section describes the forty-three organizations that supply water for municipal purposes in the San Pedro River watershed. The forty-three organizations are comprised of thirty franchised water companies (Table 5-1), eight domestic water improvement districts, cooperatives, or providers (Table 5-2), and five water systems operated by municipalities (Table 5-3). Forty-two of the organizations utilize groundwater for their municipal supply systems. The City of Tombstone supplements its supply with surface water. The Arizona Water Company - San Manuel System is supplied by wells located within the Zone 1 groundwater. The Huachuca City Municipal Water Supply delivers water from wells located within Zone 1 and Zone 2. The extent of the service areas for the forty-three municipal water providers is shown on Figure 5-1. The amount of water delivered by each provider during the 1980 through 1988 period is listed in Table 5-6 at the end of this section. The individual service areas and locations of wells for each organization are shown on the regional water use maps in Volume 9 of this HSR.

TABLE 5-1

STATE FRANCHISED WATER COMPANIES

WATER PROVIDERS	REGIONAL MAP(S)	PAGE
Antelope Run Water Company	23	269
Arizona Water Company - Bisbee System	24	269
Arizona Water Company - San Manuel System	8	271
Arizona Water Company - Fuller and Sulger Systems	23, 20	274
Bella Vista Water Company	20, 23	277
Cloud 9 Water Company	23	278
Cochise Water Company	23	281
Coronado Estates Water Company	20	283
Crystal Water Company	20	283
East Slope Water Company	23	284
Frarer Water Company	17	285
Holiday Enterprises, Incorporated	21	285
Horseshoe Ranch Water Company	23	286
Hougland Water Company	23	287
Indiada Water Company	23	288
Lucky Hills Water Company	21, 20	289
Mescal Lakes Water Company	16	290
Miracle Valley Water Company	23	290
Mustang Water Company	20	291
Naco Water Company	24	291
Nicksville Water Company	23	292
Pomerene Domestic Water Users Association	17	294
Pueblo Del Sol Water Company	23	278
Santa Cruz Water Company	19	294
Sierra Sunset Water Company	20	295
Southland Utility Company	23	295
St. David Water Association	17	296
Stratman Water Company	17	296
Sue Juan Water Company	17	296
Willow Lakes Water Company	14	300

TABLE 5-2

DOMESTIC WATER IMPROVEMENT DISTRICTS, CO-OPS OR PROVIDERS

WATER PROVIDERS	REGIONAL MAP(S)	PAGE
Dakota Water Association	23	283
Desert Estates Water Co-op	4	284
Howe Water Provider	8	287
NRB Community Well Co-op	23	293
Parcel H Water Co-op	23	293
Thunder Mountain Estates Water Co-op	22	297
Vista Estates Water Co-op	23	299
Whetstone Water Improvement District	20	300

TABLE 5-3

MUNICIPAL WATER SYSTEMS

WATER PROVIDER	REGIONAL MAP(S)	PAGE
Benson Municipal Water Supply	17	272
Huachuca City Municipal Water Supply	20	288
Mammoth Municipal Water Company	4	289
Sierra Vista Municipal Water Supply	20, 23	279
Tombstone Municipal Water Supply	21	297

ANTELOPE RUN WATER COMPANY (WFR #111-23-40)

History

The Antelope Run Water Company, established in 1979, began supplying water for the Antelope Run Estates in 1984. There are currently ten service connections within the 640 acre subdivision. As population increases, it is anticipated that the water company service will expand.

Water Supply System

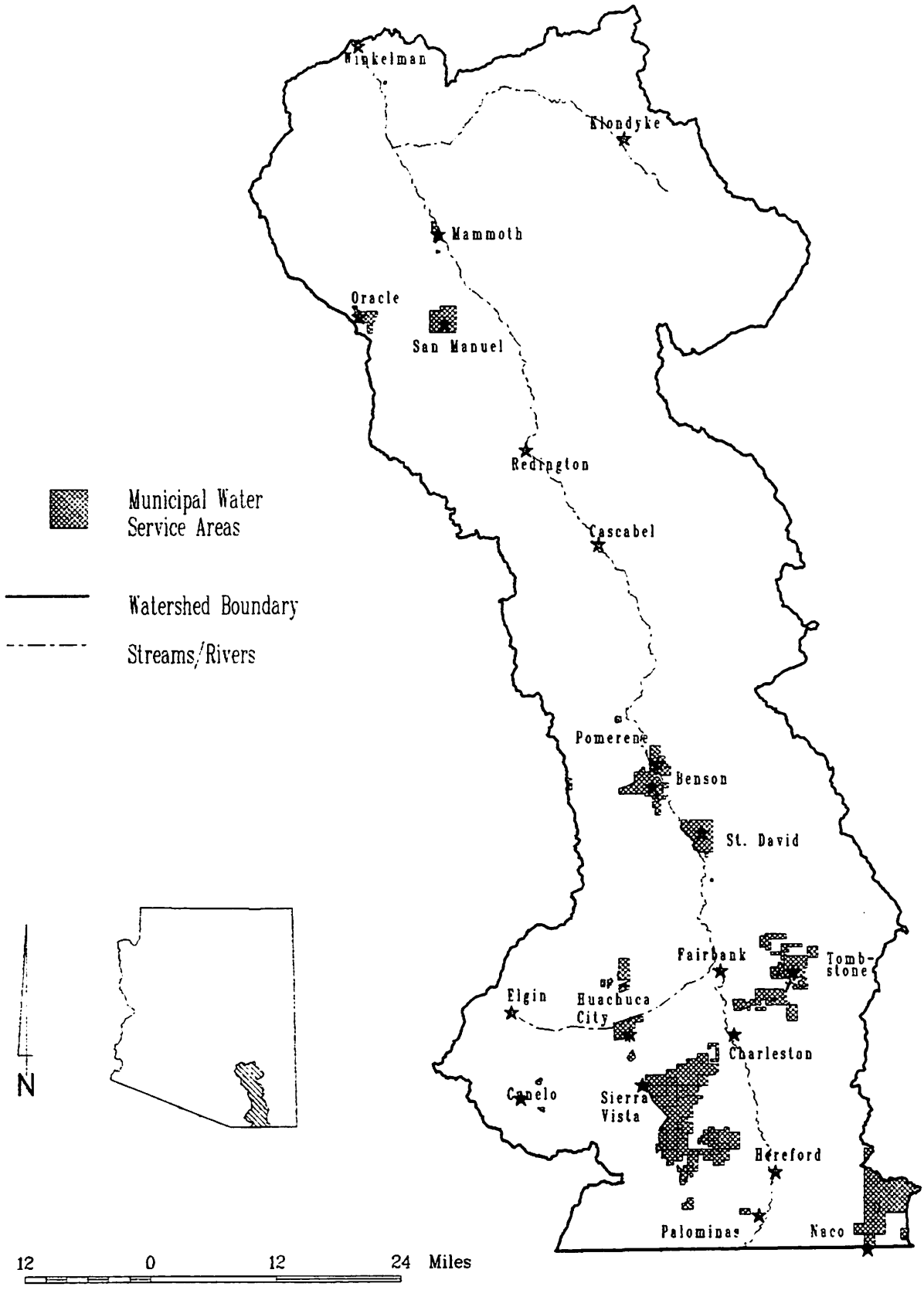
The water supply system consists of two wells. The primary well supplies a 15,000 gallon storage tank and the other well is intended as a standby well and is equipped with a small pressure tank. There is a backup tie-in with the Indiada Water Company (refer to WFR #111-23-41) through which water can be conveyed to supply both water companies in times of short supply or mechanical failure. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

ARIZONA WATER COMPANY - Bisbee System (WFR #111-24-59)

History

In 1955, the Arizona Water Company purchased the Bisbee water supply system from the Arizona Public Service (APS). It is unknown how APS had been operating that system. Much of the Certificate of Convenience & Necessity (CC&N) area for the Arizona Water Company is outside the San Pedro River



Source: Watershed File Reports, Volumes 3 through 8 of this HSR.

Figure 5-1. Water company service areas in the San Pedro River watershed

watershed. This includes the City of Bisbee. The CC&N area within the watershed covers about twenty square miles. There are currently 3,221 service connections, but it is unknown how many of these exist within the San Pedro River watershed.

Water Supply System

The water supply system consists of two wells located near the Town of Naco. The maximum water storage capacity is reported as 2,630,000 gallons. Most of the customers within the Bisbee city limits are connected to the municipal wastewater treatment system while the majority of customers in the county area outside the city have individual septic tank systems. The municipal wastewater treatment system discharges effluent outside the San Pedro River watershed. The City of Bisbee owns and operates one well for fire protection purposes.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

ARIZONA WATER COMPANY - San Manuel System (WFR #113-8-3)

History

The Town of San Manuel was established in 1952 at the time Magma Copper Company initiated mining and smelting operations. Prior to 1955, municipal water was supplied by APS. In 1955, the system was acquired by the Arizona Water Company. There are currently 1,523 service connections.

Water Supply System

Magma Copper Company operates eleven wells located along the west bank of the San Pedro River. Five of these wells are located within Zone 1. The remaining six wells are located in Zone 2. Water pumped by these wells is commingled in a common pipeline and provides water for both the community of San Manuel and the Magma smelter. The water supply for San Manuel is sold to the Arizona Water Company for distribution within the community. The distribution system is owned by the Arizona Water Company and includes two storage tanks with a total capacity of 1,000,000 gallons. The wastewater from San Manuel is conveyed through a sewer system and discharged into a lagoon

treatment system adjacent to the smelter. Municipal effluent is then discharged into evaporation ponds at the smelter.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

BENSON MUNICIPAL WATER SUPPLY (WFR #112-17-39)

History

The City of Benson was founded in 1880 with the present city limits encompassing approximately six square miles. The earliest available record of first water use is the Benson Water Company's articles of incorporation filed with the Cochise County Recorder's office on September 29, 1905. Prior to 1905, private water sources presumably supplied domestic requirements. In addition to the municipal water supply, a portion of the residences are also serviced by the Sue Juan Water Company (refer to page 283 and WFR #112-17-38) that is interconnected with the municipal system enabling either supplier to obtain water from the other.

Water Supply System and Wastewater Disposal

Benson's water supply system consists of eight wells, two of which have been abandoned with a total maximum water storage capacity of 1.1 million gallons. Municipal wastewater is conveyed through a sewer system and discharged into the City of Benson wastewater treatment facility (Figure 5-2). Currently the facility, which began operation in 1980, treats approximately 0.5 million gallons of effluent (i.e. treated wastewater) per day. This plant is designed to make use of the effluent by irrigating about fifty-six acres of surrounding land owned or leased by the City of Benson to grow a productive crop (generally alfalfa). The effluent is applied to these fields by means of a center-pivot sprinkler system. Twenty-nine acres of privately owned land, supplied solely by effluent piped from the facility, is irrigated by means of a flood irrigation and pumpback system. An additional fifteen acres of privately owned land supplements its irrigation supply with effluent from the wastewater treatment facility (refer to WFR #112-17-BAD-3).

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

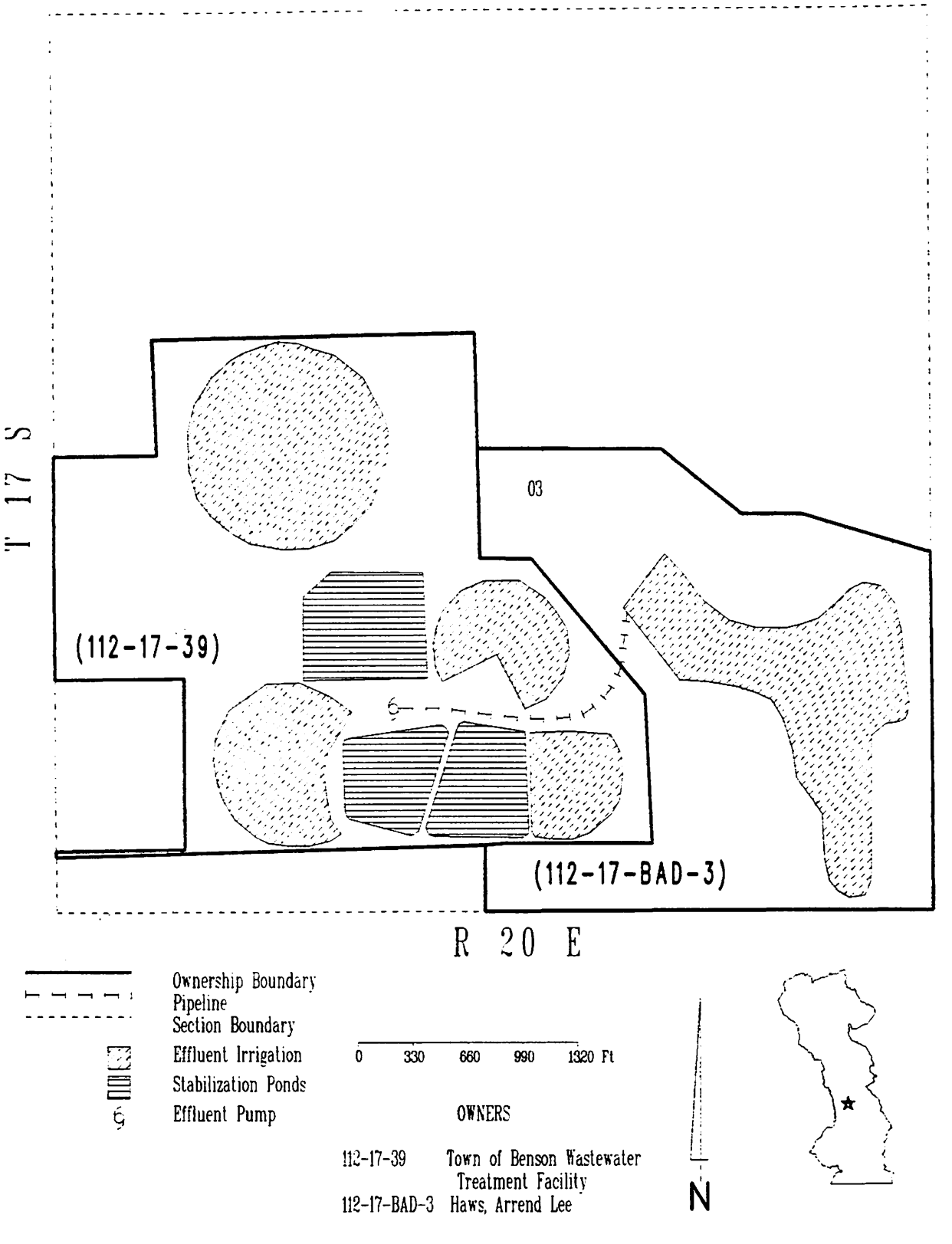


Figure 5-2. City of Benson wastewater treatment facility

CITY OF SIERRA VISTA METROPOLITAN AREA REPORT

The City of Sierra Vista receives its domestic, commercial, industrial, and recreational water supply from four privately owned companies and the City of Sierra Vista municipal water supply system. The Fort Huachuca Military Reservation, which was incorporated into Sierra Vista in 1971, maintains its own water supply and wastewater treatment systems. Figure 5-3 shows the areas served by the water providers and Table 5-4 summarizes pertinent information for each provider.

TABLE 5-4

SUMMARY OF THE CITY OF SIERRA VISTA METROPOLITAN AREA WATER PROVIDERS

WATER SERVICE ORGANIZATION	NUMBER OF WELLS	STORAGE CAPACITY (GALLONS)	WASTEWATER DISPOSAL AND TREATMENT
1. Arizona Water Company - Fuller and Sulger Systems	9	1,356,000	Sierra Vista System Septic Tanks
2. Bella Vista Water Company	18	4,095,000	Sierra Vista System Septic Tanks
3. Cloud 9 Water Company	2	380,000	Sierra Vista System
4. Pueblo Del Sol Water Company	3	954,000	Sierra Vista System Septic Tanks
5. Sierra Vista Municipal Water Supply	3	954,000	Sierra Vista System Septic Tanks
TOTAL	35	7,739,000	

A description of the history and water supply system of each water provider is presented below.

1. ARIZONA WATER COMPANY - Fuller and Sulger Systems (WFR #111-23-33)

History

The Arizona Water Company owns the Fuller and Sulger water system whose service areas are both located within or adjacent to the City of Sierra Vista. The systems are operating independently, though their pumpage figures are combined in reports to the Arizona Corporation Commission. The Fuller

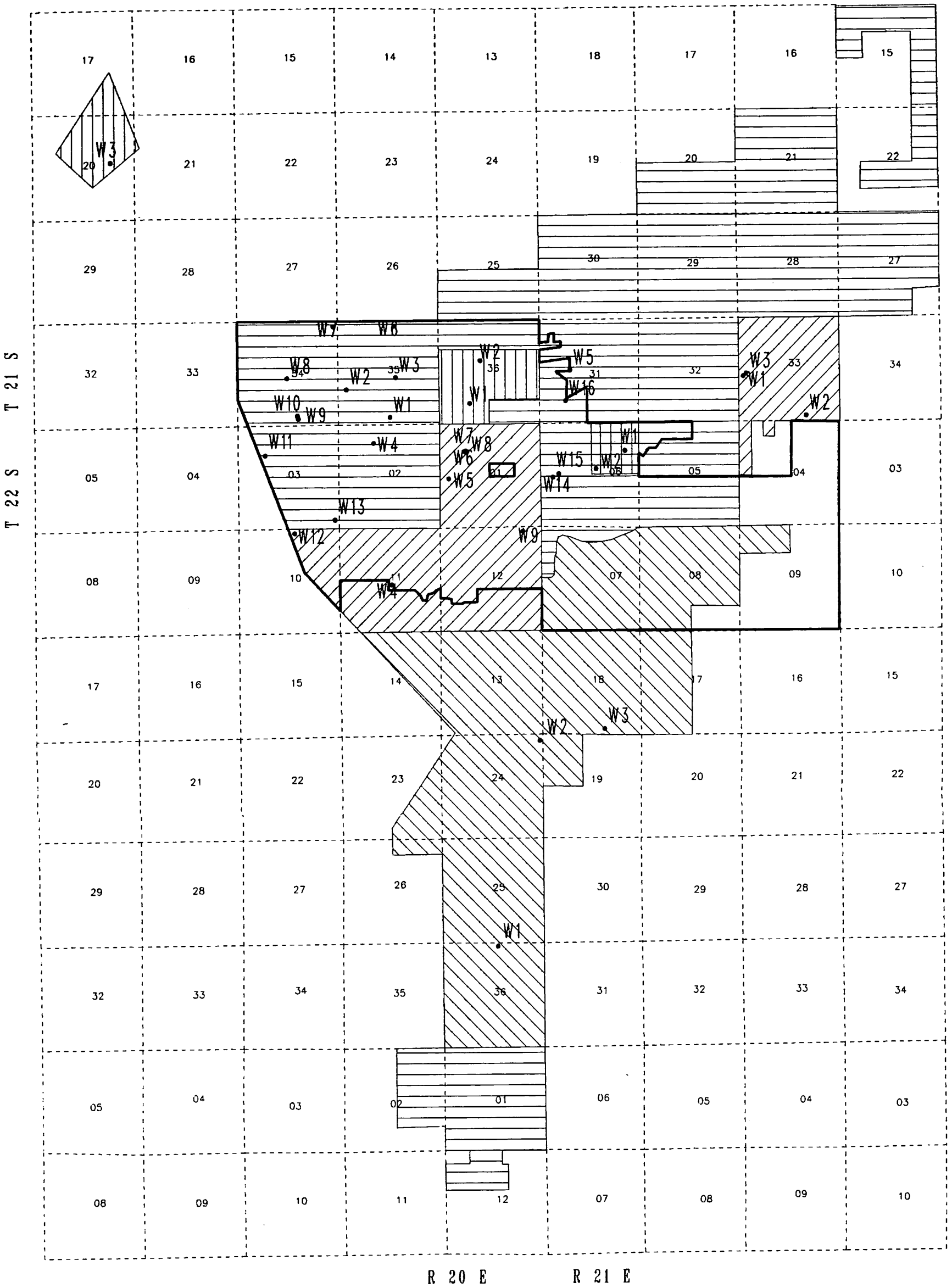


Figure 5-3. Water supply organizations serving Sierra Vista

system was purchased in 1960 from the Fuller Development Company. As the number of customers increased, three wells were added while one well was abandoned. The Sulger system was purchased in 1964 and one well has been added as the number of customers grew from fourteen to approximately 250 today. Both CC&N areas have remained unchanged since their purchase by the Arizona Water Company, although the areas of actual service have changed substantially. There are currently 2,007 service connections.

Water Supply System

The Sulger water supply system consists of three wells and two storage tanks having a maximum capacity of 106,000 gallons. Wastewater disposal is processed through individual septic tank systems. The Fuller water supply system consists of six wells with a maximum water storage capacity reported as 1,250,000 gallons. Portions of the Fuller sewage system are connected to the Sierra Vista municipal wastewater treatment system while the remainder of its service area utilizes individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

2. BELLA VISTA WATER COMPANY (WFR #111-20-62)

History

The Bella Vista Water Company is the primary supplier of water to residential and commercial customers in the City of Sierra Vista. The Bella Vista Water Company and Southwest Water Company combined service areas and facilities in 1980 to form the Bella Vista/Southwest Water Company. In the late 1980s, the Welch Water Company, which reportedly began operation in 1929, was purchased and consolidated with the Bella Vista/Southwest Water Company, forming the Bella Vista Water Company, Inc.

The Bella Vista Water Company drilled their first service well in 1956 and established service by 1957. Southwest Water Company started service to the area in 1954. Bella Vista Ranches, LTD Partnership is the holding company for this combined operation.

Water Supply System

The Bella Vista Water Company owns and operates eighteen wells that comprise the water supply system. The maximum water storage capacity of the system is reported as 4,095,000 gallons. The disposal of wastewater in the service area is handled primarily by the Sierra Vista wastewater treatment system and individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

3. CLOUD 9 WATER COMPANY (WFR #111-23-26)

History

Cloud 9 Water Company furnishes water for the Cloud 9 Ranch Estates, a mobile home park located in Sierra Vista. There are currently 265 service connections.

Water Supply System

The water supply system consists of two wells. One well is used regularly and has a 3,000 gallon pressure tank and a 380,000 gallon storage tank. The other well is used as a standby well. The total capacity of both wells is 575 gallons per minute (gpm). The mobile home park has a sewer system which discharges wastewater to a treatment lagoon system near the east border of the property. The effluent from this treatment process is then transported to the Sierra Vista wastewater treatment system.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

4. PUEBLO DEL SOL WATER COMPANY (WFR #111-23-34)

History

The Pueblo Del Sol Water Company was incorporated in 1972. The service area is located just south of Sierra Vista within the Pueblo Del Sol subdivision.

Water Supply System

The water supply system consists of three wells with a maximum water storage capacity reported as 954,000 gallons. The water company supplies potable water to the Pueblo Del Sol Golf Course and occasionally provides water for irrigation of the golf course as required, although the golf course has independent irrigation wells. A portion of the service area is connected to the Sierra Vista wastewater treatment system with the remainder of its service area using individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

5. SIERRA VISTA MUNICIPAL WATER SUPPLY (WFR #111-20-56)

History

The City of Sierra Vista was incorporated in 1956. Fort Huachuca was incorporated into Sierra Vista in 1971. The Sierra Vista municipal system serves water for domestic use, the irrigation of parks, potable water for recreational facilities, and commercial/industrial operations.

Water Supply System

The Sierra Vista municipal system consists of three wells. The "Airport" well produces 350 gpm and has a 60,000 gallon storage tank and a 1,500 gallon pressure tank. It is anticipated the well will service the airfield terminal and industrial park to be developed. The Sierra Vista-Libbey Airfield is a facility operated through an agreement between Fort Huachuca and the City of Sierra Vista. Disposal of wastewater is accomplished in this area by a septic tank system. The "Park" well produces 650 gpm and has a 3,000 gallon pressure tank. It is used to irrigate forty acres of grassland park from April through October. It is also used for potable water source for drinking fountains and restrooms at recreational facilities. The "Community Center" well produces 650 gpm and has a 3,000 gallon pressure tank, irrigates nineteen acres of parks, and serves buildings occupied by an average of sixty persons per day. Sierra Vista provides a sewer system for 95 percent of municipal wastewater, which is discharged to the Sierra Vista wastewater treatment facility located

one mile east of Sierra Vista. The remainder is disposed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

Wastewater Treatment and Disposal

The wastewater from the Sierra Vista water service organizations is delivered to the Sierra Vista wastewater treatment facility located approximately one mile east of Sierra Vista. The facility is designed to make use of the effluent by applying it to irrigated fields surrounding the facility. The effluent is applied to each field by means of a center-pivot sprinkler system. Currently, the capacity of the treatment works is 2.9 million gallons per day and the current average flow is 1.85 million gallons of effluent per day with 1.5 million gallons being used to irrigate approximately 334 acres of alfalfa (Figure 5-4). The City of Sierra Vista estimated that 0.35 million gallons of effluent are lost each day to evaporation during the treatment process and application of irrigation water. The effluent is transported to the sprinkler system by three pumps located in the pump room of the operations building (City of Sierra Vista, 1983).

The City of Sierra Vista submitted five filings which claim uses in the area of the wastewater treatment facility (Table 5-5). Two of the claims reference domestic and stockwatering uses, two reference irrigation water uses of effluent, and one claim references stock and wildlife watering.

In APS v. Long (1989), the Arizona Supreme Court ruled that effluent waters are not considered to be appropriate public waters. Consequently, any current water uses served by effluent water at this facility are not given potential water right designations by DWR.

Projected Future Water Use in the Sierra Vista Area

Data provided by the Arizona Department of Economic Security as of July 1989 indicates that the population in Sierra Vista is likely to increase at a rate comparable to the rest of the State of Arizona.

TABLE 5-5

CLAIMS FILED BY THE CITY OF SIERRA VISTA
PERTAINING TO THE WASTEWATER TREATMENT FACILITY

CLAIM NUMBER	CLAIMED USES	CLAIMED QUANTITY (AC/YR)	USES FOUND BY DWR
33-89139	Irrigation	3,240.00	Effluent supplied irrigation
36-29080	Domestic Stockwatering	10.00	None
38-28620	Stockwatering Wildlife	4.50	None
39-2752	Domestic Stockwatering	10.00	None
39-5807	Irrigation	30.00	Effluent supplied irrigation

This being the case, there will be a need for existing water supply organizations to either expand their service capabilities or for new service organizations to provide the additional water requirements.

COCHISE WATER COMPANY (WFR #111-23-25)

History

The Cochise Water Company was established in 1964 and supplies the water for an estimated 1.5 square miles service area.

Water Supply System

The water supply system consists of two wells with the maximum water storage capacity reported as 12,000 gallons. One of these wells (W2) also supplies water to the Horseshoe Ranch Water Company (111-23-28). Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

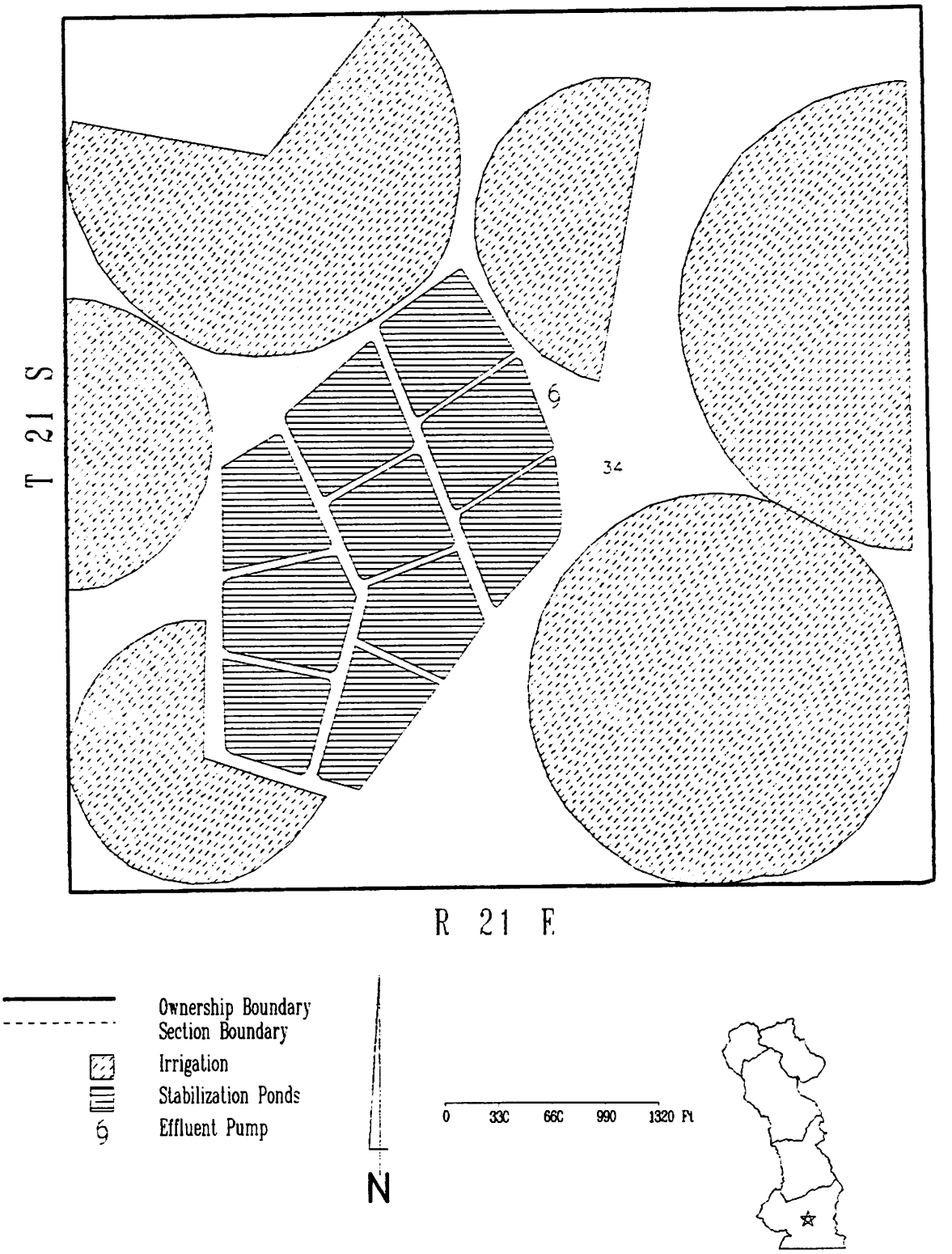


Figure 5-4. City of Sierra Vista wastewater treatment facility

CORONADO ESTATES WATER COMPANY (WFR #111-20-51)

History

The Coronado Estates Water Company was established in 1960 and supplies water for an estimated 320 acre subdivision.

Water Supply System

The water supply system consists of one well, a 2,500 gallon pressure tank, and a 30,000 gallon storage tank. These two tanks give an estimated maximum water storage capacity of 32,500 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

CRYSTAL WATER COMPANY (WFR #112-20-11)

History

The Crystal Water Company was issued a CC&N in 1978. The water company currently furnishes water for an estimated 150 acre service area.

Water Supply System

The water storage system consists of one well. The maximum water storage capacity is not known. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

DAKOTA WATER ASSOCIATION (WFR #111-23-66)

History

The Dakota Water Association was formed in 1988 to establish a formal agreement to maintain and operate a commonly owned domestic well which serves seven parcels in the Greater San Pedro Ranches subdivision. The well was completed in December 1983. The first two families began water use in early

1984. There are now five active users and two vacant parcels. Usage is primarily for domestic purposes, but includes a kennel and a small nursing home. No future expansion is anticipated.

Water Supply System

The water supply system consists of one commonly owned well on a sixteen feet by sixteen feet parcel divided into nine equal interests. There are two booster pumps with small tanks. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

DESERT ESTATES WATER CO-OP (WFR #114-4-30)

History

The Desert Estates Water Co-op was established in 1976 to supply water for domestic users in the SE¼, NE¼, Section 8, Township 6 South, Range 16 East. The co-op is presently serving eleven domestic users.

Water Supply System

The Desert Estates Water Co-op is served by a 485 foot deep well with a pumping capacity of twenty gpm. A 10,000 gallon tank is used for water storage. No pumpage figures are available since the parcel owners share the cost for maintenance and pumpage fees. Wastewater is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

EAST SLOPE WATER COMPANY (WFR #111-23-42)

History

The East Slope Water Company was established in the early 1960s and was known as the S.V.E. Water Company because it furnished water for the Sierra Vista Estates subdivision. It was renamed the East Slope Water Company in

1980 after purchase by Sierra Vista Realty. The company supplies a service area of two square miles located about five miles south of Sierra Vista. There are currently 543 service connections.

Water Supply System

The water supply system consists of four wells. Two wells each have a 3,000 gallon pressure storage tank, one well has a 5,000 gallon storage tank, and one well has a 10,000 gallon storage tank. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

FRARER WATER COMPANY (WFR #112-17-42)

History

In 1964 the Frarer Water Company was granted a CC&N. It currently furnishes water to an estimated forty acre service area.

Water Supply System

The water supply system consists of one well with a maximum water storage capacity reported as 16,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

HOLIDAY ENTERPRISES, INCORPORATED (WFR #111-21-31)

History

The Holiday Enterprises, Incorporated water provider was incorporated in 1962 to serve the Holiday Ranch Estates subdivision adjacent to the City of Tombstone. The prior owner of Holiday Enterprises, Incorporated indicated that the company operated one well in 1963. In 1976, the company established a mutual backup tie-in with the Tombstone Municipal Water Supply system. The

tie-in with the Tombstone system was used only once in 1983. There are currently ninety-two service connections.

Water Supply System

The water supply system consists of one well yielding 100 gpm serving an area of approximately one square mile. Operation of the backup tie-in is undertaken jointly by Holiday Enterprises and the City of Tombstone. The maximum water storage capacity of the system is reported as 22,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

HORSESHOE RANCH WATER COMPANY (WFR #111-23-28)

History

The Ranch Water Company was granted a franchise in 1973 to serve an area of 120 acres including the eighty acre Circle S Ranch Estates subdivision. In 1988, the water system was sold and the name of the company was changed to the Horseshoe Ranch Water Company. Currently water is furnished to approximately forty-five customers within the subdivision.

Water Supply System

The water supply system consists of one well with a maximum water storage capacity reported as 35,000 gallons. A second well, owned by the Cochise Water Company (WFR #111-23-25), is also used to supply water to users served by this water company. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

HOUGLAND WATER COMPANY (WFR #111-23-29)

History

The Hougland Water Company was established in 1979 and furnishes water to twelve customers within an estimated twenty acre service area.

Water Supply System

The water supply system consists of one primary well. A standby community well which is not owned by Houghland Water Company may be utilized in an emergency. The maximum water storage capacity is reported as 16,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

HOWE WATER PROVIDER (WFR #113-8-45)

History

The Howe Water Provider began operation approximately twenty-five years ago and supplies water to dwellings located in the NE¼, Section 31, Township 8 South, Range 17 East. There are currently ten service connections.

Water Supply System

The Howe Water Provider customers are served by a 100 gpm well. A 1,000 gallon pressurized tank is used for storage. No backup well exists. No pumpage figures are available. Water is sold to the individual dwellings for a flat rate. All maintenance costs are paid by the owner. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

HUACHUCA CITY MUNICIPAL WATER SUPPLY (WFR #111-20-50)

History

The Town of Huachuca City was incorporated in 1958 with a population of approximately 1,200 persons. It has grown to approximately 2,297 residents in 1990 and is increasing approximately 100 households per year.

In 1963, the town purchased and consolidated three existing water companies. All three systems were interconnected in 1983. The town has subsequently installed new mains in the business district, larger mains for residential customers, and drilled two wells to supplement the water supply. There are currently 840 service connections, 250 at which are located in an unincorporated area outside of the city limits.

Water Supply System

The municipal system consists of five wells, one of which has been out of service for at least ten years. Two wells have 5,000 gallon pressure tanks while the other two wells have 10,000 gallon pressure tanks. The wells are connected to a 750,000 gallon main storage tank. All of the wastewater from the service area is collected and treated in evaporation lagoons located northeast of town.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

INDIADA WATER COMPANY (WFR #111-23-41)

History

Indiada Water Company furnishes water for the Indiada Mountain Park subdivision located six miles south of Sierra Vista and is comprised of sixty-two one acre lots. The water company was formed in 1969 when development of the Indiada subdivision began.

Water Supply System

The water supply system consists of four wells and a 12,000 gallon storage tank. The system provides a backup tie-in with the Antelope Run Water Company (refer to WFR #111-23-40) through which water can be conveyed to

supply both the water companies in time of short supply or mechanical failure. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

LUCKY HILLS WATER COMPANY (WFR #111-21-30)

History

The Lucky Hills Water Company was incorporated in 1965 to serve a subdivided area three miles northwest of Tombstone. The water company currently furnishes water to four dwellings in the subdivision, but it is designed to serve approximately forty residences. At present, the franchised service area greatly exceeds the actual area served by the water company.

Water Supply System

The water supply system consists of one well and an estimated maximum water storage capacity of 22,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

MAMMOTH MUNICIPAL WATER SUPPLY (WFR #113-4-3)

History

The Town of Mammoth was incorporated in 1958, and its municipal water use was supplied by the Arizona Water Company and the San Pedro Valley Water Company. The town purchased and consolidated the two water companies in 1977, which constitute the present municipal system. Prior to 1958, private wells presumably supplied water for domestic requirements.

Water Supply System

The town operates five wells, two wells are used regularly and three are standby wells, that supply a service area of one square mile. The maximum

water storage capacity is reported as 500,000 gallons. Municipal wastewater is conveyed through a sewer system and discharged into a lagoon treatment system on the north end of town adjacent to the San Pedro River.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

MESCAL LAKES WATER COMPANY (WFR #112-16-10)

History

In September 1973, the Verde Utilities Corporation received a CC&N. It later went bankrupt, but 320 acres of the area it once served water is now served by the Mescal Lakes Water Company. There are currently 147 service connections.

Water Supply System

The water supply system consists of two wells with a combined pumping capacity of 180 gpm. The maximum water storage capacity is 15,500 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

MIRACLE VALLEY WATER COMPANY (WFR #111-23-27)

History

The Bible College in Miracle Valley was established in 1958. During the following four years, a 320 acre subdivision was developed. The Miracle Valley Water Company was established in 1962 following the completion of the subdivision.

Water Supply System

The water supply system consists of three wells with a maximum water storage capacity reported as 5,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

MUSTANG WATER COMPANY (WFR #112-20-10)

History

The Mustang Water Company obtained a CC&N in 1973.

Water Supply System

The water supply system consists of two wells with one well currently unused. The estimated maximum water storage capacity is 2,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

NACO WATER COMPANY (WFR #111-24-60)

History

In 1946, the Arizona Edison Company pumped water into a 20,000 gallon storage tank to supply water for the Town of Naco. The Naco Water Company replaced that company in 1951 and in that year drilled its first well. A second well was drilled in 1955. A third well was drilled in 1964 to supply the Country Club Estates. The Bisbee Junction area located three miles northeast of Naco was first supplied water in 1964 using an existing well leased from the Southern Pacific Railroad. A backup well for Bisbee Junction was drilled in 1984. At the present time there are 196 users in Naco, seven in the County Club Estates, and fifty at Bisbee Junction.

Water Supply System

The water supply system consists of five wells: four wells which are owned by the water company and one well which is leased from the Southern Pacific Transportation Company. The maximum water storage capacity is reported as 21,750 gallons. The well leased from Southern Pacific has a 20,000 gallon storage tank and it is used solely for fire protection.

Wastewater disposal is processed through the Naco Sanitary District of Cochise County and individual septic tank systems. For more information on the Naco Sanitary District of Cochise County, see Chapter 7, Section 7.6 and WFR #111-24-86.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

NICKSVILLE WATER COMPANY (WFR #111-23-30)

History

The Nicksville Water Company was issued a CC&N in 1958. At that time the company served a small number of customers from shallow wells in Miller Canyon. In 1980, a corporation was formed to purchase the company from the estate of the original owner. Today the water company services 137 residential customers and six commercial operations within an estimated one square mile service area.

Water Supply System

The water supply system consists of ten wells with one well disconnected from the system. The water company used to have twenty wells, however, ten wells have been sold or abandoned. The nine remaining wells are hand dug and produce a total of thirty gpm via gravity flow. The hand dug wells are located outside the service area in Miller Canyon on United States Forest Service land. The maximum water storage capacity is reported as 167,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

NRB COMMUNITY WELL CO-OP (WFR #111-23-56)

History

The NRB Community Well Co-op was established in 1979 to supply water to domestic users in the NE¼, NE¼, Section 34, Township 22 South, Range 21 East. The NRB Community Well is presently serving an unknown number of users.

Water Supply System

The NRB Community Well Co-op is served by a 250 foot deep well with a pumping capacity of fifteen gpm. No backup well exists. No pumpage figures are available since the property owners share the cost for maintenance and pumpage fees. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

PARCEL H WATER CO-OP (WFR #111-23-68)

History

The Parcel H Water Co-op was established in 1973 to serve domestic users in the NW¼, NW¼, Section 2, Township 23 South, Range 21 East. The co-op is currently serving domestic users on six of the eight parcels in the service area.

Water Supply System

The Parcel H Water Co-op is served by a 310 foot deep well. It has a three horsepower pump and has two pressure tanks. One and one-half inch pipes convey water to each parcel from a main pipeline. No pumpage figures are available since the property owners split the costs associated with the service. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

POMERENE DOMESTIC WATER USERS ASSOCIATION (WFR #112-17-37)

History

The Pomerene Domestic Water Users Association has supplied water to the Town of Pomerene for municipal use since 1948. The association received its CC&N in 1976. It currently furnishes water to 184 customers located within a four square mile service area.

Water Supply System

The water supply system consists of two wells and a maximum water storage capacity of 250,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

SANTA CRUZ WATER COMPANY (WFR #111-19-44)

History

The Santa Cruz Water Company was established in 1971 at the time the Westgate subdivision was being developed. The Westgate subdivision is a small residential area located in Santa Cruz County, approximately two miles from the western entrance to the Fort Huachuca Military Reservation. The service area of the Santa Cruz Water Company coincides with the subdivision boundaries and includes approximately thirty residences. About one-half of the residences currently receive water from the company.

Water Supply System

The water supply system consists of one well within the 150 acre service area. This well has a reported pumping capacity of fifty to seventy gpm. The reported water storage capacity of the system is approximately 2,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

SIERRA SUNSET WATER COMPANY (WFR #111-20-59)

History

The Sierra Sunset Water Company was established in 1964 and has not been registered with the Arizona Corporation Commission since 1982. It currently furnishes water to an estimated 320 acre service area.

Water Supply System

The water supply system consists of one well with a maximum water storage capacity reported as 3,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

SOUTHLAND UTILITY COMPANY (WFR #111-23-23)

History

The Southland Utility Company was established in 1968 and serves the communities of Golden Acres Estates and Golden Meadows. In 1978, the company expanded its two square mile franchised area to include approximately eight square miles southeast of Golden Acres. Currently, this expanded area does not contain water facilities to serve the local residents.

Water Supply System

The water supply system consists of two wells that serve Golden Acres Estates and Golden Meadows. The maximum water storage capacity is reported as 40,000 gallons. The company operates a sewer system that discharges into a lagoon treatment facility located at the east end of Golden Acres Estates. There is also a community lake which is maintained by the Home Owners Association. The association reportedly purchases 100,000 gallons per month to maintain the lake for recreational and wildlife uses. The lake is located on a small natural channel, but rarely captures surface water.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

ST. DAVID WATER ASSOCIATION (WFR #112-17-44)

History

The St. David Water Association received a CC&N in 1969 to serve the Town of St. David. It currently furnishes water for 319 customers for an estimated seven square mile service area.

Water Supply System

The water supply system consists of two wells with a maximum water storage capacity reported as 45,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

STRATMAN WATER COMPANY (WFR #112-17-43)

History

In September of 1977, the Stratman Water Company was granted a CC&N. It currently furnishes water to an estimated seventy-five acre service area.

Water Supply System

The water supply system consists of one well with a maximum water storage capacity reported as 2,800 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

SUE JUAN WATER COMPANY (WFR #112-17-38)

History

The Sue Juan Water Company was issued a CC&N in 1956 to furnish water to an estimated 100 acre service area.

Water Supply System

The water supply system consists of two wells with a maximum water storage capacity reported as 15,000 gallons. The distribution system is interconnected with the City of Benson's municipal system (refer to WFR #112-17-39). Wastewater disposal is processed through the Benson wastewater treatment facility.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

THUNDER MOUNTAIN ESTATES WATER CO-OP (WFR #111-22-29)

History

The Thunder Mountain Estates Water Co-op was established in 1962 to supply water to domestic users in the NE¼, Section 4 and the NW¼, Section 13, Township 22 South, Range 18 East. The co-op is presently serving eight users (five full-time and three part-time) within the service area.

Water Supply System

The Thunder Mountain Estates Co-op is served by two wells with a combined pumping capacity of eighteen gpm. One 5,000 gallon water tank is used for storage. No pumpage figures are available since the property owners share the cost for maintenance and pumpage fees. Wastewater is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

TOMBSTONE MUNICIPAL WATER SUPPLY (WFR #111-21-32)

History

The City of Tombstone began using surface water from springs located in the Huachuca Mountains in 1881. Through a special use permit with the Coronado National Forest, water was diverted from Clark, Miller, and Gardiner Springs in Miller Canyon, and Carr and Rock Springs in Carr Canyon and transported to Tombstone via a pipeline until 1977. Forest fires and heavy

storm runoff in the Huachuca Mountains during 1977 severely damaged the Tombstone pipeline system in the canyons. Currently, the town diverts water from Miller (DV1) and Carr Springs (DV2). The remaining three springs have been unused since 1977. See regional water use maps 111-20, 111-21, and 111-23 for the locations of the springs and the route of the pipeline.

To supplement the water sources from the Huachuca Mountains, the City of Tombstone installed an instream pump along the San Pedro River, and constructed three wells in Tombstone. The instream pump was used once in 1945 as an emergency source during a drought period, but has been discontinued since that time.

Water Supply System

Currently, water from Miller and Carr Springs in the Huachuca Mountains is conveyed to Tombstone along an 80,000 foot gravity fed, seven inch diameter, steel pipeline. The theoretical maximum capacity of the Tombstone

Figure 5-5. A source of water supply for a portion of the City of Tombstone municipal water supply are springs located in Miller Canyon in the Huachuca Mountains in the Sierra Vista subwatershed. Tombstone uses the springs in Miller and Carr Canyons to supplement its groundwater sources.

aqueduct is estimated by DWR to be 1.4 cubic feet per second, or 1,013 acre-feet per year. This water is stored in an enclosed 1.1 million gallon concrete reservoir located in Tombstone. Tombstone also operates three wells, located within the town limits, to supplement the spring water. Water from these wells is stored in three 25,000 gallon tanks and one 100,000 gallon storage tank. Surface and groundwater is commingled through the town water distribution system. Municipal wastewater disposal is processed through a sewer system that discharges to a wastewater treatment plant located northwest of Tombstone.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

VISTA ESTATES WATER CO-OP (WFR #111-23-70)

History

The Vista Estates Water Co-op was formed in 1979 to supply water to domestic users in the SW¼, NW¼, Section 27, Township 22 South, Range 21 East. The co-op is presently serving domestic users on nine of the ten parcels within the service area.

Water Supply System

The Vista Estates Water Co-op is served primarily by a 270 foot deep well with a 3½ horsepower pump. A 1,000 gallon tank is used for storage. A second well is used as a backup well in times of emergency or maintenance. No pumpage figures are available since the property owners split the costs associated with the service. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

WHETSTONE WATER IMPROVEMENT DISTRICT (WFR #112-20-9)

History

In 1983, the Whetstone Water Improvement District was organized by the Cochise County government to supply water to an estimated two square mile area previously served by the Sulger #1 and Sulger #2 Water Companies. The Sulger Water Companies originally filed for a CC&N in 1978.

Water Supply System

The water supply system consists of two wells. The maximum water storage capacity is not known. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

WILLOW LAKES WATER COMPANY (WFR #112-14-24)

History

The Willow Lakes Water Company was founded in early 1971 by the United States Pension Company. The organization went bankrupt in 1973 and as part of the disposition of property, the water company was transferred to Mr. Robert C. Million. He operated the water company until 1981 when it was sold to the Willow Lakes Property Owners Association. The Property Owners Association functions as a nonprofit organization and supplies water to the residents of Willow Lakes subdivision units I and II.

Water Supply System

The water supply system consists of two submersible pumps located in a 24 inch steel cased well. The maximum water storage capacity is reported as 40,000 gallons. Wastewater disposal is processed through individual septic tank systems.

Annual water use data is provided in Table 5-6 for the time period 1980 through 1988.

TABLE 5-6

ANNUAL WATER USE FOR MUNICIPAL WATER SERVICE ORGANIZATIONS IN THE SAN PEDRO RIVER WATERSHED (DATA SOURCE: ARIZONA CORPORATION COMMISSION)

WATER SOURCE ORGANIZATIONS	WATERSHED FILE REPORT NUMBER	1980		1981		1982		1983	
		TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS
Antelope Run Water Company	111-23-40	ND	ND	ND	ND	ND	ND	ND	ND
Arizona Water Company - Bisbee System	111-24-59	1,158.9	3,201	963.7	3,203	986.5	3,278	1,011.9	3,282
Arizona Water Company - San Manuel System	111-8-3	1,051.8	1,567	1,026.2	1,624	885.7	1,606	889.0	1,604
Arizona Water Company - Fuller & Sulger Systems	111-23-33	743.9	1,511	804.8	1,551	933.7	1,590	668.1	1,648
Bella Vista Water Company	111-20-62	885.3	1,426	2,458.2	4,403	2,485.9	4,714	2,345.8	5,186
Benson (1)	112-17-39	ND	ND	609.0	ND	339.0	ND	715.0	1,400
Cloud 9 Water Company	111-23-26	ND	ND	10.0	46	29.5	50	16.3	50
Cochise Water Company	111-23-25	ND	ND	10.7	26	9.9	26	ND	ND
Coronado Estates Water Company	111-20-51	ND	ND	34.6	113	15.0	111	34.9	110
Crystal Water Company	112-20-11	ND	ND	ND	9	ND	10	7.4	13
Dakota Water Association	111-23-66	ND	ND	ND	ND	ND	ND	ND	ND
Desert Estates Water Co-op (1)	114-4-30	ND	ND	ND	ND	ND	ND	ND	ND
East Slope Water Company (1)	111-23-42	ND	ND	156.0	360	149.0	350	149.0	400
Frarer Water Company	112-17-42	ND	ND	0.01	2	0.01	2	ND	ND
Holiday Enterprises, Incorporated	111-21-31	ND	ND	21.4	81	22.2	82	22.8	86
Horseshoe Ranch Water Company	111-23-28	4.0	19	4.8	19	4.6	20	4.8	29
Hougland Water Company	111-23-29	ND	ND	9.2	28	9.2	12	9.2	12
Howe Water Provider (1)	113-8-43	ND	ND	ND	ND	ND	ND	ND	ND
Huachuca City (1)	111-20-50	ND	ND	ND	ND	ND	ND	ND	ND
Indiada Water Company	111-23-41	ND	ND	10.4	35	10.0	35	ND	35
Lucky Hills Water Company	111-21-30	ND	ND	ND	ND	2.4	2	2.5	2
Mammoth (1)	113-4-3	ND	ND	ND	ND	147.0	505	142.0	516
Mescal Lakes Water Company	112-16-10	ND	ND	ND	ND	3.8	36	7.0	44
Miracle Valley Water Company	111-23-27	ND	ND	57.1	130	48.3	114	48.0	111
Mustang Water Company	112-20-10	3.3	17	5.0	18	5.5	25	6.0	27
Naco Water Company	111-24-60	ND	ND	68.1	212	66.3	215	67.2	215
Nicksville Water Company	111-23-30	ND	ND	27.1	115	30.8	117	26.3	128
NRB Community Well Co-op (1)	111-23-56	ND	ND	ND	ND	ND	ND	ND	ND
Parcel H Co-op (1)	111-23-68	ND	ND	.	ND	ND	ND	ND	ND
Pomerene Domestic Water Users Association	112-17-37	133.0	171	134.0	204	116.0	206	153.0	168
Pueblo Del Sol Water Company	111-23-34	ND	ND	203.7	456	207.1	471	178.1	559
Santa Cruz Water Company	111-19-44	ND	ND	4.6	32	7.3	25	5.1	18
Sierra Sunset Water Company	111-20-59	ND	ND	1.5	ND	1.5	ND	ND	ND
Sierra Vista (1)	111-20-56	108.0	ND	108.0	ND	147.4	ND	117.6	ND
Southland Utility Company	111-23-23	ND	ND	72.0	235	67.8	272	74.6	307
St. David Water Association	112-17-44	104.0	259	104.0	259	105.1	265	100.0	270
Stratman Water Company	112-17-43	1.2	4	1.2	4	1.0	5	1.1	5

ND - No data available.

(1) Water use data provided by water service organization.

TABLE 5-6 (cont'd)

WATER SOURCE ORGANIZATIONS	WATERSHED FILE REPORT NUMBER	1980		1981		1982		1983	
		TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS
Sue Juan Water Company	112-17-38	35.0	72	44.0	64	42.0	63	41.0	57
Thunder Mountain Estates Water Co-op (1)	111-29-29	ND	ND	ND	ND	ND	ND	ND	ND
Toabstone (1)	111-21-32	ND	ND	ND	ND	ND	ND	ND	ND
Vista Estates Water Co-op (1)	111-23-7	ND	ND	ND	ND	ND	ND	ND	ND
Whetstone Water Improvement District (1)	112-20-9	3.4	12	3.2	14	ND	ND	21.0	117
Willow Lakes Water Company	112-14-24	ND	ND	7.5	31	6.0	28	4.9	31

(1) Water use data provided by water service organization.

ND - No data available.

TABLE 5-6 (cont'd)

WATER SOURCE ORGANIZATIONS	WATERSHED FILE REPORT NUMBER	1984		1985		1986		1987		1988	
		TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS
Antelope Run Water Company	111-23-40	0.1	2	1.0	4	1.6	10	0.3	10	4.0	10
Arizona Water Company - Bisbee System	111-24-59	1,123.2	3,279	1,137.2	3,240	905.6	3,249	942.7	3,224	962.0	3,221
Arizona Water Company - San Manuel System	113-8-3	911.4	1,580	901.2	1,559	956.6	1,601	923.5	1,565	908.0	1,523
Arizona Water Company - Fuller and Sulger Systems	111-23-33	666.4	1,698	775.5	1,776	857.1	1,881	829.7	1,970	861.9	2,007
Bella Vista Water Company	111-20-62	2,528.8	5,701	1,824.9	3,519	2,815.2	5,620	2,761.6	5,797	2,906.6	5,843
Benson (1)	112-17-39	ND	ND	ND	1,700	715.3	1,700	620.3	1,477	544.6	1,374
Cloud 9 Water Company	111-23-26	13.6	54	32.1	63	ND	265	ND	265	43.7	265
Cochise Water Company	111-23-25	10.0	32	14.5	50	19.9	60	ND	ND	ND	ND
Coronado Estates Water Company	111-20-51	29.3	103	29.2	104	29.5	106	ND	ND	ND	ND
Crystal Water Company	112-20-11	1.8	12	11.8	11	ND	13	ND	ND	ND	ND
Dakota Water Association(1)	111-23-66	ND	2	ND	4	ND	5	ND	5	ND	5
Desert Estate Water Co-op(1)	114-4-30	ND	ND	ND	ND	ND	ND	ND	ND	ND	11
East Slope Water Company (1)	111-23-42	142.0	480	150.0	486	144.8	515	178.5	517	175.6	543
Frarer Water Company	112-17-42	ND	ND	ND	ND	ND	ND	ND	4	ND	ND
Holiday Enterprise Incorporated	111-21-31	22.8	87	23.2	89	22.0	88	23.0	88	22.9	92
Horseshoe Ranch Water Company	111-23-28	5.7	30	7.2	35	8.5	44	9.2	44	13.1	45
Hougland Water Company	111-23-29	9.2	15	9.2	15	3.7	12	3.9	12	ND	12
Howe Water Provider	113-8045	ND	11	ND	10	ND	10	ND	10	ND	10
Huachuca City (1)	111-20-50	ND	ND	179.5	780	181.2	800	274.4	820	268.3	840
Indiada Water Company	111-23-41	7.8	34	7.9	29	ND	ND	8.3	34	8.4	35
Lucky Hills Water Company	111-21-30	2.6	4	1.8	3	1.1	4	0.8	4	0.4	4
Mammoth (1)	113-4-3	146.0	500	146.0	510	147.0	520	146.0	515	146.0	510
Mescal Lakes Water Company	112-16-10	7.7	52	12.0	65	15.8	92	23.3	125	25.0	147
Miracle Valley Water Company	111-23-27	46.6	110	43.3	113	ND	ND	28.8	114	39.7	117
Mustang Water Company	112-20-10	5.9	27	7.4	31	6.1	30	ND	ND	ND	ND
Naco Water Company	111-24-60	68.7	217	66.6	231	72.4	236	69.4	244	72.4	253
Nicksville Water Company	111-23-30	28.9	128	29.9	136	28.6	131	28.4	138	34.1	143
NRB Community Well Co-op (1)	111-23-56	ND	ND	ND	ND	ND	7	ND	ND	ND	ND

(1) Water use data provided by water service organization.

ND - No data available.

TABLE 5-6 (cont'd)

WATER SOURCE ORGANIZATIONS	WATERSHED FILE REPORT NUMBER	1984		1985		1986		1987		1988	
		TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS
Parcel H Co-op (1)	111-23-68	ND	ND	ND	ND	ND	ND	ND	ND	ND	6
Pomerene Domestic Water Users Association	112-17-37	111.3	171	118.4	171	129.7	176	129.0	176	127.0	184
Pueblo Del Sol Water Company	111-23-34	208.0	627	219.1	ND	234.0	829	314.8	1,021	360.2	1,114
Santa Cruz Water Company	111-19-44	ND	18	ND	18	ND	18	4.0	18	ND	ND
Sierra Sunset Water Company	111-20-59	ND	ND	19.3	35	ND	ND	ND	ND	ND	ND
Sierra Vista (1)	111-20-56	126.4	ND	ND	ND	197.0	ND	157.0	ND	168.8	ND
Southland Utility Company	111-23-23	72.8	336	80.5	342	87.6	350	91.9	373	99.9	415
St. David Water Association(1)	112-17-44	100.5	276	102.6	276	113.6	281	125.1	289	125.4	319
Stratman Water Company	112-17-43	1.0	5	1.2	5	3.4	6	5.1	10	4.4	12
Sue Juan Water Company	112-17-38	54.2	61	62.3	63	58.5	66	55.9	66	60.9	67
Thunder Mountain Estates Water Co-op (1)	111-22-29	ND	ND	10.0	ND	ND	ND	ND	ND	ND	ND
Tombstone (1)	111-21-32	ND	ND	389.7	612	ND	ND	ND	ND	ND	ND
Vista Estates Water Co-op (1)	111-23-70	ND	ND	ND	ND	ND	ND	ND	ND	ND	9
Whetstone Water Improvement District (1)	112-20-9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Willow Lakes Water Company	112-14-24	5.8	26	7.0	28	9.8	27	9.8	30	10.1	31

ND - No data available.

(1) Water use data provided by water service organization.

5.2 IRRIGATION WATER PROVIDERS

This section describes the two organizations that divert and supply water for irrigation purposes to multiple individual water users in the San Pedro River watershed, one private party irrigation diversion, and surface water users located along Aravaipa Creek. The Bayless and Berkalew diversion and the Aravaipa Creek water users are included in this section to provide a complete description of the major surface water diversions occurring in the San Pedro River watershed. One of the two organizations, the St. David Irrigation District, supplies both surface water and groundwater. The other organization, the Pomerene Water Users Association, supplies surface water only.

The location of the two irrigation water providers and the Aravaipa Creek water users are shown on Plates 12 through 14 located in the pocket of this volume. The Bayless and Berkalew Diversion, ditch system, and acreage are shown on water use maps found in Volume 9 of this HSR. Detailed water use maps showing the irrigated lands, and diversion and conveyance systems for all irrigation water uses are shown on the appropriate subregion water use maps contained in Volume 9 of the HSR. Each irrigation water provider report that follows in this section lists the applicable subregion map numbers for that association/district/diversion.

The irrigation water providers described in this section are:

WATER PROVIDER	PAGE
Aravaipa Creek Water Users	305
Bayless and Berkalew Company	312
Pomerene Water Users Association	319
St. David Irrigation District	333

ARAVAIPA CREEK IRRIGATION WATER USERS

Aravaipa Creek is a perennial stream and the largest tributary of the San Pedro River. As such, it was designated as a separate subwatershed for the investigation of water uses by DWR. There are currently twenty-two land owners diverting surface water or appropriable subflow to serve approximately

394 acres of irrigation. There are nearly 987 acres being irrigated with both surface water and water withdrawn from wells within the Aravaipa subwatershed.

Table 5-7 lists the subregional water use maps that pertain to the irrigation uses supplied by Aravaipa Creek.

TABLE 5-7

SUBREGIONAL WATER USE MAPS CONTAINING WATER USES, SOURCES, AND CONVEYANCE SYSTEMS SUPPLIED BY ARAVAIPA CREEK AND TRIBUTARIES

WATERSHED/SUBWATERSHED	REGION	SUBREGION
115	4	AAD
115	4	ADA
115	4	ADB
115	4	ADC
115	5	AB
115	5	AC
115	5	DB
115	10	BA
115	10	BBC

Geography

Aravaipa Creek is located in portions of Pinal and Graham counties in southeastern Arizona. Aravaipa Creek is approximately fifty miles long from the headwaters to the confluence with the San Pedro River eleven miles south of Winkelman (Plate 1). Much of Aravaipa Creek is perennial beginning about four miles southeast of the Aravaipa Canyon Wilderness Area boundary and continuing almost to the confluence with the San Pedro River.

Elevations of Aravaipa Creek range from 2,200 feet above sea level at its confluence with the San Pedro River, to 4,200 feet above sea level at its headwaters. The subwatershed is bounded by the Pinaleno and Santa Teresa Mountains on the east which attain an elevation of just over 10,000 feet above sea level at Heliograph Peak, and the Galiuro Mountains with several peaks at, or near, 7,600 feet above sea level.

Annual precipitation within the Aravaipa subwatershed ranges from ten inches at the confluence to sixteen inches at the headwaters. Precipitation in the Pinaleno Mountains is between twenty-five and thirty inches, and in the Galiuro Mountains between twenty and twenty-five inches.

Vegetative habitat types within the subwatershed are varied dependent upon elevation and precipitation. The creek bottom is well represented by what can be described as an Interior-Riparian Deciduous Forest which is comprised of the cottonwood-willow and mixed broadleaf series. Some of the overstory species represented are: Arizona sycamore, mesquite, velvet ash, and willow trees. Along the flanks of the Pinaleno, Santa Teresa, and Galiuro Mountains are found various oak species, junipers, and pinyon pines. Near the headwaters of Aravaipa Creek the valley bottom is broad with rolling hills. The dominant vegetative habitat type in this area is semi-desert grasslands interspersed with mesquite trees.

The United States Geological Survey (USGS) operates a stream gaging station approximately six miles upstream from the mouth of Aravaipa Creek. This gage delineates the beginning of the Aravaipa subwatershed which encompasses 541 square miles. The average streamflow measured at this station over a period of twenty-seven years is 30.0 cubic feet per second (cfs). However, the average yearly peak discharge is 5,918 cfs with several events exceeding 10,000 cfs.

During the winter of 1978-1979, unusually high precipitation resulted in high runoff and a peak streamflow of 16,200 cfs on December 18, 1978. This flood destroyed diversions and eroded fields at locations throughout the the length of the creek.

The flood of October 1983 was the result of a strong monsoon storm system which began influencing the streamflows on September 27 and was immediately followed by the remnants of Hurricane Octave on September 30. Rainfall ranged from four to ten inches in southern Arizona and produced flows approaching or exceeding the 100-year flood along many rivers and streams. The peak flow on Aravaipa Creek occurred on October 1, 1983 and was estimated at 78,000 cfs, more than four times the previous recorded high. Damage from this flooding event was extensive and is described in Chapter 7, Section 7.1 of this volume of the HSR.

History

Settlement along Aravaipa Creek began about fifteen years after the acquisition of the Gadsden Purchase in 1853. The first recorded beneficial use of water along Aravaipa Creek was by Epigmenio Salazar in 1867, at the

Salazar homestead which was located in what is now the Bureau of Land Management's (BLM) Aravaipa Canyon Wilderness Area.

In the 1880s, several small orchards were started along Aravaipa Creek, as well as other small ranches and farms. By the turn of the century some of this produce was becoming famous; one rancher sent 1,000 pounds of apples to the St. Louis Worlds Fair in 1904.

The United States Government conducted a survey in 1905, of all of the ranches and farms along Aravaipa Creek at the request of the local residents. Based upon this survey many of the land owners were issued deeds to their properties in 1909.

The Arizona State Water Commissioner conducted a survey of all irrigated lands along Aravaipa Creek between 1921 and 1923 as part of the Gila River Determination. The result of this survey identified just under 400 acres of active irrigation and about 63 acres which were classified as "previously cultivated prior to the survey."

In 1979, the Defenders of Wildlife acquired properties in Aravaipa Canyon with the intent of preserving the fragile riparian habitat. In 1988, much of this land was deeded to the Arizona Chapter of the Nature Conservancy (ANC). At this time, the BLM acquired more parcels adjacent to the Aravaipa Canyon Primitive Area and its status was changed to the Aravaipa Canyon Wilderness Area (refer to WFR #115-5-19). Again, in November 1990, additional acreages were added which greatly expanded the total area of the Aravaipa Canyon Wilderness Area (ACWA). These actions have effectively placed all of the lands within Aravaipa Canyon under federal, or private nature preserve, jurisdiction.

Water Uses

There are many small ranches and farms along Aravaipa Creek which utilize surface and well water for irrigation, lives tockwatering, and domestic uses. Aravaipa Creek provides a reliable source of surface water compared to much of the rest of the San Pedro River watershed. Most of the surface water diversions along Aravaipa Creek are found on either side of Aravaipa Canyon.

The irrigators along Aravaipa Creek who utilize surface water use two types of diversions, small earthen dams, and portable instream pumps. The earthen dams divert a portion of the streamflow or, in one case, the entire

Figure 5-6. Some of the irrigated acreage along Aravaipa Creek are now supplied by portable instream pumps because many of the original surface water diversions were damaged or destroyed in the October 1983 flood.

flow of Aravaipa Creek into unlined earthen ditches. These ditches have short runs from the point of diversion to the point of application at the field. The portable instream pumps are placed in the creek when surface water is required and provide water to hoses or pipelines which transport the water to the acreages. The acreages served by these diversions are generally small and are located very close to the creek. There are 411 acres of surface water supplied irrigation. Much of this acreage is supplemented by well water. A variety of crops served by surface water are raised, such as pasture, alfalfa, and lesser amounts of orchard.

There is a total of 1,003 acres of irrigation within the Aravaipa subwatershed. Of this amount, 411 acres are supplied by surface water exclusively or are supplemented by water from wells (Zone 1 and Zone 2 wells). There are a total of 593 acres served solely by wells (both Zone 1 and Zone 2) within the subwatershed. The wells located within Zone 1 supply

Figure 5-7. Furrow irrigated field of small grains, located in the upper Aravaipa subwatershed, is supplied by a surface water diversion and ditch system. This method is commonly utilized along the upper reaches of Aravaipa Creek.

water to twenty-four acres exclusively. The remaining 569 acres are served by wells located within Zone 2.

One land owner in the upper portion of the Aravaipa Creek subwatershed irrigates one and one-half acres with water supplied by a spring. Table 5-8 depicts the water sources and total amount of irrigated acreage supplied

TABLE 5-8

SOURCE OF SUPPLY AND IRRIGATED ACRES WITHIN THE ARAVAIPA SUBWATERSHED

SOURCE OF SUPPLY	IRRIGATED ACRES
Surface water	192
Zone 1 wells	24
Zone 2 wells	568
Surface water and Zone 1 wells	13
Surface water and Zone 2 wells	206
Total Acres Irrigated	1,003

within the Aravaipa subwatershed. The bulk of this acreage is cultivated as pasture, associated with cattle ranching, with native grasses the sole crop raised. One irrigator raises small grains (oats, barley, etc.) east of Aravaipa Canyon. There are also several small orchard properties being irrigated west of Aravaipa Canyon.

Irrigation methods range from wild flooding to the use of center pivot sprinklers, and PVC pipelines to individual tree wells in orchards. Much of the larger pasture acreage in the upper portion of the subwatershed is irrigated with side-roll sprinkler or center pivot sprinkler systems. Generally, the surface water diversions utilize border flood or wild flood systems without pumpbacks or tailwater recovery systems to apply water to the acreage. On the west side of Aravaipa Canyon, small portable instream pumps supply water to pipelines which utilize gates or sprinkler system applications.

Table 5-9 lists each of the irrigators which diverts surface water which may be supplemented by well pumpage and the acres served. For specific watershed file reports within the Aravaipa subwatershed, refer to Volume 6 of this HSR.

TABLE 5-9

IRRIGATORS DIVERTING SURFACE WATER FROM ARAVAIPA CREEK AND TRIBUTARIES

CLAIMANT	DIVERSION NAME	ACRES IRRIGATED	WATERSHED FILE REPORT NUMBER
Arizona Chapter of the Nature Conservancy	Westerfield Ditch and Instream Pumps,	15.0	115-4-AAD-2
	East Diversion and Unnamed Diversions	70.0	115-5-AC-5
Anderson Development Corporation	Unnamed Diversions	199.0	115-10-BA-1
BLM - Safford District	Unnamed Diversion	2.0	115-5-AC-10
Claridge, Wilford H.	Unnamed Diversion	26.0	115-5-AC-4
Fraser, Tapia and Lupke	Salazar-Tapia Ditch	6.2	115-5-AB-4
Geldmacher, Donald E. and Beverly A.	Unnamed Diversion and Instream Pump	15.9	115-4-ADC-1
Goodwin, Robert Sewell	Bluff Spring	1.5	115-10-BBC-1
Iser, Jerry and Vera	Instream Pump	0.3	115-4-ADB-3
Lackner and Sons, Ltd.	Unnamed Springs	22.9	115-5-DB-1
Luebberman, Henri A. and Susan E.	Instream Pump	10.7	115-4-ADA-2
Miranda, Miguel and et al.	Salazar-Tapia Ditch	4.7	115-5-AB-3
O'Neil, James T. and Mary E.	Instream Pumps	7.6	115-4-ADA-1
Pacheco, Alex and Christine	Salazar-Tapia Ditch	1.7	115-5-AB-2
Richardson, Anthon G. and Barbara L.	Instream Pump	1.3	115-4-ADB-9

TABLE 5-9 (cont'd)

CLAIMANT	DIVERSION NAME	ACRES IRRIGATED	WATERSHED FILE REPORT NUMBER
Rubin, Joel W.	Unnamed Diversion	1.7	115-4-ADC-6
Salazar, Epigmenio G.	Salazar-Tapia Ditch	4.1	115-5-AB-1
SLD	Unnamed Springs	8.4	115-5-DB-2
White, Jeptha O. and Peggy	Instream Pump	6.6	115-4-ADB-1
Young, Harold D. and Nancy L.	Instream Pump	0.8	115-4-ADB-10
Young, Lemuel B. and Margaret	Instream Pump	1.0	115-4-ADB-6
Young, Lester and Thelma L.	Instream Pumps	1.1	115-4-ADB-8
Young, Mary L.	Instream Pumps	2.3	115-4-ADB-7
Total Acres Supplied by Surface Water		410.8	

BAYLESS AND BERKALEW COMPANY (WFR #113-12-BD-4)

The Bayless and Berkalew Company ditch and diversion (herein referred to as the Bayless ditch and/or diversion) are located approximately five miles south of the Town of Redington on the San Pedro River. Redington is located about fifteen miles south of San Manuel and nearly thirty miles north of Benson. The Bayless ditch and diversion, and the acreage served are located in the Redington subwatershed.

History

The Bayless and Berkalew Company began irrigating acreage along the San Pedro River sometime in early 1888 according to a Notice of Appropriation filed in January 1888 (10-0202786-11). From the claimed information, it appears that the diversion dam and ditch system were constructed at this time. The amount of irrigated acreage supplied by the diversion was initially close to ninety acres. An analysis of the applicable State Water Commissioner maps depicted fifty-one actively irrigated acres and approximately seventy-four acres classified as "previously cultivated" during the survey period of 1921 through 1923.

At the present time, surface water is supplied to approximately 150 acres by the Bayless ditch. The Bayless and Berkalew Company irrigates an additional 806 acres of pasture and small grain crops using well water. Of the 806 acres, 786 acres are supplied by well water and another twenty acres

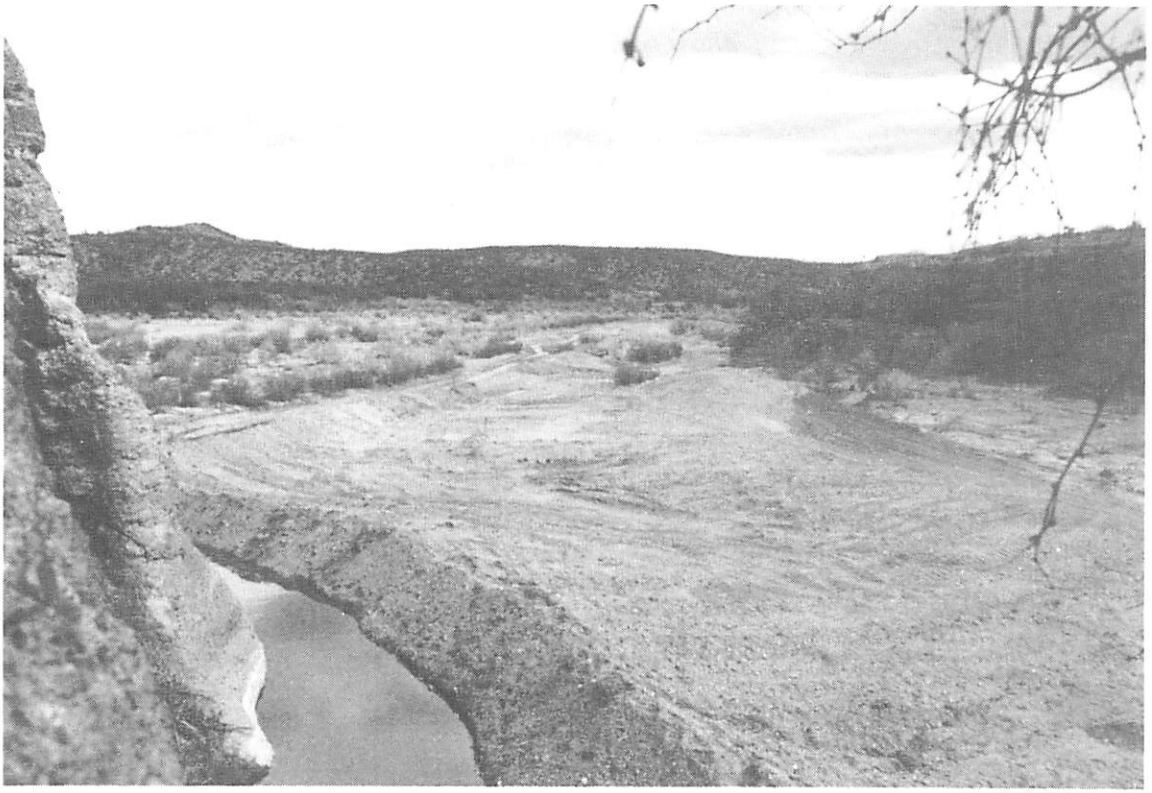


Figure 5-8. The Bayless and Berkalew Company diversion is located on the San Pedro River near Redington. This diversion can capture the entire flow of the San Pedro River. Surface water is not diverted throughout the irrigation season because of insufficient streamflow or high flood flows which can breach this diversion, thus rendering it inoperable.

are supplied by the rarely used Markham ditch and well water. All of this acreage is cultivated for use by livestock as part of a ranching operation. Of the 806 acres supplied by well pumpage, there are approximately 611 acres supplied by Zone 1 wells and an additional 195 acres supplied by Zone 2 wells.

Facilities

The Bayless ditch and diversion are located on the San Pedro River next to the USGS gaging station No. 4720. Originally, the ditch passed through a tunnel which had been dug through a conglomerate formation which outcrops at the river's edge. The ditch has since been routed around the base of the bluff, probably to allow for easier access during maintenance periods. The diversion is activated by simply pushing up a berm of earth across the river and channelling the entire flow into the ditch system. During periods of high streamflow the diversion and portions of the ditch system may be washed away

and rendered unusable. The Bayless ditch does not have any headgates or sluices near its head end, and consequently, diverts the entire flow of the river when surface water is available.

The Bayless ditch also supplies surface water to a large primary storage reservoir, PS1. This reservoir has a measured surface area and capacity of 5.5 acres and 21.5 acre-feet. This reservoir is utilized to provide water for irrigation and stockwatering purposes.

Diversion Capacities and Quantities of Irrigation Uses

An examination of the USGS gaging station data for the Redington gage reveals that the San Pedro River does not often flow in this reach between the month of April and mid-July. In July, flow resumes in response to monsoon rains, in effect recharging the alluvial aquifer. When the monsoon rains begin, they tend to be locally intense and cause large flash flood discharges past the gage which are brief in duration.

The maximum theoretical diversion capacity was estimated by DWR to be approximately 13.8 cfs. It is assumed that flows much greater than 13.8 cfs would breach the diverison dam and render the ditch system inoperable during the monsoon season. The maximum flows recorded each year by the USGS gage generally occur during the period from mid-July through October.

DWR has conducted instantaneous flow measurements on the Bayless Ditch from June 1985 through November 1990. An average flow of 0.8 cfs was measured over the monitoring period. This average flow would provide just over 660 acre-feet per year available at the diversion. Seepage losses of nearly ninety-seven acre-feet per year are estimated to occur along the one and three-quarters mile canal occur due to the highly permeable nature of the alluvium in which both the diversion and the ditch are situated. Evaporation losses from the canal are relatively insignificant with a value of just over four acre-feet per year. The total losses to the system would leave a net volume available to the field of about 560 acre-feet per year. If the 560 acre-feet per year are applied to the 150 acres of surface water supplied acreage this yields a value of 3.7 acre-feet per year for each acre irrigated at the point of application.

Even though the Bayless and Berkalew Company Ranch diverts an estimated average annual amount of about 660 acre-feet of surface water per year, most

of this water is received during the winter months when the demand for water by the crops is low. As a result, DWR has determined that of the amount of water received during these months, only a portion will go towards meeting the gross irrigation requirements (GIR) of the crop. The GIR can be met by irrigating for the immediate demands of the crop as well as by storing the water in the plant root zone for later use by the crop. Any amount exceeding the crop demand and storage potential of the soil is considered excess irrigation.

To determine what amount of surface water is actually being used to supply the overall GIR, DWR first calculated the average monthly diversion amounts, the losses from the ditch due to seepage and evaporation, and the amount of diversion water reaching the fields. Also determined was the GIR based on the crop distribution within the fields receiving surface water. These quantities and calculations can be seen in Table 5-10. An irrigation efficiency of 41 percent for the Redington subwatershed was used to calculate the GIR within approximately 150 crop surveyed acres of the Bayless Ranch. The crop surveyed acres provide a measure of the total irrigated acreage and crop types in any given year. These calculations allow DWR to compare the amount of surface water reaching the field to the amount of water needed by the crop at the field.

Table 5-10 shows that much more water is supplied during many of the months of high surface flows than can actually be used by the crop during those months (January through April). In order to make an analysis of the amount of surface water that actually meets the GIR of the crop, DWR has assumed that the soil moisture profile (water held in the soil for plant growth) of the irrigated fields is somewhat depleted during the summer months and made up during the winter months with the less expensive supply of surface water. This would result in storing some of the excess surface water in the soil for use when surface water supply becomes inadequate to meet immediate crop demands. DWR has also assumed that the surface water not used to provide the portion of the GIR in the manner mentioned above is lost through runoff, deep percolation, or return flow and becomes unavailable for plant growth. Table 5-11 shows the results of this analysis. A soil water holding capacity of eight inches of water was assumed based on the soil water holding capacity of soils in the area (Soil Conservation Service, General Soil Map, Cochise

County, Arizona). An average soil moisture deficit after any given irrigation event during the summer months of two inches, or a net soil water profile of six inches, was also assumed.

The total amount of water supplied by wells in Table 5-11 is the amount of well water that would need to be supplied to make up the difference between usable surface supply and the GIR. The Bayless Ranch appears to actually utilize 421 acre-feet per year of surface water out of 660 acre-feet that is supplied. Of this supply, about 100 acre-feet are lost through seepage and evaporation and about 560 acre-feet actually reach the field. A net excess of nearly 139 acre-feet of surface water reaches the field.

TABLE 5-10

SURFACE WATER DELIVERED AND GROSS IRRIGATION REQUIREMENTS FOR THE BAYLESS AND BERKALEW COMPANY RANCH

MONTH	TOTAL CFS/MONTH DIVERTED	ACRE-FEET DIVERTED	EQUIVALENT INCHES DIVERTED (1)	CONVEYANCE AND SEEPAGE LOSSES (INCHES)	INCHES OF WATER DELIVERED TO FIELD	CROP WATER USE (INCHES)	GROSS IRRIGATION REQUIREMENT (2) (INCHES)
January	36.6	72.5	5.8	1.0	4.8	0.7	1.7
February	70.0	138.6	11.1	2.0	9.1	1.7	4.1
March	98.4	194.8	15.6	2.8	12.8	3.1	7.6
April	61.2	121.2	9.7	1.7	8.0	4.5	11.0
May	11.8	23.4	1.9	0.3	1.6	6.2	15.1
June	5.7	11.3	0.9	0.1	0.8	6.6	16.1
July	0.0	0.0	0.0	0.0	0.0	3.7	9.0
August	0.0	0.0	0.0	0.0	0.0	3.1	7.6
September	0.0	0.0	0.0	0.0	0.0	3.3	8.0
October	14.3	28.3	2.3	0.0	2.3	2.5	6.1
November	32.7	64.7	5.2	0.0	5.2	1.8	4.4
December	3.1	6.1	0.5	0.2	0.3	0.8	2.0
TOTAL INCHES			53.0	8.1	44.9	38.0	92.7
TOTAL ACRE-FEET		660.9	660.9	100.3	559.6	473.1	1,152.9

(1) The equivalent inches of water is the volume of water supplied divided by the area receiving surface water (149.3 acres).

(2) Bayless & Berkalew irrigation potential water right (IR1, IR10, IR11) efficiency (41 percent).

Discrepancies in values are due to rounding of values.

TABLE 5-11

SURFACE WATER AND WELL WATER UTILIZED TO SUPPLY THE GROSS IRRIGATION REQUIREMENTS OF THE BAYLESS AND BERKALEW COMPANY RANCH (IN EQUIVALENT INCHES OF WATER) (1)

MONTH	GROSS IRRIGATION REQUIREMENT	INCHES OF SURFACE WATER DELIVERED	AMOUNT OF SURFACE SUPPLY USED	AMOUNT SUPPLIED BY WELLS	POST IRRIGATION NET SOIL MOISTURE
January	1.7	4.8	3.8	0.0	7.9
February	4.1	9.1	4.2	0.0	8.0
March	7.6	12.8	7.5	0.0	8.0
April	11.0	8.0	8.1	2.9	8.0
May	15.1	1.6	1.6	11.6	6.0
June	16.1	0.8	0.8	15.2	6.0
July	9.0	0.0	0.0	9.0	6.0
August	7.6	0.0	0.0	7.6	6.0
September	8.0	0.0	0.0	8.0	6.0
October	6.1	2.3	2.3	3.8	6.0
November	4.4	5.2	5.2	0.0	6.9
December	2.0	0.3	0.3	0.7	5.9
TOTAL INCHES	1,152.9	559.6	33.8	58.8	
TOTAL ACRE-FEET	1,154.1	559.0	420.8	732.1	

(1) The equivalent inches of water is the volume of water supplied divided by the area receiving surface water (149.4 acres).

Discrepancies in values are due to rounding of values.

Table 5-12 provides a summary of the surface water and well water components on the Bayless Ranch. The well water is not conveyed for any great distance and conveyance losses are considered negligible. The GIR calculated for the portion of the Bayless Ranch that receives surface water is just over 1,154 acre-feet or 7.7 feet of water per acre. Of this amount, 421 acre-feet or 2.8 feet per acre of water is supplied by surface water and approximately 732 acre-feet or 4.9 feet per acre of water is supplied by wells.

TABLE 5-12

SURFACE WATER AND WELL WATER COMPONENTS
OF THE BAYLESS AND BERKALEW COMPANY RANCH
(FROM CROP SURVEY ACRES)

	SURFACE WATER	WELL WATER (1)	TOTAL
Total volume diverted in acre-feet	660.9	732.1	1,393.0
Total acre-feet per acre diverted	4.4	4.9	9.3
System canal seepage in acre-feet	96.9	0.0 (2)	96.9
System canal evaporation in acre-feet	4.4	0.0 (2)	9.4
Total losses in acre-feet	101.3	0.0 (2)	101.3
Net volume delivered in acre-feet	559.6	732.1	1,291.7
Net acre-feet per acre delivered	3.7	4.9	8.6
Net volume required by crop in acre-feet	420.8	732.1	1,152.9
Net volume of excess application in acre-feet	138.8	0.0 (3)	138.8
Net acre-feet per acre required by the crop	2.8	4.9	7.7

(1) All of the well water on the Bayless and Berkalew Company Ranch is supplied by wells located near the fields. The well water component is considered to be the amount of water supplied to make up for the deficit supply of surface water in meeting the total crop irrigation requirement.

(2) Conveyance losses were considered negligible since all of the diversions are located near the field and the water is conveyed for short distances.

(3) Assumes that well water is supplied to meet the gross irrigation requirement at the Bayless & Berkalew irrigation potential water right (IR1, IR10, IR11) field application efficiency (51 percent).

It is apparent that the Bayless ditch cannot divert all of the available surface water due to constraints upon the maximum ditch system capacity. During periods of high flow, the diversion would in all probability be breached and portions of the ditch system damaged. According to the USGS records from the gaging station, the surface water is primarily available from October through April in any given year.

The Bayless and Berkalew Company also irrigates 806 acres of pasture and small grain crops, utilizing well water as the source of water supply. Irrigation methods for this acreage are commonly side-roll sprinkler systems and furrow methods. The surface water supplied acreage (149 acres) is irrigated by the furrow method.

POMERENE WATER USERS ASSOCIATION (WFR #112-17-89)

The Pomerene Water Users Association (PWUA) operates a canal that diverts surface water from the San Pedro River approximately three-fourths of a mile north of the State Route 80 highway bridge at St. David. The Pomerene Canal extends generally to the north about seven miles to the community of Pomerene. Surface water diversions are normally confined to the period from November through May when surface water is usually available and the flow is relatively sediment free. The Pomerene Canal serves a total of thirty-nine land owners who irrigate nearly 1,052 acres of land. The area served by the Pomerene Canal is located east of the City of Benson (Figure 5-9).

Table 5-12 describes all of the subregions on which water uses and conveyance systems are mapped. These subregional maps may be found in Volume 9 of the HSR entitled "Water Use Maps".

TABLE 5-13

SUBREGIONAL WATER USE MAPS CONTAINING WATER USES, SOURCES, AND CONVEYANCE SYSTEMS WITHIN THE PWUA

WATERSHED/SUBWATERSHED	REGION	SUBREGION
112	17	ABC
112	17	ACB
112	17	ACC
112	17	BAA
112	17	BAD
112	17	BDA

History

The Benson Canal Company, predecessor of the PWUA, filed a notice with the Cochise County Recorder in 1908 to appropriate 2,000 miner's inches (50 cubic feet per second) from the San Pedro River. Construction of a dam to divert water from the river was begun in 1910 and completed in 1912. The diversion dam was reportedly destroyed in 1927 and again on the evening of August 13, 1931, which led to the bankruptcy of the Benson Canal Company. The present dam was constructed about three-fourths mile upstream from the previous dams and completed in April 1934. The PWUA filed its articles of incorporation in 1936 with the Arizona Corporation Commission and maintained its corporate status until 1972.

The PWUA canal had its northernmost extent in 1923 approximately two miles north of Pomerene. During the period 1921-1923, the SWC conducted an analysis of irrigated acreages in the San Pedro River watershed as part of the Gila River Determination. The published SWC maps reveal that nearly 768 acres were under cultivation within PWUA at the time of the survey. An additional 781 acres were classified as "previously cultivated." Sometime in the 1950s, perhaps due to a deficient supply of water, deliveries to about 500 acres, located along the northern (downstream) end of the canal, were permanently discontinued. DWR's investigations found that approximately 289 of these acres are currently irrigated with pumped well water.

Applicable Filings and Decrees

On behalf of the users of Pomerene Canal water, the PWUA filed a claim in 1976 of Rights to Use Public Waters of the State under the Water Rights Registration Act (A.R.S. § 45-181) asserting a 1908 claimed priority date (Table 5-14). The PWUA did not file a statement of claimant in the adjudication for the collective use of Pomerene Canal water by the shareholders of the association. Each shareholder was made responsible for filing in the adjudication on his own behalf. Numerous filings were made by individual users within the PWUA service area claiming rights to the waters provided by the association, as well as to water withdrawn from privately owned wells.

TABLE 5-14

POMERENE WATER USERS ASSOCIATION
WATER RIGHTS REGISTRATIONS

CLAIM NUMBER	WATER SOURCE CLAIMED	CLAIMED AMOUNT
36-37822	San Pedro River	16,130 acre-feet per year

Organization and Operation

The PWUA presently functions as an agricultural water company. The association does not have a legally described service area with definite boundaries. The service area is defined instead by the lands that the association serves, which are shown in Figure 5-9.

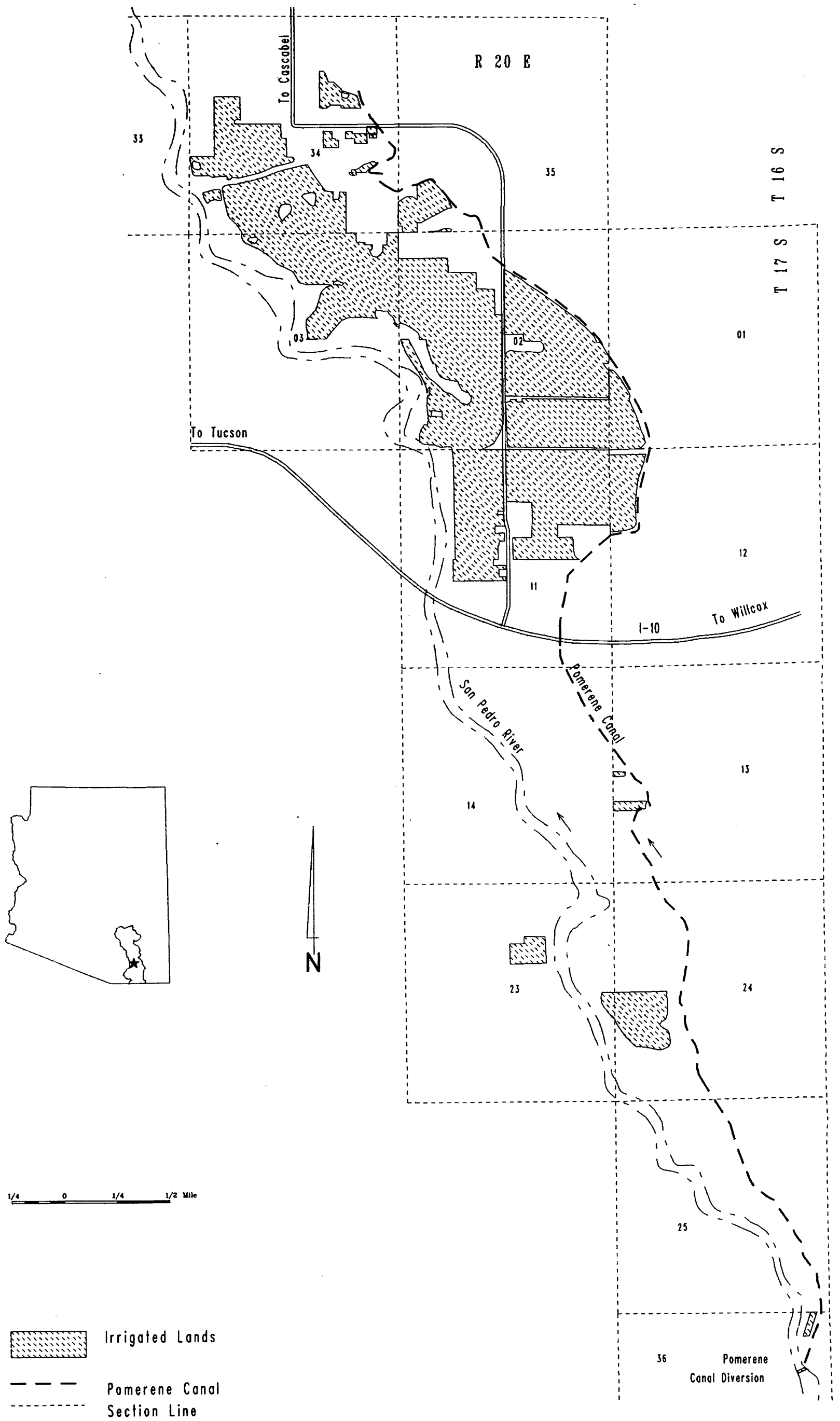


Figure 5-9. Area served by the Pomerene Water Users Association

The PWUA was formed as a nonprofit corporation but no longer maintains its corporate status; however, according to the the association's officials it continues to operate under its original articles of incorporation. The officials provided a list of the thirteen shareholders and the number of shares held by each affiliate (Table 5-15). According to the articles of incorporation, a shareholder must own land or have a "fixed and determined interest in land or the use thereof" which is subject to irrigation by the association's delivery system. Each share entitles the holder to use an amount of canal water determined by the board of directors. The shares are apparently appurtenant to specific lands and may not be transferred to other lands except for temporary use.

TABLE 5-15

SHAREHOLDERS OF THE POMERENE WATER USERS ASSOCIATION

NAME	NUMBER OF SHARES
Barney, Eldon	158
Barney, Leland	300
Matthews, Harold	31
Sherman, Ernest	10
Larson, Thurber	16
Sherman, Branson	5
East, Franklin	8¼
Housely, Glade (Masonry Contractors)	5
Sabin, Frances	3
Kartchner, Max	29
Farnsworth, Thomas	8
Fenn, Eli	27
Fenn, Jeddy (Fenn Enterprises)	40
	640¼

The PWUA is governed by a board of directors who are elected annually by the shareholders on a one vote per share basis. The board conducts the business of the association, including apportionment of water, the regulation of flow in the canal, the maintenance of the facilities, and the determination of charges for the use of the water.

The apportionment of water for each share is currently thirty minutes of the total flow of the canal. Under this system, each shareholder would receive water once every two weeks during a period of continuous flow. The

use of the water is rotated among the shareholders. When the flow resumes after an interruption it is given to the shareholder who would have been next in the rotation had the interruption not occurred. The diversion period is generally confined to the months of November through May, the months when the San Pedro River normally flows continuously and is relatively sediment-free as compared to the summer months. There is no maximum annual entitlement per share. The amount of water actually delivered is governed by the unregulated flow available in the San Pedro River and the capacity of the Pomerene Canal.

Facilities

The PWUA operates and maintains the Pomerene Canal and its associated facilities as its sole irrigation delivery system. The only source of water for the association is the water diverted from the San Pedro River by a diversion dam in the NE¼, NE¼, NE¼, Section 36, Township 17 South, Range 20 East (Figure 5-9). The canal is approximately seven miles long. The maximum

Figure 5-10. The Pomerene Water Users Association diversion, reconstructed in 1934, supplies water from the San Pedro River to approximately 1,052 acres of irrigated acreage in the Benson - Pomerene area. Much of this acreage is also supplemented by pumped well water.

theoretical capacity of the Pomerene Canal was calculated by DWR to be nearly 20.0 cfs. However, the capacity is reduced in the latter part of the diversion season when the canal becomes overgrown with weeds. The maximum discharge measured by DWR was found to be 10.2 cfs on March 19, 1987.

The PWUA does not pump underground water itself for delivery to shareholders. However, several of the shareholders use the canal system to convey their own pumped water to fields which they irrigate. The canal is concrete lined in portions that carry both water from private wells and surface water; the rest of the canal is unlined.

The major components of the distribution system of the Pomerene Canal are shown in Figure 5-9. Although most of the headgates are permanent structures, a few of them are places where the side of the canal is temporarily cut to allow the water to run into a spreader ditch to the fields. Not all properties served by the PWUA actually have a headgate or lateral ditch, but are instead supplied by water conveyed over the field of another land owner.

The amount of water that reaches the lands served by the PWUA is limited both by the amount of water that flows in the river at the diversion dam and by the maximum capacity of the canal. At the beginning and again at the end of the diversion season the flow of the water in the river is less than the canal capacity and the entire flow is diverted.

During the height of the diversion season, particularly during January and February, the flow of the river often exceeds the capacity of the canal and excess water is returned to the river prior to use by a sluice, or flow is restricted by reducing the headgate opening. The elevation of the wingwalls and flashboards in this sluice, located in Section 24, Township 17 South, Range 20 East, limits the amount of water that can pass through the canal.

No records of the amount of water used by the shareholders of the PWUA have been kept. A gaging station was maintained by the USGS from June 1967 until December 1969 when it was relocated 1.4 miles downstream. Record is available until the gage was discontinued in September 1972. The gage was located upstream from the sluice gate and on many days during the height of the diversion season it recorded more water than actually passed down the canal to the places of use. No other records or measurements of the amount of water delivered are known to have been made.

Figure 5-11. The Pomerene Canal is shown located just south of Interstate 10. After maintenance, the canal has the capacity to convey nearly twenty cfs. The measured discharge at the time of the photograph in March 1987 was ten cfs.

In order to estimate the amount of water that actually flowed down the canal below the sluice, the gage records were adjusted by reducing all daily mean discharges that exceeded twenty cfs to that value, the approximate maximum capacity of the canal. When this was done, the greatest amount of water passing through the Pomerene Canal in any year when the gage was in operation was calculated to be 2,338 acre-feet in 1971 and the average amount for the four years 1968 to 1971 was estimated to be 1,563 acre-feet. Since the canal began operation in 1912, there have probably been years more favorable when the canal delivered somewhat more water than those years when the gage was in operation. However, it is almost certain that the amount that flowed down the canal to the shareholder's land in any year could not have exceeded 7,180 acre-feet, the amount of water the canal could deliver if it were to run completely full for six months.

Quantification of Irrigation Uses

Even though the PWUA receives an average annual amount of about 1,564 acre-feet of surface water per year, most of this water is received during the winter months when the water requirement for crops is low. As a result, DWR has determined that of the amount of water delivered during these months, only a portion of this amount will go towards meeting the TIR of the crops grown within the PWUA service area. The irrigation water requirement can be met by irrigating for the immediate demands of the crop as well as by storing the water in the plant root zone for later use by the crop. Any amount exceeding the crop demand and storage potential of the soil will be lost.

To determine what amount of surface water is actually being used to supply the overall irrigation requirement, DWR determined the average monthly diversion amounts, the losses from the ditch due to seepage and evaporation, and the amount of diversion water reaching the fields. Also determined was the TIR of the PWUA irrigation district based on the crop distribution within the district. These quantities can be seen in Table 5-16. An irrigation district irrigation efficiency of 45 percent for the PWUA was used to determine the total irrigation requirements within the 1,051.9 crop surveyed acres of the PWUA. The crop surveyed acres provide a measure of the total irrigated acreage and crop types grown in any given year.

Table 5-16 shows that much more water is supplied during many of the months of high surface flows than can actually be used by the crops during these months (November through February). In order to make an analysis of the amount of surface water that actually meets the TIR of the crop, DWR assumed that the soil moisture profile (water held in the soil for plant growth) of the irrigated fields is somewhat depleted during the summer months and made up during the winter months with the less expensive supply of surface water. The irrigated acreage listed in the months of November and December includes both cropped and noncropped acres. The summer moisture deficit is assumed to be made up on these acres. This would result in storing some of the excess surface water in the soil for use when surface water supply becomes inadequate to meet immediate crop demand. DWR also assumed that the surface water not used to provide the portion of the GIR in the manner mentioned above is lost through run off, deep percolation or return flow and becomes unavailable for plant growth. Table 5-17 shows the results of this analysis. A soil water holding capacity of eight inches of water was assumed based on the soil water

holding capacity of soils in the area (Soil Conservation Service, General Soil Map, Cochise County, Arizona, 1971). An average soil moisture deficit after any given irrigation event during the summer months of two inches, or a net soil water profile of six inches, was also assumed.

The total amount of water supplied by wells in Table 5-17 is the amount of well water that would need to be supplied to make up the difference between useable surface supply and the GIR. The irrigators in the PWUA, therefore, utilize just over 1,134 acre-feet per year of surface water out of the 1,563 acre-feet that is diverted. Of this supply, about 37 acre-feet are lost through seepage and evaporation and just under 1,526 acre-feet actually reach the field. A net excess of nearly 391.9 acre-feet of surface water reaches the field.

TABLE 5-16

SURFACE WATER DELIVERED AND GROSS IRRIGATION REQUIREMENTS FOR THE POMERENE WATER USERS ASSOCIATION

MONTH	TOTAL CFS/MONTH DIVERTED	ACRE-FEET DIVERTED	ACRES ACTIVELY IRRIGATED	EQUIVALENT INCHES DIVERTED(1)	CONVEYANCE AND SEEPAGE LOSSES (INCHES)	INCHES OF WATER DELIVERED TO FIELD(1)	CROP WATER USE (INCHES)	GROSS IRRIGATION REQUIREMENT(2) (INCHES)
January	111.5	221.2	461.6	5.8	0.1	5.7	0.5	1.0
February	147.3	292.2	673.9	5.2	0.1	5.1	1.6	3.7
March	178.8	354.7	836.5	5.1	0.1	5.0	3.0	6.9
April	104.9	208.1	840.9	3.0	0.0	2.8	3.8	8.6
May	24.6	48.7	893.1	0.7	0.0	0.7	3.9	8.9
June	0.3	0.6	735.4	0.0	0.0	0.0	5.4	12.3
July	4.0	8.0	845.3	0.1	0.0	0.1	3.8	8.6
August	5.9	11.8	845.3	0.2	0.0	0.2	3.4	7.8
September	0.9	1.8	845.3	0.0	0.0	0.0	3.3	7.5
October	0.0	0.0	718.8	0.0	0.0	0.0	2.0	4.6
November	123.6	245.2	893.1	3.3	0.1	3.2	0.6	1.3
December	86.3	171.2	893.1	2.3	0.1	2.2	0.2	0.4
TOTAL INCHES				25.6	0.5	25.0	32.6	74.5
TOTAL ACRE-FEET		1,563.5		1,563.5	37.3	1,526.2	2,124.3	4,720.6

(1) The equivalent inches of water is the volume of water supplied divided by the actively irrigated acres per month within the PWUA.

(2) At the irrigation district efficiency in the PWUA (45 percent).

Discrepancies in values are due to rounding of values.

TABLE 5-17

SURFACE WATER AND WELL WATER UTILIZED TO SUPPLY
THE GROSS IRRIGATION REQUIREMENTS FOR THE
POMERENE WATER USERS ASSOCIATION
(IN EQUIVALENT INCHES IN WATER) (1)

MONTH	GROSS IRRIGATION REQUIREMENT	INCHES OF SURFACE WATER DELIVERED (1)	AMOUNT OF SURFACE SUPPLY USED	AMOUNT SUPPLIED BY WELLS	POST IRRIGATION NET SOIL MOISTURE
January	1.1	5.7	1.0	0.0	8.0
February	3.7	5.1	3.6	0.0	8.0
March	6.9	5.0	5.0	1.8	8.0
April	8.6	2.8	2.8	5.6	8.0
May	8.9	0.7	0.7	6.1	6.0
June	12.3	0.0	0.0	12.0	6.0
July	8.6	0.1	0.1	8.3	6.0
August	7.8	0.2	0.2	7.4	6.0
September	7.5	0.0	0.0	7.3	6.0
October	4.6	0.0	0.0	4.5	6.0
November	1.3	3.2	3.2	0.0	8.0
December	0.4	2.2	0.4	0.0	8.0
TOTAL INCHES	70.0	25.0	17.1	52.8	
TOTAL ACRE-FEET	4,720.6	1,526.2	1,134.3	3,586.3	

(1) The equivalent inches of water is the volume of water supplied divided by the actively irrigated acres per month within the PWUA.

Discrepancies in values are due to rounding of values.

Table 5-18 provides a summary of the surface water and well water components within the PWUA. Since the irrigation district does not supply any well water, it is all supplied by the individual irrigators. The well water provided by the individual is not conveyed for any great distance and, therefore, conveyance losses are negligible. The GIR estimated for the PWUA is 4,720.6 acre-feet or 5.8 acre-feet per acre. Of this amount, nearly 1,135 acre-feet or 1.4 acre-feet per acre of water is supplied by surface water and 3,586 acre-feet or 4.4 acre-feet per acre of water is supplied by individually operated wells.

TABLE 5-18

SURFACE WATER AND WELL WATER COMPONENTS OF THE POMERENE WATER USERS ASSOCIATION (FROM CROP SURVEY ACRES)

	SURFACE WATER	WELL WATER (1)	TOTAL
Total volume diverted in acre-feet	1,563.5	3,586.3	5,149.8
Total acre-feet per acre diverted	2.1	4.4	6.5
System canal seepage in acre-feet	35.8	0.0 (2)	35.8
System canal evaporation in acre-feet	1.5	0.0 (2)	1.5
Total losses in acre-feet	37.3	0.0 (2)	37.3
Net volume delivered in acre-feet	1,526.2	3,586.3	5,112.5
Net acre-feet per acre delivered	2.1	4.4	6.5
Net volume required by crop in acre-feet	1,134.3	3,586.3	4,720.6
Net volume of excess application in acre-feet	391.9	0.0 (3)	391.9
Net acre-feet per acre required by the crop	1.4	4.4	5.8

(1) All of the well water in the Pomerene Water Users Association is supplied by individual land owners. It is considered to be the amount of water supplied to make up for the deficit supply of surface water in meeting total crop irrigation requirement demands.

(2) Since all of the well water is supplied by individual land owners and is conveyed short distances for delivery at the field, the conveyance losses were considered negligible.

(3) Assumed well water is supplied to meet the gross irrigation requirement at irrigation district field application efficiency (45 percent).

Table 5-19 shows the land owner, watershed file report, potential water right number, number of acres and apparent date of first use of irrigated lands served by the PWUA. Other lands were formerly irrigated with water from the Pomerene Canal but no longer receive this source of water. This may be due to the PWUA having an inadequate supply to provide these acres or the development of a separate water source. Table 5-20 depicts the irrigated lands formerly served by the PWUA.

TABLE 5-19

LANDS SERVED BY THE POMERENE WATER USERS ASSOCIATION

NAME	WATERSHED FILE REPORT NUMBER	POTENTIAL WATER RIGHT NUMBER	ACRES	APPARENT DATE OF FIRST USE
Barney, Eldon J. and Shirley	112-17-BAA-206	IR1	0.6	1912
Barney, Gerald A. and Judy G.	112-17-BAD-1	IR1	186.5	1912
	112-17-BAD-29	IR1	2.8	1912
Barney, Leland K. and Paula F.	112-17-BAD-16	IR1	64.4	1912
Barney, Newell A. and Katherine	112-17-BAD-28	IR1	63.3	1912
Brick, H. Paul and Sandra L.	112-17-BAA-218	IR1	13.5	1912
Brown, Chester L.	112-17-BAD-18	IR1	35.4	1912
Corp. Presiding Bishop Church of LDS	112-17-BAD-31	IR1	3.5	1912
East, Franklin T. and Vernalee	112-17-BAA-62	IR1	11.3	1912
East, Harold R. and Lois	112-17-BAA-24	IR1	20.8	1912
Edington, Dalen M. and Polly Jean	112-17-BAD-30	IR90	2.0	1912
El Paso Natural Gas Company	112-17-BAD-15	IR1	4.2	1912
FHA	112-17-BAD-10	IR1	34.1	1912
Farnsworth, Thomas A. and Leora	112-17-BAA-2	IR1	9.5	1912
Fenn Enterprises, Inc.	112-17-BAD-12	IR1	2.5	1912
		IR90	12.3	1912
Fenn, Eli and Ila V.	112-17-ABC-1	IR1	26.7	1912
Goodman, Ronald L. and Deborah H.	112-17-BAD-17	OT1	1.0	1912
Housley, George G.	112-17-ACB-3	IR1	4.0	1912
Jones, Arda T.	112-17-BAA-34	OT1	1.8	1912
Kading, Kirk	112-17-BAD-9	IR1	51.4	1912
		IR90	9.8	1912
Klones, Lee L.	112-17-BAA-37	IR1	1.0	1912
Larson, Thurber E.	112-17-BAD-21	IR1	14.2	1912
Matthews, Harold I. and Daphne L.	112-17-BAD-11	IR1	54.9	1912
Pomerene School District #64	112-17-BAA-207	RC1	2.7	1912
Sherman, Ernest A.	112-17-BAA-117	IR1	8.7	1912
SLD	112-17-BAD-13	IR1	3.7	1912
Virgil, David O. and Viola G.	112-17-BAA-25	IR90	11.2	1912
Welker, Randall and Joyce	112-17-BAD-19	IR1	10.2	1912
Fenn, Eli and lLa V.	112-17-ABC-1	IR2	47.8	1930
Kartchner, Max J. and Donna L.	112-17-BDA-7	IR91	12.1	1939
Barney, Leland K. and Paula F.	112-17-BAD-16	IR2	39.5	1944
Barney, Rex O. and Gail	112-17-BAD-14	IR1	47.5	1944
SLD	112-17-BAD-13	IR2	2.2	1944
Fenn, Eli and Ila V.	112-17-ABC-1	IR3	21.6	1950
Barney, Eldon J. and Shirley	112-17-BAD-1	IR2	23.3	1955
Matthews, Harold I. and Daphne L.	112-17-BAD-11	IR2	73.3	1955
Barney, Eldon J. and Shirley	112-17-BAD-1	IR3	15.7	1964
Fenn Enterprises, Inc.	112-17-BAD-12	IR2	36.5	1964
Heder, Helen A.	112-17-BAA-53	OT1	0.3	1967
Barney, Eldon J. and Shirley	112-17-BAD-1	IR4	11.9	1972
Sherman, Barry G. and Judy	112-17-BAA-208	OT1	0.2	1972

TABLE 5-19 (cont'd)

NAME	WATERSHED FILE REPORT NUMBER	POTENTIAL WATER RIGHT NUMBER	ACRES	APPARENT DATE OF FIRST USE
Sherman, Branson L. and Geneva	112-17-BAA-38	IR1	2.5	1972
Sherman, Russell L. and Norma Jean	112-17-BAA-209	OT1	0.2	1972
Shull, K. Gene	112-17-ACB-1	IR90	0.8	1972
Matthews, Harold I. and Daphne L.	112-17-BAD-11	IR3	3.8	1979
Kartchner, Max J. and Donna L.	112-17-BDA-7	IR4	14.6	1983
Matthews, Harold I. and Daphne L.	112-17-BAD-11	IR4	1.6	1983
Tucson Pathology Associates P.C.	112-17-BDA-14	IR1	11.0	1983
Vega, Luis E. and Patricia A.	112-17-ACB-8	IR1	15.4	1983
Jacobs, Benjamin P., Jr. and Bette J.	112-17-ACC-75	IR1	2.1	1986
TOTAL ACRES SUPPLIED BY THE POMERENE WATER USERS ASSOCIATION			1,051.9	

TABLE 5-20

IRRIGATED LANDS FORMERLY SUPPLIED FROM THE POMERENE CANAL

NAME	WATERSHED FILE REPORT NUMBER	POTENTIAL WATER RIGHT NUMBER	IRRIGATED ACRES
Barney, Leland K. and Paula	112-17-BAA-1	IR1	104.4
Bernal, Robert and Sherrie	112-17-BAD-27	IR1	7.7
Berryhill, Lloyd E. and Ann M.	112-17-BAA-92	IR1	4.1
Coons, Alice B.	112-17-BAA-8	IR1	2.4
East, Acel W. and Nila	112-17-BAA-185	IR1	35.4
Farnsworth, Thomas A. and Leora	112-17-BAA-2	IR1	9.5
Fenn, Alvah F. and Barbara	112-17-BAD-22	IR2	1.7
George, Albert E. and Nancy P.	112-17-BAA-59	IR1	4.0
Gessert, Lowell P. and Roberta S.	112-17-ACB-6	IR1	39.8
Harold, T.P. and Phyllis M.	112-17-BAA-162	IR1	2.0
Larson, Esther C.	112-17-BAA-180	IR1	18.1
Sherman, Lloyd and Elva M.	112-17-BAA-16	IR1	5.4
Shull, K. Gene	112-17-ACB-1	IR1	0.8
		TOTAL	235.3

ST. DAVID IRRIGATION DISTRICT (WFR #112-17-88)

The St. David Irrigation District (SDID) diverts water from the San Pedro River to irrigate just over 1,087 acres within and south of the community of St. David (Figure 5-12). The district diverts water whenever flows in the river are sufficient for irrigation. This is typically during the winter and early spring when the river is normally sustained by a stable baseflow. Generally during the July to October "monsoon" season, the river flows at the SDID diversion only in response to direct rainfall events. This water is generally unusable due to high sediment loads and frequent breaching of the earthen diversion dam by high flows. The SDID operates two wells which provide supplemental water and are used during periods when surface water is insufficient or unavailable to meet the district's needs. The St. David Ditch has been in existence since 1881 and has been operated by the legally organized irrigation district since 1936.

Table 5-21 describes all of the subregions on which the water uses and conveyance systems are mapped. These subregional maps may be found in Volume 9 of the HSR entitled "Water Use Maps."

TABLE 5-21

SUBREGIONAL WATER USE MAPS CONTAINING WATER USES, SOURCES, AND CONVEYANCE SYSTEMS WITHIN THE SDID

WATERSHED/SUBWATERSHED	REGION	SUBREGION
112	17	ACC
112	17	ACD
112	17	DBA
112	17	DBB
112	17	DBD
112	17	DCA
112	17	DCD

History

The St. David Canal Company, predecessor of the SDID, initially filed Articles of Incorporation with the Cochise County Recorder in 1883. A Notice of Appropriation was filed with the Pima County Recorder on May 26, 1980 which described the physical attributes of the SDID diversion. However, the notice did not claim or specify a diversion amount from the San Pedro River. New Articles of Incorporation were filed with the same office on February 18,

1908. A second notice of appropriation was then filed April 27, 1908, with the county recorder to appropriate 5,000 miner's inches (125 cfs) from the San Pedro River. Articles of Incorporation were again filed with the Cochise County Recorder on March 10, 1933.

A Petition of Organization for the SDID was filed with the Cochise County Board of Supervisors on October 20, 1936. The petition was accepted, filed, and recorded with the recorder's office January 28, 1937.

An agreement establishing an easement for a well site was notarized on July 19, 1947. The actual document was not recorded with the Cochise County Recorder until October 8, 1958.

A major realignment of the ditch system occurred in 1916 which added approximately 584 irrigated acres of land, as of 1990, to the district (Figure 5-12). Traces of the old ditch system are still visible in several places within the district (Figure 5-12). The SDID presently supplies surface water and well pumpage to just under 1,090 irrigated acres.

As part of the Gila River Determination, the SWC undertook a detailed survey and analysis of agricultural irrigation uses within the San Pedro River watershed in 1921 through 1923. The SWC maps reveal that SDID supplied water to approximately 424 acres of active irrigation. The maps also classified an additional 525 acres within SDID as having been "previously cultivated."

Applicable Filings and Decrees

On June 15 and 16, 1977, the SDID filed three water rights registrations with the Arizona State Land Department (SLD) pursuant to the 1974 Water Rights Registration Act (A.R.S. § 45-180). Table 5-22 displays the claim numbers, location of claimed sources, and the claimed amount of annual water use for each of these filings.

TABLE 5-22

ST. DAVID IRRIGATION DISTRICT
WATER RIGHTS REGISTRATIONS

CLAIM NUMBER	WATER SOURCE CLAIMED	CLAIMED AMOUNT
36-46175	Well D(18-21) 28abb	800 acre-feet per year
36-46184	Well D(18-21) 28cb	1,200 acre-feet per year
36-46185	San Pedro River	6,000 acre-feet per year

Irrigated Lands

1881 Claimed Priority Date

1916 or Later Claimed Priority Date

St. David Irrigation District Well

St. David Ditch

Pipeline

St. David Ditch Prior to 1916 Realignment

Section Line

Figure 5-12. Area served by the St. David Irrigation District

Two statements of claimant for the San Pedro River watershed adjudication were filed by the SDID on July 1, 1980. Claimed water sources are given in Table 5-23.

TABLE 5-23

ST. DAVID IRRIGATION DISTRICT
ADJUDICATION STATEMENTS OF CLAIMANTS

CLAIM NUMBER	STREAMS	GROUNDWATER	CLAIMED AMOUNT
39-6593	San Pedro River	Well Registration #612818 Well Registration #612819	5,500 acre-feet per year
39-6594	San Pedro River	Well Registration #612818 Well Registration #612819	8,550 acre-feet per year

Additionally, numerous filings were made by individual users within the SDID claiming rights to the waters provided by the district, as well as to water withdrawn from privately owned wells.

Organization and Operation

The SDID has a legally described service area with definite boundaries (Table 5-24). However, not all of the lands assessed and located within the district boundaries irrigate with water delivered by the SDID.

TABLE 5-24

ST. DAVID IRRIGATION DISTRICT
SERVICE AREA BOUNDARY

TOWNSHIP	RANGE	SECTIONS
17 South	21 East	31, 32
18 South	21 East	4-6, 8, 9, 16, 17 21, 28, 29, 32, 33

The SDID operates as it was structured within the original petition for organization filed in 1936. It is managed by a three member board of directors elected on an acreage voting basis. A secretary and a ditch rider are employed full-time.

The district's operations were ascertained through interviews with the SDID board of directors and field investigations by DWR. Irrigators receive water on an average of once every three weeks, with each acre allotted one hour of the volume of flow in the ditch available to the user's headgate. In some instances, water is allocated based upon the total acreage owned or assessed, and not the acres actually irrigated. An assessment is made each year on a per acre basis to pay distribution costs and to provide for maintenance of the facilities. The amount of water actually delivered is governed by the flow available from the river, the capacity of the ditch, and the affordability of the well water.

When high flows in the river breach the diversion dam, or there is insufficient water available in the ditch, irrigators may call for water supplied by the SDID's wells. An hourly charge is assessed for this water and is therefore used less frequently than water supplied by privately owned

Figure 5-13. The St. David Irrigation District diversion, located on the San Pedro River south of St. David, was constructed in 1881, which makes it the second oldest surface water diversion in the watershed. The SDID ditch capacity is twenty-four cfs after maintenance.

wells. Many of these privately owned wells flow under artesian conditions, without the aid of pumps, and provide an economical supplement to other available water.

Facilities

The SDID operates and maintains the St. David Ditch, associated facilities, and two wells as its sole irrigation supply and delivery system. Water is directed from the San Pedro River by an earthen diversion dam located in the SE¼, NW¼, SW¼, Section 4, Township 19 South, Range 21 East, Gila and Salt River Baseline and Meridian. The ditch in its entirety is approximately nine miles long.

The diversion dam and approximately 1½ miles of the ditch are located on lands owned by the BLM. This property is the northern most portion of the San Pedro Riparian National Conservation Area (SPRNCA) and is managed similar to lands designated as wilderness areas. The SDID and the BLM negotiated a fifty year Right-of-Way/Temporary Use Permit Agreement. This agreement allows the SDID to reconstruct the diversion dam and perform routine maintenance as needed.

The two supplemental irrigation wells are located in the SE¼, NW¼, SW¼ and the NW¼, SW¼, SW¼, Section 28, Township 18 South, Range 21 East, Gila and Salt River Baseline and Meridian. Both of these wells are located next to the SDID ditch and are operated by pumps fueled by natural gas. These wells combined are able to supply approximately 10.5 cfs directly into the SDID ditch system.

Along the course of the ditch there are numerous inverted siphons and flumes which allow the ditch to cross washes and roads without interruption. These structures often determine the maximum amount of water which can be provided by the district, not the physical characteristics of the open ditch itself.

There are also two sluice ways which can divert water back to the San Pedro River. Because there is no headgate on the ditch, these sluice ways provide the SDID with a means of controlling flow in the ditch. When flows in the San Pedro River exceed the SDID's ability to deliver water, these sluice ways protect the ditch and the ditch-side property owners from flood damage. The ditch capacity decreases considerably downstream of these sluice ways.

Figure 5-14. One of the two St. David Irrigation District wells supplements the surface water supply from the San Pedro River. These two wells are located in Zone 2. The two wells combined are able to pump approximately ten cfs.

The earthen diversion dam also is used to protect other SDID facilities from flood damage. When flows in the San Pedro River are excessively high, the dam fails, releasing these flood waters down the main river channel and away from the ditch served lands.

Diversion Data

Since the publication of the first HSR in February 1987, several changes have been made to the district's system. The SDID changed the power source for the two wells from electric to natural gas and installed a flow meter on each well outlet pipe. The SDID also installed a five-foot parshall flume and water stage recorder on the ditch downstream from the wells in October 1987 to accurately monitor flows in the ditch. The flume was relocated in November 1989 in an effort to improve the accuracy of the flow measurements. The ditch was cleaned thoroughly from the wells upstream to the diversion on the San

Figure 5-15. A Parshall flume and Stevens Type F recording gage are located about 100 yards downstream (north) of the two St. David Irrigation District wells. The gage and flume were installed to enable the district to monitor flows in their ditch.

Pedro River. The SDID also reconstructed the diversion dam to capture more of the surface flows in the river.

Survey measurements of the diversion structure and ditch system, taken by DWR, have been used to calculate a maximum theoretical diversion rate of 24.3 cfs. However, the capacity of the ditch is steadily reduced throughout the irrigation season due to sedimentation and the growth of weeds. The maximum discharge measured by DWR was 22.3 cfs on March 19, 1991. The amount of water reaching irrigators is limited by the amount of water flowing in the river at the diversion dam, by the maximum capacity of the ditch, and the conveyance losses. When there is sufficient water in the ditch, water may be delivered to more than one irrigator at a time. During periods of low flow, one water user may receive the entire flow of the ditch.

Tables 5-25 and 5-26 give pertinent surface water and groundwater diversion information.

TABLE 5-25

ST. DAVID IRRIGATION DISTRICT
PERTINENT DIVERSION INFORMATION

DIVERSION NAME	DIVERSION LOCATION	MAXIMUM CAPACITY (CFS)	MAXIMUM MEASURED FLOW (CFS)	LENGTH OF DITCH
St. David Diversion (D1) Diversion	SE¼, NW¼, SW¼, Section 4, T.19S., R.21E.	24.3	22.3	9 Miles

TABLE 5-26

ST. DAVID IRRIGATION DISTRICT
PERTINENT WELL INFORMATION

WELL NUMBER	WELL LOCATION	PUMP CAPACITY (GALLONS PER MINUTE)	DEPTH (FT)	INSTALLATION DATE	DWR WELL REGISTRATION NUMBER
#1 (W1)	SE¼, NW¼, SW¼, Section 28, T.18S., R.21E.	2,900	110	1947	612819
#2 (W2)	NW¼, SW¼, SW¼, Section 28, T.18S., R.21E.	1,800	108	1952	612818

Quantification of Irrigation Uses

Adequate records of the amount of water supplied by the St. David Ditch have apparently not been kept. A gaging station near the head of the ditch was maintained by the USGS from June 1967 to September 1972. The gage was located upstream of the sluice gates and on many occasions during the height of the diversion season it has recorded more water than could have passed through the ditch below the sluices to the irrigators. In order to estimate the amount of water that actually flowed down the ditch past the sluice, the gage records were adjusted by reducing all daily mean discharge data that exceeded 24.0 cfs to that value, the approximate maximum theoretical capacity of the canal. When this was done, the greatest amount of water passing through the St. David Ditch in any year when the gage was in operation was calculated to be just over 4,877 acre-feet in 1971 and the average amount for the four years 1968 to 1971 was estimated to be about 4,425 acre-feet.

Since the ditch began operating in 1881, there have probably been more favorable years when the canal delivered somewhat more water than those years when the gage was in operation. However, it is almost certain that the amount that flowed down the ditch to the shareholder's land in any year could not have exceeded 8,616 acre-feet, the amount of water the canal could deliver if it were to run completely full for six months.

Even though the SDID receives an average annual amount of 4,425 acre-feet of surface water per year, most of this water is received during the winter months when the demand for water by the crops is low. As a result, DWR determined that of the amount of water received during these months, only a portion of this amount will go towards meeting the GIR of the crop. The irrigation water requirements can be met by irrigating for the immediate demands of the crop as well as by storing the water in the plant root zone for later use by the crop. Any amount exceeding the crop demand and storage potential of the soil will be lost.

To determine what amount of surface water is actually being used to supply the overall GIR, DWR first calculated the average monthly diversion amounts, the losses from the ditch due to seepage and evaporation, and the amount of diversion water reaching the fields. Also determined was the GIR of the SDID irrigation district based on the crop distribution within the district. These quantities and calculations can be seen in Table 5-27. An irrigation district irrigation efficiency of 52 percent for SDID was used to calculate the total irrigation requirements within the 1,036 crop surveyed acres of SDID. The crop surveyed acres provide a measure of the total irrigated acreage in any given year. These calculations allow DWR to compare the amount of surface water reaching the field to the amount of water needed by the crop at the field.

Table 5-27 indicates that much more water is supplied during many of the months of high surface flows than can actually be used by the crop during those months (November through April). In order to make an analysis of the amount of surface water that actually meets the GIR of the crop, DWR assumed that the soil moisture profile (water held in the soil for plant growth) of the irrigated fields is somewhat depleted during the summer months and made up during the winter months with the less expensive supply of surface water. The irrigated acreage listed for the month of November includes both cropped and noncropped acreage. The summer moisture deficit is assumed to be made up on

TABLE 5-27

SURFACE WATER DELIVERED AND
GROSS IRRIGATION REQUIREMENTS FOR THE
ST. DAVID IRRIGATION DISTRICT

MONTH	TOTAL CFS/MONTH DIVERTED	ACRE-FEET DIVERTED	CROP SURVEY ACRES ACTIVELY IRRIGATED	EQUIVALENT INCHES DIVERTED(1)	CONVEYANCE AND SEEPAGE LOSSES (INCHES)	INCHES OF WATER DELIVERED TO FIELD(1)	CROP WATER USE (INCHES)	GROSS IRRIGATION REQUIREMENT(2) (INCHES)
January	327.7	650.0	739.0	10.6	0.6	9.9	0.7	1.7
February	377.1	748.0	746.0	12.0	0.6	11.4	1.7	4.0
March	423.6	840.2	795.0	12.7	0.7	12.0	3.0	7.1
April	287.1	569.5	832.0	8.2	0.5	7.7	4.4	10.5
May	104.4	207.1	936.0	2.7	0.2	2.4	5.9	14.0
June	3.3	6.6	921.0	0.1	0.0	0.1	6.7	15.8
July	5.9	11.7	923.0	0.2	0.0	0.2	3.8	9.1
August	6.6	13.1	923.0	0.2	0.0	0.2	3.3	7.8
September	0.0	0.0	923.0	0.0	0.0	0.0	3.3	7.9
October	2.3	4.6	926.0	0.1	0.0	0.1	2.3	5.5
November	250.8	497.2	832.2	7.2	0.4	6.8	1.6	3.8
December	442.3	877.3	753.0	14.0	0.6	13.3	0.8	2.0
TOTAL INCHES				67.8	3.1	64.0	37.5	89.2
TOTAL ACRE-FEET		4,425.4		4,425.4	245.8	4,179.6	2,760.5	6,578.8

(1) The equivalent inches of water is the volume of water supplied divided by the actively irrigated acres per month within SDID.

(2) At the irrigation district efficiency in the SDID (42 percent).

Discrepancies in values are due to rounding of values.

this amount of acreage. This would result in storing some of the excess surface water in the soil for use when surface water supply becomes inadequate to meet immediate crop demand. DWR has also assumed that the surface water not used to provide the portion of the GIR in the manner mentioned above is lost through run off, deep percolation or return flow and becomes unavailable for plant growth. Table 5-28 shows the results of this analysis. A soil water holding capacity of eight inches of water was assumed based on the soil water holding capacity of soils in the area (Soil Conservation Service, General Soil Map, Cochise County, Arizona, 1971). An average soil moisture

deficit after any given irrigation event during the summer months of two inches, or a net soil water profile of six inches, was also assumed.

The total amount of water pumped by wells in Table 5-28 is the amount of well water that would need to be supplied to make up the difference between usable surface supply, conveyance losses of the well water and the GIR. The amount of water supplied by wells is the amount of water pumped minus the conveyance losses of the well water. The irrigators in SDID, therefore, utilize 2,104 acre-feet per year of surface water out of the 4,425 acre-feet that is supplied. Of this supply, nearly 246 acre-feet is lost through seepage and evaporation and approximately 4,180 acre-feet actually reach the field. A net excess of 2,076 acre-feet of surface water reaches the field.

Table 5-29 provides a summary of the surface water and well water components within the SDID. Since the irrigation district supplies most of the well water needed for the GIR, conveyance losses are significant. The GIR calculated within SDID is about 6,579 acre-feet or 7.4 feet of water. Of this amount, nearly 2,104 acre-feet or 2.6 acre-feet per acre of water is supplied by surface water and about 4,475 acre-feet or 4.8 acre-feet per acre of water is supplied by wells.

Table 5-30 shows the land owner, watershed file report, potential water right number, number of acres and apparent date of first use of irrigated lands served by the SDID. Other lands were formerly irrigated with water from the St. David Ditch but no longer receive this source of water. This may be due to development of a separate water source or removing the irrigated acreage from production. Table 5-31 depicts the irrigated lands formerly served by the SDID.

TABLE 5-28

SURFACE WATER AND WELL WATER UTILIZED TO SUPPLY GROSS IRRIGATION REQUIREMENTS FOR THE ST. DAVID IRRIGATION DISTRICT (IN EQUIVALENT INCHES OF WATER) (1)

MONTH	GROSS IRRIGATION REQUIREMENT	INCHES OF SURFACE WATER DELIVERED	AMOUNT OF SURFACE SUPPLY USED	AMOUNT PUMPED BY WELLS	AMOUNT PUMPED BY DISTRICT WELLS	WELL WATER CONVEYANCE LOSSES	AMOUNT SUPPLIED BY DISTRICT WELLS	AMOUNT SUPPLIED BY PRIVATE WELLS	POST IRRIGATION NET SOIL MOISTURE
January	1.7	9.9	1.7	0.0	0.0	0.0	0.0	0.0	8.0
February	4.0	11.4	4.0	0.0	0.0	0.0	0.0	0.0	8.0
March	7.0	12.0	7.0	0.0	0.0	0.0	0.0	0.0	8.0
April	10.5	7.7	7.7	0.9	0.5	0.1	0.4	0.3	6.0
May	14.0	2.4	2.4	12.0	7.4	0.4	7.0	4.7	6.0
June	15.8	0.1	0.1	16.4	10.0	0.6	9.4	6.3	6.0
July	9.1	0.2	0.2	9.3	5.7	0.3	5.4	3.6	6.0
August	7.8	0.2	0.2	7.9	4.9	0.3	4.6	3.1	6.0
September	7.9	0.0	0.0	8.2	5.0	0.3	4.7	3.2	6.0
October	5.5	0.1	0.1	5.7	3.5	0.2	3.3	2.2	6.0
November	3.8	6.8	5.8	0.0	0.0	0.0	0.0	0.0	8.0
December	2.0	13.3	2.0	0.0	0.0	0.0	0.0	0.0	8.0
TOTAL INCHES	89.2	64.0	31.1	58.3	36.9	2.2	34.7	23.4	
TOTAL ACRE-FEET	6,578.8	4,179.6	2,103.9	4,469.5	2,843.2	172.1	2,671.1	1,803.7	

(1) The equivalent inches of water is the volume of water supplied divided by the actively irrigated acres per month within SDID. Discrepancies in values are due to rounding of values.

TABLE 5-29

SURFACE WATER AND WELL WATER COMPONENTS OF THE ST. DAVID IRRIGATION DISTRICT (FROM CROP SURVEY ACRES)

	SURFACE WATER	DISTRICT WELLS	NON-DISTRICT WELLS	TOTAL
Total volume diverted in acre-feet	4,425.4	2,843.2	1,803.7	9,072.3
Total acre-feet per acre diverted	5.7	3.1	2.0	10.8
System canal seepage in acre-feet	229.7	160.8	0.0	390.5
System canal evaporation in acre-feet	16.1	11.3	0.0	27.4
Total losses in acre-feet	245.8	172.1	0.0	417.9
Net volume delivered in acre-feet	4,179.6	2,671.1	1,803.7	8,654.4
Net acre-feet per acre delivered	5.3	2.9	2.0	10.2
Net volume required by crop in acre-feet	2,103.9	2,671.1	1,803.7	6,578.7
Net volume of excess application in acre-feet	2,075.7	0.0 (1)	0.0 (1)	2,075.7
Net acre-feet per acre required by the crop	2.6	2.9	2.0	7.4

(1) Assumes well water is supplied to meet the gross irrigation requirement at irrigation district field application efficiency (42%).

Discrepancies in values are due to rounding of values.

TABLE 5-30

LANDS SERVED BY THE ST. DAVID IRRIGATION DISTRICT

NAME	WATERSHED FILE REPORT NUMBER	POTENTIAL WATER RIGHT NUMBER	ACRES	APPARENT DATE OF FIRST USE
Alberding, Doris M.	112-17-DBA-199	OT1	0.4	1881
Alexander, James L. and Mary L.	112-17-DBB-4	IR1	2.7	1881
Alexander, James W. and Betty J.	112-17-DBB-55	IR1	9.9	1881
Allgeier, Frank D. and Margaret	112-17-DBA-323	OT1	0.5	1881
Bruner, Wade W. and Corrine G.	112-17-DBA-63	OT1	0.5	1881
Carroll, Edith E.	112-17-DBA-185	IR1	27.9	1881
		IR2	1.3	
Christensen, Bernard E. and Claudia M.	112-17-DBA-163	OT1	1.0	1881
Darnell, Katherine R.	112-17-DBD-17	IR1	8.9	1881
Evans, Kenny J. and Linda Ann	112-17-DBB-69	IR1	2.1	1881
Garcia, Arnold C. and Thelma	112-17-DCA-10	IR1	11.7	1881
Gill, Stanley A. and Peggy L.	112-17-DBA-85	OT1	1.8	1881
Goodman, Donald E.	112-17-DBA-62	IR1	9.3	1881
Goodman, Wayne C. and Norma J.	112-17-DBB-68	IR1	5.7	1881
Goss, Michael C. and Laurette	112-17-DBA-164	IR1	1.0	1881
Haymore, Elishus L.	112-17-DBA-79	IR1	2.9	1881
Holy Trinity Monastary of Our Lady of Guadalupe	112-17-DBD-1	IR1	21.6	1881
Husted, Eugene S. and Debra	112-17-DBD-10	IR1	3.9	1881

TABLE 5-30 (cont'd)

NAME	WATERSHED FILE REPORT NUMBER	POTENTIAL WATER RIGHT NUMBER	ACRES	APPARENT DATE OF FIRST USE
Johnson, Shirley M.	112-17-DBD-18	IR1	0.8	1881
Judd, Grant and Rosie I.	112-17-DBD-5	IR1	6.3	1881
Judd, Jimmy V. and Edna R.	112-17-DBD-7	IR1	3.4	1881
	112-17-DBB-28	IR1	3.2	1881
Judd, Laren D.	112-17-DBA-151	IR90	4.5	1881
Judd, Merlin C. and Judy C.	112-17-DBD-8	IR1	2.9	1881
Judd, Thomas A. and Bethany A.	112-17-DBD-6	IR1	3.8	1881
Kartchner, Max J.	112-17-DBA-1	IR1	54.7	1881
Kartchner, Paul B. and Susan D.	112-17-DBA-282	IR1	11.6	1881
Mayberry, Andrew B. and Lavee T.	112-17-DBB-37	IR1	2.4	1881
Mayberry, E. Jimmie and Gwendolyn Y.	112-17-DBB-21	IR1	10.7	1881
McCommas, James E. and Dora F.	112-17-DCA-3	IR1	7.1	1881
		RC1	5.1	1881
McGee, Thomas	112-17-DBD-4	IR1	21.5	1881
McKeighen, Larry M.	112-17-DBA-177	IR1	6.6	1881
		IR2	1.0	1881
McNelly, Robert W. and Kathleen	112-17-DBD-9	IR90	1.7	1881
Mikeal, Judith M.	112-17-DBD-11	IR1	8.0	1881
Miller, Larry H.	112-17-DBD-2	IR1	7.3	1881
		IR2	5.0	1881
Miller, Marwood	112-17-DBA-3	IR1	39.0	1881
Miller, Frank M.		IR2	42.9	1881
		IR8	1.8	1881
Miller, Quentin H.	112-17-DBA-2	IR1	3.0	1881
		IR2	7.3	1881
		IR3	19.5	1881
Mortenson, Duane O. and Dolores A.	112-17-DBA-80	IR1	2.1	1881
Owens, Orie A. Sr.	112-17-DBA-61	IR1	0.7	1881
Povlich, Rudolph P. and Winona M.	112-17-DBD-30	IR90	35.6	1881
Richey, Robin L. and Linda M.	112-17-DBB-23	IR1	10.9	1881
Rocha, Mario F. and Genoveva L.	112-17-DCA-12	IR1	0.1	1881
Singer, Ruth B.	112-17-DBA-247	OT1	0.3	1881
Smith, Danny S.	112-17-DBB-1	IR1	7.7	1881
Smith, Sanford G.				
Smith, Gail W. and Patty J.	112-17-DBB-9	IR1	2.3	1881
Smith, Gail W.	112-17-DBB-66	IR1	9.8	1881
Smith, Sanford G.				
Smith, Guy L.	112-17-DBB-65	IR1	15.0	1881
Smith, Sanford G.				
Taylor, William H. Jr. and Esther I.	112-17-DBA-88	OT1	0.6	1881
Tenney, Gerald W. and Ila K.	112-17-DBA-124	IR1	3.4	1881
Trejo, Alfred J. and Marzette B.	112-17-DBB-7	IR1	7.6	1881
Trejo, Gary A. and Susan L.	112-17-DBB-34	IR1	6.1	1881
Trejo, Ralph C. and Edna C.	112-17-DBB-6	IR1	22.5	1881
Valley National Bank	112-17-DBA-87	IR1	12.3	1881
c/o Stecker, George H.				
Weitekamp, Raymond J. and Elizabeth A.	112-17-DBA-113	IR1	10.7	1881
White, Eulas E. and Winifred	112-17-DBB-10	IR1	7.4	1881
White, Henry I.	112-17-DBA-181	OT1	0.5	1881
Zweifelhofer-Summers, Janice E.				

TABLE 5-30 (cont'd)

NAME	WATERSHED FILE REPORT NUMBER	POTENTIAL WATER RIGHT NUMBER	ACRES	APPARENT DATE OF FIRST USE
White, Henry G.	112-17-DBA-321	IR1	6.2	1881
White, Marcia D.				
Zweifelhofer-Summers, Janice E.				
Whitehead, George	112-17-DBA-122	IR90	12.2	1881
Willhite, George E. and Irene E.	112-17-DBA-255	OT1	1.9	1881
Libby, Fred J.	112-17-DBA-156	OT1	0.9	1902
Behr, Henry	112-17-ACC-11	IR1	4.4	1916
Bingham, James D.	112-17-ACC-89	IR1	7.6	1916
Black, Carl W. and Mary E.	112-17-ACC-110	IR1	2.2	1916
Black, Mary E.	112-17-ACC-111	IR1	21.9	1916
Corporation of the Presiding Bishop, Church of Jesus Christ of Latter Day Saints	112-17-ACC-28	IR1	25.5	1916
Evans, Arnold D. and Fern B.	112-17-ACC-47	IR1	5.6	1916
Fenn, Golden L. and Annie L.	112-17-ACC-41	IR1	3.0	1916
Fletcher, Donald F. and Caroline H.	112-17-ACC-35	IR1	7.0	1916
Gappmayer, Francis R. and Joan C.	112-17-ACD-137	OT1	1.8	1916
Gauthier, M. Ruth	112-17-ACD-143	OT1	1.4	1916
Goodman, A. D. and Ella S.	112-17-ACD-122	IR1	22.4	1916
Goodman, Dean R. and Bonnie B.	112-17-ACC-50	IR1	3.9	1916
Goodman, Donald E.	112-17-DBA-62	IR2	8.9	1916
Goodman, Lee A. and Karen S.	112-17-ACC-51	IR1	2.3	1916
Jarehsiah-Beth Shean Enterprises, Ltd. c/o Apache Mobile Park	112-17-ACD-115	IR1	8.0	1916
Kartchner, Max J.	112-17-DBA-1	IR2	26.6	1916
Larson, Steven R.	112-17-ACC-45	IR1	4.0	1916
Leitner, Francis J.	112-17-ACD-184	OT1	0.8	1916
Mayberry, Andrew B. and Lavee T.	112-17-ACC-13	IR1	26.6	1916
Mayberry, Roland and Verna	112-17-ACC-10	IR1	20.8	1916
McCraney, Phillip R. and Judith R.	112-17-ACD-183	OT1	0.8	1916
Merrill, Glenn E. and Lorina G.	112-17-ACC-101	IR1	1.1	1916
Merrill, Glenn E.	112-17-ACC-102	OT1	0.9	1916
Merrill, Orland and Glennis F.	112-17-ACC-31	OT1	1.7	1916
Nelson, Ronald J. and Marla	112-17-ACD-185	OT1	0.3	1916
Owens, Orie A. Sr.	112-17-DBA-61	IR2	6.8	1916
Povlich, Rudolph P. and Winona M.	112-17-ACC-9	IR1	21.5	1916
Preston, Donald R. and Karen P.	112-17-ACD-112	IR1	26.5	1916
Sanders, Dane and Lola L.	112-17-ACC-114	OT1	1.4	1916
Sandve, Patricia A.	112-17-ACC-26	IR90	6.6	1916
Stein, Leonard W. and Francis J.	112-17-ACC-112	IR1	11.3	1916
Valdez, Donald J. and Connie F.	112-17-ACC-93	IR1	2.5	1916
Goodman, Donald E. and Della L.	112-17-ACC-32	IR1	9.8	1916
Darnell, Katherine R.	112-17-DBD-17	IR3	5.4	1955
Martin, Harry H. Jr. and Kim	112-17-DBA-101	IR1	3.6	1955
McGee, Patrick	112-17-DBD-25	IR1	4.1	1955
McGee, Thomas	112-17-DBD-4	IR3	19.3	1955
Miller, Marwood	112-17-DBA-3	IR4	19.9	1955
Miller, Frank M.		IR5	29.4	1955
Miller, Rollin J. and Deborah Lynne	112-17-DBA-302	OT1	1.0	1955
Miller, Sarah	112-17-DBA-4	IR1	22.8	1955

TABLE 5-30 (cont'd)

NAME	WATERSHED FILE REPORT NUMBER	POTENTIAL WATER RIGHT NUMBER	ACRES	APPARENT DATE OF FIRST USE
Nelson, James R.	112-17-ACD-113	OT1	1.1	1955
Nelson, Jay M.	112-17-ACD-130	IR1	14.6	1955
Povlich, Rudolph P. and Winona M.	112-17-ACC-9	IR2	1.4	1955
San Pedro Investments, Inc.	112-17-DBA-322	IR1	2.6	1955
Preston, Donald R. and Karen P.	112-17-ACD-112	IR2	1.3	1964
Gibbens, Merlene L.	112-17-DBA-143	IR1	4.0	1964
Guinn, Evelyn M.	112-17-DBD-3	OT1	0.5	1964
Higginbotham, Ronald B. and Venice J.	112-17-ACD-97	IR1	3.4	1964
McGee, Thomas	112-17-DBD-4	IR91	15.1	1964
Miller, Marwood	112-17-DBA-3	IR6	10.6	1964
Miller, Frank M.				
San Pedro Investments, Inc.	112-17-DBA-322	IR2	1.4	1964
Valley National Bank	112-17-DBA-87	IR2	4.5	1964
c/o Stecker, George H.				
White, Eulas E. and Winifred	112-17-DBB-10	IR2	5.3	1964
Darnell, Katherine R.	112-17-DBD-17	IR4	5.4	1972
San Pedro Investments, Inc.	112-17-DBA-322	IR3	2.1	1972
Miller, Marwood	112-17-DBA-3	IR7	20.7	1976
Miller, Frank M.				
Stamps, Charles D. and Margarette	112-17-ACD-204	OT1	0.1	1979
Kartchner, Glen R. and Dixie D.	112-17-DBA-274	OT1	1.0	1980
Gustafson, Wayne T. and Dorothy E.	112-17-DBD-16	IR1	10.7	1983
Garcia, Arnold C. and Thelma	112-17-DCA-10	IR2	1.2	1986
Behr, Henry	112-17-ACC-11	IR2	4.7	1987
Rocha, Mario F. and Genoveva L.	112-17-DCA-12	OT1	0.7	1987
Miller, Quentin H.	112-17-DBA-2	IR4	0.2	1989
Mayberry, Esker R. and Linda D.	112-17-ACC-119	OT1	1.0	1990
TOTAL ACRES SUPPLIED BY THE ST. DAVID IRRIGATION DISTRICT			1,087.1	

TABLE 5-31

IRRIGATED LANDS FORMERLY SUPPLIED FROM THE ST. DAVID IRRIGATION DISTRICT DITCH

NAME	WATERSHED FILE REPORT NUMBER	POTENTIAL WATER RIGHT NUMBER	IRRIGATED ACRES
Branch, Chester R.	112-17-DBA-84	IR1	19.6
Ross, Robert A.		IR2	4.9
		IR3	2.5
Curtis, Doris M.	112-17-DBA-199	OT1	0.4
Gappmayer, Francis Reed and Joan C.	112-17-ACD-137	OT1	1.8
Gauthier, M. Ruth	112-17-ACD-143	OT1	1.4
Guinn, Evelyn	112-17-DBA-3	IR1	39.0
Howe, James Jr. and Leonor E.	112-17-DBA-198	IR90	2.0
Libby, Fred	112-17-DBA-156	OT1	0.9
Merrill, Frank W. and Barbara A.	112-17-DBA-123	IR1	17.0
Miller, Larry Hatch	112-17-DBA-2	IR1	3.0
Owens, Orie Alvin Sr.	112-17-DBA-61	IR2	6.8
Simmons, Dorothy	112-17-DBA-188	IR1	0.3
White, Henry L.	112-17-DBA-181	OT1	0.5
White, Wilbur W.	112-17-DBA-180	IR1	6.0
Willhite, G.E. and Irene	112-17-DBA-255	OT1	1.9
		TOTAL	108.0

5.3 INDUSTRIAL/MINING MAJOR USERS

This section describes seven industrial and six major mining users in the San Pedro watershed. Six of the seven major industrial users are sand and gravel operations which supply rock and concrete products. The sixth is Apache Nitrogen Products, Inc., which is located near St. David and manufactures explosives and farm chemicals. The major mining users are comprised of two precious metal mines located near the City of Tombstone, the Magma Copper Company facility located near San Manuel, the American Smelting and Refining Company's (ASARCO) well fields near Winkelman and Dudleyville, and the Oracle Ridge Mining Company. ASARCO exports water to its Hayden and Ray mining and smelting facilities, which are located in the Upper Gila River watershed.

The reports and water use maps for each of these major users are found as shown below.

INDUSTRIAL AND MINING WATER USE REPORTS	SUBWATERSHED	WATER USE MAP NUMBER	PAGE
ALANCO Ltd.	Sierra Vista	Region 21	353
Apache Nitrogen Products, Inc.	Benson	Region 17	354
ASARCO - Hayden Unit	Winkelman	Region 1	356
ASARCO - Ray Unit	Winkelman	Region 4	359
Babocomari Ranch Company/Huachuca Concrete, Inc.	Sierra Vista	Region 20	362
Clark Trucking Company	Redington	Region 4	363
Desert Concrete Company	Sierra Vista	Region 23	363
Magma Copper Company - San Manuel Operation	Redington	Region 8	364
Oracle Ridge Mining Company	Redington	REgion 8	370
RAMCO Inc. - PBR Minerals Plant	Sierra Vista	Region 21	371
Sierra Ready Mix and Contracting Company	Sierra Vista	Region 20	372
SLD/Cashway Concrete and Material Company	Sierra Vista	Region 20	373
Young Concrete and Block Company	Sierra Vista	Region 20	374

Table 5-32 shows the water use for the industrial/mining major users for the years 1985 and 1989.

TABLE 5-32

WATER USE FOR INDUSTRIAL AND MINING MAJOR USERS FOR 1985 AND 1989
(ACRE-FEET)

USER	WATERSHED FILE REPORT NUMBER	1985	1989
Industrial			
Apache Nitrogen Products, Inc.	112-17-90	331.0	542.0
Babocomari Ranch Company/Huachuca Concrete, Inc.	111-20-35	21.5	71.8
Clark Trucking	113-04-05	143.6	143.6
Desert Concrete Company	111-23-50	61.1	11.1
Sierra Ready Mix and Contracting Company	111-20-64	63.2	63.2
SLD/Cashway Concrete and Materials Company			
Young Concrete and Rock Company	111-20-69 111-20-63	1.2	58.6
Mining			
ALANCO Ltd.	111-21-38	38.7	1.0
ASARCO - Hayden Unit	114-1-5	1,138.0	808.0
ASARCO - Ray Unit	114-4-35	236.0	1,053.0
Magma Copper Company	113-8-22	20,318.0	24,076.0
Oracle Ridge Mining Company	113-8-11	(1)	(1)
RAMCO, Inc. - PBR Minerals Plant	111-21-37	1.0	1.0

(1) Constructed in February 1990; began production in March 1991.

ALANCO LTD. (WFR #111-21-38)

History

ALANCO Ltd., formerly Tombstone Mineral Reserves Inc. (TMR), operates the AR-MEX Custom Mill located 3½ miles southwest of the City of Tombstone on the Charleston Road. The facility is designed to mill high to medium grade silver and gold ores through cyanide agitated leach, cyanide heap leach, and gravity concentration processes. The facility also provides metallurgical testing and smelting and refining services.

The AR-MEX Custom Mill, formerly known as ARMCO Custom Mill, was constructed in 1970, but was not activated until 1978 when milling operations began. In 1980, TMR acquired ALANCO Ltd. and assumed the name ALANCO Ltd. at that time. Operations at the mill continued until 1986 when expansion plans and depressed mineral prices forced closure of the mill. The mill has remained closed through 1989. ALANCO Ltd. has announced the reopening of the facility scheduled for early 1990.

Water Supply System

Water at the facility is supplied from a single well located at the site. Water used in the leaching processess is recycled and reused in leaching solutions. Eventually the water from these solutions is disposed of within lined tailing ponds. Other water uses at the mill include smelting and refining, laboratory testing, and for drinking and washing by facility personnel. The water used by the laboratory, the smelter, and refinery is disposed of in lined tailing ponds. Water used for domestic purposes is disposed of in septic tanks.

Annual water use at the facility varies with plant activity which is a function of the minerals market. Annual water use data are shown in Table 5-33. The data was provided by ALANCO Ltd.

TABLE 5-33

ALANCO LTD.
ANNUAL WATER USE FOR THE AR-MEX CUSTOM MILL
(ACRE-FEET)

YEAR	1983	1984	1985	1986	1987	1988	1989
Amount	38.7	38.7	38.7	1	1	1	1

APACHE NITROGEN PRODUCTS, INC. (WFR #112-17-090)

History

Apache Nitrogen Products, Inc. manufacturer of explosives and chemicals, is located on the west side of the San Pedro River two miles southwest of the Town of St. David. The company occupies the majority of Section 7 and a portion of the south half of Section 6, Township 18 South, Range 21 East as well as a portion of the east half of Section 12, Township 18 South, Range 20 East (Figure 5-16).

The company (formerly known as Apache Powder Company) has been in operation since 1922, producing mining explosives and farm chemicals. The company produced nitroglycerin from 1922 through 1983. It has manufactured ammonium nitrate and nitric acid since 1922, fuse products since 1968, and blasting agents since the 1960s.

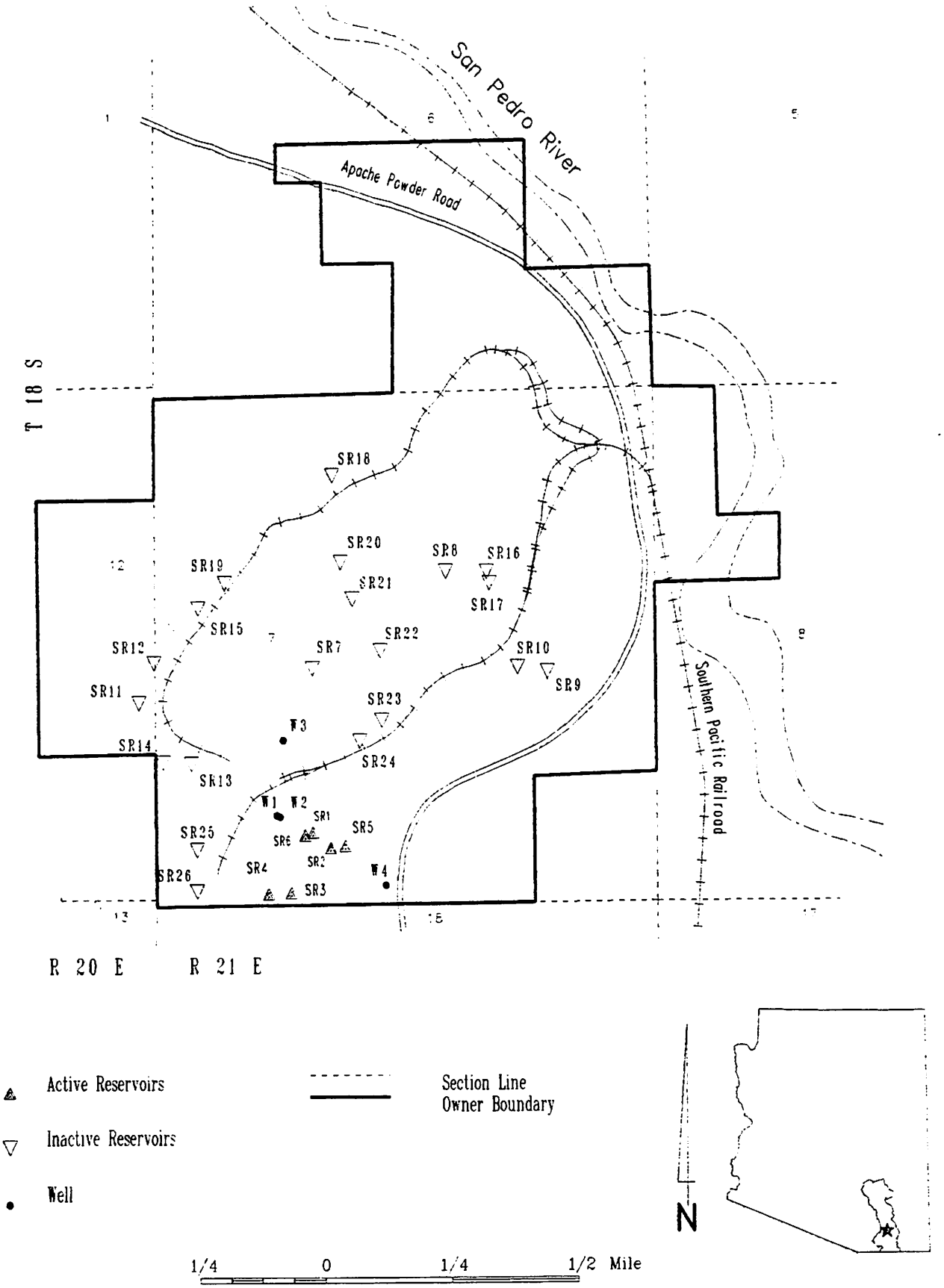


Figure 5-16. Apache Nitrogen Products, Inc. facilities

Water Supply System

Water is supplied to Apache Nitrogen Products from three wells, W1, W3, and W4, pumping groundwater located on the property. A fourth well, W2, also located at the site, is unused. There are twenty-five reservoirs associated with the facility (Figure 5-16). The majority of these are currently unused catchments. Six of the reservoirs are used periodically for wastewater storage.

Water at the facility is utilized for cooling purposes, as steam in chemical production processes, and for domestic purposes. Cooling processes and steam production utilize the bulk of water at the plant. Domestic uses constitutes only minor quantities of water at the facility.

Annual water use varies at the plant and is dependent upon local mining and farming activity. No amount of use was determined for the reservoirs because the amount of water used by the few reservoirs utilized is accounted for from well data. Total annual water use is listed in Table 5-34 and is based on data obtained from Apache Nitrogen Products.

TABLE 5-34

APACHE NITROGEN PRODUCTS, INC.
ANNUAL WATER USE
(ACRE-FEET)

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Amount	752	736	426	302	381	331	354	346	473	542

ASARCO, INC. - Hayden Unit (WFR #114-1-5)

ASARCO, Inc. owns approximately 250 irrigated acres one mile south of the Town of Winkelman, east of the San Pedro River (refer to WFR #114-1-CDD-1). Four wells have been used for industrial purposes and are here called the ASARCO wells. Two of the ASARCO wells, W1 and W3, are currently in use. These wells are located within Zone 1 (Figure 5-17). These two wells export water from the San Pedro watershed to the Upper Gila watershed to ASARCO's smelting and refining facility at the Town of Hayden.

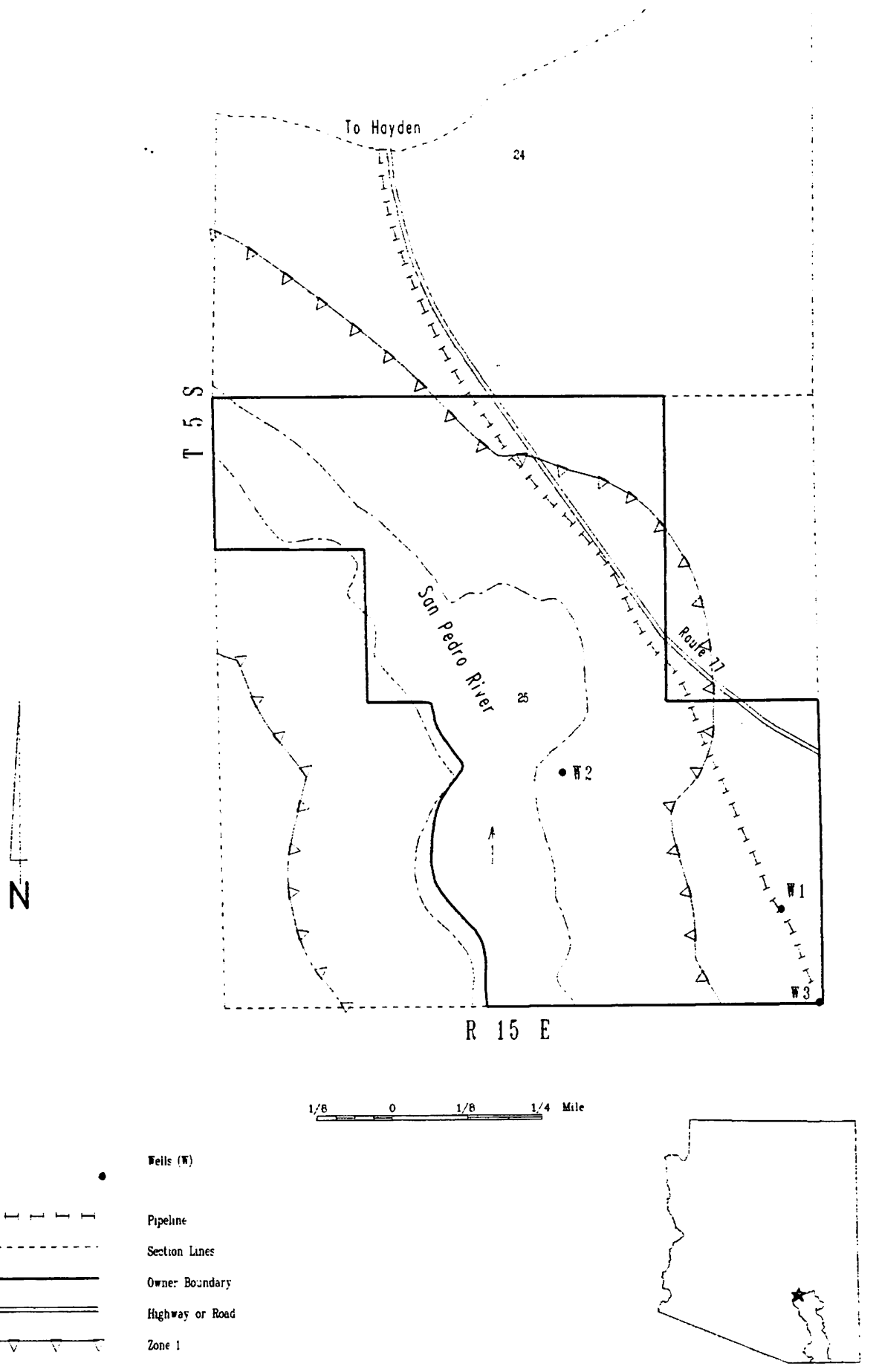


Figure 5-17. ASARCO - Hayden Unit well field and pipeline

History

The Hayden smelting and refining operation, located one mile northwest of the confluence of the Gila and San Pedro Rivers, has been in operation since 1910. The modern sulfuric acid plant was opened at the site in 1972. ASARCO Inc. acquired Kennecott Copper Company's Hayden and Ray operations in 1986.

Water Supply System

ASARCO wells W1, W2, and W3 provided water for the Hayden facility by a pipeline until 1983. W1 was drilled in 1948. W2 was drilled in 1967. W3 was drilled in 1968. W1, W2, and W3 were destroyed in the 1983 flood and the Hayden pipeline was damaged. W1 and W3 were redrilled and the pipeline repaired. W2 was abandoned. W4 was drilled in 1970. It provided water for a silica crushing plant on the property. The plant, owned and operated by McFarland and Hullinger Company, supplied silica flux to the Hayden smelter. The silica plant and the well were abandoned in 1985.

Water exported from the ASARCO wells provides only a portion of the water used at the Hayden facility. The balance of water is obtained from the Ray Unit (refer to WFR #114-4-35), the Gila River, and other sources in the Upper Gila watershed. The water from the ASARCO wells is commingled with water from other sources at the Hayden Unit. Excess water is delivered from the Hayden Unit to the Town of Hayden.

Table 5-35 shows the amount of water exported from the ASARCO wells to the Hayden Unit, as well as total water use at the Hayden Unit. The amount of water used varies as a function of demand. Demand for water at the Hayden Unit is a result of smelter activity which reflects the strength of the minerals market. The data is supplied by ASARCO.

TABLE 5-35

ASARCO, INC. - HAYDEN UNIT
ANNUAL WATER EXPORT AND USE
(ACRE-FEET)

YEAR	ASARCO WELLS EXPORT	HAYDEN UNIT TOTAL
1976	850	1,613
1977	647	1,345
1978	721	1,482
1979	580	1,508
1980	729	1,170
1981	636	1,468
1982	829	1,391
1983	1,205*	1,355
1985	1,138	1,944
1986	800	1,954
1987	687	1,540
1988	677	1,524
1989	202**	226**

*W2 abandoned.
**First three months only, estimated 808 acre-feet for 1989.

ASARCO, INC. - Ray Unit (WFR #114-4-35)

ASARCO owns the PZ Ranch property, formerly owned by Kennecott Copper Company. The ranch is located near the Town of Dudleyville, 1½ miles north of the confluence of Aravaipa Creek and the San Pedro River. The ranch still maintains an agricultural operation (refer to WFR #114-4-BDA-1). There are six wells, W1 through W6, on the property exporting water for various uses at the Ray Unit, which is located in the Upper Gila watershed, twelve miles northwest of the Town of Hayden. All wells on the property are located outside Zone 1 (or located within Zone 2) (Figure 5-18).

History

The mining operation began at the Ray Mine in 1883. Kennecott Copper Company acquired the operation in 1933. ASARCO purchased Kennecott's Ray and Hayden units in 1986. The PZ Ranch was in operation by 1873. Kennecott drilled wells W1, W2, and W3 in 1964. The Ray pipeline, which is supplied by the wells and which exports water to the Ray Unit, was completed in 1964.

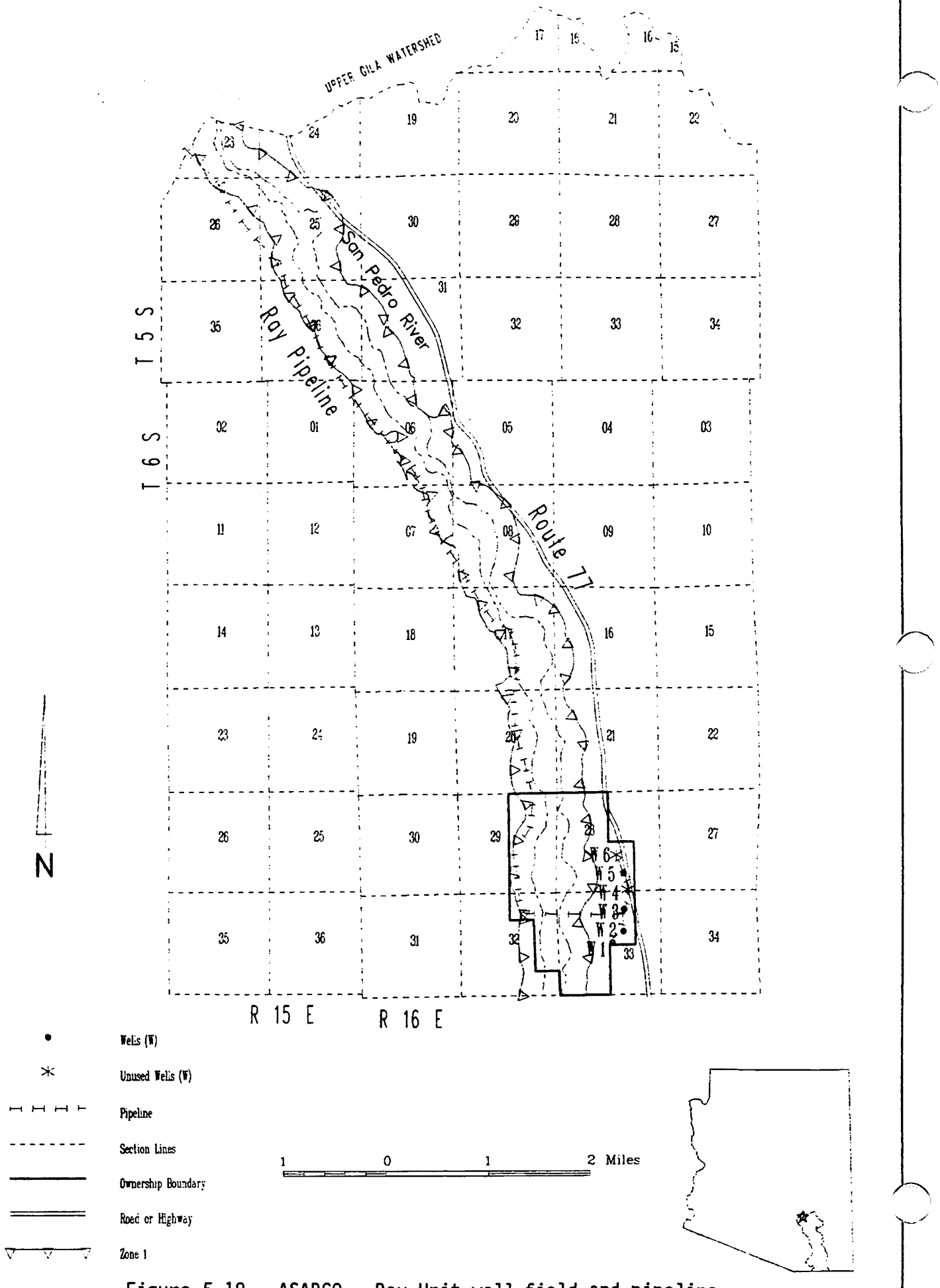


Figure 5-18. ASARCO - Ray Unit well field and pipeline

Wells W4, W5, and W6 were drilled in 1974. Well W6 was drilled into a gypsum horizon and was never used extensively. Well W7 was drilled in 1989. Wells W1 through W5 were in use continuously until the 1983 flood. The flood of 1983 severed the Ray pipeline and damaged the wells. The Ray pipeline and wells W1, W2, W3, and W5 were repaired while well W4 was abandoned.

Water Supply System

Wells W1 through W3, W5, and W7 export water from the San Pedro watershed to ASARCO's Ray Unit in the Upper Gila watershed via the Ray pipeline (Figure 5-18). The Ray Unit uses water for an open pit mine, heap leaching, solvent extraction, and electrowinning. Water is also supplied to the Ray Unit from wells at the Ray Mine. The water pumped from the San Pedro watershed is commingled with Ray mine water. The Ray Unit exports excess water to the Hayden Unit twelve miles to the southeast.

Wells on the PZ Ranch property are included in the 1977 Water Rights Settlement and Exchange Agreement entered into by the Gila River Indian Community and Kennecott Copper Company. The agreement is essentially a covenant not to sue, and is not a resolution of conflicting claims. The agreement has not yet been assigned from Kennecott to ASARCO.

The annual amount of water exported by the wells to the Ray Unit is shown in Table 5-36. Annual demand for water is a function of mining activity which reflects the nature of the minerals market. The data is provided by ASARCO.

TABLE 5-36

ASARCO, INC. - RAY UNIT
ANNUAL AMOUNT EXPORTED
(ACRE-FEET)

YEAR	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Amount	9	55	252	2,876	1,395	*	*	236	589	0	1,035	1,053

*Flood damage, no data.

BABOCOMARI RANCH COMPANY/HUACHUCA CONCRETE, INC. (WFR #111-20-35)

Huachuca Concrete, Inc. is located one-half mile west of Highway 90 near the Babocomari River and is within the San Ignacio Del Babocomari Grant owned by the Babocomari Ranch Company. Various other operations have produced ready-mix concrete at this location since January 1983. In 1987, Huachuca Concrete, Inc. assumed control of the ready-mix concrete operation and began washing sand and gravel at this time.,

Water Supply System

Two wells on this property are utilized for this operation. However, only one well is in constant use. The unused well is connected to electrical service and could be used if necessary. This well has an output capacity of 800 gpm. A 300 gpm well currently provides water to all of the plant uses. This well is in use approximately five hours per day, five days per week. Domestic water use is also supplied by this well.

Four reservoirs, two metal tanks, and two ponds are used by Huachuca Concrete, Inc. One tank is supplied directly from the well. The two ponds precipitate particles from the washing of sand and gravel. All wastewater is then recycled into a series of retaining and settling ponds.

Annual water use data is provided in Table 5-37 for the time period 1985 through 1989.

TABLE 5-37

BABOCOMARI RANCH COMPANY/HUACHUCA CONCRETE, INC.
ANNUAL WATER USE
(ACRE-FEET)

YEAR	1985	1986	1987	1988	1989
Amount	21.5	21.5	71.8	71.8	71.8

CLARK TRUCKING COMPANY (WFR #113-04-05)

History

Clark Trucking Company operates a ready-mix concrete plant and a sand and gravel washing operation within the Town of Mammoth. The Clark family has been running the operation near the community of Mammoth since the 1920s and 1930s and has been at this same location since 1941.

Water Supply System

One well, located on this property, supplies water for industrial uses at the rate of 300,000 gallons per day, three days per week. Although the usage rate varies throughout the course of a year, the annual amount pumped reportedly remains the same from year to year. Wastewater from the operation is diverted into a settling basin where the water either seeps into the river system or flows over a spillway into the San Pedro River. The water for domestic uses is provided by the Town of Mammoth Municipal Water Supply.

Annual water use data is provided in Table 5-38 for the time period 1985 through 1989.

TABLE 5-38

CLARK TRUCKING COMPANY
ANNUAL WATER USE
(ACRE-FEET)

YEAR	1985	1986	1987	1988	1989
Amount	143.6	143.6	143.6	143.6	143.6

DESERT CONCRETE COMPANY (WFR #111-23-50)

History

Desert Concrete Company has operated a ready-mix concrete plant three miles south of Sierra Vista on Highway 92 since August 1983. Dreeszen Gravel Company and Sierra Ready Mix have historically operated on this property which was owned by Tenneco West. Dreeszen Gravel Company installed a well in 1972. Sand and gravel was also washed at this site at one time, but this use

has been discontinued since 1988. Epsilon Trust then bought this property on which the Desert Concrete Company operates.

Water Supply System

Complete water use data was unavailable, however, estimates were made based on available data. One well on this property provides water to both the industrial and domestic uses. This well has an estimated capacity of 145 gpm and operates one day per week. The water is pumped into a 10,000 gallon pressure tank where it is later used. When the sand and gravel washing aspect of this operation was still in use, the pump would operate 5½ days per week. The wastewater then flows into two settling basins where particles could be precipitated. This water is then recirculated through the washing process.

Annual water use data is provided in Table 5-39 for the time period 1985 through 1989.

TABLE 5-39

DESERT CONCRETE COMPANY
ANNUAL WATER USE
(ACRE-FEET)

YEAR	1985	1986	1987	1988	1989
Amount	61.1	61.1	61.1	11.1	11.1

MAGMA COPPER COMPANY - San Manuel Operation (WFR #113-8-22, #113-8-3 AND #113-8-AC-1)

Magma Copper Company operates a copper production facility in and around the Town of San Manuel. Magma's major products are cathode copper and copper rod. Magma also produces molybdemum concentrate and sulfuric acid at the San Manuel site. Magma's milling, smelting, and refining plants for sulfide ore are located in the Town of San Manuel while the mine itself is located approximately seven miles north of the town. The mine site consists of the underground mine for sulfide ore and the open pit mine for oxide ore. The mine site is also the location of the heap leaching, in-situ leaching, solvent extraction, and electrowinning facilities.

Magma is the largest single user of water in the San Pedro River watershed. Magma supplies water to its San Manuel operations from a well field adjacent to the San Pedro River and from the dewatering unit located at the mine site. The well field, located one mile east of town on the west side of the San Pedro River, supplies water to the mill, smelter, and refinery as well as to the Town of San Manuel (refer to WFR #113-8-22 and #113-8-3). The mine dewatering unit, located in the underground mine, supplies water for the mine. Excess mine water is exported to the mill and the San Manuel Golf Course (refer to WFR #113-8-AC-1).

History

Mining began in the San Manuel area in 1879. Magma purchased the San Manuel mining claims and began extensive exploration in the area in 1944. Exploration culminated with the discovery of the San Manuel ore body in 1952. By 1956, the mine and smelter at San Manuel were in full production. Magma Copper Company merged with Newmont Mining Corporation in 1969. In 1985, Magma initiated construction of oxide ore production facilities at the mine site. By 1986, the open pit, heap leaching, solvent extraction, and electrowinning facilities were in operation. In 1987, Magma reorganized and separated from Newmont Mining Corporation. In that same year, Magma began an aggressive retrofit and modernization program at the mill, smelter, and refinery, as well as initiated in-situ leaching operations at the mine site. By 1989, the smelter retrofit was completed with an oxygen unit and modernized sulfuric acid plant.

Operations

The Magma Copper Company has two distinct processing units: the sulfide unit and the oxide unit. The sulfide unit consists of the underground mine, the mill, smelter, and refinery. The oxide unit consists of the open pit mine, heap leaching, in-situ leaching, solvent extraction, and electrowinning.

The sulfide unit processes copper sulfide ore supplied from the underground mine. The underground mine is projected to produce 40,000 tons per day of sulfide ore in 1990. The ore is shipped by rail from the underground mine to the mill at San Manuel. At the mill, the ore is crushed and ground then conveyed to the concentrator. The concentrator processes the ore into copper concentrate, molybdenum concentrate and tailings. The copper

concentrate is sent to the smelter. The molybdenum concentrate is shipped to an independent processor. The tailings are thickened and conveyed to the tailings dam.

The smelter produces copper anodes from the copper concentrate. The smelter has a production capacity of 1,025 tons of copper per day. The refinery processes the anode copper by electrolitic methods creating cathode copper. The cathode copper is 99.8 percent pure.

The oxide unit processes copper oxide ore. The oxide ore is processed by leaching methods. Two leaching methods are currently in use: heap leaching and in-situ leaching. Ore from the open pit is heap leached. That portion of the open pit that is inaccessible to conventional mining methods is under in-situ leaching. The leaching process yields a leachate solution pregnant with copper. The pregnant leachate solution (PLS) is collected in a 5,000,000 gallon pond then piped to a 10,000,000 gallon pond for solvent extraction and electrowinning.

The solvent extraction and electrowinning produce approximately 50,000 tons of cathode copper per year.

Water Supply System

Water is supplied to Magma's San Manuel plant and mine facilities from a well field adjacent to the San Pedro River and from the mine dewatering unit. The well field consists of eleven wells along the San Pedro River. The dewatering unit consists of a system pumping groundwater, here called mine water, from the underground mine located at the mine site. A small line from the San Pedro River well field provides the mine with potable water.

The San Pedro wells are located along the San Pedro River one mile east of San Manuel immediately west of the river. Magma wells W3, W7, W9, W10, and W12 have been determined to be located in Zone 1. Magma wells W2, W4, W5, W6, W8, and W11 have been determined to be located in Zone 2. The water is pumped from a booster station to the San Manuel facilities in the main pipeline. The main line serves the mill and trunk lines feed the smelter, refinery, and the Town of San Manuel. Plate 18 displays Magma's water supply system.

Magma began withdrawing from the San Pedro well field in 1954 with the completion of its first well. Development of the well field continued until 1974. The eleven wells range in depth from 976 feet (for well W2) to 1,528

feet (for well W11). The estimated maximum pump capacity for the San Pedro wells ranges from 1,500 gpm to 2,160 gpm. Table 5-40 shows the production from W2 through W12 from 1985 through 1990, as well as other pertinent data. A sharp increase of water production occurred in 1988 and 1989. This increase was caused by the mine site expansion in 1988 and an increase in ore processing at San Manuel.

TABLE 5-40

MAGMA COPPER COMPANY - SAN MANUEL OPERATION
ANNUAL PUMPAGE - SAN PEDRO RIVER WELLS

WELL	DATE DRILLED	TOTAL DEPTH FEET	CAPACITY (GPM)	GROUNDWATER PUMPAGE (ACRE-FEET) 1985	1986	1987	1988	1989	1990
W2 (2)	1955	976	1,500	49	328	83	911	1,102	598
W3 (1)	1961	1,306	1,800	316	506	641	675	1,525	2,112
W4 (2)	1961	1,414	1,500	157	108	6	519	770	445
W5 (2)	1954	1,004	1,500	724	1,676	1,185	1,203	1,381	1,083
W6 (2)	1955	1,006	1,500	635	252	1,461	1,657	1,160	1,295
W7 (1)	1958	1,303	1,500	362	767	700	1,835	1,415	1,225
W8 (2)	1964	1,290	1,500	758	1,771	1,139	1,356	1,657	1,640
W9 (2)	1964	1,520	1,500	1,504	1,544	1,289	2,139	1,952	1,410
W10 (1)	1969	1,435	2,000	1,894	1,762	2,817	1,795	2,648	1,956
W11 (2)	1970	1,238	1,538	2,977	3,317	2,872	2,872	1,970	1,916
W12 (1)	1974	1,380	2,160	2,292	3,222	1,544	2,440	1,522	3,070
			TOTAL	11,668	15,253	13,737	17,347	17,102	16,750

(1) Zone 1 groundwater well.

(2) Zone 2 groundwater well.

The San Pedro wells provide water to the sulfide ore processing plants at San Manuel, the Town of San Manuel, and the mine. The mill uses water supplied from the San Pedro wells in the crusher, concentrator, and tailings circuits. The smelter and refinery use water supplied from the San Pedro wells to produce steam in the waste heat boiler and to cool slag. The Town of San Manuel uses water from the San Pedro wells for its water supply. The mine uses water from the San Pedro wells for potable water.

The mine dewatering unit located in the underground mine supplies water to the oxide ore processing unit, the open pit mine, the San Manuel mill, and

the San Manuel Golf Course. Magma uses shafts #1 and #5 to pump mine water to the surface. DWR has described these shafts as mine shaft wells W13 and W14, respectively. The mine shaft wells W13 and W14 are located in hardrock as shown on Plate 18. Due to the geographic location of W13 and W14, they have been categorized as Zone 3 wells.

Mine water serves the open pit, solvent extraction, electrowinning, in-situ, and heap leaching. The open pit operation uses only minor amounts of water. Magma estimates the open pit uses 125 gpm for dust control and equipment washing.

The in-situ leach unit uses the bulk of water at the mine site. The in-situ uses approximately 2,000 gpm. The other major water use is in the solvent extraction unit. The solvent extraction unit must make up for losses due to evaporation. When operating at full capacity solvent extraction the unit must make up eighty-six gpm.

Water Use

The Magma Copper Company diverted a total of 24,394 acre-feet of water from the San Pedro River watershed in 1989. The water was provided by three sources: Zone 1 wells, Zone 2 wells, and Zone 3 wells.

The Zone 1 wells and Zone 2 wells located in the well field adjacent to the San Pedro River provide water to a common pipeline. The water is commingled and supplied a total of 17,102 acre-feet of water in 1989. The commingled water provides 8,510 acre-feet to the mill, 5,710 acre-feet to smelter and refinery, 1,057 acre-feet to the Town of San Manuel, and 1,773 acre-feet to the mine site. Approximately sixty acre-feet of water was wasted during various pump tests and repairs.

The Zone 3 "mine shaft" wells provide water to the open pit mine, solvent extraction/electrowinning (SX/EW) plant, in-situ leaching, the mill, and the San Manuel golf course. The operations served by Zone 3 water received a total of 7,292 acre-feet in 1989. The open pit received 229 acre-feet, the SX/EW operation 137 acre-feet, the in-situ leaching 3,050 acre-feet, and the mill 3,575 acre-feet in 1989. The San Manuel golf course was provided with 301 acre-feet of water in 1989.

Magma's diversions for 1989 are summarized in Table 5-41. The uses supplied by the commingled Zone 1 and Zone 2 water and Zone 3 wells are

summarized in Table 5-42. It should be noted that the volumes shown here are based on water budgets and pump capacities and not necessarily on flow meter data. The data is provided by Magma Copper Company.

The sources of water diverted by the Magma Copper Company San Manuel operation are found in WFR #113-8-22. The water from WFR #113-8-22 is shared with WFRs #113-8-3 and #113-8-AC-1. The uses in WFR #113-8-22 consist of the sulfide ore processing facilities (MI1), the oxide ore processing plants (MI2), and the San Manuel golf course (RC1). The uses in WFR #113-8-3 consist of the Arizona Water Company San Manuel system (MU1). The uses found in WFR #113-8-AC-1 are the San Manuel golf course (RC1). The volume of water diverted to each of these uses is summarized in Table 5-43.

TABLE 5-41

SUMMARY OF USES SERVED BY DIVERSIONS FROM MAGMA COPPER COMPANY IN 1989

WFR	USE	DIVERSION	VOLUME
113-8-22	MI1	Zone 1 + Zone 2	14,272.0
		Zone 3	3,575.0
	MI2	Zone 1 + Zone 2	1,773.0
		Zone 3	3,416.0
	RC1	Zone 3	24.5
113-8-3	MU1	Zone 1 + Zone 2	1,057.0
113-8-AC-1	RC1	Zone 3	276.5
		TOTAL	24,394.0

TABLE 5-42

1989 TOTAL WATER DIVERTED BY MAGMA COPPER COMPANY SAN MANUEL OPERATION (ACRE-FEET)

SOURCE	AMOUNT
Zone 1 wells	9,062
Zone 2 wells	8,040
Zone 3 wells	6,974
TOTAL	24,394

TABLE 5-43

MAGMA COPPER COMPANY - SAN MANUEL OPERATION
USES SUPPLIED BY SAN PEDRO RIVER WELLS AND "MINE" WATER IN 1989
(ACRE-FEET)

USES SUPPLIED BY ZONES 1 AND 2 GROUNDWATER WELLS

USE	AMOUNT
Mill	8,510
Smelter/Refinery	5,710
Townsite	1,057
Mine	1,773
Wastage	52
TOTAL	17,102

USES SUPPLIED BY "MINE" WATER

USE	AMOUNT
In-situ	3,050
Open pit	229
Solvent extraction/electrowinning	137
Mill	3,575
Golf course	301
TOTAL	7,292

ORACLE RIDGE MINING COMPANY (WFR #113-8-11)

The Oracle Ridge Mining Company operates an undergound copper mine and a floatation mill ten miles south of the Town of San Manuel. Construction of the mine and mill began in February 1990. The facility began production on March 3, 1991. The mine produces 700 tons of copper ore per day. The mill produces thrity-five tons of copper concentrate per day. The copper concentrate is sold to a local smelter for final refining.

Water is provided to the facility from three sources: the mine shaft well, a production well, and reclaimed water. The mine shaft well is the primary source of water for the mill. The mine shaft well provides water from the underground mine workings. DWR has determined that the mine shaft well provides Zone 3 water. The production well is a secondary source of water for the facility and provides Zone 2 water. Reclaimed water provides a limited source of water for the mill. The reclaimed water is reclaimed from a thirty acre tailings pond. The reclaimed water originates from the mine shaft well.

The Oracle Ridge Mining Company estimates that it uses 250 acre-feet per year in its mining and milling operation. The estimate is based upon mining and milling operations using 150 gpm to produce copper concentrate. The company also estimates that it pumps 16,000 gallons per year from four monitoring wells. The monitoring wells are sampled quarterly to meet EPA and DEQ regulations.

RAMCO, INC. - PBR Minerals Plant (WFR #111-21-037)

RAMCO, Inc. owns the PBR Minerals plant, an open pit heap leach plant at the Contention Mine near the City of Tombstone. PBR Minerals processes silver and gold ore by cyanide heap leaching and zinc precipitation methods.

History

Tombstone Development Company began the open pit operation at the site in 1979. They operated the mine until 1982 when it was sold to Tombstone Exploration, Inc. (TEI). TEI continued operations until 1985 when low metals prices and a cyanide spill forced closure of the operation. TEI then went into bankruptcy. In 1987, the operation renewed under the name of PBR Minerals owned by RAMCO, Inc. The mining and ore processing continued until 1988. The facility is currently closed, but RAMCO, Inc. plans to resume operation some time in 1990.

Water Supply System

Water for the processing and mining facility is supplied by one well W1 pumping groundwater. Another well W3 is unused. The other well on the property W2 was contaminated by a cyanide spill at a heap leaching pad upslope of the well in 1984. Since that time, water from W2 is pumped to a sealed evaporation pond and tested weekly for cyanide contamination. The contaminated soil was treated and removed in 1988.

Water is used primarily for ore processing, tailings neutralization, and domestic uses. Ore processing constitutes the predominant use at the site, which is a closed circuit system with the bulk of water recycled in the circuit. The processing includes heap leaching the ore with a sodium cyanide solution on a lined leaching pad. The pregnant leachate solution is recovered from the base of the leaching pad and piped to a collection pond, clarified, and zinc precipitated to obtain gold and silver. The gold and silver is then shipped to a refinery to be purified.

Annual water use at the facility varies with mining activity which is a function of the precious metals market. Table 5-44 summarizes are annual water use data provided by RAMCO, Inc.

TABLE 5-44

RAMCO, INC.
ANNUAL WATER USE
(ACRE-FEET)

YEAR	1982	1983	1984	1985	1986	1987	1988	1989
Amount	28	30	1	1	1	18	1	1

SIERRA READY MIX AND CONTRACTING COMPANY (WFR #111-20-64)

History

Sierra Ready Mix and Contracting Company located within the City of Sierra Vista near State Route 90, has been producing sand, gravel, and ready mix concrete since 1956. The raw materials for the production of sand and gravel are transported from a gravel pit one mile west of Huachuca City.

Water Supply System

One well provides water to all industrial uses on this property. The well operates four hours per day, 5½ days per week at a pumping capacity of 300 gpm. A backup water supply from Bella Vista Water Company could sustain the operation in the event of a pump failure. Wastewater from the washing of sand and gravel flows into two settling ponds where the silt and clay particles are precipitated. This water is then recirculated through the washing process. Bella Vista Water Company currently supplies water for domestic needs on this property.

Annual water use data is provided in Table 5-45 for the time period 1985 through 1989.

TABLE 5-45

SIERRA READY MIX AND CONTRACTING COMPANY
ANNUAL WATER USE
(ACRE-FEET)

YEAR	1985	1986	1987	1988	1989
Amount	63.2	63.2	63.2	63.2	63.2

ARIZONA STATE LAND DEPARTMENT/CASHWAY CONCRETE AND MATERIAL COMPANY (WFR #111-20-26)

History

Cashway Concrete and Material Company is located on Arizona State Trust land, north of Highway 90, two miles east of the intersection of Highways 90 and 92. Cashway Concrete and Material Company has been providing asphalt since 1987.

Water Supply System

Water for industrial and domestic uses at this facility is supplied by a well (W1) located on this property. W1 operates for 1 to 1½ hours per day, 5 days per week during the months that the plant is in operation, at a pumping capacity of 200 gpm. There is a 10,000 gallon storage tank and an 8,000 gallon pressure tank with a maximum total storage capacity of 18,000 gallons. No backup water supply exists for this facility.

Water from the W1 is pumped to a recovery/settling pond where it is then pumped to an emissions scrubber and used for removing pollutants that are emitted from the asphalt plant. Water that is not evaporated out of the scrubber is pumped back to the recovery/settling pond where particulates from the asphalt plant are precipitated and the water is then recycled back to the scrubber. Water conservation is enhanced with this type of system.

Water from the recovery/settling pond is also pumped to the rock crusher for the washing of gravel, rock, and also dust control. Water from W1 currently supplies water for domestic needs at the office/maintenance building and scale house. Annual water use data is provided in Table 5-46 for the time period 1986 through 1990.

TABLE 5-46

CASHWAY CONCRETE AND MATERIAL COMPANY
ANNUAL WATER USE
(ACRE-FEET)

YEAR	1986	1987	1988	1989	1990
AMOUNT	0	1.4	10.1	5.8	4.6

YOUNG CONCRETE AND BLOCK COMPANY (WFR #111-20-63 and #111-20-69)

History

Young Concrete and Block Company, located north of Highway 90, two miles east of the intersection of Highways 90 and 92, has been manufacturing concrete block since 1972. Young Concrete and Block Company had been crushing gravel and washing sand and gravel near the San Pedro River, but this aspect of the operation was moved to the property described above in February 1988.

Water Supply System

Two wells are located on the property described in this WFR. The small well pumps three hours per week at forty gpm and supplies water for dust control and the block manufacturing process. This small well also provides water for dust control and domestic uses. The larger well pumps fifteen hours per week at 400 gpm and supplies water for washing and crushing of gravel and washing of sand.

One pond on the property is used to precipitate particles from the wastewater that are picked up in the washing process. All wastewater that is not lost to evaporation or infiltration is reused. A 100 gallon pressure tank is supplied by the smaller well.

Annual water use data is provided in Table 5-47 for the time period 1985 through 1989.

TABLE 5-47

YOUNG CONCRETE AND BLOCK COMPANY
ANNUAL WATER USE
(ACRE-FEET)

YEAR	1985	1986	1987	1988	1989
Amount	1.2	1.2	1.2	54.2	58.6

5.4 NON-INDIAN FEDERAL CLAIMS

This section describes one state agency and four federal agencies that have made claims for rights established under federal law. The major user reports describe the history and description of the federal reservation, analysis of the claim(s), and the results of DWR's investigations of the claimed water uses.

The agencies described in the section are:

AGENCY	WATERSHED FILE REPORT NUMBER	PAGE
Arizona State Land Department	113-12-36	375
Bureau of Land Management - Safford District	Various	376
Coronado National Forest - Powers Garden	115-9-10	380
Fort Huachuca Military Reservation	111-23-76	382
National Park Service - Coronado National Memorial	111-23-16	431
National Park Service - Saguaro National Monument	114-14-29	435

ARIZONA STATE LAND DEPARTMENT (WFR #113-12-26)

The State of Arizona, through the State Land Department, has filed 1,546 statements of claimant in the San Pedro River watershed. Many of these filings claim rights established under state law as well as rights established under federal law. Rights established under federal law are claimed on the basis that "water was reserved to fulfill the purposes of the United States in establishing the Trust by the withdrawal of Sections 2, 16, 32 and 36 from the public domain. The grant of sections 16 and 36 was effective on December 30, 1853, and the grant of sections 2 and 32 was made on June 20, 1910. [These claims include] indemnity in lieu selections and the University Grant of February 19, 1881." These sections are found throughout the State of Arizona at various township and range locations. The purpose of the grants is to support the common schools and other beneficiaries. The State claims that "the trust could not be fully accomplished without the water the United States intended to reserve." Each claim states wildlife, stockwatering, and rainfall retention as the intended purposes and quantifies the current use for each purpose. Future uses are claimed but not quantified.

BUREAU OF LAND MANAGEMENT - Safford District (Various WFRs)

Legal Record

The Bureau of Land Management (BLM) currently controls approximately 27 percent of the federal land within the San Pedro River watershed. This section contains claimed water use information for all statements of claimant claiming a "federal reserve" water right on BLM land. The BLM claims this right to be based upon Solicitor's Opinion M-36914 (Krulitz, 1979). In this opinion, Krulitz discusses the nature and extent of the federal water right on United States Government land. The BLM claims specifically Public Water Reserve No. 107. Section IV of the Krulitz opinion discusses this Executive Order and how it relates to BLM land. In general, the order deals with the withdrawal "for general public use and benefit unreserved public lands containing water holes or other bodies of water needed or used by the public for watering purposes." Solicitor Coldiron's opinion of February 16, 1983 reassesses Public Water Reserve No. 107. He concludes that "the Executive Order of April 17, 1926, reserved the minimum amount of water necessary in springs and waterholes to provide water for the purposes of human and animal consumption. The entire flow of these water sources was not necessarily reserved. The purpose of reserving land surrounding important springs and waterholes was to prevent monopolization of the surrounding public lands." Table 5-48 presents the legal history following Public Water Reserve No. 107.

TABLE 5-48

HISTORY OF PUBLIC WATER RESERVE NO. 107

ACTION	DATE
Public Water Reserve No. 107	April 17, 1926
Solicitor's Opinion M-36914 (Krulitz)	June 25, 1979
Supp. to Solicitor's Opinion M-36914 (Martz)	January 16, 1981
Supp. I to Solicitor's Opinion M-36914 (Coldiron)	September 11, 1981
Supp. II to Solicitor's Opinion M-36914 (Coldiron)	February 16, 1983

The BLM also states Executive Order 11990, dated May 24, 1977, as their basis for claiming riparian habitat maintenance. Section 5, part b of this order states, "maintenance of natural systems, including conservation and long

term productivity of existing flora and fauna, species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and flood and fiber resources," should all be considered when a proposal effects the area of a wetland.

Many of the uses claimed by the BLM under federal law have also been claimed under state law. Table 5-49 contains a list of watershed file reports where these dual claims exist. The previous filings column contains additional claims filed by the BLM according to state law. These claims may correspond to the same uses claimed under federal law and reported in Table 5-50.

The BLM has filed two statements of claimant, 39-13610 and 39-13611, for the San Pedro Riparian National Conservation Area (SPRNCA). Statement of claimant 39-13610 claims a federal reserved water right and 39-13611 claims water rights based upon state water law for the perennial reaches within the SPRNCA. The BLM also recently filed statements of claimant 39-14413 and 39-68704 claiming federal reserved water rights for the Redfield (39-14413) and Aravaipa (39-68704) Canyon Wilderness areas. See Chapter 6, Section 6.3 for more information on these claims.

TABLE 5-49

BUREAU OF LAND MANAGEMENT
SAFFORD DISTRICT
WATERSHED FILE REPORTS WITH POTENTIAL DUAL CLAIMS

WATERSHED FILE REPORT NUMBER	PREVIOUS FILING NUMBER
113-5-9	36-20689
	36-20695
113-12-8	33-89478
113-12-17	33-89480
115-2-7	36-20676
115-2-10	36-20664 to 36-20672
115-2-11	36-20677
	36-20683 to 36-20684
115-04-5	33-87718
	36-20687

TABLE 5-50

BUREAU OF LAND MANAGEMENT
SAFFORD DISTRICT
COMPARISON OF CLAIMANT INFORMATION WITH DWR FINDINGS

CLAIMED INFORMATION							DWR FINDINGS					
STATEMENT OF CLAIMANT	CLAIMED SOURCE	CLAIMED USE LOCATION	CLAIMED USE	NAME	CLAIMED WATERCOURSE	CLAIMED ANNUAL USE	WATER USE NO.	WATER USE TYPE	USE STATUS	USE LOCATION	WATERSHED FILE REPORT NUMBER	MAP NUMBER
39-11157	Spring	SWSW 30 13S 19E	SW, WL, OT	Roble Spring	Roble Canyon	0.15 Ac-ft	SW24	SW, WL, OT	Spring	SWSW 30 13S 19E	113-12-17	113-12
39-11160[1]	Spring	SESE 22 11S 20E	SW, WL, OT	Miller Spring	Sycamore Canyon	0.10 Ac-ft	SW23	SW, WL, OT	Spring	SESE 22 11S 20E	113-12-8	113-12
39-11161	Spring	SWNW 06 16S 22E	SW, WL, OT	Unnamed Spring	Clark Canyon	7.43 Ac-ft	SW28	SW, WL, OT	Spring	SWNW 06 16S 22E	112-15-109	112-15
39-11169	Spring	SWSW 30 13S 19E	SW, WL, OT	Roble Spring	Roble Canyon	0.15 Ac-ft	SW24	SW, WL, OT	Spring	SWSW 30 13S 19E	113-12-17	113-12
39-11180	Spring	SENW 27 06S 17E	SW, WL, OT	Unnamed Seep	Unnamed Wash	0.16 Ac-ft	SW18	SW, WL, OT	Spring	SENW 27 06S 17E	115-4-5	115-4
39-11181	Spring	NWSW 29 05S 19E	SW, WL, OT	Oak Spring	Black Canyon	0.16 Ac-ft	SW8	SW, WL, OT	Spring	NWSW 29 05S 19E	115-2-7	115-2
39-11182	Spring	NWSE 30 05S 19E	SW, WL, OT	John Spring	Horse Canyon	1.13 Ac-ft	SW11	SW, WL, OT	Spring	NWSE 30 05S 19E	115-2-7	115-2
39-11183	Spring	SESE 30 05S 19E	SW, WL, OT	Juniper Spring	Horse Canyon	0.64 Ac-ft	SW13	SW, WL, OT	Spring	SESE 30 05S 19E	115-2-7	115-2
39-11187	Spring	NWSW 30 05S 19E	SW, WL, OT	Unnamed Spring	Horse Canyon	0.09 Ac-ft	SW10	SW, WL, OT	Spring	SWNE 30 05S 19E	115-2-7	115-2
39-11188	Spring	NESW 29 05S 19E (SESW 29 05S 19E)[2]	SW, WL, OT	Black Canyon Spring	Black Canyon	0.16 Ac-ft	SW9	SW, WL, OT	Spring	SESW 29 05S 19E	115-2-7	115-2
39-11189	Spring	SWSE 30 05S 19E	SW, WL, OT	Unnamed Spring	Horse Canyon	0.16 Ac-ft	SW12	SW, WL, OT	Spring	SWSE 30 05S 19E	115-2-7	115-2
39-11201	Spring	NWNE 29 05S 19E (SWSE 20 05S 19E)[2]	SW, WL, OT	Unnamed Spring	Black Canyon	0.64 Ac-ft	SW6	SW, WL, OT	Spring	SWSE 20 05S 19E	115-2-11	115-2
39-11202	Spring	NESW 20 05S 19E	SW, WL, OT	Upper Boulder Spring	Black Canyon	2.10 Ac-ft	SW4	SW, WL, OT	Spring	NESW 20 05S 19E	115-2-11	115-2
39-11203	Spring	SESW 20 05S 19E	SW, WL, OT	Black Canyon Spring	Black Canyon	0.21 Ac-ft	SW5	SW, WL, OT	Spring	SESW 20 05S 19E	115-2-11	115-2
39-11204	Spring	NENW 29 05S 19E	SW, WL, OT	Cottonwood Spring	Black Canyon	1.03 Ac-ft	SW7	SW, WL, OT	Spring	NENW 29 05S 19E	115-2-7	115-2
39-11205	Spring	NENE 18 05S 20E	SW, WL, OT	Unnamed Spring	Deer Creek	0.20 Ac-ft	SW15	SW, WL, OT	Spring	NENE 18 05S 20E	115-2-16	115-2
39-11206	Spring	SESW 07 05S 20E	SW, WL, OT	Unnamed Spring	Unnamed Wash	1.05 Ac-ft	SW14	SW, WL, OT	Spring	SESW 07 05S 20E	115-2-16	115-2
39-11207	Spring	NENE 18 05S 20E	SW, WL, OT	Unnamed Spring	Deer Creek	0.15 Ac-ft	SW16	SW, WL, OT	Spring	NENE 18 05S 20E	115-2-16	115-2
39-11208	Spring	NESW 13 05S 19E	SW, WL, OT	Unnamed Spring	Deer Creek	1.57 Ac-ft	SW1	SW, WL, OT	Spring	NESW 13 05S 19E	115-2-16	115-2
39-11209	Spring	SENE 13 05S 19E (NWSE 13 05S 19E)[2]	SW, WL, OT	Unnamed Spring	Deer Creek	0.89 Ac-ft	SW2	SW, WL, OT	Spring	NWSE 13 05S 19E	115-2-16	115-2
39-11210	Spring	SWSW 18 05S 20E	SW, WL, OT	Unnamed Spring	Horse Creek	0.24 Ac-ft	SW17	SW, WL, OT	Spring	SWSW 18 05S 20E	115-2-16	115-2

[1] Amended.

[2] From BLM comments dated May 11, 1987 on the 1987 preliminary HSR.

TABLE 5-50 (cont'd)

CLAIMED INFORMATION							DWR FINDINGS					
STATEMENT OF CLAIMANT	CLAIMED SOURCE	CLAIMED USE LOCATION	CLAIMED USE	NAME	CLAIMED WATERCOURSE	CLAIMED ANNUAL USE	WATER USE NO.	WATER USE TYPE	USE STATUS	USE LOCATION	WATERSHED FILE REPORT NUMBER	MAP NUMBER
39-11211	Spring	SESE 13 05S 19E	SW, WL, OT	Unnamed Spring	Horse Creek	0.63 Ac-ft	SW3	SW, WL, OT	Spring	SESE 13 05S 19E	115-2-16	115-2
39-11217	Spring	NESW 10 08S 18E	SW, WL	Unnamed Spring	Copper Creek	0.10 Ac-ft	SW20	SW, WL	Spring	NESW 10 08S 18E	113-5-13	113-5
39-11219	Dam	SENW 11 08S 18E	SW, WL, OT	Unnamed Spring	Copper Creek	0.33 Ac-ft			NO USE FOUND		113-5-8	
39-11221	Spring	NWNW 23 08S 18E	SW, WL	Unnamed Spring	Scalon Wash	0.26 Ac-ft	SW22	SW, WL	Spring	NWNW 23 08S 18E	113-5-8	113-5
39-11222	Spring	SESE 11 08S 18E	SW, WL, OT	Unnamed Spring	Copper Creek	1.47 Ac-ft	SW21	SW, WL, OT	Spring	SESE 11 08S 18E	113-5-8	113-5
39-11228	Spring	NENE 12 23S 23E	SW, WL, OT	Unnamed Spring	Banning Creek	0.36 Ac-ft	SW31	SW, WL, OT	Spring	NENE 12 23S 23E	111-24-87	111-24
39-11243	Spring	SESW 30 22S 23E	SW, WL, OT	Unnamed Spring	Unnamed Wash	0.16 Ac-ft	SW30	SW, WL, OT	Spring	SESW 30 22S 23E	111-24-22	111-24
39-14438	Spring	SENW 22 07S 18E	SW, WL	Wooden Trough Spring	Sycamore Canyon	0.06 Ac-ft	SW38	SW, WL	Spring	SENW 22 07S 18E	115-5-17	115-5
39-14439	Spring	NWNW 21 08S 16E	SW, WL	Tar Wash Spring	Tar Wash	0.21 Ac-ft	SW37	SW, WL	Spring	NWNW 21 08S 16E	114-4-10	114-4
39-14440	Spring	NESW 24 23S 23E (POD LOCATION: NENE 13 23S 23E)	SW, REC, FISH, WL	Ursula Capt	Abrigo Canyon	0.27 Ac-ft	SW32	SW, REC, FISH, WL	Spring and tank	NESW 24 23S 23E	111-24-20	111-24
39-14441	Spring	SWNE 34 11S 20E	SW, REC, FISH, WL	Lost Trail Spring[3]	Swamp Springs Canyon	0.09 Ac-ft	SW35	SW, REC, FISH, WL	Spring	SWNE 34 11S 20E	113-12-8	113-12
39-14442	Spring	SENE 34 11S 20E	SW, REC, FISH, WL	Swamp Spring[3]	Swamp Springs Canyon	1.20 Ac-ft	SW36	SW, REC, FISH, WL	Spring	SENE 34 11S 20E	113-12-8	113-12
39-14443	Spring	NWSE 13 06S 18E	REC, FISH, WL	Saltuna Spring	Deer Creek	10.00 Ac-ft	WL39	REC, FISH, WL	Spring	NWSE 13 06S 18E	115-5-19	115-5
39-14444	Spring	NWSW 13 06S 18E	REC, FISH, WL	Purgatory Spring	Aravaipa Creek	0.70 Ac-ft	WL40	REC, FISH, WL	Spring	NWSW 13 06S 18E	115-5-19	115-5
39-14445	Spring	NESW 23 05S 19E	SW, REC, FISH, WL	Warm Spring	Deer Creek	0.08 Ac-ft	SW41	SW, REC, FISH, WL	Spring	NESW 23 05S 19E	115-2-11	115-2
39-14446	Spring	SWNW 29 05S 19E	SW, WL	Chest Spring	Black Canyon	0.06 Ac-ft	SW33	SW, WL	Spring	SWNW 29 05S 19E	115-2-7	115-2
39-14492	Spring	NWSW 25 06S 18E	SW, REC, FISH, WL	Goat Spring	Parsons Canyon	0.10 Ac-ft	WL6	REC, FISH, WL	Spring	NWSW 25 06S 18E	115-5-19	115-5
39-14499	Spring	NWSE 20 15S 22E	SW, REC, FISH, WL	McEwen Spring	Tres Alamos Wash	0.08 Ac-ft	SW34	SW, REC, FISH, WL	Spring	NWSE 20 15S 22E	112-15-54	112-15
39-14500	Spring	NENE 29 15S 22E	SW, REC, FISH, WL	Lime Peak Spring	Tres Alamos Wash	0.08 Ac-ft	SW45	SW, REC, FISH, WL	Spring	NENE 29 15S 22E	112-15-54	112-15

KEY: FISH = Fish; OT = Other; REC = Recreation; SW = Stockwatering; WL = Wildlife

[3]Also claimed on statement of claimant 39-14413 - Redfield Canyon Wilderness Area federal reserved right claim.

Analysis of Claim

The BLM has claimed a federal reserved right for thirty-nine springs and one stockpond based on Public Water Reserve No. 107. Table 5-47 compares the claimed information versus DWR's investigation findings for each statement of claimant. The claimed use and flow figures have been converted to acre-feet per year. The average claimed use per spring is 0.88 acre-feet per year. The average claimed flow per spring is 2.41 acre-feet per year. The stockpond claimed on 39-11219 is reported to be silted in. The claim states that water seeps past the pond embankment to form a pool of water below the stockpond. The pool of water is claimed to be twenty feet by ten feet with a depth of one foot. This would give it a capacity of approximately 1,500 gallons. The estimated average flow which fills the "pool" is 0.32 acre-feet per year. DWR could not find photographic (aerial photography) evidence of this stockpond.

CORONADO NATIONAL FOREST - Powers Garden (WFR #115-9-1)

The Coronado National Forest has filed two statements of claimant (39-8034 and 39-8321) for a "reserved" right within the San Pedro River watershed. These claims are for the Powers Garden Administrative site located on Rattlesnake Creek approximately twenty miles south of Klondyke, Arizona. The site is located approximately four miles within the Galiuro Wilderness Area; access was not readily available at the time of the investigation.

Legal Record

Statement of claimant 39-8321 claims a federal reserved water right, but it does not state the basis for the claim. Statement of claimant 39-8034 was amended on April 27, 1989 to change the basis for the claim from a state law right to a federal reserved water right claim based on the reservation of land for the Coronado National Forest on September 26, 1910.

The water uses at Powers Garden have also been claimed under state law. Table 5-51 summarizes a portion of watershed file report number 115-9-1 where these claims are located.

TABLE 5-51

CORONADO NATIONAL FOREST
POWERS GARDEN
115-9-1
SUMMARY OF CLAIMS FILED UNDER STATE LAW THAT CORRESPOND TO FEDERAL CLAIMS

STATEMENT OF CLAIMANT NUMBER	PREVIOUS FILING NUMBER	POTENTIAL WATER RIGHT NUMBER
39-4214 - Isley, Mike	36-82404 - Isley, Mike	DM1,SW3
	4A-2237 - Coronado National Forest (CWR #1284)	DM1,SW3

The two potential water rights (PWRs) in Table 5-51 (DM1 = Domestic use and SW3 = Powers Garden Spring) correspond to PWRs claimed under federal law.

Analysis of Claim

The National Forest has claimed current uses including fire fighting, periodic domestic and stockwatering, and occasional irrigation. Future uses are not stated in the claims. Table 5-52 compares the claimed information versus DWR's investigation findings for statements of claimant 39-8034 and 39-8321.

TABLE 5-52

CORONADO NATIONAL FOREST
POWERS GARDEN
115-9-1
STATEMENTS OF CLAIMANT 39-8034 AND 39-8321
COMPARISON OF CLAIMANT INFORMATION WITH DWR FINDINGS

	CLAIMED INFORMATION						DWR FINDINGS				
STATEMENT OF CLAIMANT	CLAIMED SOURCE	CLAIMED USE LOCATION	CLAIMED USE	NAME	CLAIMED ANNUAL	CLAIMED DATE OF FIRST USE	WATER USE NO.	USE TYPE	USE LOCATION	USE STATUS	MAP NUMBER
39-8034	Spring	NESW 13 09S 19E	DM,SW	Powers Garden	0.49 Ac-ft	1910	SW3	DM,SW	SWNESW 13 09S 19E	Spring	115-09
39-8321	Well	SENW 13 09S 19E	OT	Administration	0.56 Ac-ft	1959	DM1	DM	NESWNW 13 09S 19E	Verified	Unmapped
	Dam	SENW 13 09S 19E	OT	Cow Camp Tank			SP18	SW	NESWNW 13 09S 19E	Verified	115-09
	Spring	SENW 13 09S 19E	OT	Powers Garden Spring			SW3	SW	SWNESW 13 09S 19E	Spring	115-09

KEY: DM = Domestic, OT = Other, SP = Stockpond, SW = Stockwatering

Statement of claimant 39-8034 claims a total current annual use of 0.49 acre-feet for domestic and stockwatering uses. Statement of claimant 39-8321 claims a current total annual use of 0.56 acre-feet. This total includes the claimed irrigation use. The irrigation was not field verified due to the inaccessibility of the area, and the aerial photographic evidence was inconclusive.

FORT HUACHUCA MILITARY RESERVATION (WFR #111-23-73)

Location

Fort Huachuca, currently the headquarters of the United States Army Intelligence Center, is located approximately sixty miles southeast of Tucson, and about fifteen miles north of the International Border with Mexico as shown in Figure 5-19. The installation is situated along the northern range of the Huachuca Mountains in Cochise County, just west of the City of Sierra Vista, and south of Huachuca City along state highway 90.

Climate

The climate in the vicinity of Fort Huachuca is characterized by mild temperatures and moderate amounts of rainfall. The average annual temperature is 61.7°F, although temperature extremes of 1°F to 107°F have been recorded. Rainfall from summer monsoon thunderstorms accounts for approximately 50 percent of the annual precipitation, with winter snows accounting for an additional 10 percent. The mean annual precipitation is 16.45 inches at Fort Huachuca with a high of twenty-five inches in the Huachuca Mountains.

Geography

Fort Huachuca falls within Arizona's basin and range lowlands region. The Huachuca Mountains form the western geographical boundary of the Fort, with the Babocomari River providing the northern boundary (Figure 5-20). The Huachuca Mountains provide the most rugged terrain of the military reservation. However, the majority of the Fort lies in the gently sloping foothills of this range.

The Fort has claimed an on-post land area of 73,272 acres. When the post was established by Executive Order #35 on October 28, 1881, the size of the

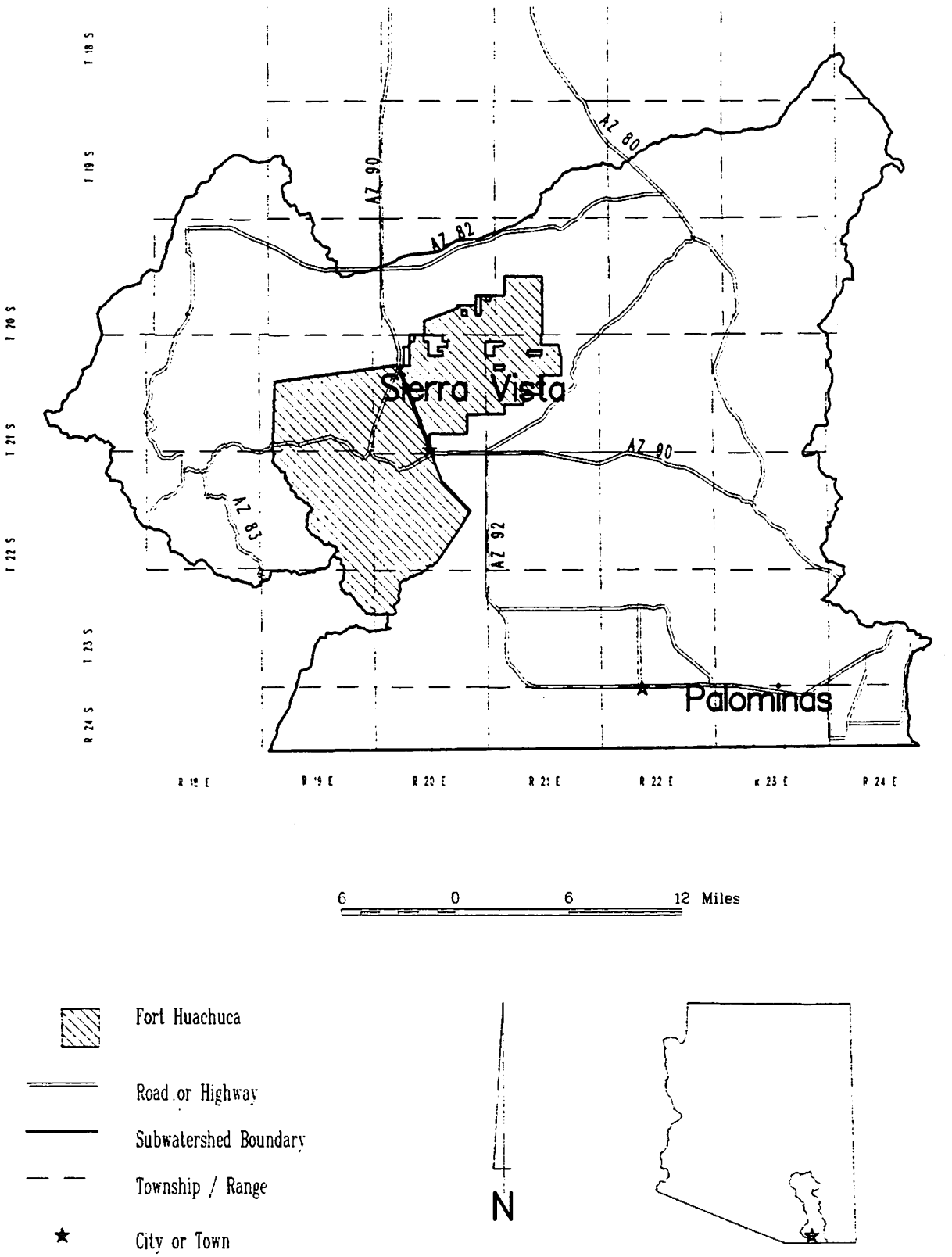


Figure 5-19. Location of Fort Huachuca within the San Pedro River watershed

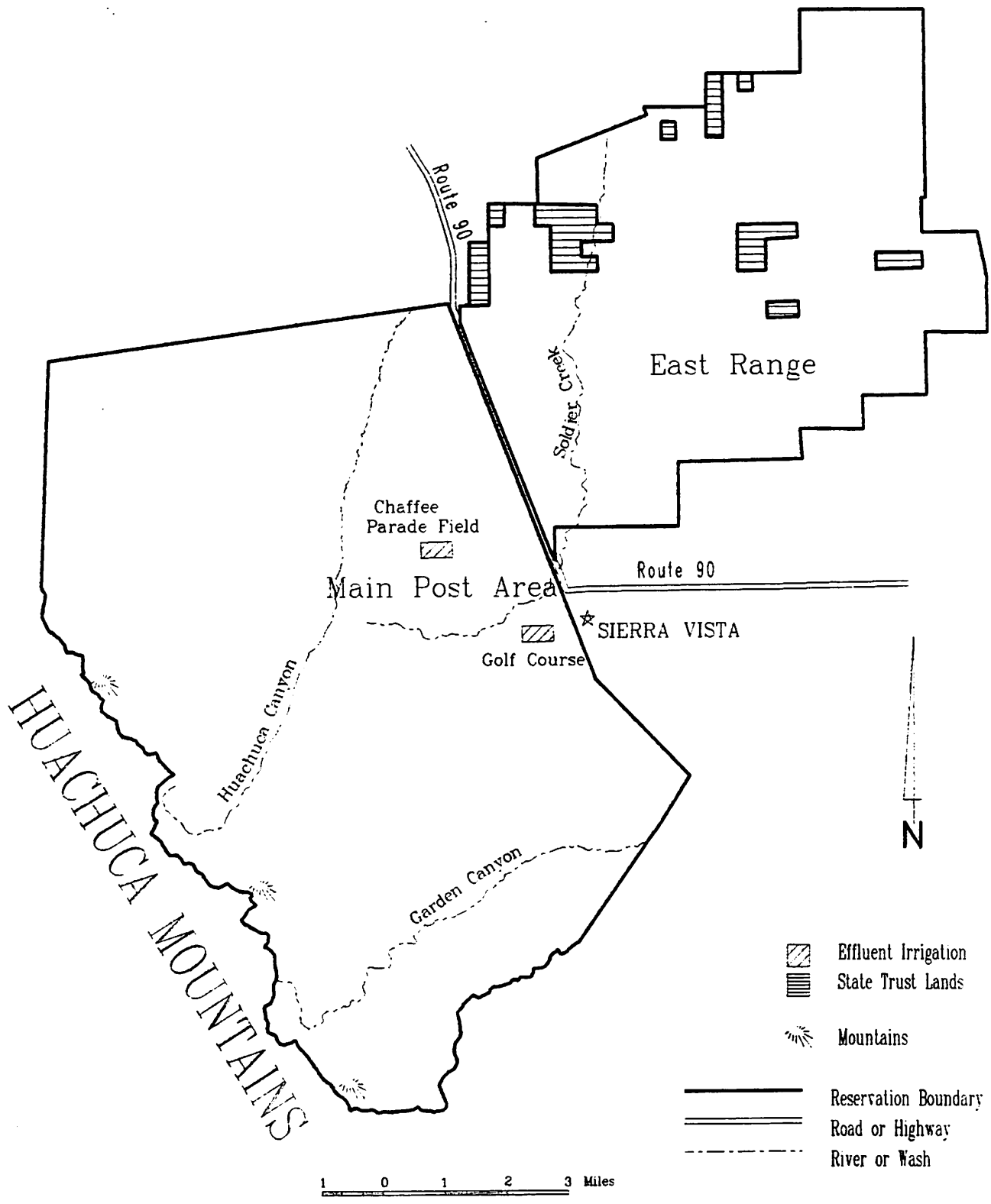


Figure 5-20. Boundary of Fort Huachuca, including state trust lands

Fort was 41,760 acres. On May 14, 1883, the Fort boundaries were expanded by Executive Order #36 to 44,800 acres (Figure 5-21). In the 1940s, Fort Huachuca was expanded again to include lands east of the original boundaries. This area is known as the East Range and encompasses approximately 13,545 acres (Figure 5-22). This brought the total area of Fort Huachuca to about 58,345 acres. In August 1957, 13,463 acres of BLM land were removed from the public domain and transferred to Fort Huachuca, bringing the Fort's total acreage to 71,808 acres. The remaining acreage claimed by the Fort (1,536 acres) is currently state trust land that is utilized by the Fort pending exchange between the State of Arizona and the United States Government. By deeds in 1982 and 1989, seventy-two acres were quit-claimed to the City of Sierra Vista for airport purposes.

Population

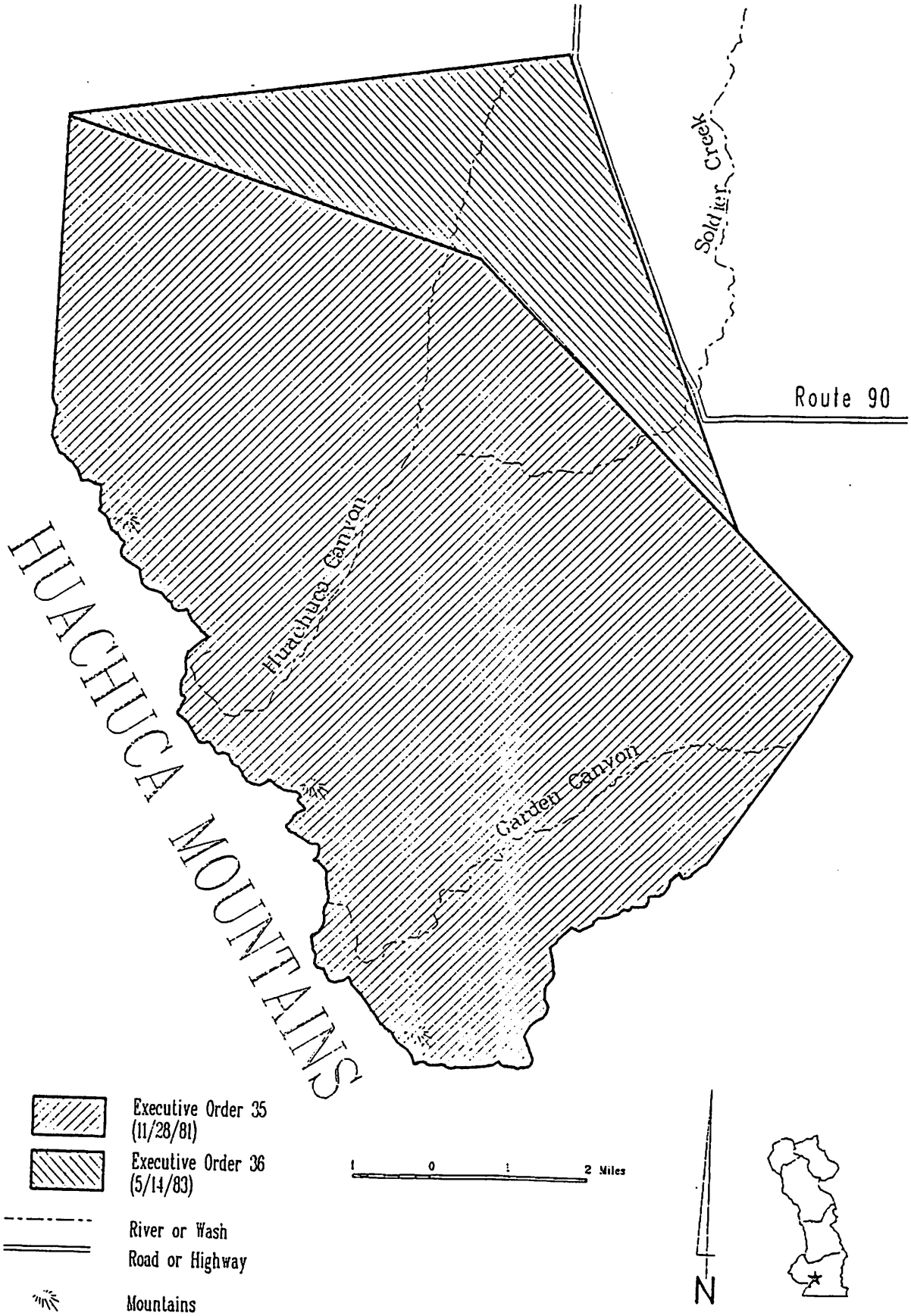
Fort Huachuca was incorporated into the city limits of Sierra Vista on February 17, 1971. In 1970, the post population was 6,659, and in 1980, the population was 9,301. Post population for 1990 is estimated at 9,200. Current population of Sierra Vista (excluding Fort Huachuca) is nearly 36,000. It should be noted that the population growth in the Sierra Vista area has increased markedly in the last decade from 24,937 to 35,868, an increase of 44 percent. Table 5-53 shows the Fort's population since 1980.

TABLE 5-53

FORT HUACHUCA
MILITARY POPULATION

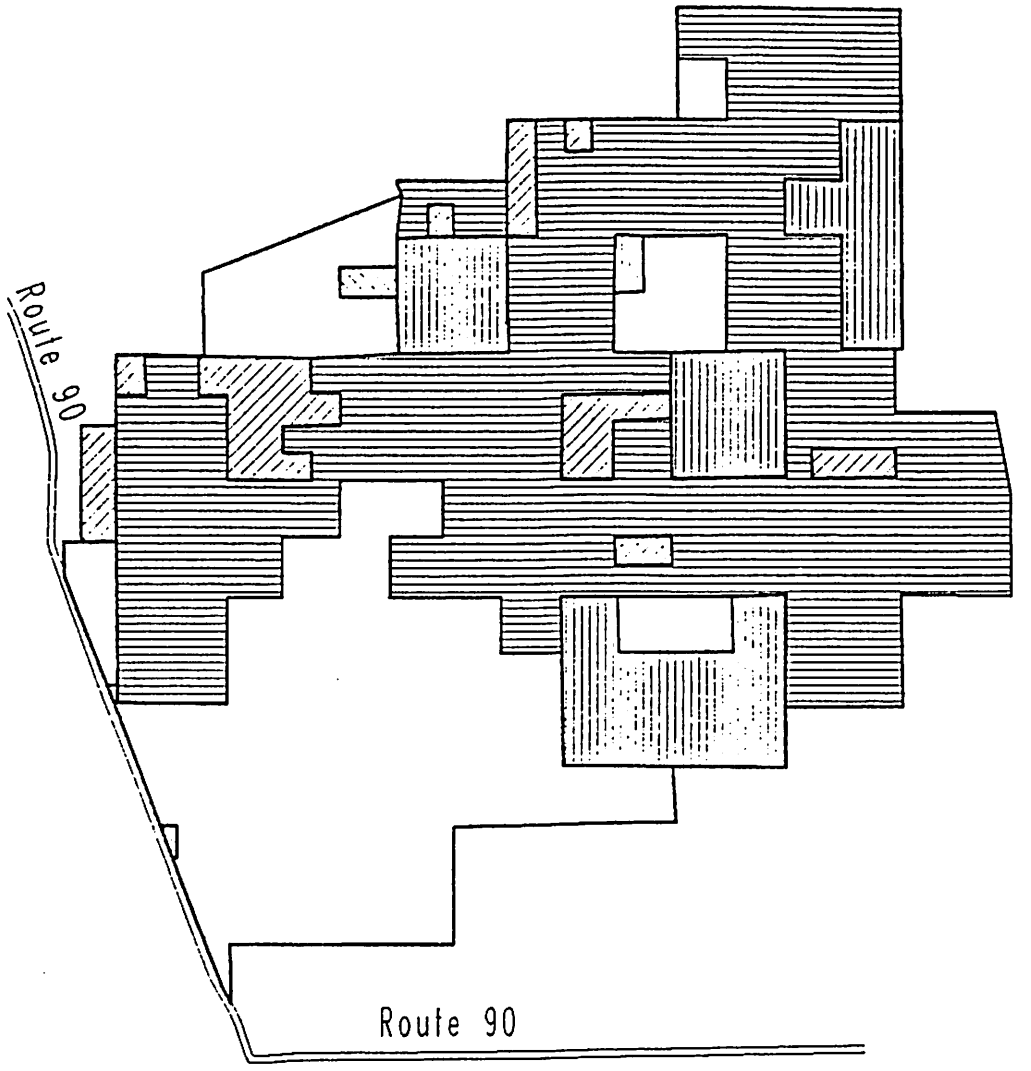
YEAR	POPULATION
1980	9,301
1981	8,602
1982	9,433
1983	9,996
1984	10,127
1985	10,502
1986	8,890
1987	9,667
1988	9,142
1989	9,204
1990	9,210

Source: Fort Huachuca



Source: U.S. Army Corps of Engineers, 1991

Figure 5-21. Map showing the original boundaries of Fort Huachuca



Source: U.S. Army Corps of Engineers, 1991

Figure 5-22. Map showing the establishment of the East Range boundaries of Fort Huachuca

From a hydrologic standpoint, the population growth is important because Fort Huachuca and Sierra Vista utilize the same aquifer as their primary source of supply. There is a direct correlation between population growth and water usage as seen by the declining groundwater levels in the Sierra Vista area. This situation is discussed in more detail later in this section.

History

In the Treaty of Guadalupe Hidalgo (1848) Mexico ceded its northern provinces (present day New Mexico and Arizona) to the United States. Article XI of the treaty provided that the United States would stop Indian raids into Mexico and could cross the International Border to pursue the Apaches. Although the Mexican Government rescinded Article XI in the Gadsden Purchase of 1853, they unofficially held the United States responsible for protecting them against Apache raids and war parties. The United States complied with Mexico's wishes by building eleven posts south of the Gila River from 1856 until 1876 to protect Anglo settlers from growing Indian unrest. Discontent among the Indian tribes had reached such proportions by 1877 that United States Army Headquarters, Department of Arizona ordered two troops of calvary at Fort Lowell into the vicinity of the Huachuca Mountains to establish a temporary camp. Captain Samuel Marmaduke Whitside headed the detachment and decided on a location at the mouth of Huachuca Canyon because of its commanding view of the San Pedro Valley and its abundant water supply from natural springs running through the canyon. Thus, on March 3, 1877, the Cavalry set up Camp Huachuca to protect the settlers residing in southeastern Arizona (Whitside, Statement of Service; 31 March 1877). The U.S. War Department declared the camp a permanent installation on January 21, 1878 (Whitside; Letter to Adjutant General, U.S.A.; April 6, 1878).

After twenty-five years, the Indian wars were finally ended in 1886 with the surrender of Geronimo. The Army decided to keep Fort Huachuca as a permanent post because of its close proximity to Mexico, the general good health enjoyed by those stationed at the Fort, and its abundant water supply. Fort Huachuca, the only permanent military post along the International Border west of El Paso, formed the nucleus of patrolling operations along the International Border from 1902 until 1917. During this time Pancho Villa began his attacks on United States border towns in defiance of President Woodrow Wilson's recognition of Mexico's new government under

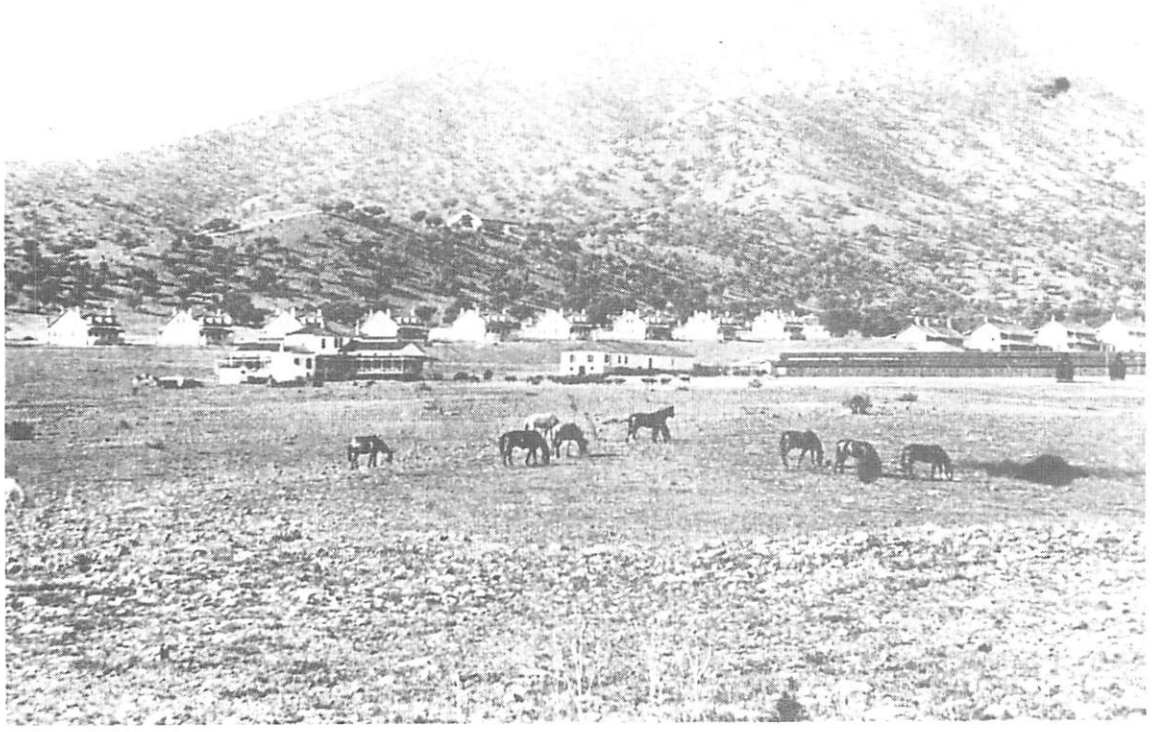


Figure 5-23. A photograph of Fort Huachuca taken circa 1885. The site chosen for the Fort, located at the northeast flank of the Huachuca Mountains, utilized the springs in Garden and Huachuca Canyons to supply the main post, and for pasture of calvary horses.

General Venustiano Carranza. The United States responded with an extensive mounted expedition into Mexico to capture Villa. Within months, Carranza decided he no longer needed the help of this government to pursue Villa. President Wilson ordered the formal withdrawal of United States troops in 1917 as the country prepared to enter World War I against Germany. The American Government perceived a threat of German espionage against this country via Mexico during this conflict. This threat proved to be more than mere perception and, because it is located twenty-five miles from the Mexico-United States border, troops at Fort Huachuca patrolled the border to assure national security.

During World War II (1941-1945), the Army utilized the Fort as an infantry training ground. This mission ended with the war and in 1949 the Army turned the post over to the State of Arizona for use by the Arizona Game and Fish Commission as a wildlife reserve and to the Arizona National Guard for military use. From 1949 to 1951, the Arizona National Guard and the

Arizona Game and Fish Commission had use of the post for their respective missions. The Defense Department reactivated the Fort to train Aviation Engineers in 1951 at the onset of the Korean War.

At the end of the Korean conflict, the Fort experienced a brief inactive period until 1954 when it became the United States Army Electronic Proving Ground. In 1967, the Strategic Communications Command (redesignated the United States Army Information Systems Command in 1984) moved to Fort Huachuca continuing a communications history which began in 1886 with the heliograph (a system of reflective mirrors using Morse code). At present, the post is home to these commands as well as the United States Army Intelligence Center as well as the Department of Defense Joint Element of the Joint Tactical Command, Control, and Communications Agency, the 11th Signal Brigade, and the United States Army Communications Security Logistics Activity.

Applicable Filings and Decrees

Previous Filings

The claim filed by Fort Huachuca does not include previous water rights filings (33s, 36s, or 38s), in the form of applications, permits, or certificates.

Statement of Claimants

Fort Huachuca has filed two statements of claimant, 39-10774 and 39-10775, which claim twenty-five wells, thirty-nine springs, and seventy-four ponds. Statement of Claimant 39-10774 was amended on August 5, 1991. Statement of Claimant 39-10775 was amended on August 21, 1989 and August 5, 1991. These facilities are summarized in Table 5-54 and in Tables 5-69 and 5-70 at the end of this section.

Total amount of annual water use claimed by the Fort is 10,522 acre-feet per year (10,087 acre-feet per year claimed on 39-10774 and 435 acre-feet per year on 39-10775). The Fort based these claims on federal water rights, and legitimate and authorized federal activities.

TABLE 5-54

FORT HUACHUCA
SUMMARY OF CLAIMED FACILITIES

CLAIMED FACILITIES	NUMBER CLAIMED	CLAIMED QUANTITY (ACRE-FEET PER YEAR)
Wells		
Potable (Domestic)	8	3,793.1
Nonpotable	8	73.9
Test	9	----
TOTAL	25	3,867.0
Springs		
Potable	13	122.5
Nonpotable	26	54.2
TOTAL	39	176.7
Ponds		
Effluent evaporation	10	41.8
Game management	5	3.3
Wildlife, recreation	14	82.9
Erosion control	45	74.4
TOTAL	74	201.6
Other Facilities[1]		
Check Dams	200 each	8.0
Water Bars	1,200 each	24.0
Water Terraces	8.7 miles	17.4
TOTAL		49.4

[1]From Fort Huachuca comments dated May 22, 1987 on the 1987 preliminary HSR.

For the claimed facilities, the Fort has approximated dates of first use. These dates are shown in Table 5-55.

TABLE 5-55

FORT HUACHUCA
CLAIMED DATES OF FIRST USE

CLAIMED FACILITIES	CLAIMED LOCATION	CLAIMED DATE OF FIRST USE
Wells		
Windmill #2	SW¼, SE¼, SW¼, Sec. 27, T.20S., R.20E.	1905
Windmill #1	NE¼, SE¼, SW¼, Sec. 34, T.20S., R.20E.	1910
Garden Canyon	NW¼, SE¼, SE¼, Sec. 29, T.22S., R.20E.	1930
Garden Windmill	NE¼, NE¼, NW¼, Sec. 32, T.22S., R.20E.	1930
Well #1	NW¼, NW¼, NW¼, Sec. 03, T.22S., R.20E.	1940
Well #2	NW¼, NW¼, NW¼, Sec. 03, T.22S., R.20E.	1941
Well #3	NW¼, NE¼, SE¼, Sec. 33, T.21S., R.20E.	1943
Well #4	NE¼, NW¼, NE¼, Sec. 33, T.21S., R.20E.	1943
Well #5	SW¼, NE¼, SW¼, Sec. 28, T.21S., R.20E.	1943
East Range Bunker	NW¼, SE¼, NW¼, Sec. 07, T.21S., R.21E.	1958
Well #6	NW¼, NW¼, SE¼, Sec. 33, T.21S., R.20E.	1959
Spatial Resolution Well	SE¼, NW¼, NW¼, Sec. 22, T.21S., R.20E.	1964
Test Well #1	NW¼, SW¼, SE¼, Sec. 20, T.21S., R.20E.	1971/1972[1]
Test Well #2	NE¼, SW¼, SW¼, Sec. 30, T.21S., R.20E.	1971/1972[1]
Test Well #3	NE¼, NE¼, NE¼, Sec. 16, T.21S., R.20E.	1971/1972[1]
Test Well #4	SW¼, SE¼, NE¼, Sec. 15, T.21S., R.20E.	1971/1972[1]
Well #9	NW¼, SW¼, NW¼, Sec. 10, T.21S., R.20E.	1973[1]
Test Well #6	SE¼, SW¼, SW¼, Sec. 35, T.20S., R.20E.	1973[1]
Test Well #7	SE¼, SW¼, SW¼, Sec. 11, T.21S., R.20E.	1973[1]
Test Well #8	NW¼, NW¼, SW¼, Sec. 13, T.21S., R.20E.	1973[1]
Test Well #9	SW¼, SW¼, NW¼, Sec. 17, T.21S., R.21E.	1973[1]
Rembass Well #1	NE¼, SW¼, NE¼, Sec. 26, T.21S., R.20E.	1978
Rembass Well #2	SW¼, SE¼, SE¼, Sec. 14, T.21S., R.20E.	1978
Well #7	NW¼, NW¼, NW¼, Sec. 22, T.21S., R.20E.	1982
Well #8	NE¼, SE¼, NE¼, Sec. 16, T.21S., R.20E.	1982
Springs		
Potable	Various locations (see Table 5-66)	1877
Nonpotable	Various locations (see Table 5-66)	1954
Ponds		
All, except as shown below (see Table 5-66)		1954
Lower Antelope	SE¼, NW¼, Sec. 16, T.21S., R.19E.	1975
Sycamore II	NE¼, SW¼, Sec. 29, T.21S., R.19E.	1975
West Huachuca #2	NE¼, SW¼, Sec. 21, T.22S., R.19E.	1975
Gate 5 Pond	SW¼, SW¼, Sec. 16, T.21S., R.20E.	1975

[1]From Fort Huachuca comments dated November 13, 1990, on the 1990 preliminary HSR.

TABLE 5-55 (cont'd)

CLAIMED FACILITIES	CLAIMED LOCATION	CLAIMED DATE OF FIRST USE
45 Pond	NE¼, SE¼, Sec. 10, T.21S., R.20E.	1975
#3 Sewage Pond	SW¼, NE¼, Sec. 21, T.21S., R.20E.	1975
#2 Sewage Pond	NE¼, SE¼, Sec. 21, T.21S., R.20E.	1975
Horse Pasture Pond	SE¼, SW¼, Sec. 06, T.22S., R.20E.	1975
Golf Course Fairway	NW¼, NE¼, Sec. 04, T.22S., R.20E.	1975
51	SE¼, SE¼, Sec. 10, T.21S., R.21E.	1975
Middle Garden Canyon Pond	NW¼, NE¼, Sec. 28, T.22S., R.20E.	1975
r Dam	SE¼, NW¼. Sec. 21, T.20S., R.21E.	1976
b Dam	NE¼, SE¼, Sec. 18, T.21S., R.21E.	1977
c Dam	NW¼, SW¼, Sec. 17, T.21S., R.21E.	1977
g Dam	NW¼, SW¼, Sec. 17, T.21S., R.21E.	1977
f Dam	SW¼, NW¼, Sec. 20, T.21S., R.21E.	1977
d Dam	NW¼, NE¼, Sec. 20, T.21S., R.21E.	1977
h Dam	NE¼, NE¼, Sec. 10, T.21S., R.20E.	1977
i Dam	SE¼, NW¼, Sec. 10, T.21S., R.20E.	1977
j Dam	SE¼, NE¼, Sec. 10, T.21S., R.20E.	1977
k Dam	NE¼, NE¼, Sec. 03, T.21S., R.20E.	1977
l Dam	NE¼, NE¼, Sec. 09, T.21S., R.20E.	1977
Sediment 34a	NE¼, SE¼, Sec. 21, T.21S., R.20E.	1978
Sediment 34b	SE¼, NE¼, Sec. 21, T.21S., R.20E.	1978
Sediment 34c	NE¼, NE¼, Sec. 21, T.21S., R.20E.	1978
Sediment 34d	SW¼, NW¼, Sec. 15, T.21S., R.20E.	1978
m Dam	NW¼, NE¼, Sec. 36, T.21S., R.19E.	1979
n Dam	NE¼, NE¼, Sec. 28, T.22S., R.20E.	1979
Woodcutters 1a	NW¼, SW¼, Sec. 16, T.22S., R.20E.	1979
Woodcutters 1b	NW¼, NE¼, Sec. 16, T.22S., R.20E.	1979
Woodcutters 1c	NW¼, NE¼, Sec. 10, T.22S., R.20E.	1979
Sediment #1b	NE¼, SE¼, Sec. 33, T.21S., R.20E.	1984

Analysis of Claims

DWR visited Fort Huachuca on several occasions. The purpose of these field trips was to investigate claimed water uses by the Fort, determine points of diversion, and gather other pertinent data as necessary.

DWR verified the use of wells #1 through #8 shown in Table 5-56, the spatial resolution well, East Range Bunker well, and the Garden Canyon well (nonpotable). The Garden Canyon well (no number is given in the claim) is used to fill ponds and can no longer be connected to the potable system.

TABLE 5-56

FORT HUACHUCA
LOCATION OF THE EIGHT POTABLE WELLS

WELL NUMBERS	LOCATION
1	NW¼, NW¼, NW¼, Sec. 03, T.22S., R.20E.
2	NW¼, NW¼, NW¼, Sec. 03, T.22S., R.20E.
3	NW¼, NE¼, SE¼, Sec. 33, T.21S., R.20E.
4	NE¼, NW¼, NE¼, Sec. 33, T.21S., R.20E.
5	SW¼, NE¼, SW¼, Sec. 28, T.21S., R.20E.
6	NW¼, NW¼, SE¼, Sec. 33, T.21S., R.20E.
7	NW¼, NW¼, NW¼, Sec. 22, T.21S., R.20E.
8	NE¼, SE¼, NE¼, Sec. 16, T.21S., R.20E.

All potable springs were visited and are shown in Table 5-57. DWR did not visit any nonpotable springs.

TABLE 5-57

FORT HUACHUCA
POTABLE SPRING LOCATIONS IN GARDEN AND HUACHUCA CANYONS

SPRING NAME	CLAIMED LOCATION	WATERCOURSE
Spring #1	NW¼, SW¼ Sec. 14, T.22S., R.19E.	Huachuca Canyon
Spring #2	NW¼, SW¼ Sec. 14, T.22S., R.19E.	Huachuca Canyon
Spring #3	NE¼, NE¼ Sec. 22, T.22S., R.19E.	Huachuca Canyon
Spring #3a	NE¼, NE¼ Sec. 22, T.22S., R.19E.	Huachuca Canyon
Spring #4	NE¼, NE¼ Sec. 22, T.22S., R.19E.	Huachuca Canyon
Chain Spring	SW¼, SW¼ Sec. 31, T.22S., R.20E.	Garden Canyon
Picnic Spring	NE¼, SW¼ Sec. 31, T.22S., R.20E.	Garden Canyon
Spring #1	SE¼, SE¼ Sec. 36, T.22S., R.19E.	Garden Canyon
Spring #1a	NE¼, NE¼ Sec. 01, T.23S., R.19E.	Garden Canyon
Spring #1b	SE¼, SE¼ Sec. 36, T.22S., R.19E.	Garden Canyon
Spring #2	NE¼, SW¼ Sec. 01, T.23S., R.19E.	Garden Canyon
Spring #3	NE¼, SW¼ Sec. 01, T.23S., R.19E.	Garden Canyon
Spring #4	SW¼, SW¼ Sec. 01, T.23S., R.19E.	Garden Canyon

As stated previously, Fort Huachuca claimed seventy-four ponds. DWR was able to verify all of these impoundments by aerial photography or field investigations. Of this total, sixteen impoundments were surveyed and are shown in Table 5-58.

TABLE 5-58

FORT HUACHUCA
SUMMARY OF SURVEYED IMPOUNDMENTS

WATER USE NUMBER	FACILITY NAME	CLAIMED LOCATION	AREA (ACRES)	CAPACITY (ACRE-FEET)
PS1	Antelope	NW¼, SW¼, Sec. 16, T.21S., R.19E.	2.6	26.4
PS2	Sycamore	SE¼, SW¼, Sec. 20, T.21S., R.19E.	3.9	38.8
PS3	Hidden	SE¼, NW¼, Sec. 28, T.21S., R.19E.	2.1	22.5
PS4	Golf Course	NW¼, NE¼, Sec. 09, T.22S., R.20E.	7.6	59.7
PS5	Gravel Pit	NE¼, SE¼, Sec. 17, T.22S., R.20E.	7.0	57.4
SP4	Lower Antelope	SE¼, NW¼, Sec. 16, T.21S., R.19E.	2.2	14.9
SP5	Sycamore II	NE¼, SW¼, Sec. 29, T.21S., R.19E.	1.5	10.5
SP12	Sediment (34d)	SW¼, NW¼, Sec. 15, T.21S., R.20E.	9.5	29.6
SP15	Sediment (34c)	NE¼, NE¼, Sec. 21, T.21S., R.20E.	2.5	6.0
SP16	#3 Sewage	SW¼, NE¼, Sec. 21, T.21S., R.20E.	3.5	11.0
SP18	Sediment (34a)	NW¼, SE¼, Sec. 21, T.21S., R.20E.	2.8	12.0
SP19	#2 Sewage	NE¼, SE¼, Sec. 21, T.21S., R.20E.	3.3	5.5
SP29	Lower Woodcutters	NW¼, NW¼, Sec. 10, T.22S., R.20E.	2.5	20.7
SP31	Woodcutters	NW¼, NE¼, Sec. 16, T.22S., R.20E.	1.8	8.4
SP40	n Dam	NE¼, NE¼, Sec. 28, T.22S., R.20E.	2.4	16.9
SP41	M. Garden Canyon	NW¼, NE¼, Sec. 28, T.22S., R.20E.	4.1	27.1
		TOTAL	59.3	367.4

Water Resources

This section will discuss the water resources that are available to meet the current and projected water requirements of the Fort. The existing water resources are surface water, groundwater, and effluent.

Surface Water

Surface water on the Fort Huachuca military reservation occurs as storm runoff, snowmelt runoff, and discharge from springs into the stream channels of Garden and Huachuca Canyons (Brown, 1966). Other canyons located within the boundaries of the Fort yield little water except for short durations after precipitation events.

The primary source of surface water available to the Fort are springs, which can be classified as potable and nonpotable. The nonpotable springs are located in the many canyons of the Huachuca Mountains. These springs are used as water sources for wildlife and game. There are a total of twenty-six nonpotable springs which are listed on Table 5-59. The potable springs are located in Garden and Huachuca Canyons and are summarized in Table 5-60.

TABLE 5-59

FORT HUACHUCA
NONPOTABLE SPRINGS

SPRING NAME	CLAIMED LOCATION	CLAIMED WATER COURSE
Spring #2	NE¼, SE¼, Sec. 33, T.22S., R.20E.	Tinker Canyon
Spring #3	NE¼, SE¼, Sec. 33, T.22S., R.20E.	Tinker Canyon
Spring #4	SW¼, SW¼, Sec. 07, T.23S., R.20E.	Sawmill Canyon
Spring #5	NE¼, SE¼, Sec. 35, T.22S., R.19E.	McClure Canyon
Spring #6	SE¼, SW¼, Sec. 36, T.22S., R.19E.	McClure Canyon
Spring #7	SW¼, NW¼, Sec. 36, T.22S., R.19E.	McClure Canyon
Cabin Spring	SW¼, SW¼, Sec. 01, T.23S., R.19E.	Garden Canyon
Spring #8	SW¼, SE¼, Sec. 25, T.22S., R.19E.	Garden Canyon
Spring #9	NW¼, SE¼, Sec. 25, T.22S., R.19E.	Woodcutters Canyon
Spring #10	SW¼, SW¼, Sec. 19, T.22S., R.20E.	Woodcutters Canyon
Spring #11	NE¼, SW¼, Sec. 20, T.22S., R.20E.	Woodcutters Canyon
Spring #12	NE¼, SE¼, Sec. 07, T.22S., R.20E.	Soldier Creek
Spring #13	SW¼, SW¼, Sec. 13, T.22S., R.19E.	Soldier Creek
Spring #14	SW¼, NE¼, Sec. 27, T.22S., R.19E.	Huachuca Canyon
Spring #15a	NW¼, SE¼, Sec. 22, T.22S., R.19E.	Huachuca Canyon
Spring #15b	SE¼, SE¼, Sec. 22, T.22S., R.19E.	Huachuca Canyon
Spring #16	NW¼, SW¼, Sec. 14, T.22S., R.19E.	Huachuca Canyon
Spring #17	SE¼, NW¼, Sec. 15, T.22S., R.19E.	Huachuca Canyon
Spring #18	NW¼, NE¼, Sec. 16, T.22S., R.19E.	Blacktail Canyon
Spring #19	SE¼, NE¼, Sec. 08, T.22S., R.19E.	Blacktail Canyon
Spring #20	NW¼, NE¼, Sec. 04, T.22S., R.19E.	Slaughterhouse Canyon
Spring #21	SW¼, SW¼, Sec. 26, T.21S., R.19E.	Slaughterhouse Canyon
Spring #22	NW¼, SW¼, Sec. 32, T.21S., R.19E.	Sycamore Canyon
Spring #23	SE¼, NW¼, Sec. 21, T.22S., R.20E.	Tributary of Garden Wash
Spring #24	NW¼, NW¼, Sec. 07, T.23S., R.20E.	Scheelite Canyon
Spring #25	SE¼, SW¼, Sec. 36, T.22S., R.19E.	Tributary of McClure Canyon

TABLE 5-60

FORT HUACHUCA
POTABLE SPRINGFLOW MEASUREMENTS FOR GARDEN AND HUACHUCA CANYONS

SYSTEM	SPRING NUMBER	PERIOD	NUMBER OF MEASUREMENTS	AVERAGE DISCHARGE (GPM)
Garden Canyon	1	Jan. 1962-Jun. 1963	46	194
Garden Canyon	1a	Winter, 1960-1961	Not Listed	400 (1)
Garden Canyon	2	Jan. 1960-Aug. 1961	47	176
Garden Canyon	3	Mar. 1960-Nov. 1962	43	32.9
Garden Canyon	4	Mar. 1960-Nov. 1962	43	32.9
Garden Canyon	Chain	Not Listed	Not Listed	150-250 (2)
Garden Canyon	Picnic	Not Listed	Not Listed	540 (1)
Huachuca Canyon	2	Feb. 1960-Sep. 1962	47	16.5
Huachuca Canyon	3	Apr. 1961-Jan. 1962	47	28.3

Source: USGS Report No. 1819-D.

(1) Maximum flow measured (data not listed).
(2) Based on flow during wet weather; does not flow during the remainder of the year.

These springs were at one time the sole source of water for the Fort. In 1939, the first well was drilled to provide a more reliable supply of water. In 1983, the Fort no longer used the springs as a source of potable water. In the early 1960s, the USGS undertook a survey of the water resources of the reservation. As part of the survey, the USGS measured springflow from Garden and Huachuca Canyons. These measurements are shown in Table 5-60. During the years 1958 through 1963, springflow averaged 665 acre-feet per year in Garden Canyon and 171 acre-feet per year in Huachuca Canyon. Prior to 1983, Fort Huachuca used approximately 144 acre-feet of springflow as part of its water supply.

Groundwater

The main source of groundwater for Fort Huachuca is the regional aquifer of the Upper San Pedro River Basin. The regional aquifer consists of upper and lower basin fill deposits. The upper basin fill deposits consist of clays, gravels, sand, and silt; the lower basin fill deposits consist of interbedded sand stones and gravels. Groundwater generally occurs under

unconfined or water table conditions in most of the regional aquifer. Groundwater may occur under confined (artesian) conditions where permeable and saturated material is overlain by impervious silt or clay lenses. No confined conditions exist in the regional aquifer in the vicinity of the Fort Huachuca aquifer.

Groundwater flow in the unconfined portion of the regional aquifer is generally from the valley margins near the mountains toward the San Pedro River. Centers of groundwater pumping and local flow barriers cause exceptions to the general flow regime. The flow direction is generally north eastward from the east face of the Huachuca Mountains toward the San Pedro River, except in the vicinity of the cone of depression in the Sierra Vista and Main Post area.

The sources of recharge for the regional aquifer are from mountain front recharge, streamflow infiltration, and direct infiltration of precipitation. Mountain front recharge to the regional aquifer occurs along the mountain fronts where surface runoff leaves the hard rock formations of the mountains and flows onto the permeable basin fill. Recharge occurs along the stream channels as filtration through the alluvial materials underlying the channel. Recharge also occurs as precipitation and is directly infiltrated into the aquifer through the land surface. The water recharged to the regional aquifer is later discharged to the San Pedro River, withdrawn by pumping within the basin, or withdrawan by natural vegetation. Mountain front recharge occurs along the east face of the Huachuca Mountains; streamflow infiltration occurs along the many water courses that pass through the reservation boundaries, primarily from Garden and Huachuca Canyons.

The USGS has made a preliminary estimate of the water in storage of the regional aquifer along the west side of the San Pedro River from the International Boundary to the Babocomari River to a depth of 1,200 feet. The USGS estimated that 13,400,000 acre-feet of the water was in storage in this portion of the aquifer. DWR estimates that there is approximately 11,350,000 acre-feet in storage in this portion of the aquifer to a depth of 800 feet.

Although the amount of water in underground storage in the vicinity of Fort Huachuca is quite large, a problem in the water supply for the Fort may occur due to the creation of a cone of depression from pumpage by the Fort and Sierra Vista. The cone is expanding and deepening which is resulting in

greater pump lifts and increased energy costs. This situation is discussed in more detail in the "Quantification of Significant Diminishment to Fort Huachuca" section of this report.

A local "perched aquifer" is believed to exist along the pediment of the Huachuca Mountains, in a zone where the alluvium of the basin fill is underlain at shallow depths by bedrock. The perched aquifer extends from the area of Carr Canyon toward the Fort Huachuca military reservation boundary and extends northeasterly toward the San Pedro River (Harshbarger and Associates, 1974)

Well pumpage from 1963 to 1984 has averaged 2,900 acre-feet per fiscal year. From 1982 to 1990, well production has averaged 2,889 acre-feet per calendar year. Table 5-61 shows well production for fiscal years 1963 to 1984 and calendar year 1982 to 1990.

TABLE 5-61

FORT HUACHUCA
WELL PRODUCTION
(ACRE-FEET)

FISCAL YEAR				CALENDAR YEAR		
1963	2,887	1974	3,351	1982	2,736	
1964	2,471	1975	2,597	1983	2,876	
1965	2,636	1976	2,766	1984	3,071	
1966	2,703	1977	2,871	1985	2,986	
1967	3,021	1978	2,327	1986	2,898	
1968	2,909	1979	2,802	1987	2,273	(excludes December)
1969	3,262	1980	3,011	1988	3,201	
1970	3,319	1981	3,146	1989	3,209	
1971	3,174	1982	2,597	1990	2,748	
1972	3,148	1983	2,928			
1973	2,781	1984	3,105			

Source: Fort Huachuca letters concerning statements of claimant 39-10774 and 39-10775, December 28, 1981, Tab F, revised fiscal year figures, October 17, 1989, enclosure 6, revised calendar year figures, and September 13, 1991.

Currently, the Fort has eight production wells for the potable water supply. Table 5-62 lists these wells, their depth, and discharge capacity.

TABLE 5-62

FORT HUACHUCA
DEPTH AND DISCHARGE OF THE EIGHT POTABLE WELLS

WELL NUMBER	DEPTH (FEET) (1)	DISCHARGE (GALLONS PER MINUTE) (2)
1	701 (823) (3)	500/500
2	710	700/900
3	802	700/700
4	912	700/700
5	800	700/700
6	1,230	700/310
7	762	800/ND
8	807	800/ND

(1) Figures from USGS Report (#1819-D).
(2) Figures shown are claimed data by Fort/data reported by USGS. ND means no data.
(3) Figure revised by Fort per letter dated November 13, 1990, comments on preliminary HSR.

Potential Wells

The Fort undertook a test well drilling program in the early 1970s to identify areas for future production wells to meet projected water needs. The East Range area of the Fort was determined to have the most promising aquifer characteristics and location for the new wells. The East Range is an area of forty-four square miles, which is mostly isolated from private developments that might compete with the Fort for water. The areal extent of the East Range would also permit sufficient spacing between production wells to minimize interference between wells. Seven test wells were drilled in the East Range. Four of the test wells were determined to be good producers and three were determined to be poor to moderate producers based on an analysis of the specific capacity of the wells (specific capacity is a measure of well productivity expressed in gallons per minute per foot of drawdown).

Table 5-63 lists the test wells and their specific capacities. Specific capacities for the Fort's production wells are also shown for comparison purposes. The test wells that are good producers are generally located in the north and west portions of the East Range.

TABLE 5-63

FORT HUACHUCA
EAST RANGE TEST WELL SPECIFIC CAPACITIES
COMPARED WITH PRODUCTION WELL SPECIFIC CAPACITIES

EAST RANGE TEST WELL DESIGNATION	SPECIFIC CAPACITY
Test Well 3	22 gpm/ft.
Test Well 4	7 gpm/ft.
Test Well 5 (1)	29 gpm/ft.
Test Well 6	21 gpm/ft.
Test Well 7	23 gpm/ft.
Test Well 8	10 gpm/ft.
Test Well 9	8.6 gpm/ft.

POST PRODUCTION WELL DESIGNATION	SPECIFIC CAPACITY
Spatial Resolution Well	16 gpm/ft.
Post Well 1	15.4 gpm/ft. at 593 gpm
Post Well 2	17.1 gpm/ft. at 615 gpm
Post Well 3	17.7 gpm/ft. at 760 gpm
Post Well 4	40.7 gpm/ft. at 611 gpm
Post Well 5	6.2 gpm/ft. at 450 gpm
Post Well 6	37.5 gpm/ft. at 601 gpm

Source: U.S. Army Corps of Engineers, 1974.

(1) Test Well 5 has become Post Well 8.

Effluent

Another source of water supply for Fort Huachuca is effluent. As stated earlier, the Fort uses some of the effluent to irrigate the Chaffee parade field and the Fort's golf course. The remaining effluent is placed in evaporation ponds. During 1990, the Fort produced effluent at the rate of about 1,720,000 gallons per day or about 1,923 acre-feet per year.

DWR has made a projection of effluent production to the year 2025 based on a per capita production rate of 202 gallons per capita per day (gpcd) based on the average gpcd rate for 1989 and 1990 and for population increases on the Fort of 0, 1, 3, and 6 percent. This projection is displayed in Figure 5-24.

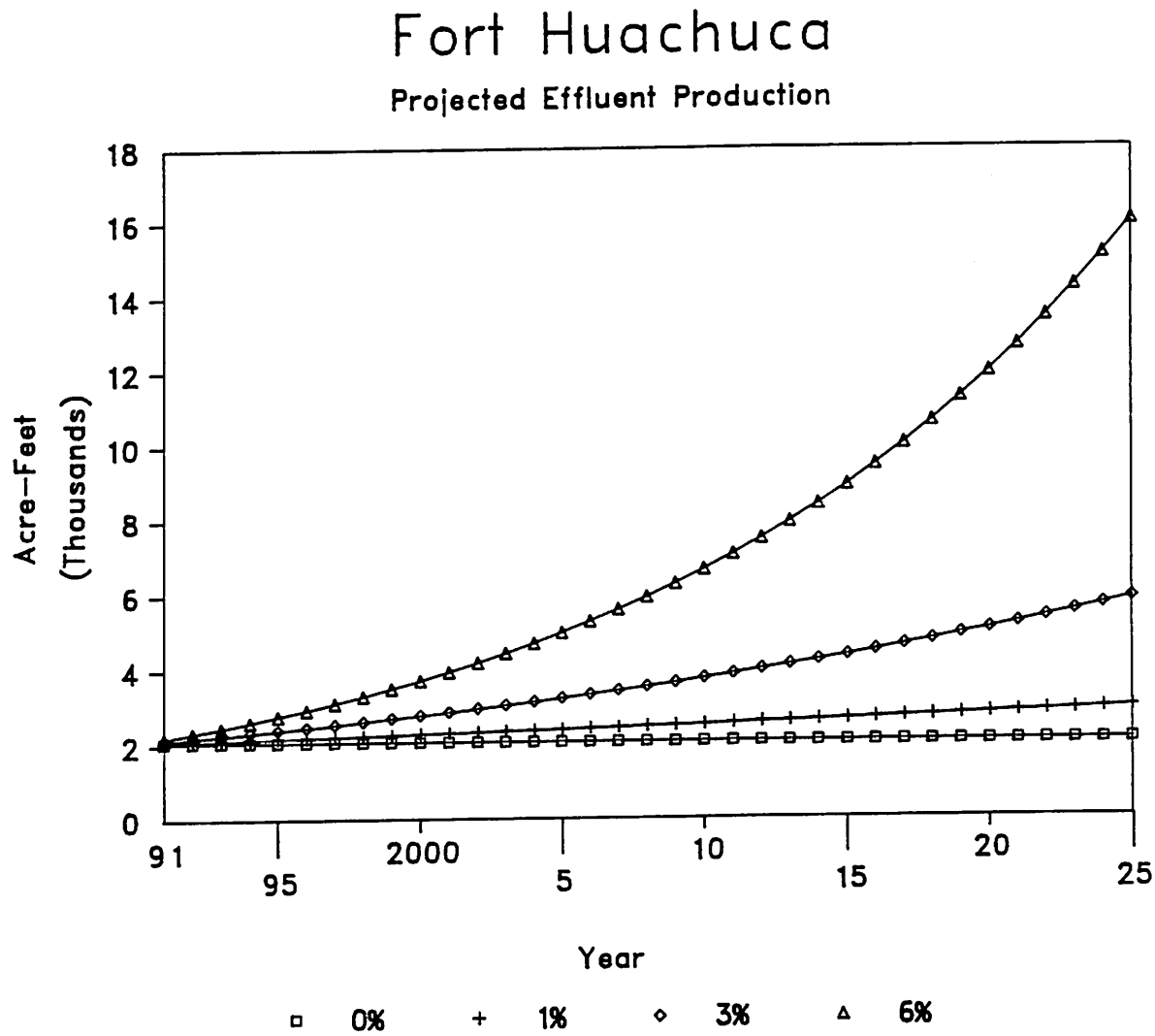


Figure 5-24. Fort Huachuca - projected effluent production using a 139 gpcd effluent production rate and for 0, 1, 3, and 6 percent rate of population increases

Table 5-64 shows the projected effluent production in acre-feet per year for selected years at 0, 1, 3, and 6 percent population growth rates.

Water Uses

This section will discuss the historical water uses and sources as well as current water uses found at Fort Huachuca.

TABLE 5-64

FORT HUACHUCA
EFFLUENT PRODUCTION
(ACRE-FEET PER YEAR)

YEAR	0%	1%	3%	6%
1995	2,084	2,190	2,416	2,789
2000	2,084	2,302	2,801	3,732
2005	2,084	2,419	3,247	4,994
2010	2,084	2,543	3,746	6,683
2015	2,084	2,673	4,363	8,944
2020	2,084	2,809	5,058	11,969
2025	2,084	2,952	5,864	16,017

Historical Water Uses And Sources

Captain Whitside chose the Fort Huachuca site primarily for its abundant water supply, however, the area regularly experienced torrential rains followed by drought. Whitside reported on September 7, 1878, that there was "water, water everywhere from July to September and drought for the remainder of the year." All adobe buildings on post were either washed away or damaged beyond repair as a result of the continuous rain. In 1880, Whitside wrote to the Regional Commander that the reservation needed to be formally surveyed to discourage civilians from settling in Tanner's Canyon (now Garden Canyon) thereby depleting the post water supply. In 1883, the Secretary of War enlarged the Fort to include the area under dispute. (General Orders, No. 36; May 24, 1883).

Water came from Sawmill Spring approximately three miles away from the post at an elevation of about 500 feet above the reservoirs which were 250 feet above the hospital, the lowest point in the camp. Iron pipes transported water from the springs to the reservoirs and then on to the points of distribution on post. Excavated in rock and cemented to inhibit seepage, each of the two reservoirs had a 220,000 gallon capacity. Overflow from these reservoirs watered the parade ground. Flood waters were carried away from post housing by deep open ditches; in front of the enlisted men's barracks and behind officer's quarters. Huachuca Creek flowed at the bottom of the slope behind the barracks and reportedly became a raging river during rain storms.

As early as 1887, the post commander restricted garden irrigation. Post Surgeon Leonard Wood wrote to the Commanding Officer that while there was a plentiful supply of water, its quality was not good. Wood based his assumption on the large number of soldiers being treated in the post hospital for stomach malfunctions a few days after the heavy rains. Apparently, the rains flooded the reservoir so that it became little more than a pool within the stream.

In 1906, plans were considered to abandon Fort Huachuca due to an acute water shortage. However, no actions were taken to move Fort Huachuca. In 1911, with an increase in troop strength, plans were made to complete a pipeline from Garden Canyon to the main post. This pipeline was completed in October 1911. Subsequently, the Army built collection works near the junction of Garden and McClure Canyons with small pipelines going up these canyons to several springs. The water was conveyed some seven miles from the collecting works to the post's 250,000 gallon masonry storage reservoir and a small 4,000 gallon capacity tank located near Carnahan Hill.

Shortages were severe during the summer of 1918. Beginning June 5, the Quartermaster began turning off the water supply during the night. One week later, water flow was restricted to six hours a day, with no water running in the irrigation ditches. By 1932, the Fort had insufficient water. All of it came from springs in Huachuca and Garden Canyons. A well was drilled in Garden Canyon to supplement the main Huachuca Canyon source, but it was never successful. Restrictions on water usage again plagued the Fort during the summers of 1934 and 1935.

In 1936, a large well was installed which tapped into the regional groundwater aquifer. This successfully supplemented the above-ground springs to insure an adequate future supply. Figures for 1940 indicate that the post population of 5,500 used 740 acre-feet of water from the well that year. The amount of water used fluctuated with the Fort population. In 1942, it was utilized as a training ground and housed 40,500 troops. Water pumpage for that year reached a high of 5,400 acre-feet.

The post was deactivated from 1947 until 1951. During this four year period, the reservation was used as a wildlife preserve by the Arizona Game and Fish Commission and for military training by the Arizona National Guard. The Fort was reactiviated in 1951 for two years during the Korean War with a

population of 10,300 and water use of 1,380 acre-feet. It was closed again for a brief time from May 1953 until February 1954 at which time it was designated the U.S. Army Electronic Proving Ground. It has remained active since that date. Water use steadily increased from 2,580 acre-feet in 1954 to 3,300 acre-feet by 1973.

Current Water Uses

1. Municipal Use

Potable water utilized in meeting the municipal demands of Fort Huachuca is supplied by eight production wells. Of this total, six are located in the main post area, the remaining two are located on the East Range. Total current water consumption (1990), not including effluent use, is estimated at 2,748 acre-feet. The pumping capacity of six wells operating sixteen hours per day is 3,500,000 gallons a day or 4,000 acre-feet per year. Fort Huachuca has claimed a total water storage capacity of 5,630,000 gallons per day and a potable water distribution system totaling 1,795,866 lineal feet.

Potable water from springs in Garden and Huachuca Canyons is available to supplement the main municipal supply. At one time, both of these springs provided good quality water part of the time to the post. Turbidity problems during rains as well as chlorination problems resulted in disconnection of these sources from the main distribution system in 1983.

Water from the springs in Garden Canyon, while no longer part of the main municipal supply, is used to fill concrete tanks at the leadership reaction course, and for sustaining water levels at the golf course pond and gravel pit pond.

Currently unused, the Huachuca Canyon source consisted of a gravity feed through a pipeline from the spring. The pipeline is still in place, but the water is rerouted to Huachuca Canyon. As a result, a greater quantity of water is retained in the area for enhanced plant growth and wildlife usage.

Domestic use accounts for a significant amount of the total municipal water demand. An additional quantity of water is needed to maintain turf and landscaped areas. Turf areas currently watered by sprinkler irrigation include the Fort cemetery, Brown Parade field, Henry Circle, as well as turf areas surrounding base residences, the Fort headquarters, and Greely Hall.

2. Irrigation

The Fort currently irrigates two areas that utilize nonpotable water. This water is in the form of effluent produced at the two wastewater treatment plants located within the Fort boundaries shown in Figure 5-25. Fort Huachuca uses the effluent to irrigate Chaffee parade field and the post golf course. These uses are summarized in Table 5-65. Both locations are sprinkler irrigated. Any surplus effluent not used at these locations is disposed of in evaporation ponds. Fort Huachuca has claimed a total of 104,560 (211,420 per letter dated November 13, 1990) lineal feet of nonpotable water lines.

TABLE 5-65

FORT HUACHUCA
IRRIGATION SUMMARY

USE	LOCATION	SOURCE	ACRES
Parade Field	Sec. 31, T.21S., R.20E. Sec. 32, T.21S., R.20E.	E2	10.25
Golf Course	Sec. 04, T.22S., R.20E. Sec. 09, T.22S., R.20E.	E1, E2	84.80

DWR has estimated the annual water requirements for the Chaffee parade field and the post golf course which is described below.

A. Chaffee Parade Field

The parade field consists primarily of pasture grasses and is irrigated by a sprinkler system. Consumptive use for pasture grasses is estimated at 3.2 acre-feet per acre. Total acres irrigated equals 10.25 acres. The sprinkler system was assigned an efficiency of 72 percent. An estimate of water required to meet these needs is calculated as shown in the following equation.

$$\frac{3.2 \text{ acre-feet per acre} \times 10.25 \text{ acres}}{72 \text{ percent}} = 45.6 \text{ acre-feet}$$

B. Golf Course

The turf irrigated at the post golf course has a consumptive use value of 2.5 acre-feet per acre. The golf course is sprinkler irrigated. This

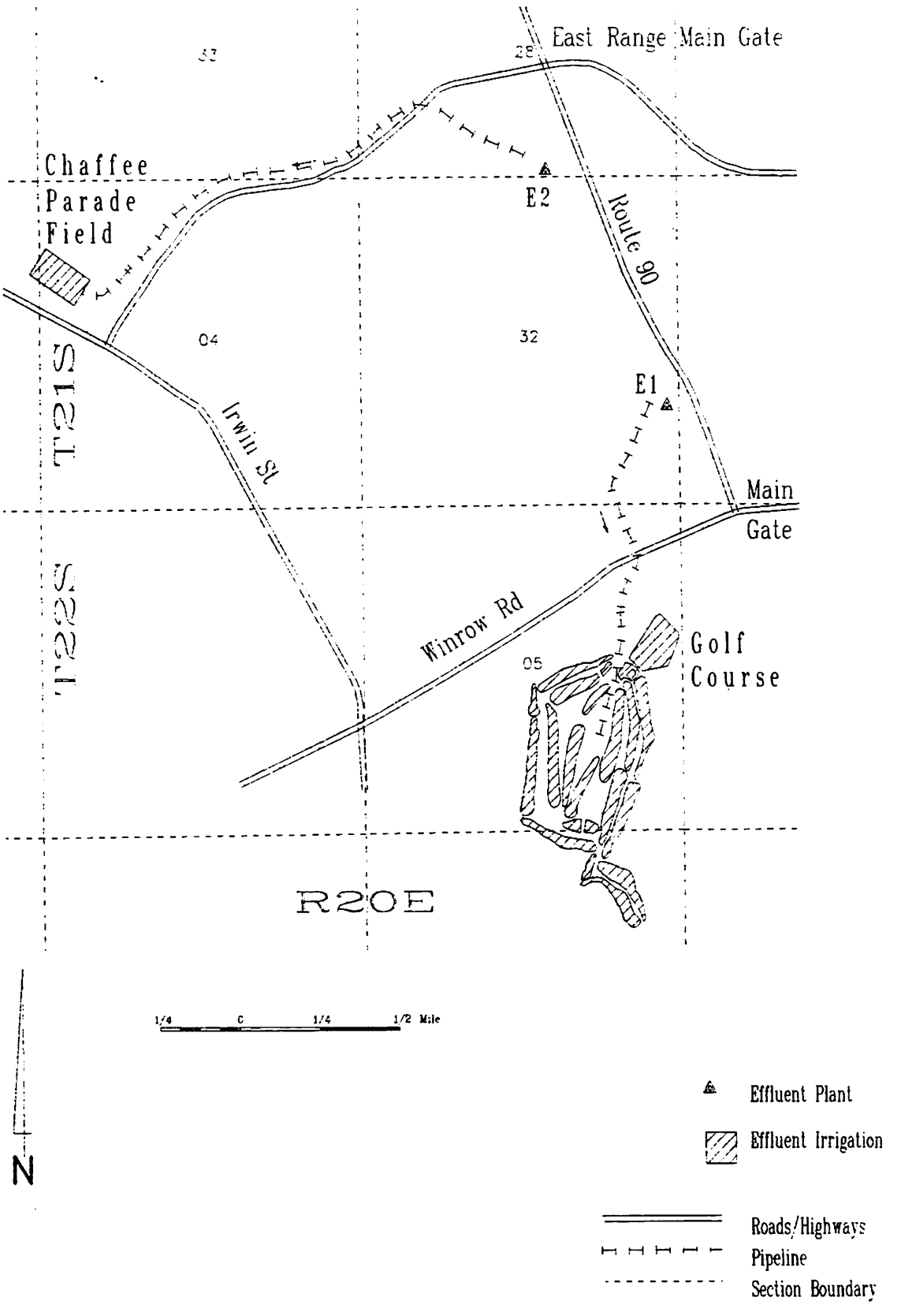


Figure 5-25. Effluent irrigation occurring at Fort Huachuca

irrigation system was also assigned an efficiency of 72 percent. Total irrigated area equals 84.8 acres.

$$\frac{2.5 \text{ acre-feet per acre} \times 84.8 \text{ acres}}{72 \text{ percent}} = 294.4 \text{ acre-feet}$$

The total quantity of effluent needed to satisfy the irrigation needs of the Chaffee parade field and golf course is equal to 340.0 acre-feet.

In 1986, Fort Huachuca was irrigating two additional areas (listening device-sensor fields) with nonpotable water as shown on Figure 5-26. These areas were sprinkler irrigated with groundwater from Rembass wells #1 and #2. Claimed acreage for these two areas was 47.87 acres. As of March 1990, these locations have been allowed to revert back to natural vegetation. (DWR estimates that irrigation requirement for the sensor fields is 212.8 acre-feet per year based on consumptive use of pasture grasses of 3.2 acre-feet per acre and an efficiency for sprinkler irrigation of 72 percent.)

3. Impoundments

The Fort has claimed a total of seventy-four impoundments for various uses such as game management, recreation, erosion control, and sewage evaporation. DWR surveyed sixteen of these impoundments and the remaining fifty-eight impoundments were determined to be less than two surface acres in area at maximum capacity. DWR estimates that total surface area subject to evaporation and seepage losses from these impoundments is eighty-eight surface acres.

The total seepage and evaporation loss is estimated to be 602 acre-feet per year.

4. Recreation Uses

Fort Huachuca has claimed fourteen ponds specifically for recreation and wildlife uses. An additional five ponds are designated for game management purposes.

Despite operating as a military installation, Fort Huachuca does offer a variety of public activities on post. Bird watching, hiking, and picnicking are popular past times. Firearm enthusiasts can enjoy sanctioned trap and skeet shooting competitions as well as bird dog field trials.

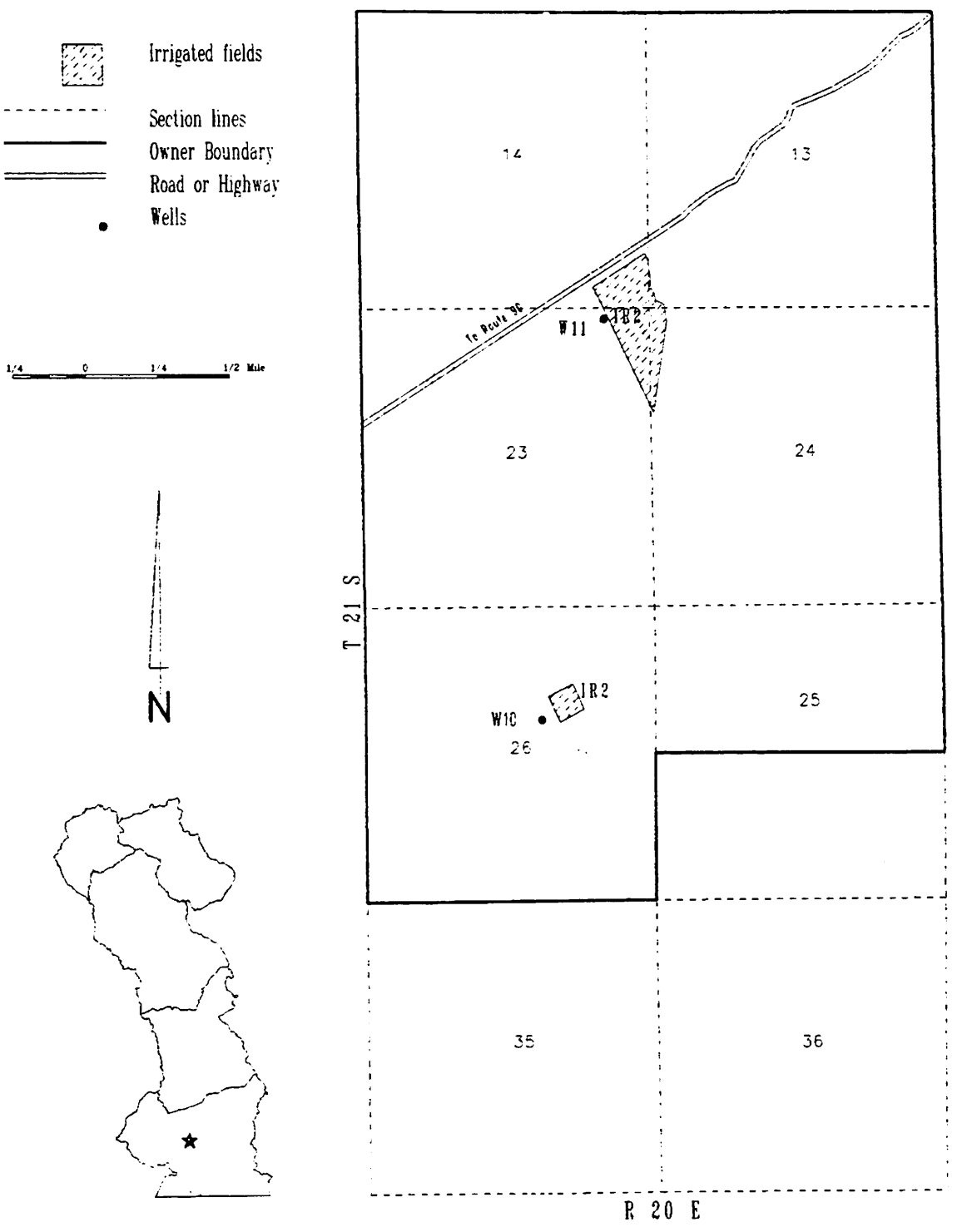


Figure 5-26. Listening device-sensor field irrigation occurring at Fort Huachuca

Water based recreation on post is limited to swimming and fishing. A semi-annual Tag Fishing Derby is held on post. The Fort's fisheries biologist tags trout which are then released into the golf course pond for the fishing competition. Rainbow trout and catfish, in addition to other fish, are released into Lower Garden Canyon pond as part of the Derby Day fishing activities.

5. Wildlife Uses

Fort Huachuca has adopted a multifaceted recreational approach to managing its wildlife resources. Highlights of their endeavors include establishment of warm water fisheries, wildlife habitat improvement, and protection of rare, threatened, and endangered Arizona and federal species. Many of those species are plants. Water conservation involved several projects. Spillways and dams were repaired to reduce erosion damage. Stream banks were stabilized using riprap stones. Renovation, relocation, and new construction of water catchment areas were completed in an effort to increase water availability for wildlife. It has been estimated that nearly one-fourth of all the bird species known to breed in North America have nesting sites in the Huachuca Mountains. The Fort is also home to big game species which include: whitetail deer, desert mule deer, pronghorn antelope, mountain lion, javelina, and black bear. The Fort has claimed a total of 54.2 acre-feet for wildlife in the form of wildlife springs.

6. Other Uses

Additional water uses claimed by the Fort include eight nonpotable wells and nine test wells. The test wells, two windmills, and one well (well #9) are currently capped. Fort Huachuca has stated that these sources have the potential for use during emergencies, mobilization, and to accomodate a change in mission. A majority of claimed nonpotable water is used for general military purposes, washing of vehicles, and dust control during construction.

Other water uses on the Fort include those at Libby Army Airfield. This facility is located on property owned by Fort Huachuca, but is jointly utilized by the Army, Air National Guard, and the City of Sierra Vista. Water uses at the airbase consist of domestic use, washing of equipment, limited irrigation, and fire prevention.

Summary of Current Uses

The estimate of current water use for Fort Huachuca is 3,744 acre-feet as shown in Table 5-66.

TABLE 5-66

FORT HUACHUCA
ESTIMATED CURRENT WATER USE

WATER USE	ESTIMATED WATER USE (ACRE-FEET)
Municipal	2,748
Effluent irrigation	340
Impoundments	602
Recreation and wildlife	54
TOTAL	3,744

Future Water Uses

1. Municipal Use

Figure 5-27 shows DWR's projected future municipal water requirements based on pumpage figures and population estimates for Fort Huachuca supplied by the Fort for the years 1982 to 1990. DWR projected the future municipal requirements based on annual population increases of 0, 1, 3, and 6 percent to provide a representative range of water requirements. Water usage rates were determined by averaging the reported information from the years 1982 to 1990. This rate was determined to be 270 gpcd. This rate is used in DWR's projection which was converted to acre-feet per year. Table 5-67 displays DWR's projection for selected years to the year 2025.

2. Irrigation

Effluent is used on the Fort's Chaffee parade field and golf course. The estimated annual water requirements for these fields is 340 acre-feet per year.

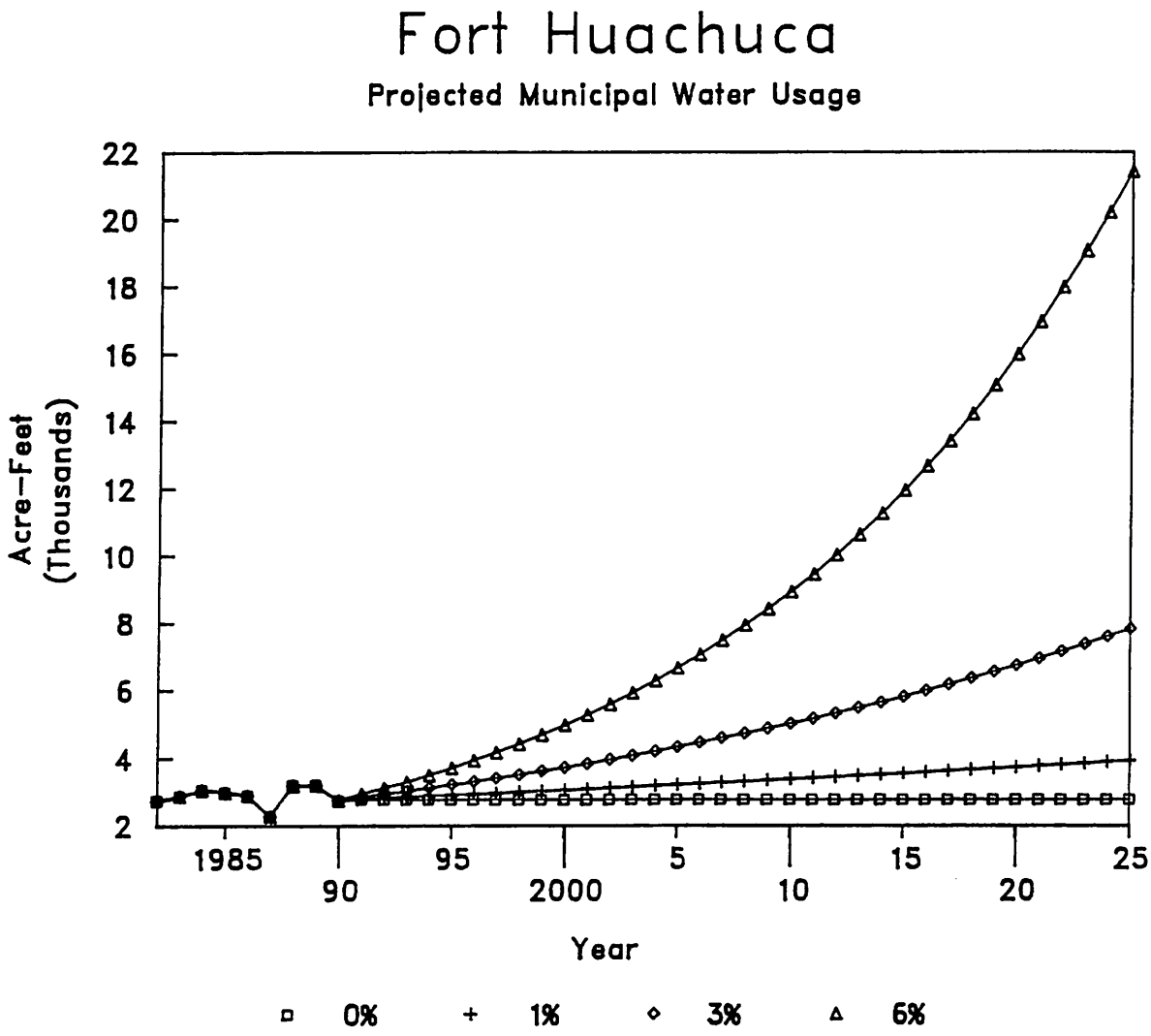


Figure 5-27. Fort Huachuca - projected municipal water use for 0, 1, 3, and 6 percent rates of population increases.

TABLE 5-67

FORT HUACHUCA
PROJECTED MUNICIPAL USE
(ACRE-FEET PER YEAR)

YEAR	0%	1%	3%	6%
1995	2,787	2,929	3,231	3,730
2000	2,787	3,079	3,746	4,991
2005	2,787	3,236	4,342	6,680
2010	2,787	3,401	5,034	8,939
2015	2,787	3,574	5,836	11,962
2020	2,787	3,757	6,785	16,008
2025	2,787	3,948	7,843	21,422

3. Impoundments

The seepage and evaporation losses for the seventy-four impoundments is estimated to be 602 acre-feet per year.

4. Recreation and Wildlife

The estimated water requirements for recreation and wildlife uses is 54 acre-feet per year.

Summary of Total Projected Water Requirements

Table 5-68 shows DWR's estimate of total projected water requirements for Fort Huachuca. The projection is shown for Fort population increases of 0, 1, 3, and 6 percent. The projection includes future municipal water requirements and total other water requirements of 996 acre-feet per year broken down into irrigation uses, impoundments, and recreation and wildlife usage equalling 340, 602, and 54 acre-feet per year.

TABLE 5-68

FORT HUACHUCA
PROJECTED WATER REQUIREMENTS (1)
(ACRE-FEET PER YEAR)

YEAR	0%	1%	3%	6%
1995	3,783	3,925	4,227	4,726
2000	3,783	4,075	4,742	5,987
2005	3,783	4,232	5,338	7,676
2010	3,783	4,397	6,030	9,935
2015	3,783	4,570	6,832	12,958
2020	3,783	4,753	7,781	17,004
2025	3,783	4,944	8,839	22,418

(1) The projection is based on the average Fort population for the years 1982 to 1990 and 270 gpcd rate.

It should be noted that increased or decreased mission requirements at Fort Huachuca cannot be forecasted with accuracy due to political events, funding, technological development, or other aspects of military operations. The projections made by DWR do not take these factors into account and are being presented to provide a basis of comparison to what the Fort has claimed. The projected amounts may not be sufficient to meet all the Fort's water requirements. The amount of water required to fulfill future military

requirements at Fort Huachuca will be totally dependent on the level of future increases (or decreases) in its military operations. An example of this mission change is the recent Department of Defense reorganization which resulted in Fort Huachuca potentially receiving many of the activities and personnel from Fort Devon, Massachusetts, which is being closed.

Quantification of Significant Diminishment to Fort Huachuca

The problem of special interest is, per the instructions of the Court's order of September 9, 1988, to: ". . . determine all stream users or diversions of either surface water or groundwater which significantly affect those sources reasonably available on, at, or near the federal parcel . . . ." (Emphasis added).

The quantification of significant diminishment to Fort Huachuca was conducted with the use of a numerical groundwater flow model developed by the USGS. APPENDIX G provides a detailed description of the methodology that was used to conduct this analysis.

The USGS Modflow model (Freethey, 1982) defined the hydrologic system of the Upper San Pedro Basin. Freethey developed a numerical model based on a conceptualization of the hydrologic system within the basin. The numerical model employed a three-dimensional, block centered, finite difference grid to simulate groundwater flow, stream/aquifer connection, and evapotranspiration. Information on hydraulic properties of the basin fill, recharge from bordering mountain ranges, discharge from evapotranspiration, and exchange of water between aquifer and stream was available from previous work or estimates. The advantages of using the model were that: 1) it is well documented, 2) it can be used to solve complex spatial and temporal relationships in a dynamic hydrologic system, and 3) the model can simulate different scenarios by changing input parameters.

In order to isolate the impacts that off-reservation pumpage has on the Fort's groundwater supply, the model compared two scenarios. The first incorporated groundwater withdrawals due only to the Fort's pumpage. The second incorporated groundwater pumpage for Fort Huachuca and the eight surrounding municipal water companies (including Huachuca City and Sierra Vista). Water level drawdown maps were constructed for the time periods 1940 through 1988 and for 1940 through 2038. These are shown in Figures 5-28 and

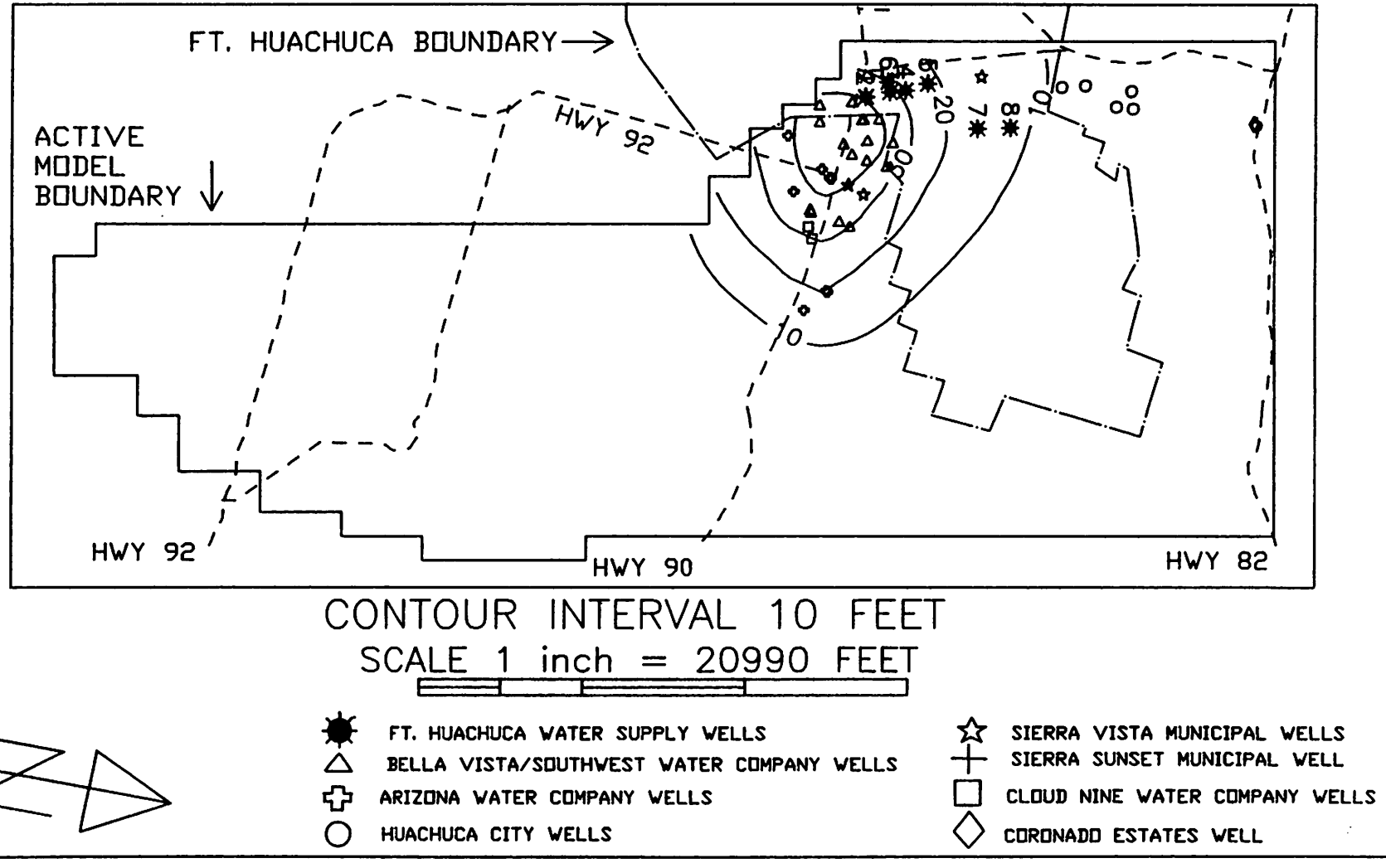


Figure 5-28. Upper San Pedro River basin drawdown map due to municipal pumpage through 1988

5-29. These drawdown maps illustrate the additional lowering of water levels solely from the municipal pumpage over the noted time periods. These drawdown maps do not reflect the total drawdown in the vicinity due to the municipal pumpage and Fort Huachuca pumpage.

The results of the model runs demonstrate that the additional drawdown to Fort Huachuca's wells because of the additional pumpage from the eight surrounding water companies from 1940 through 1988 ranges from thirteen feet at Fort Huachuca well #8 in the East Range, which is furthest from the pumping center, to forty-one feet at wells #1 and #2 nearest to the pumping center. The projected cost to the Fort over the forty-eight year period (1940-1988) could be between $75,000 to $125,000. Table G-4 in APPENDIX G shows this analysis. An explanation and description of the calculations used to derive these numbers are included in the table. The table is an attempt to quantify the economic impact that surrounding pumpage has had and might possibly have on Fort Huachuca's water supply costs. Table G-4 does not reflect actual costs incurred to the Fort by surrounding municipal pumpage. It is only an estimate, using data available to DWR at the time of the analysis.

A pumpage scenario (see Tables G-2 and G-3 in APPENDIX G for details) based on projected increases in population from 1989 through 2038 resulted in additional drawdown of seventy-two feet at well #8 to 223 feet at well #1 and #2. The projected cost from 1989-2038 could be between $500,000 and $1,880,000 over the next fifty years. This calculation was made in present dollars; energy, well deepening, and maintenance costs are not adjusted for inflation, as illustrated in Table G-4 in APPENDIX G. It cannot be overstated that such a fifty year prediction into the future is only one simulation scenario and only one approximation of many possible future growth projections. This particular scenario assumed that the pumpage rates fifty years from now would be 2.2 times the current rates. Such rates may or may not be reached by the year 2038. Future population growth might demand better water conservation techniques that would reflect in less per capita pumpage and subsequently less drawdown than the model results reflect in the Sierra Vista - Fort Huachuca area. Fort Huachuca's response to a lowering of water levels might also result in more pumpage being shifted away from the pumping center to the East Range wells (United States Army Corps of Engineers, 1987). This would result in fewer well deepening costs, repair costs, and a reduction in lift costs.

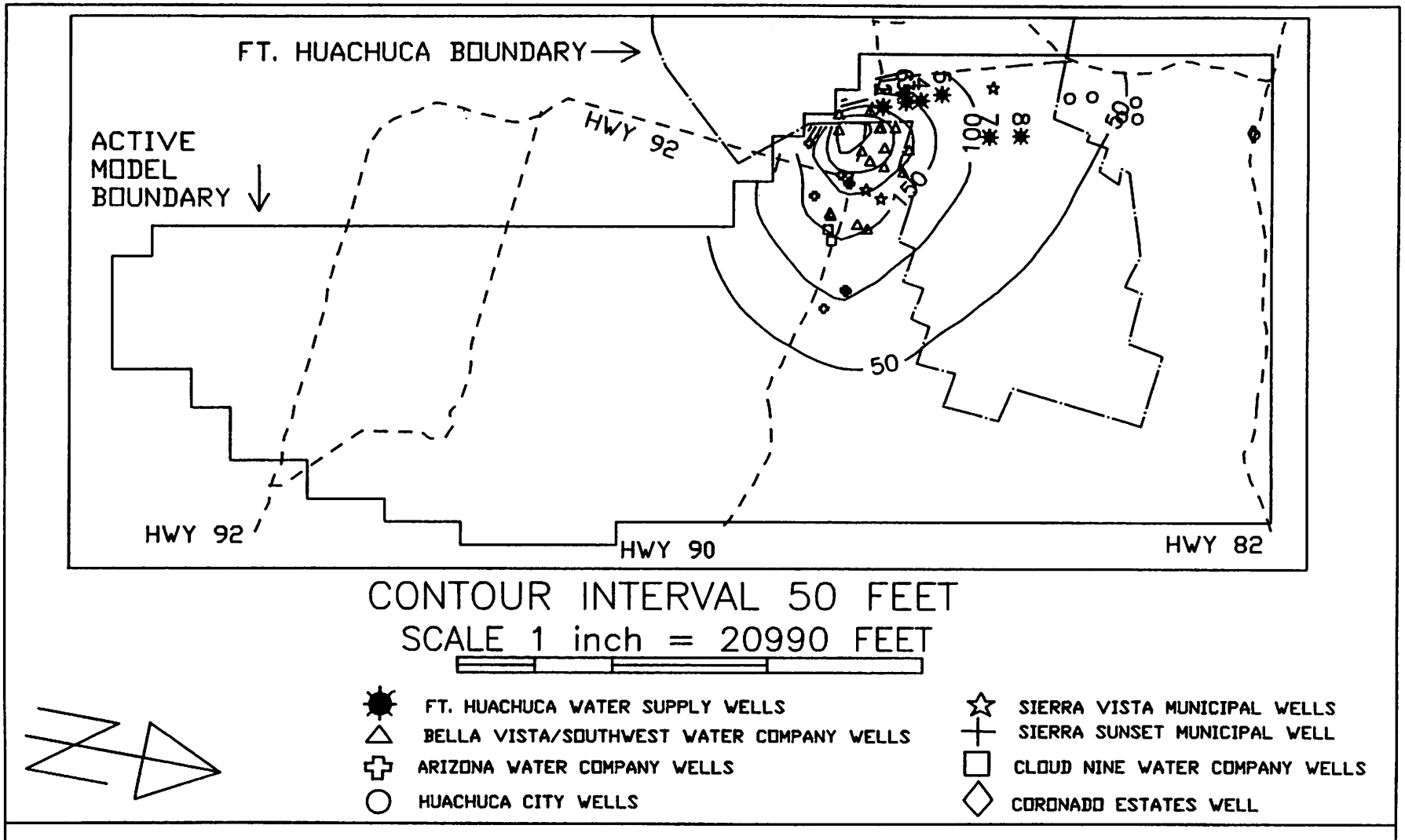


Figure 5-29. Upper San Pedro River basin drawdown map due to municipal pumpage through 2038

TABLE 5-69

UNITED STATES ARMY COMMUNICATIONS COMMAND
FORT HUACHUCA
111-23-73
COMPARISON OF CLAIMANT INFORMATION WITH DWR FINDINGS
STATEMENT OF CLAIMANT 39-10774

CLAIMED INFORMATION							DWR FINDINGS							
CLAIMED SOURCE	CLAIMED LOCATION	CLAIMED USE	NAME [FORT IDENTIFICATION]	CLAIMED WATERCOURSE	CLAIMED ANNUAL USE (AC-FT)	CLAIMED DATE OF FIRST USE	WATER USE NO.	POD NO.	WATER USE TYPE	USE STATUS	WATER USE LOCATION	POINT OF DIVERSION LOCATION	ACREAGE OR CAPACITY (AC-FT)	MAP NUMBER
Well	NESENE 16 21S 20E	DM,ML	Well #8 [W8]	Soldier Creek	412.9[1]	1982	MU1	W1	MU	Verified		NESENE 16 21S 20E		111-20
Well	NWNWNW 22 21S 20E	DM,ML	Well #7 [W7]	Soldier Creek	412.7[1]	1982	MU1	W2	MU	Verified		NWNWNW 22 21S 20E		111-20
Well	SWNESW 28 21S 20E	DM,ML	Well #5 [W5]	Soldier Creek	628.2[1]	1943	MU1	W3	MU,ML	Verified		SWNESW 28 21S 20E		111-20
Well	NENWNE 33 21S 20E	DM,ML	Well #4 [W4]	Soldier Creek	276.5[1]	1943	MU1	W4	MU,ML	Verified		NENWNE 33 21S 20E		111-20
Well	NWNWSE 33 21S 20E	DM,ML	Well #6 [W6]	Soldier Creek	802.4[1]	1959	MU1	W5	MU,ML	Verified		NWNWSE 33 21S 20E		111-20
Well	NWNESE 33 21S 20E	DM,ML	Well #3 [W3]	Soldier Creek	919.6[1]	1943	MU1	W6	MU,ML	Verified		NWNESE 33 21S 20E		111-20
Well	NWNWNW 03 22S 20E	DM,ML	Well #1 [W1]	Soldier Creek	214.9[1]	1940	MU1	W7	MU,ML	Verified		NWNWNW 03 22S 20E		111-23
Well	NWNWNW 03 22S 20E	DM,ML	Well #2 [W2]	Soldier Creek	125.9[1]	1941	MU1	W8	MU,ML	Verified		NWNWNW 03 22S 20E		111-23
Well	NWSESE 29 22S 20E	ML,WL[1]	Well [GW]	Garden Canyon	4.4[1]	1930 (est.)		W9	Capped	Unused		NWSESE 29 22S 20E		111-23
Well	NESWNE 26 21S 20E	ML	Rembass Well #1 [WR1]	Graveyard Gulch	0.8[1]	1978	IR2	W10	ML,IR	Verified	See text/map	NESWNE 26 21S 20E	47.9	See text
Well	SWSESE 14 21S 20E[1]	ML,IR	Rembass Well #2 [WR2]	Graveyard Gulch	1.3[1]	1978	IR2	W11	ML,IR	Verified	See text/map	NWNENE 23 21S 20E		See text
Well	NWSWSE 20 21S 20E	Test	Test Well #1 [TW1]	N/A	0.0			W12	Capped	Unused		NWSWSE 20 21S 20E		111-20
Well	NESWNW 30 21S 20E[1]	Test	Test Well #2 [TW2]	N/A	0.0			W13	Capped	Unused		NESWNW 30 21S 20E		111-20
Well	NENENE 16 21S 20E	Test	Test Well #3 [TW3]	N/A	0.0			W14	Capped	Unused		NENENE 16 21S 20E		111-20
Well	SWSENE 15 21S 20E	Test	Test Well #4 [TW4]	N/A	0.0			W15	Capped	Unused		SWSENE 15 21S 20E		111-20
Well	SESWSW 35 20S 20E	Test	Test Well #6 [TW6}	N/A	0.0			W16	Capped	Unused		SESWSW 35 20S 20E		111-20
Well	SESWNW 11 21S 20E	Test	Test Well #7 [TW7]	N/A	0.0			W17	Capped	Unused		SESWNW 11 21S 20E		111-20
Well	NWNWSW 13 21S 20E	Test	Test Well #8 [TW8}	N/A	0.0			W18	Capped	Unused		NWNWSW 13 21S 20E		111-20
Well	SWSWNW 17 21S 21E	Test	Test Well #9 [TW9]	N/A	0.0			W19	Capped	Unused		SWSWNW 17 21S 21E		111-20
Well	NWSENW 07 21S 21E	ML	East Range Bunker Well [ERB]	Graveyard Gulch	0.5[1]	1958		W20	ML	Source a well		NWSENW 07 21S 21E		111-20
Well	NWSWNW 10 21S 20E[1]	Test	Well #9 [W9]	Soldier Creek	0.0			W21	Capped	Unused		SWNWNW 10 21S 20E		111-20
Well	SENWNW 22 21S 20E[1]	ML	Spatial Resolution Well [SP]	Soldier Creek	66.9	1964		W22	ML	Source a well		SENWNW 22 21S 20E		111-20
Well	NESESW 34 20S 20E	ML	Windmill #1 [WM1]	Soldier Creek	0.0	1910		W23	Capped	Unused		NESESW 34 20S 20E		111-20
Well	SWSESW 27 20S 20E	ML	Windmill #2 [WM2]	Soldier Creek	0.0	1905		W24	Capped	Unused		SWSESW 27 20S 20E		111-20
Well[2]	NENENW 32 22S 20E	WL	Garden Windmill [GWM]	Garden Canyon	0.0	1930		W25	Capped	Unused		NENENW 32 22S 20E		111-23

[1]Amended on August 5, 1991.

[2]Added or amended by amendment dated August 21, 1989.

TABLE 5-69 (cont'd)

CLAIMED INFORMATION							DWR FINDINGS						
CLAIMED SOURCE	CLAIMED LOCATION	CLAIMED USE	NAME [FORT IDENTIFICATION]	CLAIMED WATERCOURSE	CLAIMED ANNUAL USE (AC-FT)	CLAIMED DATE OF FIRST USE	WATER USE NO.	POD NO.	WATER USE TYPE	USE STATUS	WATER USE LOCATION	POINT OF DIVERSION LOCATION	ACREAGE OR CAPACITY (AC-FT)	MAP NUMBER
Spring	NWSW 14 22S 19E	MU	Spring #1 [SPP1]	Huachuca Canyon	5.3[1]	1877	MU1	S1	MU	Verified		NWSW 14 22S 19E		111-23
Spring	NWSW 14 22S 19E	MU	Spring #2 [SPP2]	Huachuca Canyon	5.3[1]	1877	MU1	S2	MU	Verified		NWSW 14 22S 19E		111-23
Spring	NENE 22 22S 19E	MU	Spring #3 [SPP3]	Huachuca Canyon	5.3[1]	1877	MU1	S3	MU	Verified		NENE 22 22S 19E		111-22
Spring	NENE 22 22S 19E	MU	Spring #3a [SPP3a]	Huachuca Canyon	5.3[1]	1877	MU1	S4	MU	Verified		NENE 22 22S 19E		111-22
Spring	NENE 22 22S 19E	MU	Spring #4 [SPP4]	Huachuca Canyon	5.3[1]	1877	MU1	S5	MU	Verified		NENE 22 22S 19E		111-22
Spring	NESW 31 22S 20E	MU	Picnic Spring [PICNIC]	Garden Canyon	12.0[1]	1877	MU1	S7	MU	Verified		NESW 31 22S 20E		111-23
Spring	SWSW 31 22S 20E	MU	Chain Spring [CHAIN]	Garden Canyon	12.0[1]	1877	MU1	S8	MU	Verified		SWSW 31 22S 20E		111-23
Spring	SESE 36 22S 19E	MU	Spring #1 [SPP1]	Garden Canyon	12.0[1]	1877	MU1	S9	MU	Verified		SESE 36 22S 19E		111-23
Spring	SESE 36 22S 19E	MU	Spring #1b [SPP1b]	Garden Canyon	12.0[1]	1877	MU1	S10	MU	Verified		NENE 01 23S 19E		111-23
Spring	NENE 01 23S 19E	MU	Spring #1a [SPP1a]	Garden Canyon	12.0[1]	1877	MU1	S11	MU	Verified		NENE 01 23S 19E		111-23
Spring	NESW 01 23S 19E	MU	Spring #3 [SPP3]	Garden Canyon	12.0[1]	1877	MU1	S12	MU	Verified		NESW 01 23S 19E		111-23
Spring	NESW 01 23S 19E	MU	Spring #2 [SPP2]	Garden Canyon	12.0[1]	1877	MU1	S13	MU	Verified		NESW 01 23S 19E		111-23
Spring	SWSW 01 23S 19E	MU	Spring #4 [SPP4]	Garden Canyon	12.0[1]	1877	MU1	S14	MU	Verified		SWSW 01 23S 19E		111-23

KEY: DM = Domestic; E = Effluent (POD); EC = Erosion Control; FC = Flood Control; IR = Irrigation; ML = Military; MU = Municipal; POD = Point of Diversion; PS = Primary Storage Reservoir; RC = Recreation; SE = Sewage Evaporation; SP = Wildlife Pond; SR = Small Reservoir; W = Well (POD); WL = Wildlife

[1]Amended on August 5, 1991.

TABLE 5-70

UNITED STATES ARMY COMMUNICATIONS COMMAND
FORT HUACHUCA
111-23-73
COMPARISON OF CLAIMANT INFORMATION WITH DWR FINDINGS
STATEMENT OF CLAIMANT 39-10775

CLAIMED INFORMATION							DWR FINDINGS							
CLAIMED SOURCE	CLAIMED LOCATION	CLAIMED USE	NAME [FORT IDENTIFICATION]	CLAIMED WATERCOURSE	CLAIMED ANNUAL USE (AC-FT)	CLAIMED DATE OF FIRST USE	WATER USE NO.	POD NO.	WATER USE TYPE	USE STATUS	WATER USE LOCATION	POINT OF DIVERSION LOCATION	ACREAGE OR CAPACITY (AC-FT)	MAP NUMBER
Effluent[2]	SENESE 31 21S 20E	IR	Golf Course [Z-1/32a]	N/A	631.3	1954		E1	RC	Verified	See text	SENESE 33 21S 20E	84.8	See text
Effluent[2]	SENESE 31 21S 20E	IR	Golf Course [Z-1/32b]	N/A	631.2	1954		E1	RC	Verified	See text			
Effluent[2]	SWSESE 28 21S 20E	IR	Chaffee Parade Field [Z-2]	N/A	499.0	1954		E2	IR	Verified	See text	SWSWSE 28 21S 20E	10.3	See text
Spring	SWSW 26 21S 19E	WL	Spring #21 [SP21]	Slaughterhouse Canyon	1.0	1954	WL1		WL	Spring	SWSW 26 21S 19E			111-20
Spring	NWSW 32 21S 19E	WL	Spring #22 [SP22]	Sycamore Canyon	2.6	1954	WL2		WL	Spring	NWSW 32 21S 19E			111-19
Spring	NWNE 04 22S 19E	WL	Spring #20 [SP20]	Slaughterhouse Canyon	1.0	1954	WL3		WL	Spring	NWNE 04 22S 19E			111-22
Spring	SENE 08 22S 19E	WL	Spring #19 [SP19]	Blacktail Canyon	2.6	1954	WL4		WL	Spring	SENE 08 22S 19E			111-22
Spring	NWNE 16 22S 19E	WL	Spring #18 [SP18]	Blacktail Canyon	2.6	1954	WL5		WL	Spring	NWNE 16 22S 19E			111-22
Spring	SENW 15 22S 19E	WL	Spring #17 [SP17]	Huachuca Canyon	2.6	1954	WL6		WL	Spring	SENW 15 22S 19E			111-22
Spring	NWSW 14 22S 19E	WL	Spring #16 [SP16]	Huachuca Canyon	1.0	1954	WL7		WL	Spring	NWSW 14 22S 19E			111-23
Spring	NWSE 22 22S 19E	WL	Spring #15a [SP15a]	Huachuca Canyon	1.0	1954	WL8		WL	Spring	NWSE 22 22S 19E			111-22
Spring	NESE 07 22S 20E	WL	Spring #12 [SP12]	Soldier Creek	1.0	1954	WL9		WL	Spring	NESE 07 22S 20E			111-23
Spring	SWSW 13 22S 19E	WL	Spring #13 [SP13]	Soldier Creek	2.6	1954	WL10		WL	Spring	SWSW 13 22S 19E			111-23
Spring	NESW 20 22S 20E	WL	Spring #11 [SP11]	Woodcutters Canyon	1.0	1954	WL11		WL	Spring	NESW 20 22S 20E			111-23
Spring	SENW 21 22S 20E[1]	WL	Spring #23 [SP23]	Trib. to Garden Wash	1.0	1954	WL12		WL	Spring	SENW 21 22S 20E			111-23
Spring	SWNE 27 22S 19E[1]	WL	Spring #14 [SP14]	Huachuca Canyon	2.6	1954	WL13		WL	Spring	SWNE 27 22S 19E			111-22
Spring	NESE 35 22S 19E	WL	Spring #5 [SP5]	McClure Canyon	4.2	1954	WL14		WL	Spring	NESE 35 22S 19E			111-23
Spring	SWSW 19 22S 20E	WL	Spring #10 [SP10]	Woodcutters Canyon	2.6	1954	WL15		WL	Spring	SWSW 19 22S 20E			111-23
Spring	NWSE 25 22S 19E	WL	Spring #9 [SP9]	Woodcutters Canyon	4.2	1954	WL16		WL	Spring	NWSE 25 22S 19E			111-23
Spring	SWNW 36 22S 19E	WL	Spring #7 [SP7]	McClure Canyon	2.6	1954	WL17		WL	Spring	SWNW 36 22S 19E			111-23
Spring	SWSE 31 22S 19E[1]	WL	Spring #8 [SP8]	Garden Canyon	2.6	1954	WL18		WL	Spring	SWSE 25 22S 19E			111-23
Spring	NESE 33 22S 20E[1]	WL	Spring #2 [SP2]	Tinker Canyon	2.6	1954	WL19		WL	Spring	NESE 33 22S 20E			111-23
Spring	SESW 36 22S 19E[1]	WL	Spring #6 [SP6]	McClure Canyon	2.6	1954	WL20		WL	Spring	SESW 36 22S 19E			111-23
Spring	SESW 36 22S 19E[1]	WL	Spring #25 [SP25]	Trib. to McClure Canyon	1.4	1954	WL21		WL	Spring	SESW 36 22S 19E			111-23
Spring	NESE 33 22S 20E[1]	WL	Spring #3 [SP3]	Tinker Canyon	1.0	1954	WL22		WL	Spring	NWSE 33 22S 20E			111-23
Spring	NWNW 07 23S 20E	WL	Spring #24 [SP24]	Scheelite Canyon[1]	1.0	1954	WL23		WL	Spring	NWNW 07 23S 20E			111-23
Spring	SWSW 07 23S 20E	WL	Spring #4 [SP4]	Sawmill Canyon	4.2	1954	WL24		WL	Spring	SWSW 07 23S 20E			111-23
Spring	SWSW 01 23S 19E[1]	WL[1]	Cabin Spring [CABIN]	Garden Canyon	2.6[1]	1877	WL25		WL	Spring	SWSW 01 23S 19E			111-23

[1]Amended on August 5, 1991.

[2]Added or amended by amendment dated August 21, 1989.

TABLE 5-70 (cont'd)

CLAIMED INFORMATION							DWR FINDINGS							
CLAIMED SOURCE	CLAIMED LOCATION	CLAIMED USE	NAME [FORT IDENTIFICATION]	CLAIMED WATERCOURSE	CLAIMED ANNUAL USE (AC-FT)	CLAIMED DATE OF FIRST USE	WATER USE NO.	POD NO.	WATER USE TYPE	USE STATUS	WATER USE LOCATION	POINT OF DIVERSION LOCATION	ACREAGE OR CAPACITY (AC-FT)	MAP NUMBER
Spring[2]	SESE 22 22S 19E	WL	Moss Falls [SP15b]	Huachuca Canyon	0.0	1877	WL26		WL	Spring	SESE 22 22S 19E			111-22
Dam	NWSW 16 21S 19E	RC,WL	Antelope [19]	Trib. to Babocomari	4.8	1954	PS1		RC,WL	Verified	NWSW 16 21S 19E		26.4	111-19
Dam	SESW 20 21S 19E	RC,WL	Sycamore [9]	Sycamore Canyon	6.0	1954	PS2		RC,WL	Verified	SESW 20 21S 19E		38.8	111-19
Dam	SENW 28 21S 19E	RC,WL	Hidden [5]	Blacktail Canyon	5.6	1954	PS3		RC,WL	Verified	SENW 28 21S 19E		22.5	111-19
Dam	NWNE 09 22S 20E	RC,WL	Golf Course [2]	Trib. to Soldier Creek	14.4	1954	PS4		RC,WL	Verified	NWNE 09 22S 20E		59.7	111-23
Dam	NESE 17 22S 20E	RC,WL	Gravel Pit [1]	Trib. to Woodcutters Canyon	11.5	1954	PS5		RC,WL	Verified	NESE 17 22S 20E		57.4	111-23
Dam	NENE 03 21S 20E[1]	EC,FC	[k]	Trib. to Soldier Creek	0.5	1977	SP1		WL,EC,FC	Verified	NENE 03 21S 20E			111-20
Dam	NENE 09 21S 20E	EC,FC	[l]	Trib. to Soldier Creek	0.5	1977	SP2		WL,EC,FC	Verified	NENE 09 21S 20E			111-20
Dam	SENW 21 20S 21E	WL	[r]	Trib. to San Pedro River	0.3	1976	SP3		WL	Verified	NENW 21 20S 21E			111-20
Dam[2]	SENW 16 21S 19E	WL	Lower Antelope [41]	Sycamore Canyon	6.0	1975[1]	SP4		WL	Verified	SENW 16 21S 19E		14.9	111-19
Dam[2]	NESW 29 21S 19E	RC[1]	Sycamore II [42]	Sycamore Canyon	7.0	1975[1]	SP5		WL	Verified	NESW 29 21S 19E		10.5	111-19
Dam	SWNE 26 21S 19E	EC,FC	Buffalo Corral [12]	Sycamore Canyon[1]	0.5[1]	1954	SP6		WL	Verified	SWNE 26 21S 19E			111-20
Dam	SWNE 31 21S 19E[1]	EC,FC	[39a]	Trib. to Sycamore Canyon	0.5	1954	SP7		WL,EC,FC	Verified	SWNE 31 21S 19E			111-19
Dam[2]	NWSE 21 22S 19E[1]	EC,FC	West Huachuca [14]	Huachuca Canyon	0.7	1954	SP8		WL	Verified	SWNE 21 22S 19E			111-22
Dam	SESE 07 21S 20E	EC,FC	Lower Huachuca [23]	Huachuca Canyon	4.8	1954	SP9		WL,EC,FC	Verified	SESE 07 21S 20E			111-20
Dam	NWSE 18 21S 20E	WL	[q]	Trib. to Huachuca Canyon	0.5	1954	SP10		WL	Verified	NWSE 18 21S 20E			111-20
Dam	SENE 10 21S 20E	EC,FC	[j]	Trib. to Soldier Creek	0.5	1977	SP11		WL,EC,FC	Verified	SENE 10 21S 20E			111-20
Dam	SWNW 15 21S 20E[1]	SE	Sediment [34d]	Soldier Creek	4.0	1978	SP12		WL,EC,FC,SE	Verified	SWNW 15 21S 20E		29.6	111-20
Dam	SENE 14 21S 20E	EC,FC	East #3 [37]	Trib. to San Pedro River	3.2	1954	SP13		WL,EC,FC	Verified	SENE 14 21S 20E			111-20
Dam[2]	SWSW 16 21S 20E	EC[1],WL	Gate #5 Pond [44]	Huachuca Canyon	0.4	1975[1]	SP14		WL	Verified	SWSW 16 21S 20E			111-20
Dam[2]	NENE 21 21S 20E	SE	Sediment [34c]	Soldier Creek	1.0	1978	SP15		WL,EC,FC	Verified	NENE 21 21S 20E		6.0	111-20
Dam[2]	SWNE 21 21S 20E	SE	#3 Sewage [46]	Soldier Creek	2.2	1975[1]	SP16		SE,WL	Verified	SWNE 21 21S 20E		11.0	111-20
Dam[2]	NESE 10 21S 20E[1]	WL	Pond [45]	Soldier Creek	0.4	1975[1]	SP17		WL	Verified	NWSE 10 21S 20E			111-20
Dam	NWSE 21 21S 20E[1]	SE	Sediment [34a]	Soldier Creek	1.7[1]	1978	SP18		WL,SE	Verified	NWSE 21 21S 20E		12.0	111-20
Dam[2]	NESE 21 21S 20E	SE[1],WL	#2 Sewage [47]	Soldier Creek	0.9	1975[1]	SP19		WL	Verified	SWSE 21 21S 20E		5.5	111-20
Dam	SESE 21 21S 20E	SE	Sediment #3 [34]	Soldier Creek	16.5	1954	SP20		SE,WL	Verified	SESE 21 21S 20E			111-20
Dam	NWNE 36 21S 19E	EC,FC,RC	[m]	Huachuca Wash	2.8	1979	SP21		WL,EC,FC	Verified	NWNE 36 21S 19E			111-20
Dam	NESW 27 21S 20E[1]	EC,FC	East #4 [38]	Soldier Creek	4.1	1954	SP22		WL,EC,FC	Verified	NESW 27 21S 20E			111-20
Dam	SESW 06 22S 20E[1]	EC,FC	Lower Fly [27]	Soldier Creek	6.0	1954	SP23		WL,EC,FC	Verified	SESW 06 22S 20E			111-23
Dam	SWSW 06 22S 19E[1]	WL	Fly [8]	Soldier Creek	0.9	1954	SP24		WL,EC,FC	Verified	SESW 06 22S 20E			111-23
Dam[2]	SESW 06 22S 20E	EC[1]	Horse Pasture [48]	Soldier Creek	0.6	1975[1]	SP25		WL,EC	Verified	SESW 06 22S 20E			111-23
Dam	SESW 06 22S 20E	EC,FC[1]	Lower Horse Pasture [29]	Soldier Creek	0.8[1]	1954	SP26		WL,EC,FC	Verified	SESW 06 22S 20E			111-23
Dam	NWNW 10 22S 20E	EC,FC	Woodcutters [18]	Woodcutter Canyon	4.5[1]	1954	SP29		WL,EC,FC	Verified	NWSW 10 22S 20E		20.7	111-23
Dam	SENE 13 22S 19E	EC,FC	Upper Soldier Creek [7]	Rock Spring Creek	1.6	1954	SP30		WL,EC,FC	Verified	SENE 13 22S 19E			111-23

[1]Amended on August 5, 1991.

[2]Added or amended by amendment dated August 21, 1989.

TABLE 5-70 (cont'd)

CLAIMED INFORMATION							DWR FINDINGS						
CLAIMED SOURCE	CLAIMED LOCATION	CLAIMED USE	NAME (FORT IDENTIFICATION)	CLAIMED WATERCOURSE	CLAIMED ANNUAL USE (AC-FT)	CLAIMED DATE OF FIRST USE	WATER USE NO.	POD NO.	WATER USE TYPE	USE STATUS	WATER USE LOCATION	POINT OF DIVERSION LOCATION	ACREAGE OR CAPACITY (AC-FT)	MAP NUMBER
Dam	NWNE 16 22S 20E	EC,FC	Woodcutters [1b]	Woodcutter Canyon	2.0	1979	SP31		WL,EC,FC	Verified	NWNE 16 22S 20E		8.4	111-23
Dam	NWNE 15 22S 20E	EC,FC	[p]	Trib. to Garden Canyon	0.5	1954	SP32		WL,EC,FC	Verified	SWNE 15 22S 20E			111-23
Dam	NWSW 16 22S 20E	EC,FC	Woodcutters [1a]	Woodcutters Canyon	2.0	1979	SP33		WL,EC,FC,RC	Verified	SENW 16 22S 20E			111-23
Dam	NESW 20 22S 20E	EC,FC	Upper Woodcutters [17]	Woodcutters Canyon	7.0	1954	SP34		WL,EC,FC	Verified	NESW 20 22S 20E			111-23
Dam	NWNE 10 22S 20E[1]	EC,FC	Lower Woodcutters [1c]	Woodcutters Canyon	2.0[1]	1979	SP35		WL,EC,FC	Verified	SWNE 10 22S 20E			111-23
Dam[2]	SESE 10 21S 21E	WL	Pond [51]	Graveyard Gulch	3.0	1975[1]	SP36		WL	Verified	SESE 10 21S 21E			111-20
Dam	NWNE 20 21S 21E[1]	EC,FC	[e]	Trib. to Graveyard Gulch	0.5	1954	SP37		WL,EC,FC	Verified	NWNE 20 21S 21E			111-20
Dam	SWNW 20 21S 21E	EC,FC	[f]	Trib. to Graveyard Gulch	0.5	1977	SP38		WL,EC,FC	Verified	SWNW 20 21S 21E			111-20
Dam	SWSW 23 22S 20E	EC,FC	Lower Garden Canyon [26]	Garden Canyon	3.0	1954	SP39		WL,EC,FC	Verified	SESE 22 22S 20E			111-23
Dam	NENE 28 22S 20E	EC,FC,RC	Lower Garden [n]	Garden Wash	5.2	1979	SP40		WL,EC,FC	Verified	NENE 28 22S 20E		16.9	111-23
Dam[2]	NWNE 28 22E 20E	RC[1],WL	Mid. Garden Canyon [52]	Garden Wash	8.5	1975[1]	SP41		WL	Verified	NWNE 28 22S 20E		27.1	111-23
Dam	SESW 33 22S 20E[1]	WL,RC	Tinker[1] [a]	Trib. to Garden Canyon	0.5	1954	SP42		WL	Verified	SESW 33 22S 20E			111-23
Dam[2]	NESW 21 22S 19E	EC,WL	West Huachuca #2 [43]	Huachuca Canyon	0.3	1975[1]	SP43		WL	Verified	NESW 21 22S 19E			111-22
Dam	SESE 02 23S 19E[1]	EC,FC	Boy Scout Cabin [16]	Garden Canyon	0.5	1954	SP44		WL,EC,FC	Verified	SESE 02 23S 19E			111-23
Dam	SESE 31 21S 19E	WL,EC,FC	[o]	Trib. to Sycamore Wash	0.5	1954	SP45		WL,EC,FC	Verified	SESE 31 21S 19E			111-19
Dam	SWNE 15 21S 19E	WL	North [21]	Trib. to Babocomari River	0.3	1954	SP46		WL	Verified	SWNE 15 21S 19E			111-19
Dam	NENE 14 21S 19E[1]	RC,WL,EC[1]	Unknown West [25]	Slaughterhouse Wash	0.2	1954	SP47		WL,EC	Verified	SWNE 14 21S 19E			111-20
Dam	NWSE 27 21S 19E[1]	WL	Power Line [20]	Blacktail Canyon	1.3	1954	SP48		WL	Verified	NWSE 27 21S 19E			111-19
Dam	NWNW 35 21S 19E[1]	EC,FC	Landing Strip [11]	Coyote Canyon	0.9	1954	SP49		WL,EC,FC	Verified	NWNW 35 21S 19E			111-20
Dam	NWSW 14 22S 19E	EC,FC	Huachuca Canyon [22]	Huachuca Canyon	0.2	1954	SP50		WL,EC,FC	Verified	NWSW 14 22S 19E			111-23
Dam	NWSE 22 22S 19E	EC,FC	Huachuca Corral [15]	Huachuca Canyon	0.4	1954	SP51		WL,EC,FC	Verified	NESE 22 22S 19E			111-22
Dam	NENE 10 21S 20E[1]	EC,FC	[h]	Trib. to Soldier Creek	0.5	1977	SP52		WL,EC,FC	Verified	SENE 10 21S 20E			111-20
Dam	SENW 10 21S 20E[1]	EC,FC	[i]	Trib. to Soldier Creek	0.5	1977	SP53		WL,EC,FC	Verified	SENW 10 21S 20E			111-20
Dam	SENE 16 21S 20E[1]	SE	East #1 [35]	Soldier Creek	3.6	1954	SP54		WL,SE	Verified	SENE 16 21S 20E			111-20
Dam	SENE 21 21S 20E	SE	Sediment [34b]	Soldier Creek	2.5[1]	1978	SP55		SE	Verified	SENE 21 21S 20E			111-20
Dam	NESE 18 21S 21E[1]	EC,FC	[b]	Trib. to Graveyard Gulch	0.5	1977	SP56		WL,EC,FC	Verified	NESE 18 21S 21E			111-20
Dam	NWSW 17 21S 21E[1]	EC,FC	[g]	Trib. to Graveyard Gulch	0.5	1977	SP57		WL,EC,FC	Verified	NWSW 17 21S 21E			111-20
Dam	NWSW 17 21S 21E[1]	EC,FC	[c]	Trib. to Graveyard Gulch	0.5	1977	SP58		WL,EC,FC	Verified	NWSW 17 21S 21E			111-20
Dam	NWNE 20 21S 21E[1]	EC,FC	[d]	Trib. to Graveyard Gulch	0.5	1977	SP59		WL,EC,FC	Verified	NWNE 20 21S 21E			111-20
Dam	NWNE 22 21S 19E	EC[1],WL	Lower Blacktail [24]	Blacktail Canyon	0.5	1954	SR1		RC,WL	Verified	NWNE 22 21S 19E			111-19
Dam	SWSE 23 21S 19E	RC,WL,EC,FC	Slaughterhouse [10]	Slaughterhouse Canyon	8.4	1954	SR2		RC,WL,EC,FC	Verified	SWSE 23 21S 19E			111-20
Dam	NWSW 32 21S 19E	RC	Kino[2] [39]	Trib. to Sycamore Canyon	1.4	1954	SR3		RC	Verified	NWSW 32 21S 19E			111-19
Dam	SENE 16 22S 19E	RC,WL	Blacktail [13]	Blacktail Canyon	0.8	1954	SR4		RC,WL,EC,FC	Verified	NESE 16 22S 19E			111-22
Dam	NESE 01 22S 19E	RC,WL	Officers Club [3]	Soldier Creek	12.2	1954	SR5		RC,WL	Verified	NESE 01 22S 19E			111-23

[1]Amended on August 5, 1991.

[2]Added or amended by amendment dated August 21, 1989.

TABLE 5-70 (cont'd)

CLAIMED INFORMATION							DWR FINDINGS							
CLAIMED SOURCE	CLAIMED LOCATION	CLAIMED USE	NAME [FORT IDENTIFICATION]	CLAIMED WATERCOURSE	CLAIMED ANNUAL USE (AC-FT)	CLAIMED DATE OF FIRST USE	WATER USE NO.	POD NO.	WATER USE TYPE	USE STATUS	WATER USE LOCATION	POINT OF DIVERSION LOCATION	ACREAGE OR CAPACITY (AC-FT)	MAP NUMBER
Dam	NENE 07 22S 20E	RC,WL,EC,FC	Lower Soldier Creek [6]	Rock Spring Creek	0.6	1954	SR6		RC,WL,EC,FC	Verified	SENE 07 22S 20E			111-23
Dam	SWSE 02 23S 19E[1]	RC,WL	Upper Garden [30]	Garden Canyon	0.4	1954	SR7		RC,WL	Verified	SWSE 02 23S 19E			111-23
Dam	NWSE 04 22S 20E[1]	EC,FC	Fairway [31]	Soldier Creek	0.4	1954	SR9		RC,WL	Verified	NWSE 04 22S 20E			111-23
Dam[2]	NWNE 04 22S 20E	RC	Golf Course Fairway [50]	Soldier Creek	0.2	1975[1]	SR10		RC,WL	Verified	SWSE 04 22S 20E			111-23
E01[2]	SENESE 33 21S 20E	SE	Sediment #1a [32a]	Soldier Creek	2.2	1954				See text	SENESE 33 21S 20E			See text
E01[2]	SENESE 33 21S 20E	SE	Sediment #1b [32b]	Soldier Creek	2.2	1984				See text	SENESE 33 21S 20E			See text
E02[2]	SWSWSE 28 21S 20E	SE	Sediment #2 [33]	Soldier Creek	5.5	1954				See text	SWSWSE 28 21S 20E			See text
Dam[3]	SESW 24 21S 19E	RC,WL	Pan Am [4]	Huachuca Canyon	3.2	1954	Destroyed by Libby Air Field Expansion in 1985.							
Dam[3]	SWSW 06 22S 20E	EC	Upper Horse Pasture [28]	Soldier Creek	0.9	1954	Not found by Fort Huachuca.							
Dam[3]	NENE 04 21S 20E	EC	East #2 [36]	Trib. to Babocomari River	0.9	1954	Not found by DWR or Fort Huachuca.							

KEY: DM = Domestic; E = Effluent (POD); EC = Erosion Control; FC = Flood Control; IR = Irrigation; ML = Military; MU = Municipal; POD = Point of Diversion; PS = Primary Storage Reservoir; RC = Recreation; SE = Sewage Evaporation; SP = Wildlife Pond; SR = Small Reservoir; W = Well (POD); WL = Wildlife

[1]Amended on August 5, 1991.

[2]Added or Amended by amendment dated August 21, 1989.

[3]No longer claimed by Fort Huachuca, but no amendment received.

NATIONAL PARK SERVICE - Coronado National Memorial (WFR #111-23-16)

The Coronado National Memorial, an area of approximately 4,724 acres, is located at the southern end of the Huachuca Mountains sixteen miles south of Sierra Vista.

The Memorial was established by President Truman in 1952 from lands originally reserved as part of the Huachuca Forest Reserve, created by Proclamation on November 6, 1906 (34 Stat. 3255), for the "purpose of permanently commemorating the explorations of Francisco Vasquez de Coronado."

Legal Record

Table 5-71, as well as Figure 5-30, illustrate the legal record affecting the current boundaries of the Memorial.

TABLE 5-71

CORONADO NATIONAL MEMORIAL
LEGAL RECORD ESTABLISHING THE CORONADO NATIONAL MEMORIAL

LEGAL ACTION	DATE	BRIEF DESCRIPTION
Presidential Proclamation (34 Stat. 3255)	11/16/06	Created Huachuca Forest Reserve
Public Law 216 (55 Stat. 630)	8/18/41	Authorization and guidelines by Congress for the establishment by Proclamation of the memorial
Presidential Proclamation 2995 (66 Stat. 510)	11/05/52	Memorial established
Public Land Order 1865	5/28/59	Boundary change
Public Law 86-689 (74 Stat. 736)	9/02/60	Boundary change
Public Law 95-625 (92 Stat. 3467)	11/10/78	Boundary change

The legislation which established the memorial also provided for the continuation of grazing in the area. The grazing is divided by Coronado National Forest lease allotments (Figure 5-31). To be authorized to graze livestock on Forest Service administered land, allottees must own at least eighty acres within close proximity of their grazing allotment. Currently, portions of two grazing allotments extend within the Memorial boundary. Table 5-72 summarizes that portion of watershed file report number 111-23-16 claiming rights under state law covering these grazing allotments.

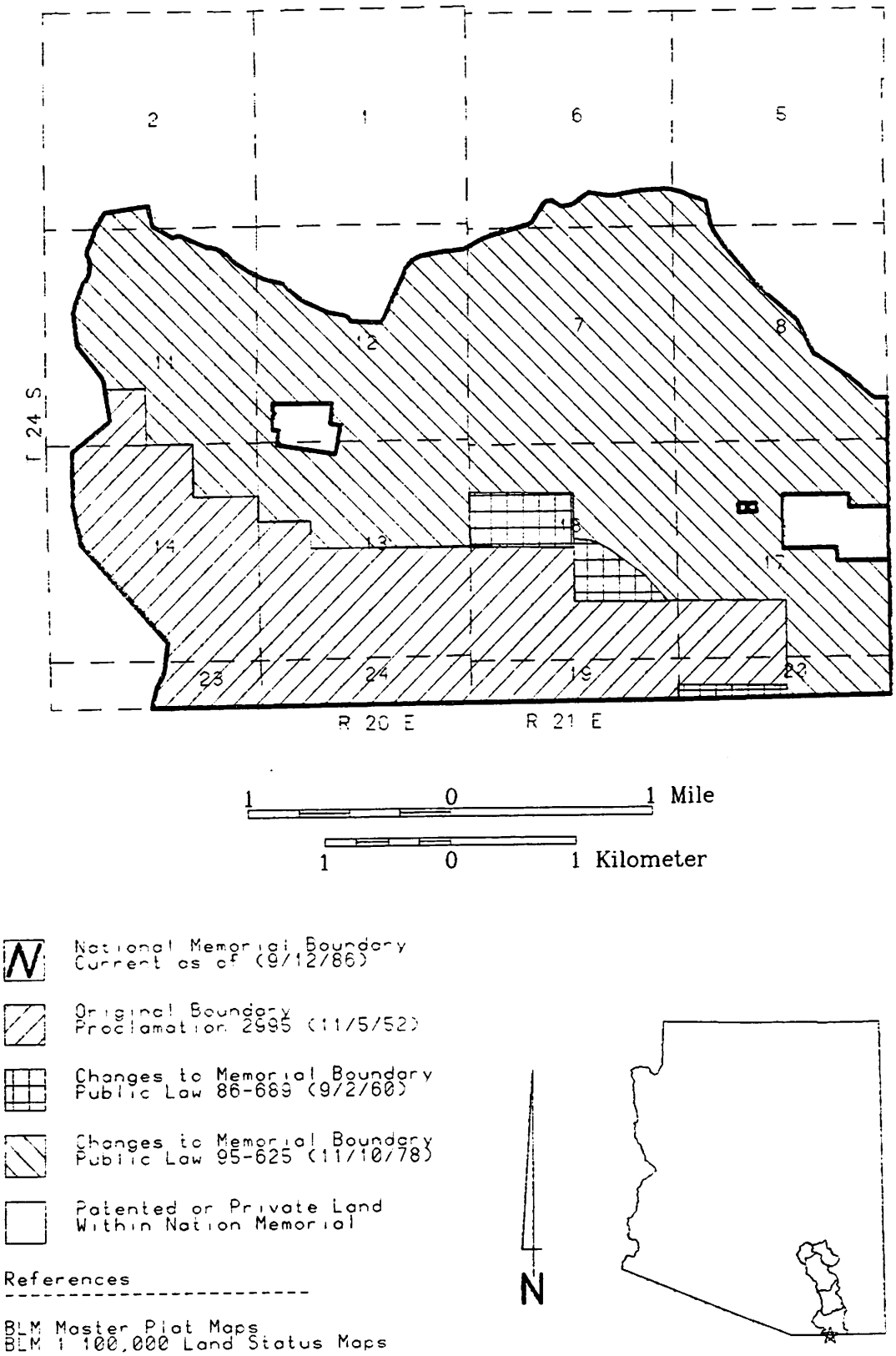


Figure 5-30. Coronado National Memorial boundary information

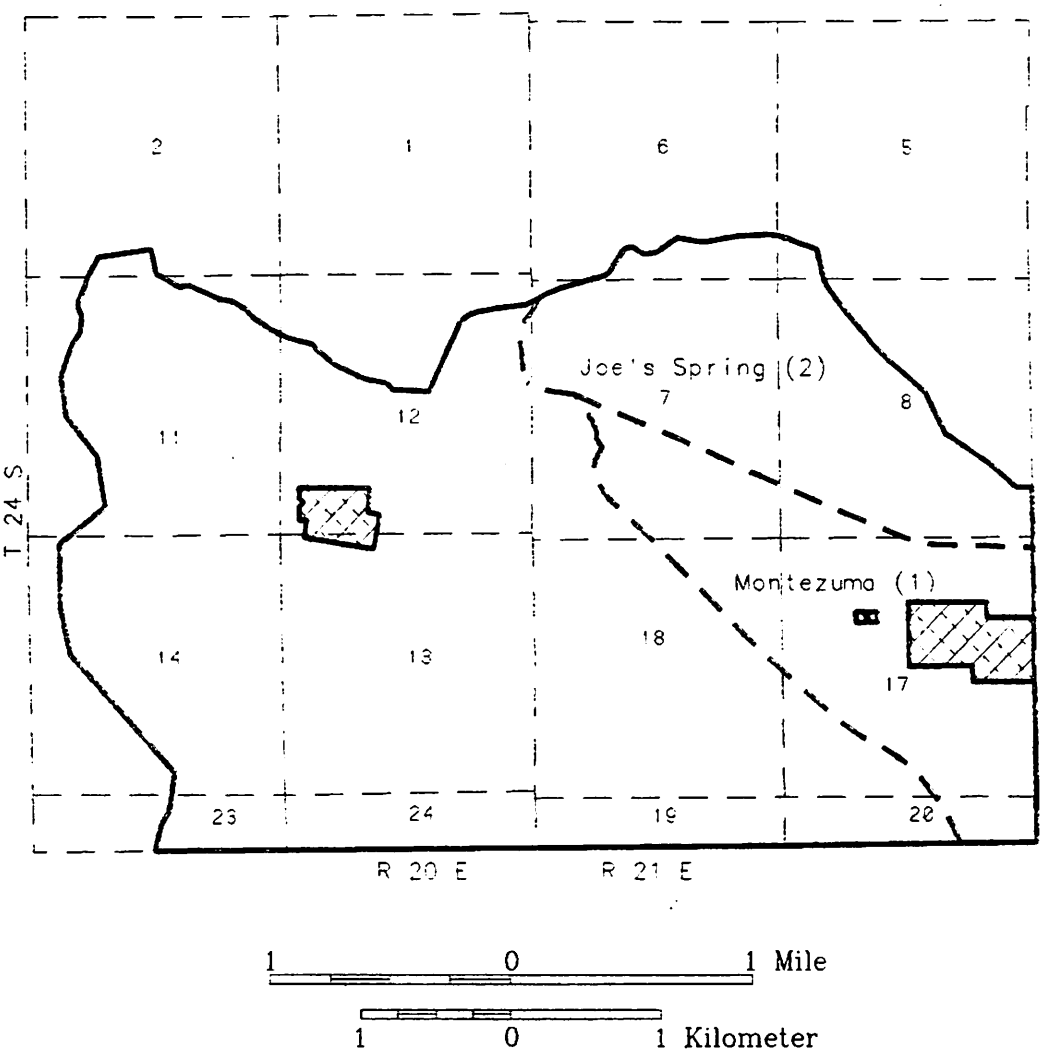


Figure 5-31. Coronado National Memorial - Coronado National Forest lease allotments

TABLE 5-72

NATIONAL PARK SERVICE
CORONADO NATIONAL MEMORIAL
111-23-16
SUMMARY OF CLAIMS FILED UNDER STATE LAW CORRESPONDING
TO EXISTING GRAZING ALLOTMENTS

ALLOTMENT	STATEMENT OF CLAIMANT NUMBER	PREVIOUS FILING NUMBER	POTENTIAL WATER RIGHT NUMBER
Joe's Spring	39-8208 - USDA Forest Service Coronado National Forest	36-11163 - USDA Forest Service Coronado National Forest	SW1
Montezuma	39-8152 - USDA Forest Service Coronado National Forest	36-11205 - USDA Forest Service Coronado National Forest	SW2
Lone Mountain - Sunnyside[1]	39-3794 - Lone Mountain Ranch	36-20949 - D'Albini Partnership (dba Bootjack Ranch)	SW3

[1]Lone Mountain Ranch relinquished grazing privileges at the request of the Coronado National Memorial on March 17, 1988.

Existing Conditions

The water resources in the area of the National Memorial are scarce. Although the drainage patterns are well defined, perennial streams are nonexistent. During rainy seasons, precipitation accumulates and flows through Montezuma Canyon; the only major drainage channel located within the Memorial. The average annual precipitation for the area is 20.21 inches. Several of the smaller canyons in the vicinity have seep springs. One spring, Tunnel Mine, flows year round and is used for wildlife watering.

Potable water for use by the Memorial's staff and visitors is obtained from a well (Headquarters) located one quarter mile from the headquarters. The water is stored in a 50,000 gallon tank and then distributed through pipelines to the various buildings and picnic area. The total staff varies between six and nine persons, depending on the season. The annual visitation in 1990 was 58,738. Sewage disposal is facilitated by the use of a leach field septic system.

Analysis of Claims

The National Park Service has submitted five water rights claims for three springs and nine wells within the boundaries of the Coronado National

Memorial. Two springs and four wells are claimed for a federal reserved water right in statements of claimant 39-11129 and 39-11130. Claim 39-11130 was amended to include an annual water use from the "Headquarters" well of six acre-feet per year and to include claims for future quantifiable and unquantifiable water uses. Table 5-73 compares the federal reserved right claims with DWR's findings.

One spring and five wells are claimed for state water rights in filings 33-87251, 39-11129, 39-11130, 39-13636, and 39-13637. Table 5-74 compares the state water claims with DWR's findings. Watershed file report number 111-23-16 contains all claims for water rights pertaining to uses found within the Coronado National Memorial.

NATIONAL PARK SERVICE - Saguaro National Monument (WFR #113-14-29)

The Rincon Mountain Unit of the Saguaro National Monument, an area comprised of 61,280 acres, is located in the Rincon Mountains approximately fifteen miles east of Tucson. Approximately 15 percent of the unit lies within the San Pedro River watershed. The remainder, along with the Tucson Mountain Unit, falls within the Upper Santa Cruz watershed. This report will deal with the claimed water uses within the San Pedro River watershed. The remaining uses will be discussed in the Upper Santa Cruz HSR.

Legal Record

The Rincon Unit was established by President Hoover's Proclamation on March 1, 1933 (47 Stat. 257) from lands originally reserved as part of the Catalina Forest Reserve, created by Presidential Proclamation on July 19, 1907 (35 Stat. 2147), for the protection and preservation of "lands . . . of outstanding scientific interest because of the exceptional growth thereon of various species of cacti, including the so-called giant cactus . . . ." The unit boundary was subsequently revised by Public Law 94-578 (90 Stat. 2732) to its present size of 62,836 acres (National Park Service, Environmental Assessment for Final Management Plan Saguaro National Monument, 1987). In October 1976, a major portion of the Rincon Unit (the entire area considered in this report) was established by Congress as a National Wilderness area.

TABLE 5-73

NATIONAL PARK SERVICE
CORONADO NATIONAL MEMORIAL
111-23-16
FEDERAL RESERVED WATER RIGHT CLAIMS
COMPARISON OF CLAIMANT INFORMATION WITH DWR FINDINGS
STATEMENTS OF CLAIMANT 39-11129 AND 39-11130

CLAIMED INFORMATION							DWR FINDINGS						
STATEMENT OF CLAIMANT	SOURCE	USE LOCATION	CLAIMED USE	NAME	ANNUAL USE	CLAIMED DATE OF FIRST USE	WATER USE NO.	POD NO.	WATER USE TYPE	USE STATUS	USE LOCATION	POD LOCATION	MAP
39-11129	Spring	NENE 12 24S 20E	WL,OT	Unnamed		1906	WL2		WL,OT	Spring	NENE 12 24S 20E		111-23
39-11130	Spring	NENE 07 24S 20E	WL,OT	Brown Allotment		1906	WL3		WL,OT	Spring	NENE 07 24S 20E		111-23
	Well	NWSESW 08 24S 20E	SW,WL,OT	Brown Allotment		1906		W1			Not in use	NWSESW 08 24S 20E	Unmapped
	Well	SESESW 17 24S 21E	Not in use	Coronado #4		1906		W2			Not in use	SESESW 17 24S 21E	Unmapped
	Well	NESENW 18 24S 21E	Not in use	Forest Service		1906		W6			Not in use	NESENW 18 24S 21E	Unmapped
	Well	NWSWNW 18 24S 21E	DM	Headquarters	360,000 gal	1906	DM1, DM2	W7	DM		SWNW 18 24S 21E	NWSWSW 18 24S 21E	Unmapped

KEY: DM = Domestic; OT = Other; POD = Point of diversion; SW = Stockwatering; W = Well (POD); WL = Wildlife

TABLE 5-74

NATIONAL PARK SERVICE
CORONADO NATIONAL MEMORIAL
111-23-16
STATE WATER RIGHT CLAIMS
COMPARISON OF CLAIMANT INFORMATION WITH DWR FINDINGS
FILING 33-87251 AND STATEMENTS OF CLAIMANT 39-11129, 39-11130, 39-13636, AND 39-13637

CLAIMED INFORMATION								DWR FINDINGS						
FILING AND STATEMENT OF CLAIMANT	SOURCE	USE LOCATION	CLAIMED USE	NAME	WATERCOURSE	ANNUAL USE	CLAIMED DATE OF FIRST USE	WATER USE NO.	POD NO.	WATER USE TYPE	USE STATUS	USE LOCATION	POD LOCATION	MAP
33-87251	Spring	NWSE 11 24S 20E	WL,OT	Tunnel Mine	Montezuma Canyon	0.08 ac-ft	1981	WL1		WL,OT	Spring	NWSE 11 24S 20E		111-23
39-11129	Spring	NWSE 11 24S 20E	WL,OT	Tunnel Mine	Montezuma Canyon	25,000 gal	1980	WL1		WL,OT	Spring	NWSE 11 24S 20E		111-23
39-11130	Well	NWSWNW 17 24S 21E	Not in use	Zalesk			1978		W3		No in use		NWSWSW 17 24S 21E	Unmapped
	Well	NWSWNW 17 24S 21E	DM,SW	Baumkirchner #2		< 35 gpm	1980		W4		No use found		NWSWSW 17 24S 21E	Unmapped
	Well	NWSWNW 17 24S 21E	DM,SW	Baumkirchner #3		< 35 gpm	1980		W5		Source a well		NWSWSW 17 24S 21E	Unmapped
39-13636	Well	SWNWNW 13 24S 20E	MU,ID,SW, REC,FISH, WL	Sparks #1		15 gpm	1941		W8		Source a well		SWNWNW 13 24S 21E	Unmapped
39-13637	Well	SWNWNW 13 24S 20E	SW,REC, FISH,WL	Sparks #2			1890		W9		Source a well		SWNWNW 13 24S 21E	Unmapped

KEY: DM = Domestic; FISH = Fish; ID = Industrial/Commercial; MU = Municipal; OT = Other; POD = Point of diversion; REC = Recreation; SW = Stockwatering; W = Well (POD); WL = Wildlife

Analysis of Claims

The National Park Service has claimed four springs in the San Pedro River watershed. Table 5-75 compares the claimed information versus DWR's investigation findings for each statement of claimant. The total estimated annual flow from all four claims is 2.28 million gallons. The claims state that the water is used for indigenous flora and fauna as well as fire suppression. The claims also state that there are "numerous seeps, tinajas, and areas of resurfaced underflow" within this area of the monument. Their flows are restricted and although small, are important components to the Monument ecosystem. The Park Service is claiming these waters for the same purposes as stated above but "due to the large number, magnitude of flow, and seasonal nature of these sources, a listing is not practical."

TABLE 5-75

NATIONAL PARK SERVICE
SAGUARO NATIONAL MONUMENT
113-14-29
COMPARISON OF CLAIMANT INFORMATION WITH DWR FINDINGS

CLAIMED INFORMATION							DWR FINDINGS				
STATEMENT OF CLAIMANT	CLAIMED SOURCE	CLAIMED USE LOCATION	CLAIMED USE	NAME	CLAIMED ANNUAL USE	CLAIMED DATE OF FIRST USE	WATER USE NO.	USE TYPE	USE LOCATION	USE STATUS	MAP NUMBER
39-11131	Spring	NWSE 16 14S 18E	WL, OT	Turtle	64,000 gal	1907	WL1	WL,OT	NWSE 16 14S 18E	Spring	113-14
39-11132	Spring	NWSW 21 14S 18E	WL, OT	Mud	6,400 gal	1907	WL2	WL,OT	NWSW 21 14S 18E	Spring	113-14
39-11133	Spring	SWNW 20 14S 18E	WL, OT	Spud Rock	6,400 gal	1907	WL3	WL,OT	SWNW 20 14S 18E	Spring	113-14
39-11134	Spring	NESW 20 14S 18E	WL, OT	Deer Head	2,200,000 gal	1907	WL4	WL,OT	NESW 20 14S 18E	Spring	113-14

KEY: DM = Domestic; OT = Other; WL = Wildlife

CHAPTER 6: INSTREAM FLOW USES

Instream flow can be described as surface water freely flowing in a natural water course at a level to protect instream flow values such as: wildlife, habitat, recreation, or aesthetics. This chapter will discuss the Arizona Department of Water Resources' (DWR) instream flow policies and criteria, the State's Riparian Habitat Task Force, instream flow uses, claims, and instream flow applications located in the San Pedro River watershed.

6.1 INSTREAM FLOW POLICIES AND PROCEDURES

State, federal, and private organizations have requested DWR to develop criteria for evaluating instream flows and the standards of proof for supporting such claims. Before initiating a rule making process, DWR reviewed all pending instream flow applications to determine the kind of information provided by the applicants and the nature of the protests lodged against many of the applications.

Most of the instream flow requests are based on the maintenance of flow to preserve wildlife, fish, and riparian habitat rather than on recreational uses such as rafting, floating, or swimming. The length of the stream reaches claimed for instream uses vary from less than one mile to more than twenty miles. In the case of longer reaches, only a few applications request a different flow rate for different stream sections based on accretions or losses. The applications request a constant year round minimum flow, although some request seasonal or monthly flow variations. Most of the applications provide information on the fish and wildlife habitat the instream flow is intended to preserve. Some applications provide extensive technical and scientific data which evaluate instream flow requirements. Nearly all of the applications are based on historical minimum flows recorded at nearby United States Geological Survey (USGS) gaging stations rather than on detailed evaluations of resource needs. The vast majority of the applicants are either state or federal agencies or land owners who control access to the stream.

DWR contacted water resource agencies of several other western states to determine if their procedures for evaluating instream flows could be adapted to Arizona. DWR learned that while many states had adopted specific statutes regulating instream flows, only a few states have adopted comprehensive procedures to deal with evaluating how much water is necessary to demonstrate beneficial use. DWR concluded that the most advanced procedures were associated with specific statutes designed to facilitate instream appropriations. Arizona does not have similar statutes at the present time.

Due to the support DWR received from applicants and their desire to assist in the formulation of rules, DWR organized an instream flow task force in December 1986. The task force consists of representatives of state and federal land management agencies, universities, and the private sector. The task force created two subcommittees to deal with the technical issues. The Biological Subcommittee was charged with the investigation of methodologies in current use for evaluating flow requirements for wildlife, including fish, and habitat, and to recommend those techniques which would be most useful in Arizona. The Hydrological Subcommittee was charged with investigating methods to estimate historical flow information for streams where gage records may or may not exist. This information is intended to be used in conjunction with the biological information to determine flow rates when requesting an instream flow water right.

The Biological Subcommittee has recommended that the applicant and DWR consider the kind of legal challenge that each application may face. On those claimed stream reaches where there is likely to be little legal challenge or protest (e.g., headwater reaches), standard setting streamflow measurement methodologies represented by the Great Plains, Tennant, and Bureau of Land Management (BLM) Value based methods are probably adequate. However, on those claimed reaches which may face significant legal challenge or protests by other water users, more detailed streamflow measurement and assessment methodologies may be required. In these cases, the United States Forest Service's (USFS) Fish Habitat Relationship System and the Department of the Interior's Instream Flow Incremental Methodology are suggested.

The Hydrologic Subcommittee has focused on techniques to correlate streamflow information and on the need for flow measurements after the issuance of a permit. The subcommittee has compiled a chart that lists acceptable techniques to assess available streamflow data. Specifically, the

recommendations indicate methods to evaluate flow data regarding the length of the data collection period, the continuity of the data collected, and the availability of gaging mechanisms. In addition, where large riparian systems exist applicants should quantify water used by the riparian habitat. A water balance approach is described for both gaged and ungaged streams to determine habitat usage.

The task force has discussed several legal and policy issues. These issues include conditions placed on the permits and certificates, requiring the applicant to be a land owner, types of beneficial uses that could be recognized, whether future water use(s) should preclude the granting of an instream flow right, and determining administrative procedures for the expeditious disposition of pending applications.

In August 1991, DWR released a Draft Guide to Filing Applications for Instream Flow Water Rights in Arizona. This guide identifies minimum requirements for assessing the need, available water supply, as well as evidence for the proposed instream flow appropriation. The guide also outlines the process of appropriating public waters for instream beneficial uses.

The application must follow the same general process as appropriators of public waters for more traditional beneficial uses (irrigation, stockwatering, etc.). However, given the nature of claimed beneficial uses of instream flow water, additional data requirements and analyses may be necessary.

As with other surface water appropriations, instream flow water rights applicants must: 1) file an Application for Permit to Appropriate Public Waters, 2) give public notice of the application, 3) subject the application to protest for sixty days, 4) resolve any protest informally or through a formal hearing process, 5) receive a permit, and 6) submit a Proof of Apropriation and an Affidavit of Appropriation. When DWR has determined that the appropriation has been perfected, a Certificate of Water Right (CWR) may be issued.

DWR suggests that each potential instream flow water right applicant meet with Department staff prior to filing the application. These meetings are intended to inform the applicant of the minimum requirements for documenting an instream flow water right application. These minimum requirements are general guidelines to ensure that the selected assessment methods are

commensurate with the legal challenge the application may receive, the water requirements of the claimed beneficial uses, and the hydrological and morphological characteristics of the stream and channel.

According to the draft guide, ". . . instream flow rates requested in the application which are consistent with available streamflow are the measure of the beneficial use. Instream flow applications cannot request an improbable quantity of streamflow to support the requested beneficial use, therefore, the applicant must establish the minimum quantity of water required to accomplish the purpose of the appropriation."

For example, on a gaged stream reach which has a lengthy period of record (greater than twenty years) the applicant is encouraged to utilize a flow duration analysis. The flow duration curve can represent the percent of time that specific discharges were equaled or exceeded during the period of record. Flow duration analyses can be performed based upon mean daily flows where the period of record is much shorter.

For ungaged streams or stream reaches of a less controversial nature, it may suffice to utilize periodic instantaneous flow measurements in an effort to document available streamflows. A continuous recording stream gage may also be utilized to measure and document streamflow. Again, a meeting with DWR technical staff may assist in the appropriate streamflow measurement method selected for the application process.

Finally, as part of the Proof of Appropriation, a report including at least four years of streamflow and assessment data must be submitted. When DWR is satisfied that all conditions and stipulations of the permit have been met and the appropriation has been perfected, a certificate can be issued.

6.2 GOVERNOR'S RIPARIAN HABITAT TASK FORCE

On June 10, 1989, Governor Rose Mofford issued Executive Order #89-16 directing all state agencies to determine whether current and proposed policies, actions, or funding impact stream and riparian resources. The order directs state agencies to implement changes that will allow for protection, and when appropriate, to implement changes that will allow for restoration of riparian areas.

The Riparian Habitat Task Force is composed of representatives from selected state agencies with a member of the Commission on the Arizona Environment serving as chairperson. The task force has requested that the recently established Arizona Rivers Assessment Committee collect, evaluate, and submit to the task force a compilation of existing riparian resource inventory data and a determination of key riparian areas. Other task force responsibilities include developing public awareness and education programs, investigating the development of incentives for public land owner cooperation, and consulting with members of the public, Indian tribes, local government, federal agencies, and private organizations. The task force is currently evaluating riparian area policy and associated management strategies that may eventually lead to legislative recommendations. The task force has been directed to report its findings to the Governor by October 31 of each year.

6.3 SAN PEDRO RIVER WATERSHED INSTREAM FLOW CLAIMS

As of September 1, 1991, DWR has received sixty-nine applications for instream flow water rights. DWR has granted one certificated water right for instream flows on Ramsey Creek - 33-78419. Four other applications have attained permit status: O'Donnell Creek - 33-78421, Aravaipa Creek - 33-87114, Peoples Canyon - 33-90410, and the Hassayampa River - 33-92304. The remaining sixty-four applications are under review by DWR and have yet to reach permit status.

Twenty instream flow water rights applications claim instream flows within the San Pedro River watershed and are shown in Table 6-1 and depicted on Figure 2-12. Of the twenty applications in the watershed, one has received a certificated water right: Ramsey Creek - 33-78419, and two have received permits: O'Donnell Creek - 33-78421 and Aravaipa Creek - 33-87114. DWR is reviewing the remaining applications and evaluating the streamflow data submitted in support of each claim.

At present, Arizona does not have statutes specifically providing for instream flow appropriations. However, DWR has granted one certificated water right and four permits based primarily upon the interpretation of the Arizona Supreme Court's ruling in McClellan v. Jantzen, 26 Ariz. App. 223, 547 p2d 494 (App. 1976) and on interpretation of the appropriation statutes. In McClellan, the Court held that the concept of "in situ appropriation" was valid for the statutory uses of "Wildlife including Fish" and "Recreation." Instream flow appropriations do not require a physical diversion of public waters from the stream channel.

The Ramsey Creek instream flow application was originally filed with DWR on June 27, 1979, by the Arizona Chapter of the Nature Conservancy (ANC). A permit was granted on the application by administrative decision and order in April 1983. The permit was granted with the following stipulations and provisions: no impoundment of surface water, no interference with the natural flow of the stream, no consumptive use other than by the natural habitat and wildlife, and no degradation of the surface water quality. The ANC was also required to monitor streamflows on the claimed reach for five years and submit the results to DWR at the conclusion of the monitoring period.

The ANC complied with the stipulations of the permit and supplied DWR with streamflow data for the years 1983 through 1988. DWR found that the ANC

TABLE 6-1

SAN PEDRO RIVER WATERSHED
INSTREAM FLOW APPLICATIONS

APPLICATION NUMBER	LOCATION	CLAIM AMOUNT (AF/YR)	CLAIMANT (1)	WATERSHED FILE REPORT NUMBER	CLAIM DATE	STATUS (2)
33-87114	Aravaipa Creek	10,860.00	BLM	115-5-19	06/01/81	P 03/17/89
33-95488	Aravaipa Creek	14,901.28	ANC	115-5-54	10/31/90	A
33-95489	Aravaipa Creek	13,566.47	ANC	115-5-54	10/31/90	A
33-95490	Aravaipa Creek	11,212.17	ANC	115-5-54	10/31/90	A
33-95771	Aravaipa Creek	10,432.68	ANC	115-4-11	10/31/90	A
33-95487	Babocomari River	3,254.00	BLM	111-20-32	10/02/90	A
33-94371	Bass Canyon	2,172.00	BLM	113-13-7	12/01/88	A
33-90249.0001	Buehman Canyon	723.00	SLD	113-13-28	10/21/85	O
33-94372	Hot Springs Canyon	15,204.00	BLM	113-12-9	12/01/88	A
				113-13-7		
33-95366	Miller Canyon Creek	510.00	USFS	111-23-9	12/29/89	A
33-78421	O'Donnell Creek	547.18	ANC	111-19-21	06/27/79	P 08/83
33-78419	Ramsey Creek	719.80	ANC	111-23-39	06/27/79	C 11/14/90
33-94369	Redfield Canyon	10,860.00	BLM	111-12-10	12/01/88	O
				111-12-11		
33-90103	San Pedro River	146,940.00	BLM	111-23-AAA-1	08/12/85	O
				111-24-CCB-11		
33-95780	San Pedro River	3,674.00	BLM	111-24-CCB-11	01/08/91	A
33-95789	San Pedro River	***	BLM	111-23-AAA-10	04/01/91	A
				111-24-CCB-11		
33-96126	San Pedro River	10,341.44	HUGHES, J.	113-12-DBC-12	08/06/91	A
33-96127	San Pedro River	8,239.00	ANC	113-12-34	08/06/91	A
33-94370	Swamp Springs Canyon	5,068.00	BLM	113-12-9	12/01/88	O
				113-12-11		
33-95454	Wildcat Canyon	452.37	BLM	113-13-7	06/06/90	A

*** = Spring flood flows.

(1) ANC - Arizona Chapter of the Nature Conservancy
BLM - Bureau of Land Management
SLD - Arizona State Land Department
USFS - United States Forest Service

(2) A - Application
C - Certificated water right
O - Protested
P - Permitted

application for surface water flows did not reflect actual flow conditions as determined from the flow data. The ANC voluntarily relinquished the permit in 1988.

In October 1988, the ANC amended the instream flow application. The amended flow application requested monthly median baseflows of instantaneous streamflows measured at a notched, broad crested weir. DWR granted a permit for the amended application on May 1, 1990. The permit was granted with the same stipulations as those of the 1983 permit. DWR granted the ANC a certificated water right for the Ramsey Creek application on November 14, 1990. The certificated water right has the same stipulations and provisions as the permit.

DWR, by granting the certificate to the ANC, has established a precedent for the creation of instream flow rights and the general criteria the applicants must meet to obtain a certificated instream flow right. The general criteria require that if an application is granted a permit, the permittee shall monitor the streamflows for a minimum of four years and provide technical data in support of the amount of water claimed for beneficial use. The permits are generally granted with four general provisions: no impoundments shall be constructed, no interference with natural flows, no consumptive use other than by the natural habitat and wildlife, and no degradation of water quality. DWR may require gage location, measurement techniques, and the installation of monitoring equipment meet with DWR approval. At the conclusion of the monitoring period, the permittee shall submit the flow records and the technical data to DWR for analysis and review. DWR will then decide if more data is required, if the claim should be amended, or if the claim should be certificated.

The O'Donnell Creek application, 33-78421, was originally filed with DWR on June 27, 1979, by the ANC. The application was permitted in April 1983 with the same stipulations as the Ramsey Creek application. The ANC complied with the stipulations and submitted the required five years of flow data in 1988. DWR reviewed the flow data and requested three more years of data from the ANC. At present, the application is still permitted and under review by DWR.

The Aravaipa Creek application, 33-87114, was originally filed with DWR on June 1, 1981, by BLM. The application is for the Aravaipa Canyon

Wilderness Area. DWR granted a permit on the application on March 17, 1989. The permit has the same stipulations as the Ramsey Creek application. DWR also required that the gage site and monitoring equipment installation meet DWR approval. The BLM is now in the second year of the four year monitoring period.

Each of the instream flow claims within the San Pedro River watershed is discussed in the following paragraphs. They are described by geographic location, claimed uses, annual volume claimed, the type and quantity of technical data provided, description of any on site monitoring programs, and any conflicts or protests to the existing applications.

ARAVAIPA CREEK (WFR #115-5-19, #115-5-54, AND #115-4-11)

Aravaipa Creek is the largest perennial tributary to the San Pedro River. The creek is located in Graham and Pinal Counties in the Aravaipa subwatershed. The creek is 56 miles long and the drainage basin comprises 537 square miles. The central twelve miles of the creek are known as Aravaipa Canyon. The canyon was designated as the BLM Aravaipa Canyon Wilderness Area (ACWA) on August 24, 1984, by an act of the United States Congress. Additions to the ACWA were confirmed by passage of the Arizona Desert Wilderness Act on November 28, 1990 (Figure 6-1).

History

Aravaipa Canyon was first settled in 1867 by Epigmenio Salazar. By the 1880s, several small farms were located in the canyon. In 1969, the United States Secretary of the Interior designated 4,044 acres of Aravaipa Canyon as a Primitive Area. In 1979, the Defenders of the Wildlife acquired several parcels of land within the canyon and adjacent to the Primitive Area. The United States Congress designated the ACWA in 1984. In 1988, the Defenders of the Wildlife deeded their holdings in the canyon to the ANC. That same year, BLM added newly acquired acreage to the ACWA. In 1990, an act of the United States Congress added additional acreage to the ACWA. At present, the ACWA comprises approximately 20,089 acres or just over thirty-one square miles.

Currently, there are five instream flow right applications for portions of Aravaipa Creek. One is held by BLM (33-87114) and four are held by the ANC (33-95488, 33-95489, 33-95490, and 33-95771). The BLM application has been permitted. The four ANC applications are pending. One federal reserved water right claim has been filed for instream flow within the ACWA. The statement of claimant 39-68704 was filed by BLM.

33-87114 BLM - Safford District (WFR #115-5-19)

On June 1, 1981, BLM filed an application for an instream flow right, 33-87114, on Aravaipa Creek within the boundaries of what was then the Aravaipa Primitive Area. The application was protested by the Bureau of Indian Affairs, the San Carlos Irrigation and Drainage District, and the San Carlos Irrigation Project. These protests were resolved and have been withdrawn. DWR granted BLM a permit with stipulations for instream flow on Aravaipa Creek within the boundaries of the ACWA on March 17, 1989.

The instream flows are claimed for wildlife and fisheries use, riparian habitat maintenance, and aesthetic recreation value. The ACWA supports over 300 species of wildlife including fish, several of which are listed on the state and federal Threatened and Endangered Species lists. These threatened and endangered species include: the round-tailed chub, spike dace, longfin dace, loach minnow, gila sucker, coatimundi, mountain lion, and several raptor species. Aravaipa Creek represents one of the last completely native fisheries in the southwest.

The application claims a total of 10,860 acre-feet per year; 3,620 acre-feet per year for recreation, and 7,240 acre-feet per year for wildlife including fish. The claimed reach begins at a point within the NE¼, SW¼, Section 19, Township 6 South, Range 19 East and ending at a point within the SW¼, SE¼, Section 13, Township 6 South, Range 17 East. The application has been amended several times to reflect additions to the ACWA.

A permit was granted to BLM on March 17, 1989, for application 33-87114. The permit grants instream flows on Aravaipa Creek within the ACWA. The permit provides several important stipulations: 1) no impoundment of, nor interference with the natural flow, 2) no consumptive use of water other than by the natural habitat, 3) no degradation of water quality, and 4) no detrimental impact on prior vested rights as a result of the permit.

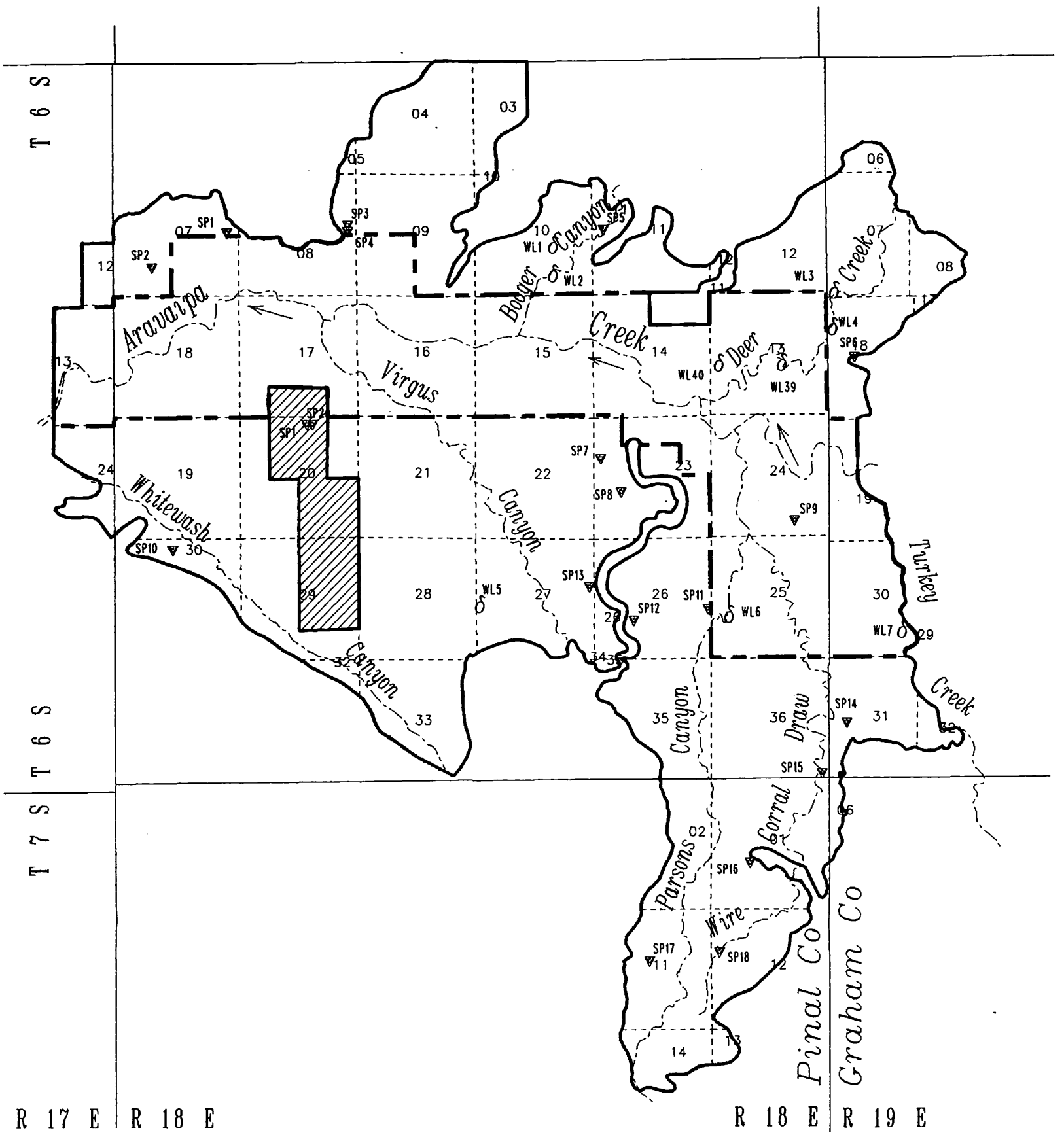


Figure 6-1. Map of the BLM - Aravaipa Canyon Wilderness Area showing past and present boundaries, mapped uses, and Arizona Chapter of the Nature Conservancy parcels.

DWR also required BLM to maintain a record of flows for five years at the eastern boundary of the ACWA. The flow record will be submitted to DWR no earlier than July 1, 1994.

The permit grants instream flows of 10,840 acre-feet per year for recreation and wildlife uses, including fish. The permit provides for flow amounts expressed as monthly averages of continuous daily flows measured in cfs as shown in Table 6-2.

TABLE 6-2

ARAVAIPA CREEK
AVERAGE MONTHLY FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average flow	20	25	20	10	10	9	10	20	11	15	10	20

DWR has evaluated the claimed instream flows and compared the claimed flows to available USGS information. This comparison is shown in Figure 6-2. The USGS maintains a continuous recording gaging station several miles downstream from the western boundary of the ACWA. The USGS has over thirty years of data from this station (U.S. Geological Survey, 1991b). The data from the USGS gage is shown as mean monthly flows.

DWR initiated an instantaneous streamflow monitoring program on Aravaipa Creek during 1990. DWR conducted seven instantaneous streamflow measurements at the eastern and western boundaries of the ACWA from April to November excluding August. The instantaneous measurements are not tied directly to any permanent gage and only represent flows at one point in time. However, the measurements do reflect actual observed flows and are useful in providing insight into typical flow conditions.

The data from the USGS correlates well with BLM claimed amounts (Figure 6-2). However, the flows permitted by DWR for the ACWA application are based upon flows recorded from the western boundary of the ACWA where Aravaipa Creek exits the ACWA. The permit requires BLM to monitor flows at the eastern boundary where Aravaipa Creek enters the ACWA. DWR flow data shows that the flows at the western boundary are generally higher than those from the eastern boundary, as shown in Table 6-3.

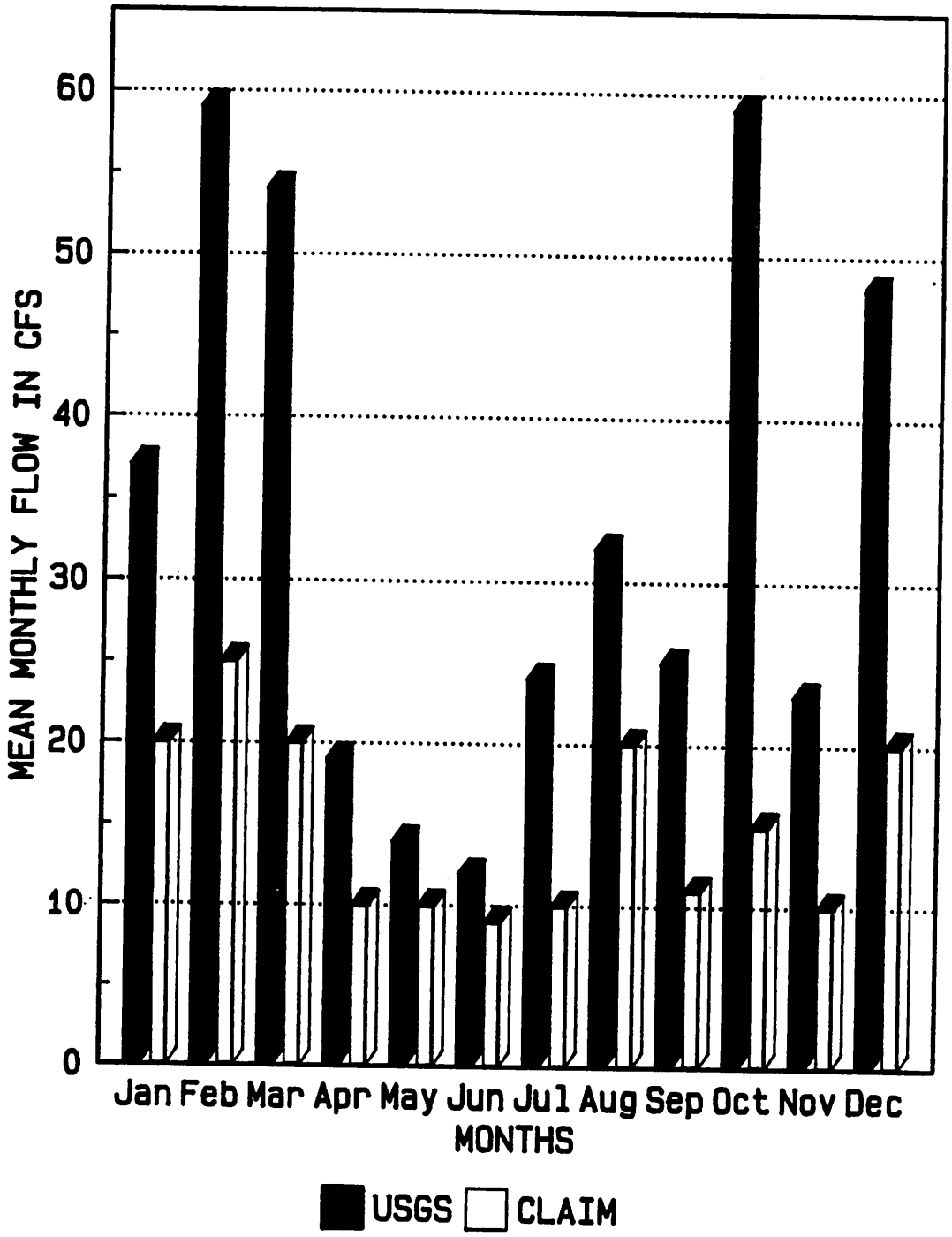


Figure 6-2. A comparison of USGS mean monthly flows at the Aravaipa continuous recording gaging station and mean monthly flows claimed for instream beneficial uses within the ACWA by BLM

The table shows that Aravaipa Creek in the ACWA gains flow during the spring and fall and loses flow in mid-summer. The gains are due to discharge from several large springs within the ACWA. The losses in June are due to phreatophyte consumptive water use during the driest period of the summer. The table shows that the flow entering the ACWA at the eastern boundary is approximately 90 to 94 percent of the flow exiting the ACWA at the western boundary during the spring and fall. DWR data suggests that the springs provide from 6 to 7 percent of the surface flow measured at the western boundary.

During mid-summer, the flow entering the ACWA is greater than the flow exiting the ACWA. This suggests that the phreatophytes in the canyon consume the discharge of the springs as well as surface water during the peak growing season. It should be noted that the phreatophyte population in the ACWA is still recovering from the effects of the 1983 flood. The consumptive use of water by the phreatophytes is expected to increase as the population matures.

By moving the monitoring site from the eastern boundary to the western boundary, the permitted flow amount may exceed the amount of water entering the ACWA.

TABLE 6-3

DWR FLOW DATA FROM THE EASTERN AND WESTERN BOUNDARIES OF THE ACWA

MONTH	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
East	16.35	11.89	12.06	17.76	ND	17.76	11.37	18.30
West	17.40	12.67	9.62	19.37	ND	19.53	16.10	19.60
East v. West in %	94.0	93.8	125.4	91.7	ND	90.9	70.6	93.4

ND - No data.

Federal Reserved Water Right Claim #39-68704

The BLM filed statement of claimant 39-68704 which claims a federal reserved water right for approximately twenty-one identified water uses and

twenty unnamed and unlocated water sources within the confines of the ACWA. Of the twenty-one identified claimed water uses, thirteen are also described on existing state water right claims.

The federal reserved water right is based upon the Act of Congress which created the Aravaipa Canyon Wilderness Area Addition, the Arizona Desert Wilderness Act (Public Law 101-628, 101st Congress, November 28, 1990). The Act specifies that, ". . . with respect to each wilderness area designated by this title, Congress hereby reserves a quantity of water sufficient to fulfill the purposes of this title. The priority date of such reserved rights shall be the date of enactment of this Act."

Figure 6-1 depicts all of the claimed or identified water uses within the ACWA including those specifically described on statement of claimant 39-68704. For specific water source and use location information, refer to watershed file report (WFR) #115-5-19 found in Volume 6 of this HSR.

33-95488, 33-95489, 33-95490 (WFR #115-5-54)

The ANC filed three instream flow rights applications, 33-95488, 33-95489, and 33-95490, on portions of Aravaipa Creek adjacent to the ACWA on October 31, 1990. These applications are included in watershed file report #115-5-54. The ANC applications claim monthly average baseflows for wildlife use including fish. The applications state that the ANC nature preserves along Aravaipa Creek support 7 native fish, 8 amphibian, 47 reptile, 237 bird, and 46 mammal species, of which 20 are federally or state protected.

The ANC instream water right applications 33-95489 and 33-95490 claim four miles of Aravaipa Creek upstream of the eastern boundary of the ACWA. Application 33-95489 claims 1.5 miles upstream and adjacent to the ACWA. The place of use is described as beginning at a point in the NW¼, SW¼, Section 21, Township 6 South, Range 19 East continuing downstream to a point in the E½, Section 19, Township 6 South, Range 19 East. Application 33-95490 claims 2.5 miles upstream of the reach claimed by application 33-95489. The place of use for application 33-95490 is described as beginning at a point in the SW¼, NE¼, Section 35, Township 6 South, Range 19 East continuing downstream to a point in the NE¼, Section 28, Township 6 South, Range 19 East.

Both applications claim monthly average baseflows as shown in Table 6-4. Application 33-95489 claims a total of 13,566.5 acre-feet per year while application 33-95490 claims 11,212.2 acre-feet per year.

TABLE 6-4

ANC ARAVAIPA APPLICATIONS
AVERAGE MONTHLY INSTREAM FLOWS
(CFS)

APPLICATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
33-95489	19	21	22	19	18	17	17	18	18	18	18	10
33-95490	16	18	18	16	14	14	14	15	14	15	15	17
33-95488	21	23	32	21	18	17	18	19	18	19	19	22
33-95771	15	16	19	16	13	12	14	14	13	12	14	15

The third ANC application, 33-95488, claims 2.5 miles of Aravaipa Creek downstream and adjacent to the western edge of the ACWA. The claimed reach begins at a point in the SW¼ of Section 13, Township 6 South, Range 17 East, continuing downstream to a point in the NE¼, SW¼, Section 26, Township 6 South, Range 17 East.

The application claims a total of 14,901.3 acre-feet per year from Aravaipa Creek. The claim is for monthly average baseflows as shown in Table 6-4.

The three ANC Aravaipa Creek instream flow right applications are pending with DWR. As of September 1, 1991, none have been permitted.

33-95771 (WFR #115-4-11)

The ANC filed an instream flow right application, 33-95771, on October 31, 1990, for a three-quarters of a mile portion of Aravaipa Creek several miles downstream from the ACWA. The application claims baseflows to provide water for wildlife use including fish. The application states that the ANC nature preserve supports 7 native, 8 amphibian, 47 reptile, 237 bird, and 47 mammal species, of which 20 are federally or state protected.

The claimed place of use begins at a point in the NW¼ of Section 3 and continues downstream to a point in the NE¼ of Section 4, Township 7 South, Range 17 East. The claim requests average monthly flows as shown in Table 6-4.

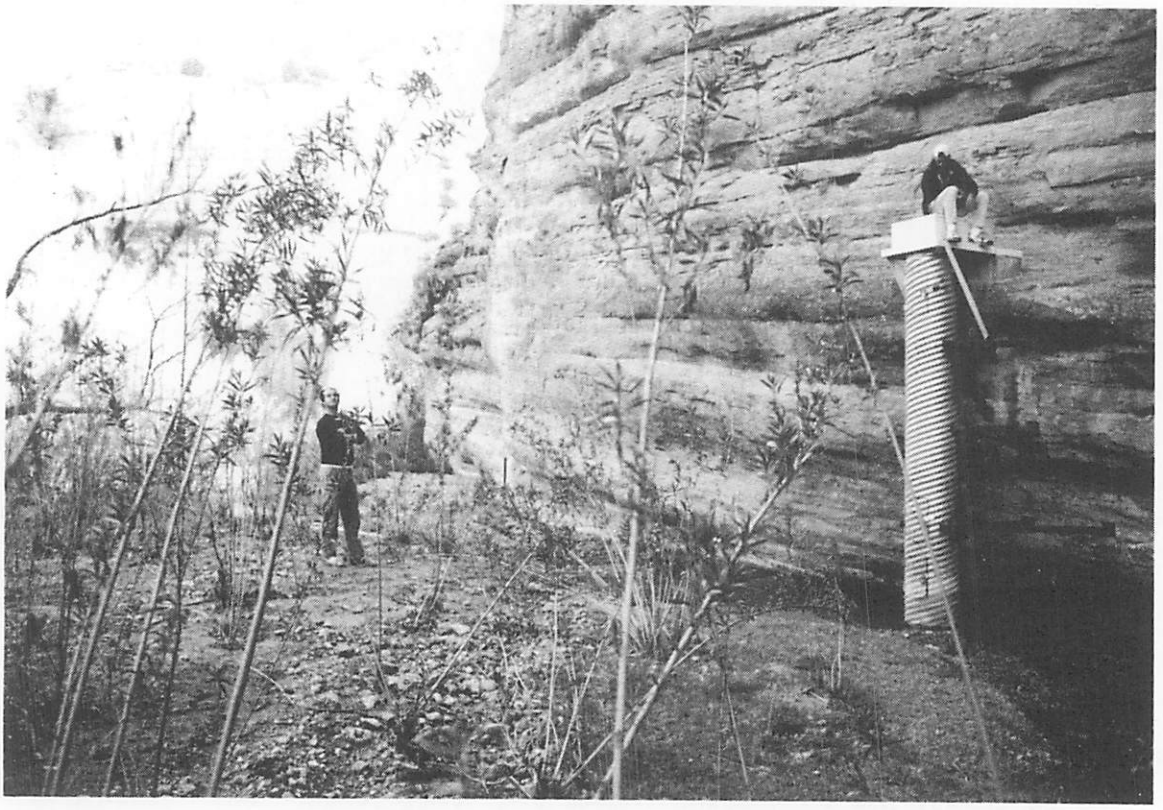


Figure 6-3. The Bureau of Land Management operates and maintains this stream gage on Aravaipa Creek near the eastern edge of the Aravaipa Canyon Wilderness Area. Discharge measurements by DWR at this location in April 1990 indicated a flow of 16.4 cfs.

The application is pending with DWR. The application has not been granted permit status.

BASS CANYON (WFR #113-13-7)

The BLM filed an application for minimum instream flow on a perennial reach of Bass Canyon, a tributary of Hot Springs Canyon. This reach of Bass Canyon flows across land owned by the Arizona Chapter of the Nature Conservancy. This application, 33-94371, was filed with DWR on December 1, 1988.

That portion of Bass Canyon referenced in the BLM application is located in the Redington subwatershed. The claim is located in the SE¼, SW¼, Section 20 and continues to the SW¼, NE¼, Section 36, Township 12 South, Range 20 East (Figure 2-12).

The application claims uses are to maintain the existing riparian habitat, protect native fisheries, and provide for wildlife usage. The BLM claims that a portion of the flow in Bass Canyon is perennial in nature. The application claims a minimum median monthly flow in cfs as shown in Table 6-5.

TABLE 6-5

BASS CANYON
CLAIMED MINIMUM MONTHLY FLOWS AND DWR OBSERVED FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Median Flow	3.0	8.0	4.0	3.0	1.0	1.0	4.0	4.0	3.0	1.0	1.0	3.0
DWR observed flows (1990)			0.6		0.2					0.3	1.2	

The application states a monthly median flow of 3.0 cfs. The BLM claims a total use amount of 2,171.39 acre-feet per year within Bass Canyon.

DWR initiated an instantaneous streamflow measurement program on Bass Canyon during 1990. Bass Canyon was measured four times: in April, June, October, and November. The results of this program are shown in Table 6-5. The instantaneous flow measurements are not tied to any permanent gage. The measurements do provide insight into the natural flow conditions.

The instream flow application is currently in a pending status with DWR. The BLM has indicated that it may combine this application with that of Hot Springs Canyon at some later date. The BLM has not provided any technical data in support of this application and does not maintain a gaging station within Bass Canyon.

BUEHMAN CANYON (WFR #113-12-28)

The Arizona State Land Department (SLD) filed a minimum instream flow application, 33-90249, on a perennial portion of Buehman Canyon. The SLD obtained the land in 1987 as part of the Fair Land Exchange Program.

The SLD Buehman Canyon application describes an area within the Redington subwatershed. The claimed reach is that portion located within the SW¼, Section 5, Township 5 South, Range 18 East (Figure 2-12). This reach is claimed to support a variety of wildlife including native fish.

The claimed uses on the application are for riparian habitat maintenance and to support the needs of wildlife, including fish. The SLD's application claims one cfs per day (724 acre-feet per year) in support of these claimed uses.

DWR initiated an instantaneous streamflow monitoring program on Buehman Canyon during 1990. Buehman Canyon was measured four times: in March, June, October, and November. The flows observed in March and June were less than 0.1 cfs. The October flow was measured at 0.1 cfs and the November flow was 0.4 cfs. The instantaneous flows are not tied to any fixed gage.

The application was protested in 1985 by the San Carlos Irrigation Project and ASARCO, Inc. These protests, at the present time, are unresolved. The SLD withdrew the claim in September 1989 and requested reactivation of the claim in October 1989.

The SLD has not, as yet, provided any technical data in support of this application and does not maintain a gage within Buehman Canyon.

Figure 6-4. Buehman Canyon drains a portion of the east flank of the Santa Catalina Mountains. The canyon contains a riparian vegetative association of cottonwood-sycamore-willow along this perennial reach.

HOT SPRINGS CANYON (WFR #113-13-7 AND #113-12-19)

The BLM filed a minimum instream flow application, 33-94372, on a perennial reach of Hot Springs Canyon, a tributary of the San Pedro River. The claimed reach crosses the Muleshoe Ranch Preserve which is owned by the ANC. The BLM has filed the application concurrently with the ANC. The BLM submitted the application to DWR on December 1, 1988.

The claimed uses of the instream flow are to maintain riparian habitat, wildlife uses, including fish, and to provide recreational use. The locale supports a variety of wildlife including: javelina, deer, several species of birds, and native fish populations. To maintain or enhance the existing riparian habitat and wildlife uses, BLM is requesting a minimum monthly median flow in cfs as shown in Table 6-6.

TABLE 6-6

HOT SPRINGS CANYON
CLAIMED MONTHLY FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Median flow	25.0	40.0	30.0	20.0	15.0	10.0	15.0	25.0	20.0	15.0	15.0	22.0

The average minimum median monthly flow claimed in the application is 21.0 cfs. The total use amount claimed by BLM is 15,199.70 acre-feet per year within Hot Springs Canyon.

In 1990, DWR visited Hot Springs Canyon in June and November and conducted instantaneous streamflow measurements. DWR measured 0.4 cfs in June and 1.2 cfs in November. These measurements record the instantaneous observed flows and are not tied to any gage or control.

The claimed location is in the Redington subwatershed. The claimed reach begins in the NE¼, NE¼, Section 36 and continues to the SW¼, SE¼, Section 32, Township 12 South, Range 20 East (Figure 2-12). The BLM application for Hot Springs Canyon minimum instream flow has not been protested at present, and is currently in a pending status with DWR. The BLM has not provided technical support for this claim as of yet, and there are no gaging stations in Hot Springs Canyon.

MILLER CREEK (WFR #111-23-9)

The USFS, Coronado National Forest, filed a minimum instream flow claim 33-95366 for Miller Creek, a tributary to the San Pedro River. The USFS filed the application with DWR on December 29, 1989.

The claimed reach of Miller Creek is located within the Sierra Vista subwatershed. The claimed location begins in the NW¼, NW¼, Section 36 and continues to the SE¼, SW¼, Section 18, Township 20 South, Range 21 East (Figure 2-12).

The application claims uses are to maintain the aesthetic values associated with a riparian habitat. The Forest Service reports that the area is used extensively for recreational uses, including: bird watching, hunting, picnicking, hiking, camping, photography, and site-seeing. To maintain the stated recreation uses, the USFS is claiming minimum median monthly flows in cfs as shown in Table 6-7.

TABLE 6-7

MILLER CREEK
CLAIMED MONTHLY FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Median flow	0.28	0.28	5.30	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28

The total amount claimed on the application is 510 acre-feet per year. The USFS claimed an amount of water needed to "produce a stream of water approximately four feet wide and one inch deep through the riparian area for most months" (0.28 cfs). The USFS claims that the March value of 5.3 cfs is due to snowmelt and would create "a stream approximately ten feet wide and four inches deep."

In 1990, DWR visited Miller Canyon in the months of March, April, May, June, July, September, October, and November. No surface water flow was observed during any of these investigations.

The USFS's Miller Creek application was protested by the City of Tombstone, the San Carlos Irrigation Project, and by Thomas L. and Edith M. Beatty. All protests have been resolved.

Currently, there are no gaging stations on Miller Creek, and the USFS is attempting to install a stage recorder at the claimed location. The application is pending.

O'DONNELL CREEK (WFR #111-19-21)

The ANC has filed an instream flow right application, 33-78421, for the perennial reach of O'Donnell Creek, a tributary to the Babocomari River. The claimed reach is within the O'Donnell Creek cienega. The ANC filed the application in June 1979. DWR permitted the application with several stipulations in August 1983. The ANC amended their application in April 1991.

The O'Donnell Creek claim is located in Cochise County within the Sierra Vista subwatershed (Figure 2-12). The claimed reach is within the ANC's Canelo Hills Cienega Preserve. The Canelo Hills Cienega Preserve is home to the rare Canelo orchid (Spiranthes graminea).

The application claims monthly median flows for wildlife use including fish and riparian habitat maintenance. The preserve is home to a wide variety of wildlife including native fish, over 170 species of birds, and rare cienega community plants.

The ANC was granted a permit for the O'Donnell Creek claim in August 1983. The permit stipulated that the ANC monitor the flows in O'Donnell Creek for a period of no less than five years. The ANC provided DWR with the flow data from 1983 to 1988. The data was obtained from instantaneous measurements at an erosion control structure at the downstream terminus of the cienega. The data proved to be incomplete and inaccurate. The ANC requested and was granted an extension of the monitoring period to August 1992.

The ANC has been conducting an extensive streamflow monitoring program on O'Donnell Creek since 1989. The ANC has installed a continuous recorder on the creek and conducted many instantaneous streamflow measurements. The ANC has amended its application based upon the preliminary results of their monitoring program.

DWR initiated a streamflow monitoring program on O'Donnell Creek during 1990. Instantaneous measurements were taken in March through November excluding August. The measurements were taken at the downstream terminus of

the cienega at an erosion control structure. The results of the program are shown in Table 6-8.

The amended application filed in April 1991 claims an annual volume of 547.2 acre-feet per year. The application claims monthly baseflows as shown in Table 6-8. The claimed flows are based on a continuous recorder installed upstream of the previous gaging site. A discrepancy exists between flow measurements by DWR at the downstream terminus of the cienega and the claimed flows as measured at the midpoint of the preserve. The discrepancy may be explained by phreatophyte consumptive water use within the cienega.

TABLE 6-8

O'DONNELL CREEK
CLAIMED AND OBSERVED FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Claim	.77	.76	.76	.76	.74	.72	.73	.78	.77	.76	.76	.76
DWR			.1	.33	.1	.1	.20		.21	.22	.16	

Figure 6-5. The riparian habitat along the banks of spring-fed O'Donnell Creek are dominated by cottonwoods, willows, and Arizona walnut. The water level recording gage is monitored by the Arizona Chapter of the Nature Conservancy in support of their instream flow application.

RAMSEY CREEK (WFR #111-23-39)

The ANC was granted a certificated water right for instream flows in Ramsey Creek within the ANC's Mile Hi-Ramsey Canyon Preserve on November 17, 1990. The ANC filed the application with DWR in July 1979. The application was granted a permit in 1983. The permit required the ANC to provide no less than five years of flow records in support of the claim. The ANC voluntarily relinquished its permit in October 1989 so that it could amend its claim based on the five years of flow records. The ANC amended its claim in October 1989. DWR permitted the amended application in May 1990 and granted a Certificate of Water Right on November 14, 1990.

Ramsey Creek is a tributary to the San Pedro River and located in Cochise County in the Sierra Vista subwatershed (Figure 2-12). The creek drains the eastern flank of the Huachuca Mountains and supports a unique mid-elevation riparian habitat. The Mile Hi-Ramsey Canyon Preserve is home to a wide variety of birds including fourteen species of hummingbirds. The unique riparian habitat and abundant bird population attract over 30,000 visitors annually to the preserve.

The certificated water right for Ramsey Creek grants an entitlement of 719.8 acre-feet per year, expressed as continuous baseflow. The baseflows are monthly averages as shown in Table 6-9.

TABLE 6-9

RAMSEY CREEK
CERTIFICATED MONTHLY BASEFLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Flow	.97	1.12	1.23	.20	.95	.67	.67	1.20	1.26	.75	.87	1.12

The certificate has several stipulations: 1) water will not be diverted from the channel, 2) beneficial will occur along the course of Ramsey Creek. The certificated reach begins at the upstream boundary of the Mile Hi-Ramsey Canyon Preserve at a point within the NE¼, SW¼, Section 9, Township 23 South, Range 20 East. The certificated reach continues within the Mile Hi-Ramsey Canyon Preserve until it reaches the downstream boundary of the preserve at a point in the SW¼, NW¼, Section 10, Township 23 South, Range 20 East.

Figure 6-6. The certificated water right for instream flow in Ramsey Creek is for a perennial reach located in the Huachuca Mountains. The broad-crested weir is monitored daily by the Arizona Chapter of the Nature Conservancy. The measured discharge in March 1990 at this site was 0.07 cfs.

REDFIELD CANYON (WFR #113-12-11 AND #113-12-10)

The BLM filed an instream flow application, 33-94369, on a portion of Redfield Canyon, a tributary of the San Pedro River. The claimed location is located on Arizona State Trust lands administered by SLD. The BLM has arranged for a land exchange in an effort to acquire the property from SLD. The BLM filed the application on December 1, 1988.

The Redfield Canyon application is located within the Redington subwatershed. The claimed perennial reach begins in the SE¼, SE¼, Section 29 and continues to the NE¼, NW¼, Section 31, Township 11 South, Range 20 East (Figure 2-12). The claimed location is located within the Redfield Canyon Wilderness Area, established by the Arizona Desert Wilderness Act of 1990.

The claimed uses of the instream flow application are to maintain existing riparian habitat, protect native fisheries and wildlife, and provide

for recreational opportunities. The BLM claims minimum median monthly flows in cfs as shown in Table 6-10.

TABLE 6-10

REDFIELD CANYON
CLAIMED MONTHLY FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Median flow	14.0	25.0	13.0	9.0	7.0	5.0	15.0	28.0	19.0	16.0	14.0	15.0

The application states an average median monthly flow of 15.0 cfs. The BLM claimed a total annual amount of 10,856.93 acre-feet of flow per year.

The Redfield Canyon application is currently protested by the Bayless and Berkalew Company. The Hope I. Jones estate has withdrawn their protest of this application.

The BLM has not, to date, provided DWR with any technical support for this application. The BLM does not maintain a gaging station at the claimed location. DWR conducted a field investigation of the claimed reach within Redfield Canyon in April 1990, but could not measure the stream due to insufficient flow.

SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA

The San Pedro Riparian National Conservation Area (SPRNCA) located in the southwestern portion of Cochise County is administered by BLM. The SPRNCA was set aside in an effort to preserve a portion of the fragile riparian ecosystem along the upper San Pedro River for wildlife habitat and future recreational opportunities. The SPRNCA encompasses 47,668 acres along the San Pedro River from the International Border with Mexico northward to a point approximately eight miles south of Benson. This reach of the San Pedro River is approximately thirty-six miles long and the inner valley varies in width from two to five miles. The total area of the SPRNCA is 47,668 acres. Much of what is now the SPRNCA is comprised of two large Mexican land grants: the San Rafael del Valle Grant and the San Juan de las Boquillas y Nogales Grant (Plate 16).

The elevation of the San Pedro River at the International Border is 4,275 feet above mean sea level. The elevation of the river at the northern boundary of the SPRNCA is 3,700 feet above mean sea level.

The climate of the San Pedro watershed in this region is arid to semi-arid. The average annual precipitation is about fifteen inches at Fort Huachuca. Most of the precipitation occurs during the summer "monsoon" months of July, August, and September. The remainder occurs as winter storm moisture during December, January, and February (Table 6-11). Mean annual temperatures of the nearby stations are between 62°F and 64°F.

TABLE 6-11

SUMMARY OF ANNUAL PRECIPITATION AND TEMPERATURE DATA AT WEATHER OBSERVATION STATIONS NEAR THE SPRNCA

STATION	ELEVATION (FEET ABOVE MEAN SEA LEVEL)	TEMPERATURE (°F)			ANNUAL PRECIPITATION (INCHES)		
		MINIMUM	AVERAGE	MAXIMUM	MINIMUM	AVERAGE	MAXIMUM
Fairbank	3,850	ND	ND	ND	4.82	11.66	19.63
Fort Huachuca	4,664	9	62.2	104	7.21	15.24	25.57
Tombstone	4,610	6	63.7	108	7.60	13.93	23.82

ND - No data.

Source: National Oceanic and Atmospheric Administration, 1989, and Sellers and Hill, 1974.

History

In 1827, Captain Ignacio Elias Gonzalez and Nepomucino Felix applied for a grant of land from the Mexican Government along the banks of the San Pedro River. At the same time, Rafael Elias Gonzalez also applied for a grant of land along the San Pedro.

The northern land grant title was issued to Gonzalez and Felix in 1833 for the San Juan de Las Boquillas y Nogales. The San Juan de Las Boquillas y Nogales started approximately five miles south of present day St. David and stretched to the south of what is now Charleston, a distance of nearly fifteen miles. The land grant was a uniform two miles wide (Plate 16).

The southern land grant, the San Rafael del Valle, with a title issued in 1832 to Rafael Elias Gonzalez encompassed an eleven mile reach of the San

Pedro River from what is now Lewis Springs south to the present ranching community of Hereford. This land grant was approximately 2½ miles wide along its entire length (Plate 16).

Ownership of the land grants changed hands several times during the latter half of the 19th century. The San Juan de las Boquillas y Nogales was owned by William Randolph Hearst at the turn of the century. In 1901, a patent was issued by the United States Government to the Hearsts for 17,355.86 acres. The Camou brothers were issued a patent for 17,474.93 acres in 1901 for the San Rafael del Valle land grant.

The Hearst family sold their grant in 1901 to the Boquillas Land and Cattle Company of Bakersfield, California. In 1905, the Camou brothers sold the San Rafael del Valle grant to Cornell Greene who founded the large Greene Cattle Company.

With Cornell Greene's death in 1912, the Greene Cattle Company sold the San Rafael del Valle land to the Boquillas Land and Cattle Company. In 1958, the Kern County Land and Cattle Company acquired both of the land grants from the Boquillas Land and Cattle Company. In 1967, Kern County Land and Cattle Company consolidated with Tenneco, Incorporated. Tenneco, Incorporated became Tenneco West, Incorporated in 1971.

Arizona White Tank Associates bought the grant lands in 1986 from Tenneco West, Incorporated, and after negotiations with BLM officials conducted land exchanges for BLM lands west of the White Tank Mountains west of Phoenix in Maricopa County. Each of the land grants was valued at 26.5 million dollars.

The BLM then began the difficult task of consolidating their holdings along the San Pedro River by acquiring small parcels of land from private land owners as well as State lease lands. These acquisitions culminated on November 18, 1988, when President Reagan signed into law the Arizona-Idaho Conservation Act which created the SPRNCA. The SPRNCA was formally dedicated on May 6, 1989, as the nation's first Riparian National Conservation Area.

The northern half of the area which includes the San Juan de las Boquillas y Nogales land grant has historically been used for livestock grazing and ranching. It also contains the old Charleston town site and the now abandoned agricultural settlement of Curtis. The southern portion of the

area contains the San Rafael del Valle land grant, the ruins of the Sobaipurai Indian village of Quiburi, and the remains of the Spanish Presidio of Santa Cruz de Terrenate.

As was previously described, the old Curtis townsite was the location of a surface water diversion and agricultural community in what is now the northern end of the SPRNCA. No information is available about the initial construction of the Curtis diversion and ditch system. However, five flow measurements taken during the period May 1920 through March 1921 indicate a mean diversion rate of approximately 5.3 cfs. Measurements taken at the same time on the mainstem San Pedro River below the Curtis ditch diversion indicated a mean discharge of 6.8 cfs. An analysis of the State Water Commission (SWC) Gila River Determination maps reveals that during the years 1921 to 1923 there were approximately 146 acres of irrigation supplied by the Curtis ditch. The SWC maps also classify just over 166 acres as "previously cultivated" prior to the survey. Plate 13 is a photographic mosaic depicting the St. David Irrigation District (SDID) lands. Within the southern portions of the SDID service area, remnants of the Curtis ditch have been mapped. The ditch was field investigated by DWR in October 1989. It is conceivable that lands now served by wells in this region may have been supplied surface water by the Curtis ditch.

Two other surface water diversions are documented within the northern half of the SPRNCA. Just north of Fairbank, the Boquillas Land and Cattle Company operated the East and West Diversion on each side of the San Pedro River, respectively. Flow measurements were made on both of these diversions during the period of April 1918 through April 1919 (USGS, 1921 and USGS, 1925). The East Diversion is reported to have diverted a mean flow of about 12.0 cfs and the West Diversion a mean flow of approximately 4.0 cfs. The SWC maps depict nearly 1,290 acres of cultivated irrigated acreage during the period 1921 through 1923. The maps also identify approximately ninety-four acres of land classified as "previously cultivated" prior to the survey.

Applicable Filings and Decrees

In accordance with the on going general adjudication of water rights within the San Pedro River watershed, a large number of statements of claimant describing water uses have been filed by land owners prior to the creation of the SPRNCA. The statements of claimant as well as other pertinent filings,

Figure 6-7. Photo mosaic of the San Pedro Riparian National Conservation Area looking south towards the Charleston Hills

old rights, notices of appropriation, and decrees are described in Table 6-12. The BLM is in the process of having all of these claims assigned to them.

TABLE 6-12

SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA CLAIMED INFORMATION

CLAIM NUMBER	CLAIMED USES	QUANTITY (AF/YR)	CLAIM DATE	CLAIMED USE LOCATION	CLAIMED DIVERSION LOCATION	WATERSHED FILE REPORT NUMBER
Filings						
33-31987	Stock	0.44	1975	SENE 17 24S 22E	SENE 17 24S 22E	111-24-CCB-11
33-31988	Stock	0.28	1975	SENE 17 24S 22E	SENE 17 24S 22E	111-24-CCB-11
33-90103	Wildlife (Minimum Flow)	92,672.00	1985	Entire Reach	NWNW 22 23S 22E	111-24-CCB-11
33-95780	Recreation	3,674.00	1991	NENE 04 24S 22E	NENE 04 24S 22E	111-24-CCB-11
	Fish/Wildlife			NWNE 04 24S 22E	NWNE 04 24S 22E	
				SWNE 04 24S 22E	SWNE 04 24S 22E	
33-95789	PROTESTED APPLICATION					111-24-CCB-11
39-370	Irrigation		1832	Entire Reach	NWNW 22 23S 22E	111-24-CCB-11
						111-23-AAA-1
39-662	Stock	19.39	1919	Entire Reach	Entire Reach	111-24-CCB-11
						111-20-32
						112-20-13
						112-17-63
39-955	Stock	0.44	1943	SENE 17 24S 22E	SENE 17 24S 22E	111-24-CCB-1
	Wildlife	0.04				
39-956	Stock	0.28	1943	SENE 17 24S 22E	SENE 17 24S 22E	111-24-CCB-11
	Wildlife	0.03				
39-957	Stock	0.22	1943	SENE 17 24S 22E	SENE 17 24S 22E	111-24-CCB-11
	Wildlife					
39-964	Irrigation	412.00	1948	SENW 4 24S 22E	SENW 4 24S 22E	111-24-CCB-11
				NWSW 4 24S 22E	NWSW 4 24S 22E	
				NESWSW 4 24S 22E	NESWSW 4 24S 22E	
39-967	Irrigation	404.00	1948	SE 8 24S 22E	NWNENW 17 24S 22E	111-24-CCB-1
				SESW 8 24S 22E		
				NENW 17 24S 22E		
39-968	Irrigation	541.60	1948	SESW 8 24S 22E	SWSENW 17 24S 22E	111-24-CCB-11
				NW 17 24S 22E		
				NW 17 24S 22E		
39-969	Irrigation	756.00	1951	SESW 7 24S 22E	SWNESW 17 24S 22E	111-24-CCB-1
				NE 17 24S 22E		
				NW 17 24S 22E		
39-970	Stock	2.50	1952		NENWSW 9 24S 22E	111-24-CCB-11
39-971	Irrigation	260.00	1952	NW 9 24S 22E	NWSENW 9 24S 22E	111-24-CCB-11
39-972	Irrigation	140.00	P 1958	NWNW 2 24S 22E	NWNWNW 3 24S 22E	111-24-CCB-11
				NENE 4 24S 22E		

P - Prior to.

TABLE 6-12 (cont'd)

CLAIM NUMBER	CLAIMED USES	QUANTITY (AF/YR)	CLAIM DATE	CLAIMED USE LOCATION	CLAIMED DIVERSION LOCATION	WATERSHED FILE REPORT NUMBER
39-973	Irrigation	800.00	1973	17 24S 22E	SWNWSW 17 24S 22E	111-24-CCB-11
				18 24S 22E		
39-974	Irrigation	1,440.00	1976	SESW 4 24S 22E	NENESW 4 24S 22E	111-24-CCB-11
				4 24S 22E		
39-975	Irrigation	400.00	1976	SW 8 24S 22E	NWNWSW 8 24S 22E	111-24-CCB-11
39-976	Irrigation	400.00	1976	SW 8 24S 22E	NWSWSW 8 24S 22E	111-24-CCB-11
39-977	Irrigation	640.00	1977	SW 17 24S 22E	NENWNW 20 24S 22E	111-24-CCB-11
				NW 20 24S 22E		
39-978	Stock	2.50	1952		NENWNW 20 24S 22E	111-24-CCB-11
39-979	Irrigation	640.00	1977	SE 18 24S 22E	SENENE 19 24S 22E	111-24-CCB-11
				NW 19 24S 22E		
39-3833	Irrigation	190.00	1952	18 24S 22E	SWNESW 18 24S 22E	111-24-CCB-11
39-5373	Irrigation	2,080.00	1948	4 24S 22E	SWSWNW 4 24S 22E	111-24-CCB-11
				5 24S 22E		
				8 24S 22E		
39-11936	Irrigation	854.20	1930	SW 4 24S 22E	NESWSW 4 24S 22E	111-24-CCB-11
	Stock	0.20		SE 8 24S 22E	SENESE 4 24S 22E	
				NE 8 24S 22E	NENWSE 4 24S 22E	
39-11941	Irrigation	315.20	1952	NW 4 24S 22E	NWSWNW 4 24S 22E	111-24-CCB-11
	Stock	0.20				
39-12281	Stock	0.03	1983		NWSE 18 24S 22E	111-24-CCB-11
39-12686	Stock	1.79	1946	NWSESW 22 23S 22E	NWSESW 22 23S 22E	111-24-CCB-11
39-12713	Stock		P 1919	SWSWSW 15 23S 22E	SWSWSW 15 23S 22E	111-24-CCB-11
39-13610	Municipal	18,728.76	1988	NENW 21 18S 21E	NENW 21 18S 21E	111-24-CCB-11
	Recreation			NWNW 21 18S 21E	NWNW 21 18S 21E	
	Fish/Wildlife			NWSW 21 18S 21E	NWNW 21 18S 21E	
39-14482	Recreation	3,674.00	1990	NENE 04 24S 22E	NENE 04 24S 22E	111-24-CCB-11
	Fish/Wildlife			NESW 04 24S 22E	NESW 04 24S 22E	
				NWNE 04 24S 22E	NWNE 04 24S 22E	
39-14485	Recreation	18,200.00	1991	NWNW21 18S 21E	NWNW 21 18S 21E	111-24-CCB-11
	Fish/Wildlife			SWSW 22 23S 22E	SWSW 22 23S 22E	
				NENE 04 24S 22E	NENE 04 24S 22E	
39-14491	Domestic	0.00	1989	SENWNW 03 24S 22E	SENWNW 03 24S 22E	111-24-CCB-11
4A-4069	Stock	19.39	1957	Entire Reach	Entire Reach	111-24-CCB-11
						111-23-AAA-1
						111-20-32
						111-20-13
						111-17-63
33-89568	Irrigation	1,250.00	1984	NENE 16 23S 22E	NWSE 16 23S 22E	111-23-AAA-1
				SWNE 16 23S 22E	NWNE 16 23S 22E	
33-89569	Irrigation	425.00	1984	SWNWNE 10 23S 22E	SWSW 10 23S 22E	111-23-AAA-1
				SENENW 10 23S 22E		
				NWNESW 10 23S 22E		
33-95393	PROTESTED APPLICATION					111-23-AAA-1
33-95394	Recreation	1.60	1990	SWNENW 08 22S 22E	SWNENW 08 22S 22E	111-23-AAA-1
	Fish/Wildlife					

P - Prior to.

TABLE 6-12 (cont'd)

CLAIM NUMBER	CLAIMED USES	QUANTITY (AF/YR)	CLAIM DATE	CLAIMED USE LOCATION	CLAIMED DIVERSION LOCATION	WATERSHED FILE REPORT NUMBER
33-95789	None	None	1991	NWNW 21 18S 21E	None	111-23-AAA-1
				SWSW 22 23S 22E	None	
				NENE 04 24S 22E	None	
36-19424	Irrigation	1,200.00	P 1919	6 22S 22E	NESE 6 22S 22E	111-23-AAA-1
				8 22S 22E		
36-19425	Irrigation	800.00	P 1919	17 22S 22E	NESE 17 22S 22E	111-23-AAA-1
				20 22S 22E		
36-19426	Irrigation	1,000.00	P 1919	8 22S 22E	NWSW 8 22S 22E	111-23-AAA-1
				17 22S 22E		
36-28399	Irrigation Domestic Stock	0.50	P 1920	SESE 30 22S 22E	SESE 30 22S 22E	111-23-AAA-1
36-75652	Irrigation Domestic Stock	None	1900	None	30 21S 22E	111-23-AAA-1
39-371	Irrigation	1,000.00	P 1919	8 22S 22E	SWNWSW 8 22S 22E	111-23-AAA-1
				17 22S 22E		
39-372	Irrigation	1,200.00	P 1919	6 22S 22E	NENESE 6 22S 22E	111-23-AAA-1
				8 22S SSE		
39-373	Irrigation	800.00	P 1919	17 22S 22E	NWNESE 17 22S 22E	111-23-AAA-1
				20 22S 22E		
39-671	Stock	0.22	P 1957	NWNW 7 22S 22E	NWNW 7 22S 22E	111-23-AAA-1
39-4274	Irrigation	1,250.00	P 1919	16 23S 22E	NENWSE 16 23S 22E	111-23-AAA-1
39-4275	Stock	1.79	P 1919	SESW 22 23E SSE	NWSESW 22 23S 22E	111-23-AAA-1
39-4292	Irrigation		P 1919	9 20S 21E	SWSESE 16 20S 21E	111-20-32
39-4293	Stock		P 1919	SENE 6 22S 22E	SWSENE 6 22S 22E	111-23-AAA-1
39-4294	Stock		P 1919	SESW 10 23S 22E	SESESW 10 23S 22E	111-23-AAA-1
39-4295	Stock		P 1919	SESW 10 23S 22E	NWSESE 10 23S 22E	111-23-AAA-1
39-4296	Irrigation	1,000.00	P 1919	10 23S 22E	NWNESW 10 23S 22E	111-23-AAA-1
39-4297	Irrigation	425.00	P 1919	NW 10 23S 22E	SWNWSE 15 23S 22E	111-23-AAA-1
				NE 10 23S 22E		
				SW 10 23S 22E		
39-4298	Stock		P 1919	NWSE 15 23S 22E	SWNWSE 15 23S 22E	111-23-AAA-1
39-4301	Irrigation Stock		P 1919	SE 21 23S 22E	SWNESE 21 23S 22E	111-23-AAA-1
39-12699	Irrigation	1,250.00	P 1919	16 23S 22E	NWNESE 16 23S 22E	111-23-AAA-1
39-12705	Irrigation	1,200.00	P 1919	6 22S 22E	NWNESE 16 22S 22E	111-23-AAA-1
				8 22S 22E		
39-12706	Irrigation	1,000.00	P 1919	8 22S 22E	NWNWSW 8 22S 22E	111-23-AAA-1
				17 22S 22E		
39-12707	Irrigation		P 1919	SW 17 22S 22E	NWSESW 17 22S 22E	111-23-AAA-1
39-12708	Irrigation	800.00	P 1919	17 22S 22E	NWNESE 17 22S 22E	
				20 22S 22E		
39-12710	Irrigation		1981	NE 29 22S 22E	NESWNE 29 22S 22E	111-23-AAA-1
39-12712	Irrigation	425.00	P 1919	NW 10 23S 22E	SWSESW 10 23S 22E	111-23-AAA-1
				NE 10 23S 22E		
				SW 10 23S 22E		

P - Prior to.

TABLE 6-12 (cont'd)

CLAIM NUMBER	CLAIMED USES	QUANTITY (AF/YR)	CLAIM DATE	CLAIMED USE LOCATION	CLAIMED DIVERSION LOCATION	WATERSHED FILE REPORT NUMBER
39-12714	Irrigation		1980	NE 16 23S 22E	SWSWNE 16 23S 22E	111-23-AAA-1
39-13610	Other (instream flow)	11,028.00	1988	Entire Reach	Entire Reach	111-F4
39-13611	Other (instream flow)	11,028.00	1985	Entire Reach	Entire Reach	111-23-AAA-1
39-12715	Domestic		P 1919		SWSWNE 16 23S 22E	111-23-AAA-1
39-13626	Irrigation	800.00	1981	NWNE 29 22S 22E	NESWNE 29 22S 22E	111-23-AAA-1
39-13627	Irrigation	800.00	1981	E2SWSW 17 22S 22E SWNE 17 22S 22E SESW 17 22S 22E	SWNESW 17 22S 22E	111-23-AAA-1
39-13996	Commercial	1.00	1990		SESESW 10 23S 22E	111-23-AAA-1
39-13998	Recreation Fish/Wildlife	1.90	1990		SWNENW 08 22S 22E	111-23-AAA-1
39-13999	Recreation Fish/Wildlife	15.00	1990		NWSESW 05 22S 22E	111-23-AAA-1
39-14506	Recreation Fish/Wildlife	15.00	1990		NWSESW 05 22S 22E	111-23-AAA-1
39-14507	Recreation Fish/Wildlife	1.90	1990		SWNENW 08 22S 22E	111-23-AAA-1
39-14508	Commercial Industrial	1.00	1990		SESESW 10 23S 22E	111-23-AAA-1
4A-4024	Stock	0.22	1957	NWNW 7 22S 22E	NWNW 7 22S 22E	111-23-AAA-1
39-11919	Industrial	150.00	1979	21 22S 22E		111-24-82
39-12709	Industrial		P 1919	SWSWNW 21 22S 22E	SWSWNW 21 22S 22E	111-24-82
33-95383	Recreation Fish/Wildlife	6,517.00	1990	NWNWNW 29 21S 22E	NWNW 29 21S 22E	111-20-32
33-95388	Stock Recreation Fish/Wildlife	0.16 0.02 0.02	19909	NESESW 20 21S 22E	NESESW 20 21S 22E	111-20-32
33-95392	Stock Recreation Fish/Wildlife	0.04 0.02 0.02	1990	SESWSW 31 21S 22E	SESWSW 31 21S 22E	111-20-32
33-95487	Recreation Fish/Wildlife	3,254.00	1990	NWSW 03 20S 21E NESE 04 20S 21E SWNE 18 20S 21E	None None None	111-20-32
36-19430	Irrigation		1832			111-20-32
36-21799	Other		1863			111-20-32
36-28874	Irrigation Mining	46.03	1877	19S 21E 20S 21E	19S 21E 20S 21E	111-20-32
36-47745	Stock	2.5	1976	NWNW 17 20W 21E	NWNW 17 20S 21E	111-20-32
36-47746	Stock	2.5	1976	NENW 17 20S 21E	NENW 17 20S 21E	111-20-32
36-47747	Stock	2.5	1976	NWNE 17 20S 21E	NWNE 17 20S 21E	111-20-32
36-47748	Stock	2.5	1976	SESE 8 20S 21E	SESE 8 20S 21E	111-20-32
36-47749	Stock	2.5	1976	SWSE 8 20S 21E	SWSE 8 20S 21E	111-20-32
36-47750	Stock	2.5	1976	NWSW 9 20S 21E	NWSW 9 20S 21E	111-20-32
36-47751	Stock	2.5	1976	NESE 8 20S 21E	NESE 8 20S 21E	111-20-32
36-47752	Stock	2.5	1976	NESW 9 20S 21E	NESW 9 20S 21E	111-20-32

P - Prior to.

TABLE 6-12 (cont'd)

CLAIM NUMBER	CLAIMED USES	QUANTITY (AF/YR)	CLAIM DATE	CLAIMED USE LOCATION	CLAIMED DIVERSION LOCATION	WATERSHED FILE REPORT NUMBER
36-47753	Stock	2.5	1976	SENW 9 20S 21E	SENW 9 20S 21E	111-20-32
36-75654	Irrigation	None	None	S2 21S 22E	S2 21S 22E	111-20-32
	Stock					
38-19221	Stock	3.0	1957	NWSW 24 20S 21E	NWSW 24 20S 21E	111-20-32
	Wildlife					
38-59878	Stock	4.0	1969	NENW 1 20S 21E	NENW 1 20S 21E	111-20-32
	Other					
39-674	Stock	0.17	1957	SESW 2 21S 21E	SESW 2 21S 21E	111-20-32
39-675	Stock	0.11	1957	NENW 13 21S 21E	NENW 13 21S 21E	111-20-32
39-676	Stock	0.22	1957	SENW 25 21S 21E	SENW 25 21S 21E	111-20-32
39-677	Stock	0.17	1957	SESE 36 21S 21E	SESE 36 21S 21E	111-20-32
30-678	Stock	0.11	1957	SWNW 29 21S 21E	SWNW 29 21S 21E	111-20-32
39-1214	Stock	0.31	1919	9 20S 21E	9 20S 21E	111-20-32
39-1215	Stock	0.31	1919	SESE 8 20S 21E	SESE 8 20S 21E	111-20-32
39-1216	Stock	0.31	1919	17 20S 21E	17 20S 21E	111-20-32
39-2612	Stock	0.22	1930	NWNWNE 12 20S 21E	NWNE 12 20S 21E	111-20-32
39-2616	Stock	0.03	1969	NENW 1 20S 21E	NENW 1 20S 21E	111-20-32
39-4276	Stock		1919	SESWSW 10 20S 21E	SWSW 10 20S 21E	111-20-32
39-4277	Stock		1919	SESWSW 10 20S 21E	SWSW 10 20S 21E	111-20-32
39-4289	Irrigation		1919	NESW 14 20S 21E	NENESW 10 20S 21E	111-20-32
39-4290	Domestic		1919	SWNW 14 20S 21E	SWSWNW 14 20S 21E	111-20-32
	Stock					
39-4291	Stock		1919	SWSE 15 20S 21E	SESWSE 15 20S 21E	111-20-32
39-4292	Irrigation		1918	9 20S 21E	SWSESE 16-20S 21E	111-20-32
39-7752	Stock	1.0	1919	NWNE 17 20S 21E	NWNW 17 20S 21E	111-20-32
	Wildlife	2.3				
	Other (R.R.)	112.0				
39-7754	Stock	2.5	1919	SENW 9 20S 21E	NWSW 9 20S 21E	111-20-32
	Wildlife	2.3				
	Other	68.0				
39-7755	Stock	1.00	1919	NESE 8 20S 21E	SWSE 8 29S 21E	111-20-32
	Wildlife	3.00				
	Other (R.R.)	149.00				
39-11232	Stock	0.05	1979	NESW 24 20S 21E	NESW 24 20S 21E	111-20-32
	Wildlife	0.01				
39-11829	Stock	0.09	1911	10 20S 21E	NENWNE 10 20S 21E	111-20-32
39-11831	Domestic		1914			111-20-32
39-12689	Stock		1919		SENENE 15 20S 20E	111-20-32
39-12690	Stock		1919	SWSW 10 20S 21E	SESWSW 10 20S 21E	111-20-32
39-12691	Stock		1919		NWNW 3 20S 21E	111-20-32
39-13992	Recreation	0.08	1990	None	SESWSW 31 21S 22E	111-20-32
	Fish/Wildlife					
39-13993	Recreation	0.20	1990	None	NESESW 20 21S 22E	111-20-32
	Fish/Wildlife					
39-13997	Recreation	0.02	1990	None	NWNWNW 29 21S 22E	111-20-32
	Fish/Wildlife					
39-14488	Recreation	1.20	1986	None	NWNWSE 03 20S 21E	111-20-32
	Fish/Wildlife					
39-14503	Recreation	0.20	1990	None	NESESW 20 21S 22E	111-20-32
	Fish/Wildlife					

TABLE 6-12 (cont'd)

CLAIM NUMBER	CLAIMED USES	QUANTITY (AF/YR)	CLAIM DATE	CLAIMED USE LOCATION	CLAIMED DIVERSION LOCATION	WATERSHED FILE REPORT NUMBER
39-14504	Recreation Fish/Widlife	0.02	1990	None	NWNWNW 29 21S 22E	111-20-32
39-14505	Recreation Fish/Wildlife	0.08	1990	None	SESWSW 31 21S 22E	111-20-32
4A-4019.0001	Stock	0.17	1957	SESW 2 21S 21E	SESW 2 21S 21E	111-20-32
4A-4020.0001	Stock	0.11	1957	NENW 13 21S 21E	NENW 13 21S 21E	111-20-32
4A-4021.0001	Stock	0.22	1957	SENW 25 21S 21E	SENW 25 21S 21E	111-20-32
4A-4022.0001	Stock	0.17	1957	SESE 36 21S 21E	SESE 36 21S 21E	111-20-32
4A-4023.0001	Stock	0.11	1957	SWNW 29 21S 22E	SWNW 29 21S 21E	111-20-32
39-670	Irrigation Stock	25.00 0.44	1957	SENW 29 18S 21E	SENW 29 18S 21E	112-17-63
39-672	Irrigation Stock	1,200.00 1.66	1957	20 18S 21E SENW 29 18S 21E NE 29 18S 21E	SENW 29 18S 21E	112-17-63
39-4283	Stock		1919	NWNWSE 19 18S 21E	NWNWSE 19 18S 21E	112-17-63
39-4286	Stock		1919	NWSW 33 18S 21E	NWSW 33 18S 21E	112-17-63
39-4287	Stock		1919	NENWSW 9 18S 21E	NENWSW 9 18S 21E	112-17-63
39-4288	Stock		1919	NWNENW 21 19S 21E	NWNENW 21 19S 21E	112-17-63
39-12692	Stock		1919	NWSE 19 18S 21E	NWNWSE 19 18S 21E	112-17-63
39-13625	Stock Recreation Fish/Wildlife	0.10	1989	33 18S 21E	SESENW 33 18S 21E	112-17-63
39-13628	Stock	0.21	1988	SENWSW 19 18S 21E	SENWSW 19 18S 21E	112-17-63
39-13994	Domestic	6.00	1990	SWSENE 33 18S 21E	SWSENE 33 18S 21E	112-17-63
39-13995	Domestic	6.00	1990	SWSENE 33 18S 21E	SWSENE 33 18S 21E	112-17-63
39-14489	Other	1.00	1989	None	NWNWSW 09 19S 21E	112-17-63
39-14490	Other	1.00	1989	None	NWSESE 19 18S 21E	112-17-63
39-14501	Domestic	6.00	1990	SWSESE 33 18E 21E	SWSESE 33 18S 21E	112-17-63
39-14502	Domestic	6.00	1990	SWSENE 33 18S 21E	SWSENE 33 18S 21E	112-17-63
4A-4012.0001	Irrigation Stock	1,200.00 1.66	1957	NE 20 18S 21E SWNE 29 18S 21E NE 29 28S 21E	SENW 29 18S 21E	112-17-63
4A-4013.0001	Irrigation Stock	25.00 0.44	1957	SENW 29 18S 21E	SENW 29 18S 21E	112-17-63
39-12679	Stock		P 1919		SWNESE 21 19S 21E	112-20-13

Old Rights

CLAIM NUMBER	CLAIM DATE	CLAIMED USE LOCATION	CLAIMED DIVERSION LOCATION	QUANTITY (AF-YR)	WATERSHED FILE REPORT NUMBER
048	1906	Insufficient information	Insufficient information	90,000	111-20-32
049	1905	Insufficient information	Insufficient information	90,000	111-20-32
0174	1892	SWSW 18 21S 22E	SWSW 18 21S 22E	15,264	111-23-AAA-1

P - Prior to.

TABLE 6-12 (cont'd)

SPRNCA Notices of Appropriation

SPRNCA NOTICES	CLAIMED USE LOCATION	CLAIMED DIVERSION LOCATION	CLAIMED USES	QUANTITY (AF-YR)	WATERSHED FILE REPORT NUMBER	DATE RECORDED
10 0201062.61	21S 21E	21S 21E	MI,PW,OT	All	111-20-32	1878
10 0201065.61	Insufficient info.	Insufficient info.	IR	Insufficient info.	111-20-32	1878
10 0201066.61	12 19S 21E	Insufficient info.	MI	Insufficient info.	111-20-32	1878
10 0201067.62	21 19S 21E	Insufficient info.	MI	All	111-20-32	1878
10 0201095.61	SWNW 29 21S 22E	SWNW 29 21S 22E	IR,DM,MI	9,050	111-20-32	1879
10 0201108.61	Insufficient info.	Insufficient info.	IR	All	111-20-32	1879
10 0201224.61	15 20S 21E	15 20S 21E	IR,MI	14,480	111-20-32	1879
10 0202790.11	29 21S 22E	29 21S 22E	IR,ST	Insufficient info.	111-20-32	1888
10 0203067.11	Insufficient info.	Insufficient info.	IR	4,525	111-20-32	1889
10 0203301.11	NESE 13 21S 21E	N2 19 21S 22E	IR	15,349	111-20-32	1892
10 0204165.11	36 21S 21E	SESE 36 21S 21E	IR,DM,ST,MI,OT	18,250	111-20-32	1896
10 0204173.11	Insufficient info.	Insufficient info.	IR,MI	73,000	111-23-AAA-1	1896
10 0207240.11	SW 22 23S 22E	SWSE 33 23S 22E	IR,DM,ST,OT	6,620	111-20-AAA-1	1903
10 0208061.11	N2NE 11 21S 21E	SESW 12 21S 21E	IR,DM,ST	Insufficient info.	111-20-32	1903
10 0211496.11	NE 28 18S 21E	NWSWNW 34 19S 21E	IR	90,500	111-20-32	1905
10 0212349.11	Boquillas Land Grant	04 20S 21E	IR	362,000	111-20-13	1906
10 0212365.11	NENWNW 14 20S 21E	NESENW 22 20S 21E	IR	362,000	111-20-32	1906
10 0216178 11	SESE 13 20S 20E	NWNW 24 20S 20E	IR,DM,ST,OT	All	111-20-23	1908
10 0216237.11	St. David area	S2 16 18S 21E	IR	90,500	111-17-88	1908
10 0221129.11	W2 03 23S 22E	SWW2SW 22 23S 22E	IR,ST,OT	All	111-23-AAA-1	1912
10 0221137.11	SE 21 23S 22E	SE 21 23S 21E	IR,ST	All	111-23-AAA-1	1912
10 0224178.12	SWSW 12 21S 21E	NWSWNW 13 21S 21E	IR,DM,ST,OT	126,700	111-20-032	1915
10 0224240.11	Insufficient info.	NENENW 11 23S 23E	IR,DM,ST,MI,OT	9,050	111-24-83	1915

Decrees

DECREE NUMBER	PARTIES	DATE	DIVERSION LOCATION	USE LOCATION	WATERSHED FILE REPORT NUMBER
20 0200011	Clifford v. Larrieu	1886	16 18S 21E	St. David area	112-17-DCD-1
20 0200197-1	Hill v. Lenormand	1888	12 19S 21E	12 19S 21E	111-20-32
20 0200716-1	Miller v. Douglas	1900	SE 13 20S 20E	SE 13 20S 20E	111-20-32
20 0204425	Wolf v. Turner et al.	1907	N2 19 21S 22E	N2 19 21S 22E	111-20-32
20 0200988	Boquillas Land & Cattle Co. v. St. David Coop. Comm. & Dev. Assn.	1907	Insufficient info.	St. David area	112-17-DCD-1

Instream Flow Right Applications

As of September 1, 1991, there are four instream flow right applications filed by BLM for the instream flows within the SPRNCA. Three of the applications, 33-90103, 33-95780, and 33-95789, are for the San Pedro River. One application, 33-95487, is for the Babocomari River, a major tributary to the San Pedro in the SPRNCA.

33-90103 (WFR #111-23-AAA-1 AND 111-24-CCB-11)

The Huachuca Audobon Society submitted an instream flow water right application to DWR on August 12, 1985. The application claimed the place of use as the San Pedro River from Hereford to eight miles south of Benson. The application has since been assigned to BLM.

The application was protested by several adjacent water users. The Huachuca Audobon Society responded to the protests. On May 28, 1986, the applicants assigned the application to BLM with the agreement that the applicants shall remain a party to the proceeding with intervenor status. However, upon the issuance of a decreed water right, BLM will be the sole owner of the water right.

On December 4, 1987, BLM amended its application to reflect the results of an extensive study of the area by Jackson et al., 1987. The amended application claims wildlife and fisheries uses, riparian habitat protection, and "recreation including aesthetic values." The amended flow claims are expressed as percentages of median daily flows for each month. The annual river flow regime was divided into four season flow periods: low flow (April through June), high flow (July through September), secondary low flow (October through November), and secondary high flow (December through March).

The BLM submitted an amendment of the application and technical support of the application to DWR on December 7, 1990. The amended application claims flows from the International Border to Palominas and from two miles south of Hereford to seven miles south of Benson. The point of measurement for the Palominas segment is the Palominas gage. The point of measurement for the northern segment is the Charleston gage. The amended claim requests median daily flows for each month for each segment as shown in Table 6-13. The total annual volume requested for the Palominas segement is 3,666 acre-feet per year. The total for the northern segment is 11,028 acre-feet per year.

TABLE 6-13

SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA
MEDIAN MONTHLY FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Palominas Gage	7.9	8.6	6.3	2.5	1.2	0.6	7.0	7.0	7.0	3.7	3.6	5.5
Charleston Gage	19.5	20.3	18.9	12.2	7.9	4.2	19.0	19.0	19.0	12.2	13.6	17.1

DWR has evaluated the BLM's claimed instream flows from Palominas and Charleston and compared these claims with available USGS data from Palominas and Charleston. These comparisons are shown in Figures 6-8 and Figure 6-9 for Palominas and Charleston, respectively. The USGS maintains continuous recording gaging stations at these locations and has compiled over thirty years of record for each gage (U.S. Geological Survey, 1991b).

The technical data supplied to DWR in support of the BLM application has been reviewed by DWR. DWR has requested more information regarding wildlife and recreational uses. The application is pending and has not been permitted.

33-95780 (WFR #111-24-CCB-11)

The BLM filed an instream flow water right application, 33-95780, with DWR for the San Pedro River within the SPRNCA on January 8, 1991. The application claims two segments of the San Pedro River: from the International Border to Palominas and from two miles south of Hereford to seven miles south of Benson. The application states that the claim seeks unappropriated water for wildlife including fish and recreational beneficial uses. The uses occur within the natural channel and are nonconsumptive with the exception of incidental wildlife uses.

The claimed flows are shown in Table 6-14 as monthly flows. The total annual volume claimed is 3,674 acre-feet per year. The point of measurement of the claimed flows is the Palominas gaging station. The claimed monthly flows are compared with the monthly flow data of the USGS in Figure 6-8. The USGS maintains a continuous recording gaging station at the Palominas site. The USGS Palominas gage has a thirty-four year continuous record of flow (U.S. Geological Survey, 1991b).

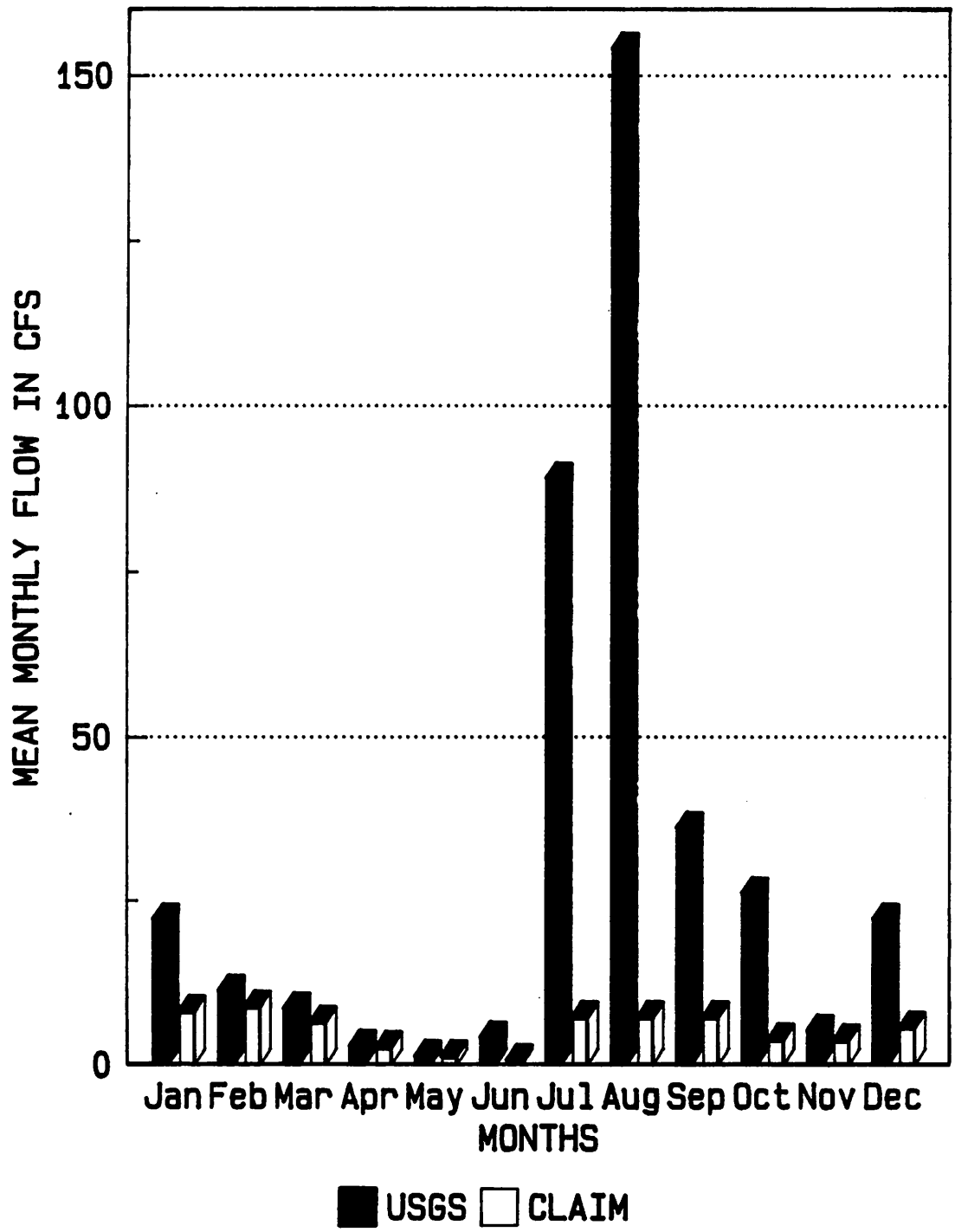


Figure 6-8. A comparison of USGS mean monthly flows at the Palominas continuous recording gaging station and mean monthly flows claimed for beneficial use within the SPRNCA by BLM as measured at the Palominas gage.

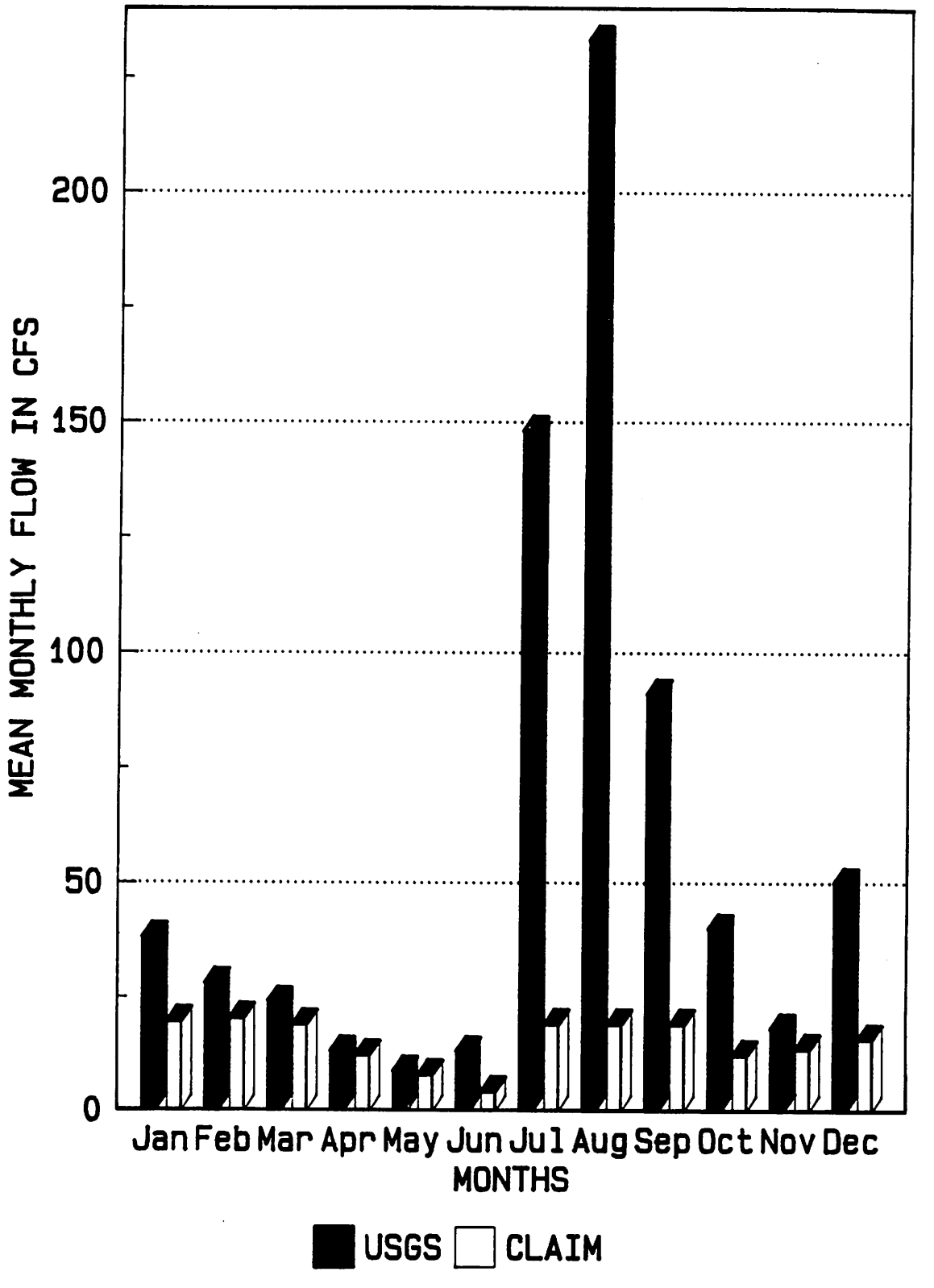


Figure 6-9. A comparison of USGS mean monthly flows at the Charleston continuous recording gaging station and mean monthly flows claimed for instream beneficial uses within the SPRNCA by BLM as measured at the Charleston gage.

TABLE 6-14

SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA
CLAIMED FLOWS BY MONTH
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Claim	7.9	8.6	6.3	2.5	1.2	0.6	7.0	7.0	7.0	3.7	3.6	5.5

The BLM has not provided DWR with any technical data in support of the application. The BLM is conducting streamflow measurements to submit to DWR at a later date. The application is currently in a pending status with DWR and has not been permitted.

33-95789 (WFR #111-23-AAA-1 AND 111-24-CCB-11)

The BLM filed an instream flow water right application, 33-95789, for segments of the San Pedro River within the SPRNCA on April 1, 1991. The claim states that the flows are to support wildlife including fish and recreational. The application claims nonconsumptive uses that occur within the natural channel of the San Pedro River except for incidental wildlife uses.

The claim does not state an annual volume or monthly flows. However, the application does request unappropriated peak flows. The peak flows are required for the germination of cottonwood seedlings and the maintenance of riparian habitat (Jackson et al., 1987). The peak flows support and maintain channel geomorphic processes and conditions.

The BLM has not provided technical data in support of the application. The application is pending and has not been granted permit status.

33-95787 (WFR# 111-20-32)

The BLM filed an instream flow application, 33-95787, for the Babocomari River within the SPRNCA. The application states an annual volume of 3,254 acre-feet per year. The flows are to support wildlife and recreational uses. The BLM has not provided any technical support of the application, but is conducting instantaneous flow measurements on the claimed reach. DWR has not granted a permit for this application. The application has a pending status.

Federal Reserved Water Right Claim

The SPRNCA was established by an Act of the United States Congress (S. 2840). Under Title 1, Section 102 (d) the Congress specified the SPRNCA water rights:

> (d) WATER RIGHTS- Congress reserves the right for the purpose of this reservation, a quantity of water sufficient to fulfill the purposes of the San Pedro Riparian National Conservation Area created by this title. The priority date of such reserve rights shall be the date of enactment of this title. The Secretary shall file a claim for the quantification of such rights in an appropriate stream adjudication.

The BLM, Safford District, administers this area and has filed a statement of claimant, 39-13610, for a federal reserved water right.

This statement of claimant has a priority date of November 18, 1988, the date of creation of the SPRNCA, and claims an instream use of 11,028 acre-feet of water per year. The amount of water claimed is based upon median monthly flows as depicted in Table 6-15.

TABLE 6-15

SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA
CLAIMED VOLUME OF WATER USE BY MONTH
(CFS)

GAGING STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Palominas	7.9	8.6	6.3	2.5	1.2	0.6	7.0	7.0	7.0	3.7	3.6	5.5
Charleston	19.5	20.3	18.9	12.2	7.9	4.2	19.0	19.0	19.0	12.2	13.6	15.8

The statement of claimant references two discreet segments of the San Pedro River: the first length from a few miles north of the International Border to a point near the Charleston gage, the second reach is from the Charleston gage to a point just south of St. David (Plate 16).

The claimed uses are: municipal, domestic, recreation, fish and wildlife, and instream flow. The means of diversion claimed by BLM is through instream flow and the pumping of existing wells. The source of the water is the San Pedro River and well water from Zone 2 (wells subject to federal claims zone).

This claim is part of a dual claim. Statement of claimant 39-13611 has been filed for the perennial reaches claiming water rights based upon state water law.

On June 4, 1991, BLM amended statement of claimant 39-13610 to claim instream flows, administrative uses, maintenance of natural hydrologic processes, watershed rehabilitation, and fire suppression. The claimed priority date is November 18, 1988, the creation date of the SPRNCA.

The instream flows claimed on this amended statement of claimant consist of baseflows and flushing flood flow components for the San Pedro and Babocomari Rivers within the confines of the SPRNCA. The baseflow amounts claimed are the same as the amounts claimed under state right claims 33-90103 and 33-95780 for the San Pedro River and 33-95487 for the Babocomari River.

This federal reserved right claims present and future uses from existing springs, ponds, cienegas, oxbow lakes, domestic wells, irrigation wells, railroad wells, livestock wells, and industrial wells. The amounts claimed for these uses are the same as the amounts claimed by previous land owners or BLM under the original state rights for the same uses.

Water Uses

Historically, much of the lands now within the SPRNCA were used for livestock grazing. Limited grazing continued until acquisition of the lands by BLM. Numerous springs and seeps supplied water for livestock. Perennial portions of the San Pedro River also provided an additional source of stockwater. During periods of drought when surface waters may have been scarce or nonexistent, supplemental stockwater was supplied by wells. Most of these stockwatering wells are no longer in use and have been capped by BLM.

With the discovery of silver in the Tombstone region in 1877, several stamp mills were constructed along the banks of the San Pedro River due to the available water supply. These mills were operated for nearly ten years until the Tombstone mines were flooded in 1887. Several towns such as Charleston, Millville, Contention City, and Emery City were founded near the mill sites. The Town of Fairbank was founded at the junction of the railroad lines which served the stamp mills, mines, and towns, The small town of Hereford was founded at the site of an ore smelter and later became a ranching community adjacent to the large Green Cattle Company ranch. Most of these small

Figure 6-10. The San Pedro Riparian National Conservation Area is shown approximately one mile upstream (south) of the St. David Irrigation District diversion. Riparian vegetative associations are comprised of medium-dense mesquite and cottonwoods. The measured discharge at this site was eleven cfs in March 1990.

Figure 6-11. The San Pedro Riparian National Conservation Area is shown south of State Highway 90. The formerly irrigated acreage, now part of the conservation area, has been classified by DWR as "discontinued." The San Pedro River is well defined by the dense stand of mature cottonwood trees.

communities have since become "ghost towns" with the waning of the mining boom. The BLM maintains an office in Fairbank for the administration of the SPRNCA.

The BLM entered into a Special Use Permit/Right of Way Agreement with SDID for the purpose of maintaining the district's surface water diversion and ditch system. From the diversion dam, the ditch flows north along the east bank of the San Pedro River for approximately three miles within the SPRNCA.

There have also been several sand and gravel processing operations along the San Pedro River. The last operation was discontinued in January 1990 when BLM declined to renew the special use permit.

A fifteen year moratorium on livestock grazing was initiated by BLM (U.S. Department of the Interior, Bureau of Land Management, 1989). This moratorium was declared to allow BLM officials time to study the past, present, and future impacts of livestock grazing within the SPRNCA.

A thorough inventory of water sources was conducted by BLM after the acquisitions of the properties in 1986. A description of these sources is depicted in Table 6-16.

TABLE 6-16

WATER SOURCES IN THE SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA

SOURCE NAME	SOURCE TYPE	CLAIMED LEGAL DESCRIPTION	APPLICABLE FILINGS	WATERSHED FILE REPORT NUMBER
Wolf #1	Well	NWNESE 16 23S 22E	39-372 39-12705	111-23-AAA-1
Wolf #2	Well[1]	NWNWSW 8 22S 22E	39-371 39-12706	111-23-AAA-1
Snake	Well[1]	NWSESW 17 22S 22E	39-12707	111-23-AAA-1
Cottonwood #1	Well[1]	SWNESW 17 22S 22E	39-13627	111-23-AAA-1
Cottonwood #3	Well[1]	NWSWNE 29 22S 22E	39-12710 39-13626	111-23-AAA-1
River	Well	SWNWSE 15 23S 22E	39-4297	111-23-AAA-1
Shugart #1	Well[1]	NWNESW 10 23S 22E	39-4296	111-23-AAA-1
Whitehouse	Well	NWSESE 16 23S 22E	33-89568 39-4274 39-12699	111-23-AAA-1
North Cobb	Well	SWSWNE 16 23S 22E	39-12714	111-23-AAA-1
Cobb Place	Well[1]	SWNESE 21 23S 22E	39-4301	111-23-AAA-1

[1]Unused well.

TABLE 6-16 (cont'd)

SOURCE NAME	SOURCE TYPE	CLAIMED LEGAL DESCRIPTION	APPLICABLE FILINGS	WATERSHED FILE REPORT NUMBER
Little Joe Spring	Spring	SENW 29 18S 21E	39-670 4A-4013	112-17-63
Pipeline Tank	Stockpond	SENWSW 19 18S 21E	39-13628 38-94145	112-17-63
Two-Cienega Spring	Spring	SENW 29 18S 21E	39-672 4A-4012	112-17-63
Graveyard Gulch Spring	Spring	SESW 2 18S 21E	39-674 4A-04019	111-20-32
Murray Spring	Spring	SENW 25 21S 21E	39-676 4A-4021	111-20-32
Horsethief Draw Spring	Spring	SESE 36 21S 22E	39-677 4A-4022	111-20-32
Meusel Spring	Spring	SWSWSE 31 21S 22E	39-14505 39-13992 33-95392	111-20-32
Lewis Springs South	Spring	SWNW 29 21S 22E	39-678 4A-4023	111-20-32
Lewis Springs North	Spring	NESESW 20 21S 22E	39-13993 39-14503 33-95388	111-20-32
Ernist Pond	Stockpond	NWSESW 5 22S 22E	39-14506 39-13999 33-95393	111-23-AAA-1
Garden Canyon Spr.	Spring	NWNW 7 22S 22E	39-671 4A-4024	111-23-AAA-1
Young Block Sump Pond	Pond	SWNENW 8 22S 22E	None	111-23-AAA-1
Moson Spring	Spring	NENW 13 21S 21E	39-675 4A-4020	111-20-32
Babocomari River	Instream Use	NESE 04 20S 21E SWSE 04 20S 21E SESE 04 20S 21E NESE 08 20S 21E SWSE 08 20S 21E SESE 08 20S 21E NWNE 09 20S 21E SWNE 09 20S 21E NENW 09 20S 21E NWNE 17 20S 21E NENW 17 20S 21E NWNW 17 20S 21E SWNE 18 20S 21E	39-7752 33-95487	111-20-32
Unnamed Well	Well	NWSE 21 19S 21E	None	112-17-63
Unnamed Well	Well	SESW 10 23S 22E	None	111-23-AAA-1
Domestic Well	Well	SENWNW 3 24S 22E	None	111-24-CCB-11
Well #7	Well	NENWSW 9 24S 22E	39-970	111-24-CCB-11
Well #15A	Well	NENWNW 20 24S 22E	39-978	111-24-CCB-11
Well #9	Well	NWNWNW 3 24S 22E	39-972	111-24-CCB-11
Well #11	Well	NENESW 4 24S 22E	39-974	111-23-CCB-11
Well #8	Well	NWSENW 9 24S 22E	39-971	111-24-CCB-11

TABLE 6-16 (cont'd)

SOURCE NAME	SOURCE TYPE	CLAIMED LEGAL DESCRIPTION	APPLICABLE FILINGS	WATERSHED FILE REPORT NUMBER
Well #12	Well	NWNWSW 8 23S 22E	39-975	111-24-CCB-11
Well #14	Well	NWSWSW 8 24S 22E	39-976	111-24-CCB-11
Well #4	Well	NWNENW 17 24S 22E	39-976	111-24-CCB-11
Well #5	Well	SWSENW 17 24S 22E	39-968	111-24-CCB-11
Well #6	Well	SWNESW 17 23S 22E	39-969	111-24-CCB-11
Well #10	Well	SWNWSW 17 24S 22E	39-973	111-24-CCB-11
Well #15	Well	NENENW NO 24S 22E	39-977	111-24-CCB-11
Well #16	Well	SENENE 19 23S 22E	39-979	111-24-CCB-11
Stonehouse Well	Well	NWNWSE 19 18S 21E	39-4283	112-17-63
			39-12692	
Curtis Flat Well	Well	SESWSW 33 18S 21E	39-4286	112-17-63
Summers Well	Well	NENWSW 9 19S 21E	39-4287	112-17-63
Contention Well	Well	NWNENW 21 19S 21E	39-4288	112-20-13
			39-12679	
Fairbank	Well	NWNWSE 3 20S 21E	39-14488	111-20-32
Fairbank #1	Well	NENESW 10 20S 21E	39-4289	111-20-32
Fairbank #2	Well	NWNW 3 20S 21E	39-12691	111-20-32
Chinese Garden #1	Well	SESWSW 10 20S 21E	39-4276	111-20-32
			39-12690	
Chinese Garden #2	Well	SWSW 10 20S 21E	39-4277	111-20-32
Fairbank Well at Boquillas	Well	SWSWNW 14 20S 21E	39-4290	111-20-32
Well #23	Well	SESWSE 15 20S 21E	39-4291	111-20-32
H & I Well	Well	SESENE 15 20S 21E	39-12689	111-20-32
Well #24	Well	SWSESE 16 20S 21E	39-4292	111-20-32
Wolf Well	Well	SWSENE 6 22S 22E	39-4293	111-23-AAA-1
Well #29	Well	NWNESE 17 22S 22E	39-373	111-23-AAA-1
			39-12708	
Sierra Ready Mix Well	Well	SWSWNW 21 22S 22E	39-12709	111-24-82
Hereford Well	Well	SESENW 10 23S 22E	39-4294	111-23-AAA-1
			39-13996	
			39-12712	
Schoolhouse Well	Well	NWSESE 10 23S 22E	39-4295	111-23-AAA-1
Sneed Well	Well	SWNWSE 15 23S 22E	39-4298	111-23-AAA-1
Hereford J	Well	SWSWSW 15 23S 22E	39-12713	111-24-CCB-11
Well #36	Well	NWNESE 16 23S 22E	None	111-23-AAA-1
Cobb House Well	Well	SWSENE 16 23S 22E	39-12715	111-23-AAA-1
Lowery	Well	NWSESW 22 23S 22E	39-4275	111-23-AAA-1
Escalante #1	Well	SWSENE 33 18S 21E	39-13994	112-17-63
			39-14501	
Escalante #2	Well	SWSENE 33 18S 21E	39-14490	112-17-63
			39-13995	
Land Bor.	Well	SESENW 19 18S 21E	39-14490	112-17-63
Summers Bor.	Well	NWNWSW 9 19S 21E	39-14489	112-17-63
Flowing Well	Well	NESENW 33 18S 21E	39-13625	112-17-63
Well #3	Well	NENWSE 8 23S 22E	None	111-24-CCB-11
Well #2	Well	NESENE 8 24S 22E	None	111-24-CCB-11
Well #1	Well	NESWSW 4 24S 22E	None	111-24-CCB-11
First Interstate Well	Well	SWSWNW 15 23S 22E	None	111-23-AAA-1
Railroad Well	Well	SESESW 19 23S 22E	39-14508	111-23-AAA-1

TABLE 6-16 (cont'd)

SOURCE NAME	SOURCE TYPE	CLAIMED LEGAL DESCRIPTION	APPLICABLE FILINGS	WATERSHED FILE REPORT NUMBER
Palominas Dike	Flood Control Structure	17 24S 22E	None	111-24-CCB-11
Tank #6	Stockpond	SENE 18 24S 22E	33-31987 39-955	111-24-CCB-11
Tank #7	Stockpond	SENE 17 24S 22E	33-31988 39-956	111-24-CCB-11
Tank #8	Stockpond	SENE 17 24S 22E	33-31988 39-957	111-24-CCB-11
Palominas Dam #9	Stockpond	SESWNE 17 24S 22E	None	111-24-CCB-11
St. David Irrigation Ditch	Diversion Dam	NENWSW 4 19S 21E	None	112-17-DCD-1
Fairbank Dam	Diversion Dam	SESESE 28 19S 21E	None	111-20-32
Concrete Structure #1	Flood Control Structure	SENESE 28 19S 21E	None	111-20-32
Concrete Structure #1	Flood Control Structure	NESESE 28 19S 21E	None	112-20-13
Lomeli Spring	Spring	NWNWNW 29 21S 22E	39-13997 39-14504 33-75383	111-20-32
Brockelsby Pond	Babocomari River	SENW 9 20S 21E	36-89569	111-23-AAA-1
Hereford Irrigation Ditch	Well	SWSW 10 23S 22E	33-89569	111-23-AAA-1
Black's Pond	Stockpond	SWNE 4 19S 21E	36-29134	112-17-63
Whitehead's Tank	Stockpond	NWSW 4 19S 21E	38-21750	112-17-63
Whitehead's Pond	Stockpond	NWSW 4 19S 21E	36-21747	112-17-63
Plainer's Well	Well	30 21S 22E	36-75652	111-23-AAA-1
San Pedro River	Instream Use	18S 21E	39-370	111-23-AAA-1
		Entire Reach	39-14485	
		19S 21E	39-662	
		20S 21E	39-13611	
		NENW 21 18S 21E	39-13610	
		Entire Reach	39-14482	
		NENE 11 21S 21E	33-90103	
		None	33-95780	
		NWNW 22 23S 22E	4A-4069	
		Entire Reach	33-95789	
Hargis Well	Well	SESE 39 22S 22E	36-28399	111-23-AAA-1
Noyes Ditch	Diversion Dam	Unknown	36-28874	112-20-13 111-20-32
Domestic Well	Well	SENWNW 03 24S 22E	39-14491	111-24-CCB-11
Fred's Lake	Instream Use	SWNENW 08 22S 22E	39-14507 39-95394 39-13998	111-23-AAA-1

The BLM located sixty-three wells, eleven springs, ten stockponds, four flood control structures, and one active surface water diversion. They also described instream uses on the Babocomari and San Pedro Rivers. During the inventory process, many of these sources were recognized as being unusable or in poor condition.

Description of Irrigation Uses

Much of the property acquired by BLM was irrigated by the former land owners, Tenneco West, Inc., and the Victorio Land and Cattle Company, utilizing well water as the source of supply. At the time of acquisition, approximately 1,946 acres were under cultivation with pasture being the predominant crop.

The sources of supply for this irrigated acreage were water from numerous wells located in both Zones 1 and 2. There were a total of twenty-two wells that supplied irrigation-type water uses within the SPRNCA. A total of twelve wells are located within Zone 1 and ten wells are found in Zone 2. The Zone 1 wells provided water to nearly 1,178 irrigated acres while the Zone 2 wells supplied water to an additional 692 acres. Commingling of well water from Zones 1 and 2 provided water to just over seventy-six acres of cropland. There were no irrigation uses supplied by surface water within the SPRNCA. The only diversion of surface water is the previously mentioned SDID diversion and ditch system in the northern end of the SPRNCA.

DWR performed crop surveys of the area in April 1990 and in September 1990. All of the acreage has been classified as discontinued irrigation. Discontinued irrigation is acreage which has not been irrigated in the last five years, but has been irrigated between five and ten years prior to DWR's field investigations.

Future Water Uses

The BLM has drawn up contingency plans to utilize pumped groundwater to maintain aquatic habitats in the San Pedro River during times of drought and reduced streamflow. Some of the existing springs and ponds may be developed to provide habitats for terrestrial and aquatic wildlife species. The plans also call for providing water for wildlife to the dry upland portions of the SPRNCA.

Much of the previously irrigated acreage had been protected from periods of high streamflow by flood control dikes and berms. The BLM plans to remove these earthen structures and allow the pre-existing drainage patterns to re-establish.

In support of the stated recreational goals, BLM will construct four large and seven small recreational sites (U.S. Department of the Interior, Bureau of Land Management, 1989). These sites may include water for domestic use depending upon perceived needs. The sites will be located in or near areas of cultural interest or visitor activity.

At this time, the only continuous water uses are domestic in nature. They are located at the SPRNCA administrative office in Fairbank and at the visitor site called the House on the San Pedro River.

A more detailed analysis of existing diversions and claimed water uses for portions of the SPRNCA may be found within the applicable WFRs shown in Table 6-17.

TABLE 6-17

LOCATIONS DESCRIBED BY WATERSHED FILE REPORTS PERTAINING TO THE SPRNCA

WATERSHED FILE REPORT NUMBER	AREAS DESCRIBED	MAJOR WATER USE
112-17-63	Section 24, T. 18S., R.21E. Sections 19, 20, 29, 30, 32, 33, T.18S., R.21E. Sections 4, 5, 8, 9, T.19S., R.21E.	Stockwatering
112-17-DCD-1	Portions of Sections 32, 33, T.18S., R.21E. Portions of Sections 4, 5, T.19S., R.21E.	Right-of-way for the St. David Irrigation District Diversion and Ditch System.
112-20-13	Portions of Sections 16, 17, 20, 21, 22, 27, 28, 29, 32, 33, T.19S., R.21E.	Stockwatering
111-20-32	Portions of Sections 27, 28, 33, 34, T.19S., R.21E. Portions of Section 6, T.20S., R.22E. Portions of Sections 1-4, 8-18, 21-24, 26, 27, 28, 33, 34, 35, 36, T.20S., R.21E. Portions of Sections 1, 2, 3, 11, 12, 13, 14, 23-26, 36, T.21S., R.21E Portions of Sections 6, 7, 18-20, 29-33, T.21S., R.22E.	Stockwatering

TABLE 6-17 (cont'd)

WATERSHED FILE REPORT NUMBER	AREAS DESCRIBED	MAJOR WATER USE
111-23-AAA-1	Sections 5-8 T.22S., R.22E. Portions of Sections 17-20, 27-34, T.22S., R.22E. Portions of Sections 3, 4, 9, 10, 15, 16, 21, 22, T.23S., R.22E.	Irrigation
111-24-CCB-11	Portions of Sections 3, 4, 8, 9, 17, 18, T.24S., R.22E.	Irrigation
111-24-82	Portions of Section 21, T.22S., R.22E.	Discontinued Industrial Use

Quantification of Significant Diminishment to the SPRNCA

The same approach that was used in analyzing the effects of off-reservation pumpage to Fort Huachuca (see Chapter 5, Section 5.4) was also used in analyzing the effects that major groundwater users would have on the SPRNCA. The USGS Modflow model (Freethey, 1982) was again used as the basis to determine the potential impacts. However, for the determination of significant impacts to the conservation area, only the scenario that incorporated groundwater withdrawals due to Fort Huachcua, Sierra Vista, and Huachuca City pumpage were used. This would show the effects that the combined groundwater withdrawals would have on the SPRNCA, as the cone of depression in the Sierra Vista - Fort Huachuca area would have the most potential for impacting the SPRNCA. For a detailed description of the methodology that was used to conduct this analysis, refer to APPENDIX G.

The results of continued groundwater withdrawals in the Sierra Vista - Fort Huachuca area and the effect they have on the SPRNCA are shown in Figure 6-12. This figure illustrates the present (1988) and projected (2038) impact to the SPRNCA and shows only the area within the SPRNCA boundaries that were impacted the most due to the major groundwater withdrawals in the Sierra Vista - Fort Huachuca area. The location of this cross-section is from Section 26, Township 21 South, Range 22 East to Section 21, Township 21 South, Range 22 East. At the present time, there is a hydraulic connection between the aquifer and the San Pedro River. This indicates that water is being discharged from the regional aquifer to the stream. This discharge provides

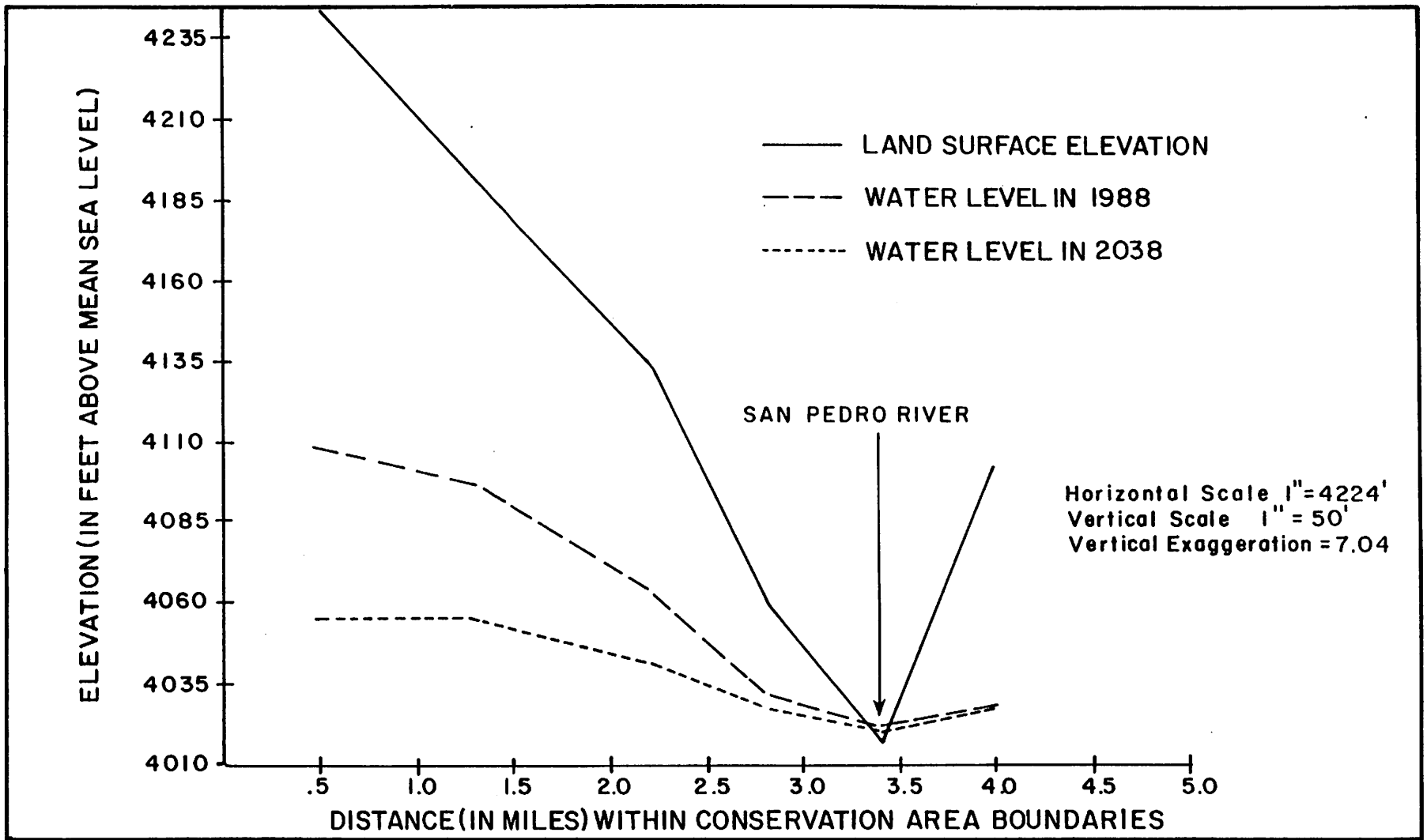


Figure 6-12. Projected impacts to the San Pedro Riparian National Conservation Area from groundwater withdrawals in the Sierra Vista - Fort Huachuca area.

the baseflow to the San Pedro River within the Sierra Vista subwatershed and can be considered a result of mountain front recharge that has infiltrated into the aquifer. Figure 6-12 also indicates that the cone of depression in the Sierra Vista - Fort Huachuca area has not intercepted the river. However, a certain amount of groundwater flow towards the river in the regional aquifer is being diverted into the cone of depression (Figure 6-12). As pumping continues through time (assuming a constant pumping rate), the cone of depression will continue to spread until it intersects the stream to which it is hydraulically connected. When this occurs, the spread of the cone will cease as the stream will prevent drawdown along the streambank. These wells would then be withdrawing water from the stream.

The projected impacts to the SPRNCA are also shown in Figure 6-12. This figure indicates that water level declines of approximately fifty to sixty feet may occur by the year 2038 near the SPRNCA boundary closest to the Sierra Vista - Fort Huachuca cone of depression. Figure 6-12 also shows that fifty years into the future, the Sierra Vista - Fort Huachuca cone of depression has not yet intercepted the stream. However, projected results indicated that gains to the San Pedro River in the reach between Palominas and Charleston and Charleston to the mouth of the Babocomari River will be 2.5 and 0.7 cfs, respectively, in the year 2038. This is a decrease of approximately 0.9 and 0.3 cfs from the year 2000 in the amount of water available to the stream. If the current rates of withdrawal continue, the potential exists for the cone of depression to intercept the stream and potentially divert and deplete surface water flows.

Conclusions

The BLM has been mandated by the United States Congress to manage the SPRNCA ". . . in a manner that conserves, protects, and enhances the riparian, wildlife, archaeological, paleontological, scientific, cultural, educational, and recreation resources of the conservation area."

In BLM's Management Plan and Environmental Impact Statement of June 1989, the preferred alternative develops a number of scenarios with which to implement the congressional mandate. These scenarios detail the proposed actions to be taken on each of the affected resources such as: cultural, visual, wildlife, archaeological and paleontological, lands, recreation, vegetation, soils and watershed, and water resources.

The BLM's management plan for the water resources are proposed as maintenance of existing potential water rights by periodic pumpage of well water on the formerly irrigated acreages. Filing of statements of claimant in the adjudication proceeding which claim instream flow values are described in the Water Rights Registration filing 33-90103 and in statements of claimant 39-13610 and 39-13611. The BLM plans to conduct research on experimental revegetation of some of the discontinued irrigation acreage and may activate one or more wells to provide water for this project. The BLM has also implemented a plan to locate and cap all unnecessary irrigation wells.

The BLM is continuing its well monitoring and surface water measuring program in an effort to quantify flows within the perennial reaches of the SPRNCA. This data is being stored in a data base system and is used by BLM managers in support of stated resource goals and in support of instream flow claims submitted to DWR.

SAN PEDRO RIVER (WFR #113-12-34)

The ANC filed an instream flow water right application, 33-96127, for a portion of the San Pedro River in the Redington subwatershed. The application was filed with DWR on August 7, 1991. The application claims a reach of the San Pedro River beginning at a point in the SE¼, SW¼, Section 15, Township 13 South, Range 19 East and continuing downstream to a point in the W½, SE¼, Section 10, Township 13 South, Range 19 East (Figure 2-12).

The application requests baseflows for the maintenance of riparian habitat and wildlife use. The flows requested are shown in Table 6-18. The annual amount requested is 8,239 acre-feet per year.

TABLE 6-18

SAN PEDRO RIVER (WFR #113-12-34)
MONTHLY CLAIMED FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Claim	14	19	17	8	6	5	11	14	13	8	10	12

No technical data accompanied the application. The applicant does not maintain a gaging station on the claimed reach. DWR has not investigated this claim.

SAN PEDRO RIVER (WFR #113-12-DBC-12)

Jack Hughes filed an instream flow water right application, 33-96126, with DWR for a portion of the San Pedro River in the Redington subwatershed. The claimed reach begins at a point in the SE¼, SW¼, Section 4, Township 13 South, Range 19 East and continues downstream to a point in the SW¼, NW¼, Section 10, Township 13 South, Range 19 East (Figure 2-12).

The application claims an annual volume of 10,341.4 acre-feet per year. The application requests monthly baseflows as shown in Table 6-19. The flows are to maintain wildlife and riparian habitat. The land owner has initiated the application with the intent of one day selling his property to the ANC.

TABLE 6-19

SAN PEDRO RIVER (WFR #113-12-DBC-12)
MONTHLY CLAIMED FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Claim	18	24	20	11	7	6	13	18	17	10	12	16

No technical data accompanied the application. The applicant does not maintain a gaging station on the claimed reach. DWR has not investigated this claim.

SWAMP SPRINGS CANYON (WFR #113-12-9 AND #113-12-11)

The BLM filed an application, 33-94370, for a minimum instream flow claim on Swamp Springs Canyon, a tributary to Redfield Canyon. The BLM filed the application with DWR on December 1, 1988. The BLM has indicated that at some future date they may combine this application with the Redfield Canyon application (33-94369).

The BLM's Swamp Springs application is located in the Redington subwatershed. The claimed perennial reach begins in the SW¼, NE¼, Section 34 and continues to the SW¼, NE¼, Section 32, Township 11 South, Range 20 East (Figure 2-12). The claimed location is within the Redfield Canyon Wilderness Area designated by Congressional Act in 1990.

The application claims uses are to maintain the existing riparian habitat, protect native fisheries and wildlife, and provide for recreation. The application's claimed amounts are minimum median monthly flows in cfs as shown in Table 6-20.

TABLE 6-20

SWAMP SPRINGS CANYON
CLAIMED MONTHLY FLOWS
(CFS)

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Median flow	6.0	11.0	6.0	5.0	4.0	2.0	7.0	13.0	10.0	8.0	5.0	7.0

The average of the minimum median monthly flows is 7.0 cfs. The total amount of water claimed by BLM for use within Swamp Springs Canyon is 5,066.57 acre-feet per year. The Swamp Springs Canyon application is currently under a protested status by the Bayless and Berkalew Company. The estate of Hope I. Jones has withdrawn its protest.

The BLM has not currently provided DWR with any technical data in support of this application. There is currently no gaging station located within Swamp Springs Canyon. DWR personnel have not yet field investigated this claimed reach.

WILDCAT CANYON (WFR #113-13-7)

The BLM filed an instream flow water right application, 33-95454, with DWR on June 6, 1990 for Wildcat Canyon, a tributary to Hot Springs Canyon (Figure 2-12). The application states the instream flow is to support wildlife and maintain riparian habitat. The canyon is home to the state protected Gray Hawk and native fishes. The application claims baseflows totaling 452.3 acre-feet per year.

The BLM has not provided any technical data in support of this claim and does not maintain a permanent gage on the claimed reach. The BLM in cooperation with the ANC has initiated an instream flow monitoring program on the canyon and will supply DWR with the results of the program at a later date.

The application is pending and has not been granted permit status.

CHAPTER 7: UNUSUAL CIRCUMSTANCES REPORTS

This chapter describes unusual claims or water use activities located in the San Pedro River watershed and investigated by the Arizona Department of Water Resources (DWR). These reports provide additional information about these unusual water uses that are not adequately covered in the watershed file reports (WFRs). The unusual water using activities presented in this chapter include: Aravaipa Creek flood damage report, cienega uses and claims, fish farming operations, the Arizona Water Company Oracle system, and the Naco Sanitary District. Water rights filings, statements of claimants, and uniform questionnaires are listed which are not included in any WFRs for the final San Pedro Hydrographic Survey Report (HSR). Finally, claims made by water users located downstream of the San Pedro River watershed are discussed.

7.1 ARAVAIPA CREEK FLOOD DAMAGE REPORT

Aravaipa Creek suffered two major flood events in the last twelve years. The first flood occurred during the winter of 1978-1979 and the second in October of 1983. High precipitation throughout the winter of 1978-1979 culminated in peak discharge along Aravaipa Creek at 16,200 cubic feet per second (cfs) on December 18, 1978. Monsoon storms and remnants of Hurricane Octave caused abnormally high precipitation in September 1983, producing a 100-year magnitude flood event. Peak discharge from this flood event occurred on October 1, 1983, and was estimated at 78,000 cfs.

The following series of flood damage reports by ownership describe in detail the effects of the October 1983 flood on agriculture supplied from Aravaipa Creek. The following reports and tables are presented for flood damages that occurred along Aravaipa Creek on the east and west sides of Aravaipa Canyon. For a comparative look at the pre-1983, post-1983 and current irrigated acreage totals refer to Tables 7-1 and 7-2, and Plate 17 located in the pocket of this volume.

EAST ARAVAIPA CREEK FLOOD DAMAGE REPORTS

Claridge, Wilford H. (WFR #115-5-AC-4)

The diversion which served this field was located on property owned by the Arizona Chapter of the Nature Conservancy (ANC). The flood of October 1983 destroyed diversion D7 and removed the ditch up to the headgate. Currently this diversion has been relocated one-fifth of a mile downstream and diverts the entire flow of Aravaipa Creek (refer to WFR #115-5AC-5).

The Arizona Chapter of the Nature Conservancy (WFR #115-5-AC-5)

The irrigated acreage owned by the ANC is comprised of numerous noncontiguous fields that were served at one time by as many as six surface water diversions. These fields and diversions were severely impacted by both the 1979 and 1983 floods.

Currently diversion D2 is being restored and will be operating soon. Diversion D3 has not yet been restored. The ANC does plan to eventually use

Figure 7-1. A headgate and diversion on upper Aravaipa Creek was damaged in the October 1983 flood. This diversion and the ditch system it supplied has since been reconstructed and now serves nearly twenty-five acres of cropland.

this diversion again. The ditch from D3 is partially silted in and overgrown with vegetation. The acreage formerly served by D3 has not been fully reclaimed due to the condition of the diversion and ditch. Diversion D7, located on property owned by the ANC, is operated by the Claridge family (WFR #115-5-AC-4). This earthen diversion diverts the entire flow of Aravaipa Creek which supplies water to 26 acres of property owned by Claridge and 15.6 acres owned by the ANC. Tailwater from this irrigation is returned to Aravaipa Creek.

Bureau of Land Management (WFR #115-5-AC-10)

This irrigated acreage leased by Jose Tapia was supplied by diversion D2 located on ANC land (refer to WFR #115-5-AC-5). The 1983 flood destroyed diversion D2 and thus this acreage is not being irrigated at the present time. However, the diversion and ditch are currently being restored by the ANC.

Salazar, Epigmenio (WFR #115-5-AB-1)

Prior to the 1983 flood, this acreage was served by the Salazar-Tapia ditch which originates at diversion D1 on the ANC property (WFR #115-5-AC-5). The Salazar family constructed this earthen ditch originally in 1908. The ditch also serves Pacheco (WFR #115-5-AB-5), Miranda (WFR #115-5-AB-3), and Tapia (WFR #115-5-AB-4), as well as the ANC. The diversion and ditch were damaged in the 1983 flood but repairs were completed by the summer of 1985. All of the pasture on the land owned by Mr. Salazar was severely scoured and destroyed by the 1983 flood, but has since been restored to use.

Pacheco, Alex and Christine (WFR #115-5-AB-2)

Prior to the 1983 flood, this acreage was served by the Salazar-Tapia ditch (refer to WFR #115-5-AB-1). The ditch was re-established in 1987. Currently the 1.7 acres of pasture has been restored and is served by the Salazar-Tapia ditch.

Miranda, Miguel and Patrio (WFR #115-5-AB-3)

This irrigated acreage is served by the Salazar-Tapia ditch (refer to WFR #115-5-AB-1 for a description of the ditch). The flood of 1983 destroyed 1.5

acres, but all of the irrigable acres (4.7 acres) were put back in use during the summer of 1985 when the diversion and ditch were repaired.

Tapia, Victoria and Jose S. (WFR #115-5-AB-4)

The Salazar-Tapia ditch and diversion D1 serves the irrigated pasture owned by the Tapia family. This pasture was heavily damaged in the 1983 flood. The remaining 6.2 acres were brought back into use when the ditch was repaired during the summer of 1985.

Summary

Of the seven land owners affected by the 1983 flood in the East Aravaipa Creek area, a total of 22.9 acres of the 103.0 pre-1983 flood acres were destroyed (Table 7-1). Most of these acres either have been or are in the process of being restored to preflood conditions. A additional 23.2 acres have been brought into production since 1983.

TABLE 7-1

EAST ARAVAIPA CREEK ACREAGE IMPACTED
BY THE 1983 FLOOD

WATERSHED FILE REPORT NUMBER	PREFLOOD IRRIGATED ACRES	POST-FLOOD IRRIGATED ACRES	ACRES CURRENTLY BEING IRRIGATED
115-5-AC-4	26.0	26.0	26.0
115-5-AC-5	58.3	48.3	81.5
115-5-AC-10	2.0	0.0	2.0
115-5-AB-1	4.1	0.0	4.1
115-5-AB-2	1.7	0.0	1.7
115-5-AB-3	4.7	3.2	4.7
115-5-AB-4	6.2	2.6	6.2
TOTALS	103.0	80.1	126.2

WEST ARAVAIPA CREEK FLOOD DAMAGE REPORTS

The Arizona Chapter of the Nature Conservancy (WFR #115-4-AAD-2)

The acreage owned by the ANC on the west side of the BLM Wilderness Area is located on both sides of the creek and was served by two diversions. The Wood Diversion D1 formerly provided water for the northern portion of

irrigated acreage, but was destroyed along with most of its ditch in the 1983 flood. None of the northern acreage was damaged and is currently being supplied by an instream pump P1, using the existing ditch system.

The Westerfield Diversion D1 was restored after the 1983 flood and still serves the southern irrigated acreage. Flood waters destroyed 1.2 acres of the southern acreage, but this acreage is currently being reclaimed.

Luebbermann, Henri A. and Susan E. (WFR #115-4-ADA-2)

The Luebbermann Ranch was inundated by the 1983 flood, but suffered no loss of acreage. Currently an instream pump and a well supply water to the irrigated fields.

White, Jeptha and Peggy (WFR #115-4-ADB-1)

The 1983 flood destroyed the diversion, formerly D1, and all of the ditch leading up to the White Ranch. The boundary ditch still exists along the northwest side of the field, but the lower half was completely silted in. Approximately 0.4 acres were eroded and lost to the floodwaters and have never been restored to use. Currently, an instream pump is used to divert water into the existing ditch system.

Barassi, Louis W. and Henrietta E. (WFR #115-4-ADB-2)

The irrigated acreage owned by Mr. Barassi was dramatically affected by the 1983 flood. During DWR's original field investigation in 1985, no trace of the diversion D2 or any part of the ditch was discovered. The acreage itself was severely eroded and is now made up of mostly cobbles and gravel. Approximately ten pecan trees survived the flood. During DWR's field investigation in April 1989, a four inch pipeline with bubblers ran the entire length of the south side of the field. No crops or sign of irrigation other than the pipeline was noticed. The field and pecan trees appeared unattended.

Young, Margaret (WFR #115-4-ADB-6)

No irrigated acreage owned by Mrs. Young was destroyed in the 1983 flood, however, an instream pump was lost in the flood. This acreage is now irrigated by a well W1 located in WFR #115-4-ADB-7 and instream pumps located in WFR #115-4-ADB-8 and #115-4-ADB-10.

Young, Lester and Thelma Lee (WFR #115-4-ADB-8)

The 1983 flood destroyed the instream pump P1 that had been serving this acreage. The instream pump has been replaced, and water is also supplied by an instream pump P2 located in WFR #115-4-ADB-10 and is jointly used by both land owners.

Young, Harold and Nancy (WFR #115-4-ADB-10)

No flood damage was suffered on this land, however, as a result of the flood, the instream pump P2 located on this parcel is now jointly used with WFR #115-4-ADB-6, #115-4-ADB-7, and #115-4-ADB-8.

Geldmacher, D.E. and Everly Ann (WFR# 115-4-ADC-1)

The acreage owned by Dr. Geldmacher was affected by both the 1979 and 1983 floods. The 1979 flood destroyed the diversion D1 and damaged nearly all of IR1. All damage was repaired only to be destroyed in the 1983 flood. The 1983 damage was much more severe and repairs are still in progress. The diversion has since been re-established. The distribution ditch is now branched such that it runs down both sides of the currently irrigated portion of IR1. Portions of the irrigated acreage on Dr. Geldmacher's property are very sandy and are in the process of being reclaimed.

Dr. Geldmacher deeded a portion of his property and assigned two adjudication statements of claimant (39-2116 and 39-11371) to the ANC in June 1988. The property deeded is restricted to the channel of Aravaipa Creek. Dr. Geldmacher still retains ownership of the diversion which supplies his acreage. The ANC has since amended the two statements of claimant to reflect claimed instream flows from Aravaipa Creek.

Farney, William Charles (WFR #115-4-ADC-2)

The diversion dam and ditch that used to serve this orchard has been out of service for an unknown period of time. The orchard is currently being irrigated by a well. No apparent damage was sustained on this property by the 1983 flood.

Figure 7-2. Irrigated acreage, damaged by the October 1983 flood, is being reclaimed by diverting surface water from Aravaipa Creek into sediment settling ponds. The measured discharge in the ditch was 3.3 cfs in December 1989.

Wallace, A.N. and K. (WFR #115-4-ADC-4)

Approximately 0.8 acres of pecan trees were lost in the 1983 flood. The diversion D1 located on land owned by Mr. Farney (WFR# 115-4-ADC-2) was destroyed in the flood along with portions of the concrete delivery ditch. The diversion and the ditch have not yet been repaired so the acreage is now watered from well W1.

Summary

Of the ten land owners affected by the 1983 flood in the West Aravaipa Creek area, a total of 9.6 acres out of 70.1 pre-83 flood acres were destroyed (Table 7-2). Most of these acres either have been or are in the process of being restored to preflood conditions. An additional 3.1 acres of irrigated cropland have been brought into production since 1983.

TABLE 7-2

WEST ARAVAIPA CREEK ACREAGE IMPACTED
BY THE 1983 FLOOD

WATERSHED FILE REPORT NUMBER	PREFLOOD IRRIGATED ACRES	POST-FLOOD IRRIGATED ACRES	ACRES CURRENTLY BEING IRRIGATED
115-4-AAD-2	15.0	13.8	15.0
115-4-ADA-2	5.4	5.4	10.7
115-4-ADB-1	7.1	6.7	6.6
115-4-ADB-2	5.5	0.0	4.6
115-4-ADB-6	1.1	1.1	1.0
115-4-ADB-8	1.2	1.2	1.1
115-4-ADB-10	1.1	1.1	0.8
115-4-ADC-1	18.8	17.1	15.9
115-4-ADC-2	11.7	11.7	14.4
115-4-ADC-4	3.2	2.4	3.1
TOTALS	70.1	60.5	73.2

Figure 7-3. The lower portion of Aravaipa Creek was severely affected by the October 1983 flood. The acreage shown was completely destroyed by the 70,800 cfs flood flow. The acreage is now being reclaimed by collecting water-borne silts and sand in settling ponds.

7.2 CIENEGA USES AND CLAIMS

The San Pedro watershed contains five cienegas: the O'Donnell Creek cienega, the Turkey Creek cienega, the Babocomari cienega, the St. David cienega, and the Bingham cienega (Figure 7-5). The cienegas support unique plant communities and rely on perennial, consistent flows provided by groundwater.

Cienegas are perennial, mid-elevation (3,000 to 6,000 feet above mean sea level) wetlands characterized by a permanently saturated hydrosoil under reducing conditions (Hendrickson and Minkley, 1985). The typical cienega is composed of three plant communities. The distributions of these communities are controlled by the degree of soil saturation and soil salinity. The central cienega plant community is composed chiefly of semi-aquatic sedges, rushes, grasses, and occasionally trees of the willow family (Hendrickson and Minkley, 1985). The soil in this area is completely saturated, salinities are normal, and reducing conditions prevail. The halo-cienega plant community is

Figure 7-4. The O'Donnell Creek cienega is the result of groundwater being forced to the surface by a sandstone-shale obstruction in the alluvium. This cienega supports a dense stand of swamp willow, gooding willow, cottonwood, and the extremely rare canelo orchid.

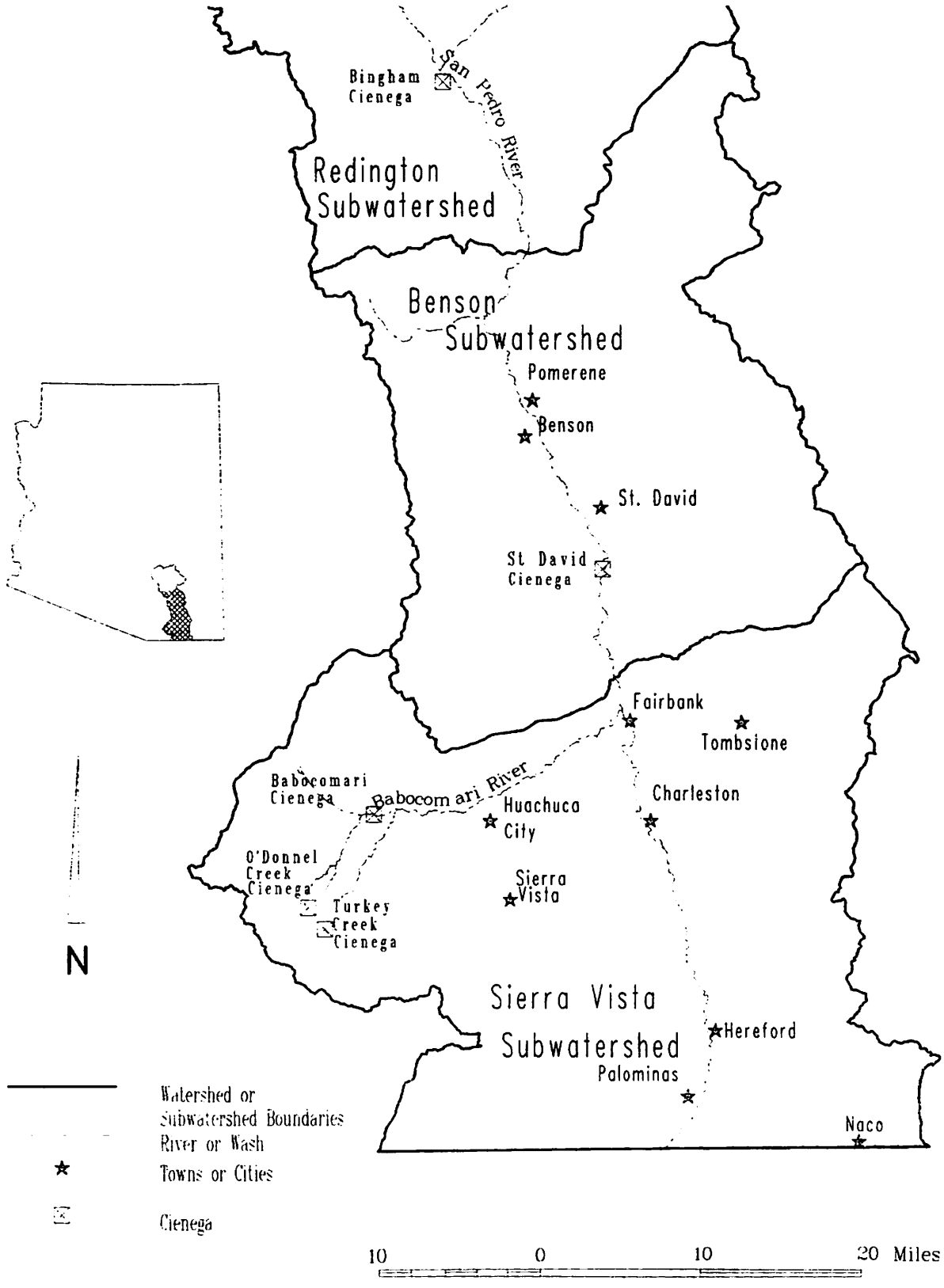


Figure 7-5. Location of cienegas in the San Pedro River watershed

dominated by halophytes such as: Salt Grass, Sacaton, and Yerba-mansa (Hendrickson and Minkley, 1985). The soil in this zone is completely to partly saturated and saline. The dry cienega plant community consists of "riparian" deciduous broadleaf trees such as: Arizona Sycamore, Fremont Cottonwood, and Arizona Ash (Hendrickson and Minkley, 1985). The soil in this area is partly unsaturated and salinities are normal.

Cienegas occur where perennial flow is consistent and scouring or flood flows are rare. In the San Pedro River watershed, cienegas persist in the upper reaches of streams, where bedrock structures force groundwater to the surface and drainage areas are small thus reducing the magnitude of flood flows. The groundwater is forced to the surface by impervious pre-Quaternary strata impounding alluvial aquifers creating perennial surface flows.

The number and size of cienegas in the San Pedro River watershed has been greatly reduced in the past 100 years. The reduction of this type of perennial wetland is due to a number of interelated factors including: increased cultural water uses, overgrazing, and climate changes (Hastings and Turner, 1965, Cooke and Reeves, 1976, and Hendrickson and Minkley, 1985).

The water uses claimed for the cienegas in the San Pedro watershed include: irrigation, stockwatering, and wildlife and habitat maintenance associated with instream flows. DWR has investigated each claim and determined the present use at each location. The results of DWR's investigation of these claims are shown on Table 7-3. The Babocomari cienega and Bingham cienega provide water for irrigation uses. The O'Donnell Creek cienega provides water for wildlife and habitat maintenance associated with an instream flow permit. The Turkey Creek cienega provides water for instream stockwatering uses. The St. David cienega, now part of the Bureau of Land Management's (BLM) San Pedro Riparian National Conservation Area, provides water for wildlife and habitat maintenance associated with an instream flow application.

Figure 7-6. The Turkey Creek cienega is caused by groundwater being forced to the surface by a hard rock obstruction. This cienega is actively utilized by livestock for water and grazing.

TABLE 7-3

CIENEGA USES AND CLAIMS

CIENEGA	CLAIMANT	WATERSHED FILE REPORT NUMBER	CLAIMED USE	USE FOUND BY DWR
Babocomari	Babocomari Ranch	111-19-DAC-11	IR	IR
	Diamond C	111-19-18	IR-SW	SW
Bingham	Pima County Flood Control	113-12-BA-12	IR-SW	IR-SW
O'Donnell Creek	Arizona Chapter of the	111-19-21	WL-HM	WL
	Nature Conservancy	111-22-18	SW	WL-SW
St. David	USDI BLM	112-17-63	WL-HM	WL
Turkey Creek	Breechen, J.	111-22-23	IR-SW	SW
	Burr, Robert	111-22-22	IR-SW	SW
	Burr, Malc.	111-22-24	IR-SW	SW
	Lindsey, E.	111-22-12	IR-SW	SW

KEY: IR = Irrigation; SW = Stockwatering; WL = Wildlife; HM = Habitat Maintenance

7.3 COMMERCIAL FISH FARM/ROBERT FLOYD (WFR #113-9-CC-38)

History

The Floyd fish farm is a commercial fish rearing operation located near the Redington Road approximately ten miles southeast of San Manuel, adjacent to the San Pedro River.

Based on adjudication statement of claimant (39-12296) information and historical photography, irrigation on this property began in 1982. The irrigation originally consisted of pecan orchards and pasture. In 1986, Mr. Floyd began converting a portion of the irrigated acreage into reservoirs for commercial fish rearing.

Presently, Mr. Floyd raises approximately 5,000 Tilapia fish with future plans to enlarge the existing reservoirs into one large reservoir totaling approximately five surface acres.

Water Supply System

The fish rearing operation consists of four unlined, interconnected reservoirs coded PS1 on the water use subregion map Redington 9-CC, found in Volume 9 of this HSR. These reservoirs have a combined total surface area of 1.9 acres, with a capacity of 6.7 acre-feet. Water which is not lost through seepage or evaporation spills onto acreage for the irrigation of adjacent pasture.

Water is supplied to the fish rearing operation by an artesian well (W1) located within Zone 1. W1 has a flow rate of approximately sixty-five gpm which flows continuously. This amounts to approximately 105 acre-feet per year. The water from W1 is geothermally heated at a constant 73° which keeps the water temperature in the reservoir where the Tilapia are located above 55° year round. Tilapia are tropical fish which apparently cannot survive in water with temperatures lower than 55°. In the remaining reservoirs that do not benefit from the high water temperatures, catfish or bass will be raised.

7.4 COMMERCIAL FISH FARM/PAUL L. SALE INVESTMENT COMPANY (WFR #114-4-BAB-7)

The Paul L. Sale Investment Company owns and operates an agricultural and fish rearing operation located five miles south of the Town of Winkelman. Since 1985, the company has been converting the irrigated lands into fish rearing reservoirs. Five wells, W2 through W6, supply water to seventeen small reservoirs, SR1 through SR17, and irrigated acreage. One well, W7, supplies stockwatering and domestic uses.

History

Irrigation was first documented on the property in 1879 with the recording of a Notice of Appropriation (10-1101313-11) on the Young and Swingle ditch. The notice states that the ditch was completed and supplying water for irrigation in 1878. The surface water system was in operation and servicing approximately 192 acres of irrigation on the Sale property by 1921, as documented by Arizona State Water Commission maps. The surface water system continued to provide water for irrigation on the property until 1966 when a flood destroyed the diversion and sections of the ditch.

After the surface water system was destroyed, wells were constructed to provide water for irrigation. Well W4 was completed in 1966, well W3 in 1968, well W2 in 1970, well W5 in 1977, and well W6 in 1987.

The Paul L. Sale Investment Company obtained the property in 1965. By 1983, 292 acres were being irrigated. Due to the catastrophic flood of October 1983, only 200 acres were being irrigated in 1984. By 1990, the total irrigated acreage had been reduced to 135.5 acres because of the conversion of irrigated lands to fish rearing reservoirs. The growth and changes to irrigation on the Sale property are shown on Plate 19.

The conversion of irrigated acreage to fish rearing reservoirs began in 1985 with the completion of five small reservoirs, SR6 through SR10. In 1987, four more reservoirs, SR13 through SR16 were added to the operation. In 1990, the conversion was completed with the addition of eight reservoirs, SR1 through SR5, SR11, SR12, and SR17, to the operation.

Water Supply System

Water is supplied to the Paul L. Sale property from seven wells all located within Zone 1. Well W1 is operative, but currently unused. Well W2

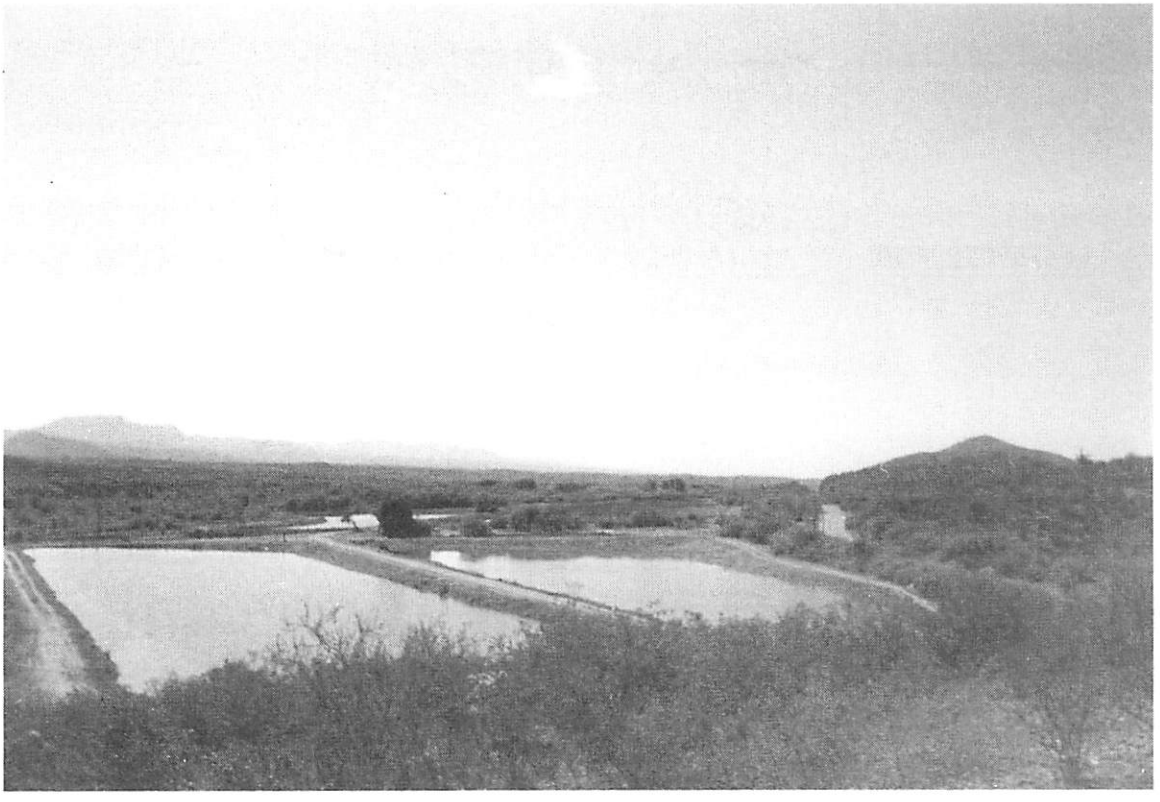


Figure 7-7. Former irrigated pasture in the Winkelman subwatershed is being replaced by large capacity reservoirs, in which fish are raised for commercial use. The reservoirs in this operation cover thirty-seven surface areas with more planned for construction.

provides water for irrigation and SR17. Well W3 provides water for irrigation and SR6 through SR17. Well W4 supplies water for domestic and irrigation uses and SR6 through SR10. Well W5 supplies water for irrigation and SR1 through SR10. Well W6 provides water for SR11 through SR17. Well W7 provides water for stockwatering uses.

The fish rearing operation has been licensed by the Arizona Department of Agriculture, Aquaculture Division. The fish rearing reservoirs are constructed of sandy-loam soil, are unlined, and are generally rectangular in shape. The reservoirs are used to raise catfish, bass, and sunfish. The fish are sold to the Arizona Game and Fish Department, private groups, and the general public. Some of the reservoirs are also used for "pay per pound" fishing named Saddle Mountain Lakes. Pertinent information on the reservoirs is shown in Table 7-4.

TABLE 7-4

PAUL L. SALE INVESTMENT COMPANY
PERTINENT RESERVOIR INFORMATION

RESERVOIR NAME	SURVEYED SURFACE AREA (ACRES)	SURVEYED CAPACITY (ACRE-FEET)	SOURCE
SR1	0.5	1.5	W5
SR2	0.4	1.3	W5
SR3	0.5	2.0	W5
SR4	0.5	1.3	W5
SR5	0.5	1.0	W5
SR6	1.6	7.9	W3, W4, W5
SR7	1.8	6.7	W3, W4, W5
SR8	1.8	3.9	W3, W4, W5
SR9	1.1	3.9	W3, W4, W5
SR10	1.0	4.3	W3, W4, W5
SR11	5.5	13.0	W3, W6
SR12	5.1	16.3	W3, W6
SR13	2.6	7.3	W3, W6
SR14	3.8	6.8	W3, W6
SR15	3.6	6.2	W3, W6
SR16	2.4	7.3	W3, W6
SR17	4.4	10.4	W2, W3, W6
TOTAL	37.1	101.1	

7.5 ARIZONA WATER COMPANY - Oracle System (WFR #113-8-51)

History

In 1960, the original pipeline was installed to convey water to the Town of Oracle from a well located at Oracle Junction. Subsequent to that date, two additional wells were developed in the same vicinity. The Arizona Water Company purchased the system in 1961 and has continued to supply water to the present. The three wells are located in the Upper Santa Cruz River watershed, but a majority of the service is located in the San Pedro River watershed. Since water is imported into the San Pedro River watershed, a watershed file report has been created for the Arizona Water Company - Oracle System to describe water uses, well locations, etc., and will also be reported in the Upper Santa Cruz River watershed HSR.

The Arizona Water Company filed two statements of claimant (39-75852 and 39-79218) in the Upper Santa Cruz River watershed. Both of these claims describe municipal uses supplied by four wells (W1-W4). Table 7-5 depicts the statements of claimant, claimed uses, quantities, locations of diversions, and uses.

Water Supply System

The water supply system is comprised of four wells located in the Upper Santa Cruz watershed, with a combined capacity of 860 gallons per minute (gpm). Water is pumped through an eight inch pipeline thirteen miles to Oracle, situated within the San Pedro River watershed. Three booster pumps are used along the pipeline to convey the water to the town's distribution system. Information is unavailable concerning Oracle's wastewater disposal system. Personal communication with Robert Van Dielen, Division Manager for the Arizona Water Company, indicated approximately 60 percent of the wastewater is disposed of through individual septic tank systems, the remaining 40 percent is processed through a sewer system that is discharged into a lagoon treatment system.

Annual water use data is provided in Table 7-6 for the time period 1980 through 1988. There are currently 1,077 service connections.

TABLE 7-5

ARIZONA WATER COMPANY - ORACLE SYSTEM
CLAIMED INFORMATION

STATEMENT OF CLAIMANT NUMBER	CLAIMED USES	CLAIMED QUANTITY (ACRE-FEET)	WATER SOURCE	DIVERSION LOCATION	USE LOCATION
39-75852	Municipal	301.8	Well	NENENE 19 10S 14E	Oracle service area
			Well	NWNENE 19 10S 14E	Oracle service area
			Well	SWNENE 19 10S 14E	Oracle service area
39-79218	Municipal	(1)	Well	NENENE 19 10S 14E	Oracle service area

(1) Statement of claimant 39-79218 does not specify a municipal use amount. The statement of claimant claims enough water to supply the service area and customer connections.

TABLE 7-6

ARIZONA WATER COMPANY - ORACLE SYSTEM
ANNUAL WATER USE

YEAR	TOTAL ACRE-FEET DELIVERED	TOTAL SERVICE CONNECTIONS
1980	266.0	903
1981	281.2	936
1982	281.4	923
1983	266.8	949
1984	268.3	967
1985	268.1	976
1986	296.4	1,007
1987	209.0	1,050
1988	312.9	1,077

7.6 NACO SANITARY DISTRICT OF COCHISE COUNTY (WFR #111-24-86)

History

Effluent from the Town of Naco is delivered to the Naco wastewater treatment facility located approximately one mile northwest of the Town of Naco. The Naco Sanitary District began service in 1983 and now serves approximately 180 residential hookups, with an average growth of approximately one hookup per month. Before 1983, residents were on septic tanks.

Future plans include the irrigation of approximately fourteen acres located west of and adjacent to the facility.

Water Supply System

Water use for the Naco wastewater treatment facility is supplied by one well (W1) located in WFR #111-24-42. Well W1 which is tied to an eighty gallon pressure tank supplies water to the flush tank located on the north side of Greenbush Draw and is used to flush wastewater through an inverted siphon pipe seventeen feet under Greenbush Draw to the headworks which in turn conveys the wastewater into a series of stabilization, polishing, and storage ponds where waste particles are dissolved or precipitated. The field at the west end of the facility will eventually be irrigated by treated effluent from this facility. Water from W1 is also used for cleanup of the ponds and headworks (Figure 7-8).

Water use totals approximately 800 gallons every other day or 0.45 acre-feet per year (Table 7-7). This has declined from 800 gallons per day or 0.9 acre-feet per year when the district began operation in 1983 through 1986. At an average temperature of 74°, losses due to evaporation are approximately 2,300 gallons per day. The total capacity for all four ponds is approximately fifty acre-feet.

Two monitoring wells are located at both ends of the facility to monitor groundwater quality. These wells serve no other purpose.

TABLE 7-7

NACO SANITARY DISTRICT OF COCHISE COUNTY
ANNUAL WATER USE
(ACRE-FEET)

YEAR	1983	1984	1985	1986	1987	1988	1989	1990
AMOUNT	0.9	0.9	0.9	0.9	0.45	0.45	0.45	0.45

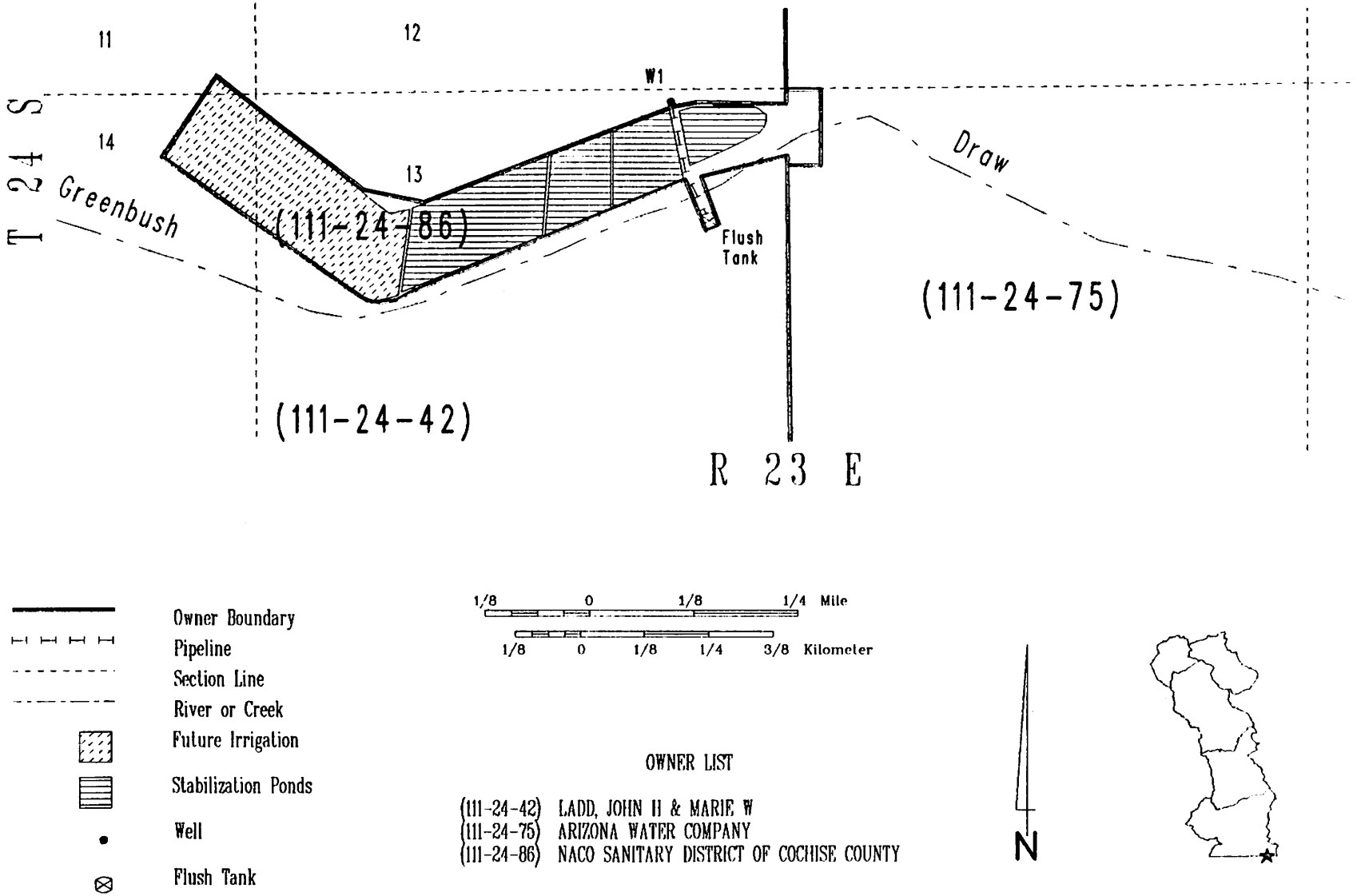


Figure 7-8. Naco Sanitary District of Cochise County

7.7 STATEMENTS OF CLAIMANT AND WATER RIGHTS FILINGS NOT INCLUDED IN THE SAN PEDRO RIVER WATERSHED FILE REPORTS

This section includes two lists of statements of claimant, a list of uniform questionnaires, and four lists of water rights filings that were not included in any San Pedro River watershed file report due to claimed future uses, insufficient locational information, blanket filings, claims not matched to existing uses, or claims located outside of the watershed.

The seven lists are shown below:

LIST	PAGE
Arizona State Land Department Blanket Statements of Claimant	520
Incomplete Statements of Claimant	522
Incomplete or Unmatched Uniform Questionnaires	525
Arizona State Land Department Blanket Water Rights Filings	525
Incomplete Water Rights Filings	526
Unmatched Old Rights and Claimed Rights Filings	526
Notices of Appropriation Which are Not Matched to a Watershed File Report	526

ARIZONA STATE LAND DEPARTMENT BLANKET STATEMENTS OF CLAIMANT

The Arizona State Land Department (SLD) filed statements of claimant for the Gila River system adjudication in September 1980. The statements of claimant list "Rainfall Retention" (i.e., all waters that infiltrate into the soil) as a beneficial use for all state trust lands in the San Pedro River watershed. No specific legal descriptions or locational information for these claimed uses appear in the filings and no specific water sources are claimed. As a result, none of the filings are included in any San Pedro River watershed file report. Table 7-8 lists all the SLD blanket statements of claimants.

TABLE 7-8

SUMMARY OF SLD BLANKET STATEMENTS OF CLAIMANT

39-6691	39-7188	39-7652
39-6692	39-7189	39-7653
39-6693	39-7220	39-7660
39-6711	39-7232	39-7661
39-6712	39-7261	39-7662
39-6731	39-7262	39-7692
39-6735	39-7264	39-7698
39-6736	39-7265	39-7713
39-6737	39-7266	39-7728
39-6738	39-7270	39-7738
39-6806	39-7300	39-7741
39-6807	39-7322	39-7749
39-6808	39-7331	39-7757
39-6867	39-7332	39-7758
39-6924	39-7350	39-7759
39-6946	39-7361	39-7772
39-6974	39-7375	39-7785
39-6976	39-7420	39-7786
39-6992	39-7459	39-7835
39-6993	39-7460	39-7843
39-6994	39-7461	39-7848
39-7009	39-7465	39-7850
39-7010	39-7466	39-7861
39-7028	39-7487	39-7863
39-7062	39-7540	39-7865
39-7063	39-7542	39-7866
39-7065	39-7543	39-7881
39-7070	39-7558	39-7895
39-7081	39-7570	39-7898
39-7082	39-7585	39-7899
39-7083	39-7589	39-7900
39-7093	39-7590	39-7904
39-7106	39-7601	39-7908
39-7140	39-7604	39-7917
39-7141	39-7610	39-7918
39-7153	39-7629	39-7924
39-7175	39-7630	
39-7187	39-7638	

INCOMPLETE STATEMENTS OF CLAIMANT

The statements of claimant listed in Table 7-9 lack sufficient locational information on claimed places of use. DWR was unable to determine the current land ownership for the uses claimed. As a result, these claims are not included in any San Pedro River watershed file report.

TABLE 7-9

INCOMPLETE STATEMENTS OF CLAIMANT

STATEMENT OF CLAIMANT NUMBER		CLAIMANT NAME	APPARENT CLAIMED USE
39-119		Dunne, Raymond F.	Domestic (Future Use)
39-125		Lane, Louise D.	Domestic
39-129	(Q)	Phelan, Etta E.	Domestic
39-130		Holbert, Steve L.	Domestic
39-327		Covey, Asalee L.	Domestic
39-368		Lacriola, Lawrence	Irrigation, Domestic
39-602		George, Shiela L.	Domestic (Future Use)
39-636		Hill, Richard G.	Domestic (Future Use)
39-637		Hill, Richard G.	Domestic (Future Use)
39-638		Hill, Richard G.	Domestic (Future Use)
39-939	(Q)	El Paso Natural Gas Company	Domestic, Other
39-1058		Anderson, Carl C.	Domestic, Stock
39-1079		Anderson, Carl C.	Stock
39-1182	(Q)	Tharp, Robert G.	Domestic
39-2196		English, Roger W and Susan L.	Domestic
39-2290		U.S. Life Title Co. c/o English, William J. Trust #3,000	Stock
39-2459		English, William L.	Irrigation, Domestic, Stock, Rec/Fish/Wldlf
39-2460		English, William L.	Irrigation, Domestic
39-2875		Meyer, Carroll O.	Domestic
39-2878		Johnson, Lee Jr.	Domestic
39-2886		Ruch, Eugene M.	Domestic
39-2896		Sullivan, William H. or Louise	Domestic
39-2912		Harris, Herschel D.	--------
39-2974		Lynch, Mary K.	Domestic
39-3188		Duty, Arthur D.	Domestic
39-3190		Nelson, Reginald P.	Domestic
39-3217	(Q)	Meeks, Waldon W.	Domestic
39-3369	(Q)	Harris, John & Carol	Domestic
39-3424	(Q)	Bush, Fred	Domestic
39-3446	(Q)	Bidwell, George D.	Irrigation, Domestic

(Q) - Uniform questionnaire received.

TABLE 7-9 (cont'd)

STATEMENT OF CLAIMANT NUMBER		CLAIMANT NAME	APPARENT CLAIMED USE
39-3448		Gonce, Willis E.	Domestic
39-3526		Uriona, George N. and Alice M.	(Future Use)
39-3827		Trejo, Alfred J.	Domestic
39-3829		Trejo, Alfred J.	Irrigation Domestic
39-3872		Baron, Samuel F.	Domestic
39-3928		Hopkins, Donald M.	Domestic
39-4005	(Q)	Amado, Ismael	Domestic
39-4040		Miller, Patrick J.	Domestic
39-4043		Wyckoff, George T.	Irrigation, Domestic
39-4057		Wray, Mark C.	Domestic
39-4072		Sorenson, Josie P.	Domestic
39-4088	(Q)	Black, Roy L.	Irrigation
39-4223		Nix, Clyde L.	Domestic
39-4869		Az Game & Fish	Rec/Fish/Wldlf
39-4874		Az Game & Fish	Domestic, Rec/Fish/Wldlf
39-4875		Az Game & Fish	Domestic, Rec/Fish/Wldlf
39-5159	(Q)	Myers, Lawrence S.	Domestic
39-5786	(Q)	Perkins, Paul L.	Domestic
39-5806		Sims, Larry E. & Carol S.	Domestic
39-5836		Loukabaugh, Harold E. and Patricia W.	--------
39-5896		Harshaw, James A.	Domestic
39-5974		Cramer, Jack J.	Domestic
39-6148		Anderson Development Company	Irrigation
39-6331		Childs, Franklin	Domestic
39-6332		Childs, Franklin	Irrigation, Domestic, Stock, Rec/Fish/Wldlf
39-6350		Martin, James A.	Domestic
39-6375	(Q)	Revago, Porfirio	Domestic
39-6396	(Q)	Reeves, Gilbert L.	Domestic
39-6491	(Q)	Young, Herman P.	Domestic
39-6510		Lupo, John or Mitze L.	Domestic
39-6512		Goodman, George A.	Irrigation, Domestic
39-6513	(Q)	Lorenz, James A.	Domestic
39-6555	(Q)	Colvin, Bill or Sara L.	Domestic
39-6618		Lofgreen, Dyantha	Domestic
39-10843		York, Robert B.	Domestic
39-10913		Sorenson, Josie P.	Domestic
39-11433		Funston, Henry H. & Debra K.	Domestic
39-11759		Neal, Jimmie L.	Domestic
39-12001		Kartchner, Mark M. or Manion B.	Domestic, Stock
39-12283	(Q)	Heaps, Alverta M.	Irrigation, Domestic, Stock

(Q) - Uniform questionnaire received.

TABLE 7-9 (cont'd)

STATEMENT OF CLAIMANT NUMBER	CLAIMANT NAME	APPARENT CLAIMED USE
39-12563	Platt/Wade	Irrigation, Domestic
39-12582	Miller, William L.	Irrigation, Domestic, Stock
39-12589	Kernahaw, Martin J.	Domestic
39-12592	Tomerlin, Jerry L.	Domestic
39-12611	Hopkins, Denver W.	Irrigation, Domestic
39-12618	Hough, Ruby R.	Irrigation, Domestic
39-12624	Hillman, Harold H.	Domestic
39-12628	Leon, Ruben	Domestic
39-12632	Daniell, Cecil M.	Irrigation, Domestic
39-12638	Grundhauser, Nicolas E.	Domestic
39-12640	Pruitt, Roy E.	Domestic, Stockwatering
39-12641	Yanken, Myrtle K.	--------
39-12643	Lewis, Melissa	Domestic
39-12717 (Q)	McKay, William M.	Domestic
39-12725 (Q)	Finley, Dorthy H.	Other
39-12727 (1)	Southern Pacific Trans Co.	Commercial/Ind
39-12728 (Q)	Sands Investment Company	Stock
39-12729 (Q)	Sands Investment Company	Stock
39-12731 (Q)	Hathaway, Lincoln L.	Irrigation, Domestic, Stock
39-12732 (Q)	Grombly, Richard Lee	Domestic
39-12733 (Q)	Carrillo, Lynne C.	Domestic
39-12734 (Q)(1)	Hathaway, William and Virginia	Domestic
39-12735 (Q)	Moss, Austin E. and Marka C.	Domestic, Stock
39-13648 (2)	Brandolino, Dennis J.	Domestic
39-13650 (2)	Brandolino, Dennis J.	Domestic
39-13651 (2)	Brandolino, Dennis J.	Domestic
39-13652 (2)	Brandolino, Dennis J.	Domestic
39-77972 (A)	Sink, Harry D. and Barbara A.	Domestic
39-78994 (1)	Conley, William F.	Domestic
39-79044	Garcia, Donna & Julia	Domestic

(Q) Uniform questionnaire received.

(1) Statements of claimant filed on a Santa Cruz River watershed form.

(2) Statements of claimant filed on an Upper Salt River watershed form.

(A) Amendment to a statement of claimant.

INCOMPLETE OR UNMATCHED UNIFORM QUESTIONNAIRES

DWR was unable to match the uniform questionnaires listed in Table 7-10 because of insufficient locational information or discrepancies in the information provided by the claimant.

TABLE 7-10

UNIFORM QUESTIONNAIRES NOT MATCHED TO A STATEMENT OF CLAIMANT

UNIFORM QUESTIONNAIRE NUMBER	CLAIMANT NAME	APPARENT CLAIMED USE
39-3447 (1)	Montano, Carlos M.	Domestic
39-4047	Kondy, J.W. (2)	--------
39-5902 (1)	Knight, Rayce and Dora	--------
39-11971 (1)	Red Mtn Mining Co.	Mining
39-12552	Quiroga, Joe and Noemi	Domestic
Unknown	Marco, Joseph	Irrigation, Domestic, Stock
Unknown	Marco, Joseph	Stock
Unknown	Marco, Joseph	Stock
Unknown	Marco, Joseph	Stock
Unknown	Marco, Joseph	Stock
Unknown	Buckenmaier, E.T.	Domestic, Stock

(1) Claimed use located outside of the San Pedro River watershed.

(2) No longer the owner.

ARIZONA STATE LAND DEPARTMENT BLANKET WATER RIGHTS FILINGS

The SLD has filed a claim under the Stockpond Registration Act for all stockponds on state trust lands. This filing, 38-21798, claims that the federal government reserved sufficient water to serve the purposes for which these lands were set aside.

A similar claim was filed under the Water Rights Registration Act for all waters of the state and for all beneficial uses listed in the Public Water Code. The filing, 36-21799, claims a "reserved" right as its basis as well.

INCOMPLETE WATER RIGHTS FILINGS

The filings listed in Table 7-11 lack sufficient locational information on claimed places of use. DWR was unable to determine the current land ownership for the uses claimed. As a result, these claims are not included in any San Pedro River watershed file report.

TABLE 7-11

INCOMPLETE WATER RIGHTS FILINGS

PRIOR FILING	CLAIMANT NAME	APPARENT CLAIMED USE
3R-916	Morris, C.E.	Stock
33-42566	Town of Winkelman	Municipal
33-67705 (1)	Gallagher, Keith E.	Stock, Rec/Fish/Wldlf
33-76346	El Paso Natural Gas Company	Domestic, Commercial/
36-29134	Black, Roy L.	Irrigation
36-29164	Knox-Arizona Corp.	Mining
36-64625	McCommas, Pearl E.	Domestic
36-64628	Holden, Olive E.	Domestic
36-64629	Holden, Olive E.	Domestic
36-70412	Haverty, Virgil R.	Irrigation, Domestic, Stock
36-70413	Haverty, Virgil R.	Irrigation, Domestic, Stock
36-80103	Sierra Vista Realty	Domestic
38-17307	BLM	Stock, Rec/Fish/Wldlf
38-27658	Anderson, Carl C.	Stock, Rec/Fish/Wldlf
38-88286	SLD	Stock, Rec/Fish/Wldlf
4A-2801	Morris, C.E.	Irrigation

(1) Located outside of the San Pedro River watershed.

UNMATCHED OLD RIGHTS AND CLAIMED RIGHTS FILINGS

The filings listed in Table 7-12 could not be matched to existing potential water rights (PWR) or uses. As a result, these claims are not included in any San Pedro River watershed file report.

NOTICES OF APPROPRIATION WHICH ARE NOT MATCHED TO A WATERSHED FILE REPORT

Within the San Pedro River watershed, there are 288 Notices of Appropriation which could not be matched to any San Pedro River watershed file report. These notices contained insufficient information regarding claimed

diversion or use locations. An electronic data base has been created by DWR which tabulates these unmatched NOAs and is available upon request (WFR #110-00-2).

TABLE 7-12

UNMATCHED OLD RIGHTS AND CLAIMED RIGHTS FILINGS

FILING NUMBER	CLAIMANT NAME	YEAR	APPARENT CLAIMED USE
C-155	Flying H Ranch	1900	ND (1)
O-3	G.M. Allen	ND (1)	ND (1)
O-38	W.A. Lines	ND (1)	ND (1)
O-39	W.A. Lines	ND (1)	ND (1)
O-60	Ursula Capt	1910	ND (1)

(1) No data or insufficient data on claim.

7.8 CLAIMS MADE BY WATER USERS DOWNSTREAM FROM THE SAN PEDRO RIVER WATERSHED

This section describes statements of claimant made by water users located downstream from the San Pedro River watershed. These water users have made claims for the rights to use waters of the San Pedro River and its tributaries. These water users are listed below.

WATER USER	PAGE
Claims made by the Gila River Indian Community	528
Claims made by the San Carlos Apache Tribe	530
Claims made by the San Carlos Irrigation and Drainage District	532

CLAIMS MADE BY THE GILA RIVER INDIAN COMMUNITY

The Gila River Indian Community (GRIC) filed a statement of claimant 39-5478 on July 11, 1980. Although the GRIC filed for a water right using a San Pedro River watershed form, the GRIC states in the claim that their reservation is not situated within the watershed of the San Pedro River.

The GRIC was originally created on February 28, 1859, by Act of Congress.[1] The GRIC base their claim on: 1) a right to surface water initiated by beneficial use prior to June 12, 1919, (36-83951 through 36-83953, filed on March 31, 1980; 2) a court decreed water right; 3) an application for permit to appropriate water; 4) a claim of water right for a stockpond, and 5) other, as stated on the statement of claimant. However, the claimant only described, in detail, 1 and 2 in an attachment to the statement of claimant as outlined below.

1. Right to surface water initiated by beneficial use prior to June 12, 1919

   A. prior appropriation (United States v. Gila River Pima-Maricopa Indian Community, 1978)

   B. aboriginal use (United States v. Winans, 1905)

   C. Acts of Congress (ch. 228,§ 8, 29 Stat. 528, dated February 15, 1897; and ch. 2285, Pub.L.No. 154, 34 stat. 1022, dated March 1, 1907)

[1]Based on claimed data.

2. Court decreed water rights

A. United States v. Gila River Irrigation District et al. (1935)

B. United States v. Haggard et al. (1903)

C. Benson v. Allison (1917)

D. GRIC v. American Smelting and Refining Co. et al. (1978)

E. United States v. Winans (1905)

F. Winters v. United States (1908)

The reservation claimed a water duty of six acre-feet per acre per year on the Gila River, with a total of 266,471 irrigation acres[1]. The GRIC claims a total water diversion of not less than 1,598,830 acre-feet per year, which includes domestic, stockwater, mining, recreational, and wildlife uses. The GRIC also claims 205,080 acre-feet for the production of power, and 266,640 acre-feet for water storage.

The reservation has claimed thirty-nine diversions along the Gila River, and seventeen diversions along the Salt River (partial list). Additionally, the GRIC claimed a total of 205 wells:

USE	NUMBER OF WELLS
Irrigation	173
Domestic	25
Use Not Listed	7
TOTAL	205

The GRIC has also claimed eight storage dams, with a total storage capacity of 3,638,050 acre-feet, five diversion dams, and five tailwater sumps (118 acre-feet total storage capacity).

The statement of claimant did not quantify the amount of their claim that pertains to the waters originating in the San Pedro River watershed.

The preceding statements regarding claims of the Gila River Indian Community or others is presented solely for purposes of general information and does not constitute a determination of any claim within the exterior

[1]Based on claim data.

boundaries of the Gila River Indian Community Reservation or any fact comprising such claim. The GRIC claim will be addressed in detail in a separate HSR.

CLAIMS MADE BY THE SAN CARLOS APACHE TRIBE

The United States Bureau of Indian Affairs submitted San Pedro River watershed statement of claimant 39-12167 on behalf of the San Carlos Apache Tribe and certain San Carlos Apache allottees on January 4, 1985. The San Carlos Apache Tribe filed a statement of claimant for the Salt River watershed, 39-12676, filed September 16, 1985 and the Upper Gila River watershed, 39-63614, filed November 1, 1985. Each claim is "a reservation-wide claim to be satisfied from any and all available water sources." The San Pedro River is claimed as a source of water under sections 6 and 7 of statements of claimant 39-12676 and 39-63614 on behalf of the San Carlos Apache Tribe.

The United States based their claim, 39-12167 on federal reserved water rights. The amounts claimed are as follows:

USE	AMOUNT (ACRE-FEET PER YEAR)
Irrigation on Trust Allotments	770
Municipal, Domestic, and Related Uses	5,935 (1)
Domestic Use on Trust Patent Allotments	20
Stockwater and Wildlife	200
Initial Filling of Future Stockponds	200
Potential Mineral Use	18,600

(1) Claimed for the entire reservation; only a portion will come from the San Pedro River watershed.

The tribe based the other claims 39-12676 and 39-63614 on the following:

1. Aboriginal Title
2. Spanish Law
3. Mexican Law
4. Treaty of Guadalupe Hidalgo
5. Gadsden Treaty

6. Treaties with the Apaches
7. International Law
8. Tribal Law
9. Reserved Rights based on Federal Law
10. Tribal Homeland
11. State and Territorial Law
12. Executive Orders
13. Agreements and Understandings with the United States
14. Court Decrees

The amount claimed on 39-12676 and 39-63614 that pertains to the San Pedro River is 12,000 acre-feet per year for irrigation of 2,000 acres. The tribe also claimed municipal, industrial, domestic, stockwater, mining, wildlife, and other uses where the place of use is throughout the entire reservation, part of which is located within the San Pedro River watershed. Additionally, there are three San Pedro River watershed claimants who claim a point of diversion that is located on San Carlos Apache land, but the place of use is located on private land. These claimants are Paul L. Sale Investment Company (39-2219), American Smelting and Refining Company, Incorporated (39-2482), and William M. Stambaugh (39-1976). One claimant, W. H. Claridge (39-3972), has claimed a point of diversion, place of use, and storage reservoir all located within reservation boundaries.

Two applications to appropriate the public waters of the State of Arizona were filed by H.H. Young on May 14, 1929. The first application, 4A-970, claims stockwatering uses from Eskeminzin Creek located in the NE¼, SW¼, SW¼, Section 30, Township 5 South, Range 17 East. The second application, 4A-971, claims stockwatering, domestic, and irrigation uses from Middle Eskeminzin Spring located in the SW¼, SW¼, Section 30, Township 5 South, Range 17 East. Both of these claimed use locations are within the boundaries of the San Carlos Apache Indian Reservation.

An application to appropriate water (4A-953) was filed by G.R. LaFrenaye on May 1, 1929 for stockwatering uses from Whitaker Number One Spring. The claimed point of diversion is in the NE¼, SW¼, Section 7, Township 6 South, Range 17 East. The claimed use is in the SE¼, SW¼, Section 7, Township 6 South, Range 17 East. Both the diversion and use locations are located on the San Carlos Apache Indian Reservation.

The preceding statements pertaining to the claims of the San Carlos Apache Tribe and certain allottees or claims by others involving waters within the San Carlos Apache Indian Reservation is presented here solely for the purposes of general information and does not constitute a determination of any claim within the exterior boundaries of the reservation or any fact comprising such claim. The San Carlos Apache claims will be discussed in further detail in a separate HSR.

CLAIMS MADE BY THE SAN CARLOS IRRIGATION AND DRAINAGE DISTRICT

The San Carlos Irrigation and Drainage District (SCIDD) filed a statement of claimant 39-6521 on July 8, 1980, for the San Pedro River watershed and its tributaries, although the SCIDD is located in the Lower Gila River watershed. The claim was filed individually and on behalf of its land owners as beneficiaries of water rights held by the United States of America in trust for the San Carlos Federal Irrigation Project (SCFIP).

The SCIDD base their claim on the following:

A. Right to surface water initiated by beneficial use prior to June 13, 1919.

   1. Statement of claim of right to use public waters of the state, filed with the SLD on June 18, 1979 (36-15201).

      a. Purpose and extent of the water use is for irrigation and stockwatering on 50,000 acres of land situated within SCIDD boundaries, and 100,546 acres (including aforesaid land) situated within the SCFIP.

      b. Quantity of water used annually is 603,276 acre-feet from January 1 to December 31 (36-15201).

      c. Date water used beneficially: time immemorial.

      d. Water sources claimed: Gila River and its tributaries. Tributary to the Colorado River.

      e. Points of diversion: Ashurst-Hayden Diversion Dam, and Sacaton Diversion Dam.

B. Court Decreed Water Right.

1. United States of America v. Gila Valley Irrigation District.

2. Act of Congress, dated May 18, 1916 (39 stat.L., 123-130).

3. Act of Congress, dated June 7, 1924 (43 stat.L., 475-476, and amendments thereto).

The SCIDD statement of claimant claims a right to use 300,000 acre-feet per year. This represents a water duty of six acre-feet per acre upon the 50,000 acres of land situated within the district. Additionally, the SCIDD, as part of the SCFIP, claims the right to store up to 18,000 acre-feet per year in Picacho Reservoir. The claimed direct source of public water diverted is the Gila River, tributary to the Colorado River. The SCIDD also receives groundwater from 104 irrigation wells owned by the United States, and desert runoff (as stated on the statement of claimant). The claimed date of initiation of right is immemorial up to 1924.

The SCIDD claim will be addressed in detail in a subsequent watershed HSR.

CHAPTER 8: INVESTIGATION CRITERIA, PROCEDURES, AND REPORTING FORMAT

This chapter describes the criteria, investigation procedures, and reporting format which the Arizona Department of Water Resources (DWR) utilizes for establishing the scope of its water use and water rights investigations, the results of which are shown in Volumes 3 through 9 of this report. DWR recognizes that the criteria are complex and, as a result, can be difficult to understand. The reasons for this complexity are the highly diverse circumstances associated with water uses and water rights in Arizona and the fact that so few of these circumstances have yet to be administratively or judicially examined.

The general criteria utilized in preparing this hydrographic survey report (HSR) follow the guidelines established by the Court in Pre-Trial Order No. 1 dated May 29, 1986, the Third Set of Issues for Decision dated January 29, 1988, the Groundwater/Surface Water Decision dated September 9, 1988, and the Water Rights Entitlement Issue Decision dated March 17, 1989. The scope of DWR's investigations include all non-Indian statements of claimant that claim water uses or rights, all previous filings or rights established under the water code (3Rs, 33s, or 4As), all claims made under the water rights and stockpond registration acts (36s and 38s), and all decreed rights, notices of appropriation (10s), old rights ("Os"), and claimed rights ("Cs"). In addition, DWR investigates all water uses without any applicable statements of claimant or previous water rights or filings, except for stockwells and nonirrigation uses within municipal water service areas. It should be noted that the Court has yet to determine the legal effect of failure to file a statement of claimant.

8.1 INFORMATION SOURCE DOCUMENTATION

The preparation of the San Pedro River watershed HSR involved extensive office and field investigations by DWR personnel. To initiate and complete the investigations, DWR compiled materials to establish water use locations and to assist in verifying potential water rights (PWRs). The basic materials that constitute the geographical investigation data base are listed as follows.

MAPS

DWR utilized the following map sources in its investigations:

- United States Geological Survey (USGS) Topographic Quandrangle Maps (7.5 and 15 minute series)

QUADRANGLE MAP NAME	SCALE	QUADRANGLE MAP NAME	SCALE	QUADRANGLE MAP NAME	SCALE
Agua Caliente Hill	1:24,000	Galleta Flat West	1:24,000	North of Oracle	1:24,000
Apache Peak	1:24,000	Haberstock Hill	1:24,000	Oracle	1:24,000
Basset Peak	1:24,000	Happy Valley	1:24,000	O'Donnell Canyon	1:24,000
Benson	1:62,500	Happy Valley	1:62,500	Pearce	1:62,500
Benson	1:24,000	Harrison Canyon	1:24,000	Peppersauce Wash	1:24,000
Bisbee	1:24,000	Hay Mountain	1:24,000	Piety Hill	1:24,000
Bisbee NE	1:24,000	Hereford	1:24,000	Potter Mountain	1:24,000
Bisbee SE	1:24,000	Hereford SW	1:24,000	Putnam Wash	1:24,000
Black Diamond Peak	1:24,000	Holy Joe Peak	1:24,000	Pyeatt Ranch	1:24,000
Black Mountain	1:24,000	Hookers Hot Springs	1:24,000	Rawhide Mountain	1:24,000
Blue Jay Peak	1:24,000	Huachuca City	1:24,000	Redington	1:24,000
Booger Canyon	1:24,000	Huachuca Peak	1:24,000	Redington	1:62,500
Brandenburg Mountain	1:24,000	Kielburg Canyon	1:24,000	Reiley Peak	1:24,000
Buehman Canyon	1:24,000	Kennedy Peak	1:24,000	Rhodes Peak	1:24,000
Bufford Hill	1:24,000	Klondyke	1:24,000	Rincon Peak	1:24,000
Campini Mesa	1:24,000	Knob Hill	1:24,000	Saddle Mountain	1:24,000
Campo Bonita	1:24,000	Land	1:24,000	St. David	1:24,000
Canelo Pass	1:24,000	Lewis Springs	1:24,000	San Carlos Reservoir	1:62,500
Cherry Spring Peak	1:24,000	Lookout Mountain	1:24,000	San Pedro Ranch	1:24,000
Clark Ranch	1:24,000	Mammoth	1:24,000	Sierra Bonita	1:24,000
Cobre Grande Mountain	1:24,000	Mammoth	1:62,500	Soza Canyon	1:24,000
Cochise Stronghold	1:24,000	McGrew Springs	1:24,000	Soza Mesa	1:24,000
Crozier Peak	1:24,000	Mescal	1:24,000	Spring Water Canyon	1:24,000
Deepwell Ranch	1:24,000	Mica Mountain	1:24,000	Stark	1:24,000
Dragoon	1:24,000	Miller Peak	1:24,000	Steele Hills	1:24,000
Dragoon	1:62,500	Montezuma Pass	1:24,000	The Mesas	1:24,000
Elgin	1:24,000	Mount Bigelow	1:24,000	Tombstone	1:24,000
Elgin	1:62,500	Mt. Hughes	1:24,000	Tombstone SE	1:24,000
Empire Mountains	1:62,500	Mt. Lemon	1:24,000	Tripp Canyon	1:24,000
Eureka Ranch	1:24,000	Mt. Turnbull	1:24,000	Wild Horse Mountain	1:62,500
Fairbank	1:24,000	Muskhog Mountain	1:24,000	Winchester Mountains	1:62,500
Fortified Peak	1:24,000	Mustang Mountains	1:24,000	Winkelman	1:24,000
Fort Huachuca	1:24,000	Naco	1:24,000		
Galleta Flat East	1:24,000	Nicksville	1:24,000		

- United States Bureau of Land Management (BLM) Surface Management Status Topographic Quadrangles (30 x 60 minute)

MAP NAME	SCALE
Mammoth	1:100,000
Douglas	1:100,000
Nogales	1:100,000
Fort Huachuca	1:100,000
Chiricahua Peak	1:100,000

- Arizona highway and county maps prepared by the Arizona Department of Transportation

- United States Forest Service (USFS) Hydrology site location maps

- USFS National Forest Maps

MAP NAME	SCALE
Chiricahua, Peloncillo, and Dragoon Mountains	1:126,720
Safford and Santa Catalina Ranger Districts	1:126,720
Santa Rita, Tumacacori, Patagonia, Huachuca, and Whetstone Mountain Ranges	1:126,720

- Arizona Corporation Commission water company franchise boundary maps

- Arizona State Water Commissioner Gila River determination maps pertaining to the San Pedro River watershed (1920, 1921, and 1923)

- General Land Office plat maps

- Cochise, Graham, Pima, Pinal, and Santa Cruz, Counties' assessor parcel ownership maps

- DWR generated maps

AERIAL PHOTOGRAPHY

In 1984, 1985, 1986, 1987, and 1990, DWR obtained stereo aerial photographic coverage of the San Pedro River watershed. This aerial photography at a nominal 1:24,000 scale has been the primary source of information used to identify certain types of water uses (e.g., stockponds, domestic uses, initial locations of irrigated areas requiring field investigation, etc.).

DWR has also obtained historical aerial photography for the San Pedro River watershed. The available historical aerial photography coverage did not provide complete coverage for the entire watershed. Historical aerial photography is utilized in much the same way as the current DWR aerial photographic coverage, however, historical aerial photographs are one of the key tools used in establishing apparent dates of first water use. The historical aerial photography utilized in DWR's investigations are shown in Table 8-1.

TABLE 8-1
HISTORICAL AERIAL PHOTOGRAPHY USED BY DWR

YEAR	AGENCY	NOMINAL SCALE	PERCENT COVERAGE OF SAN PEDRO RIVER WATERSHED (1)
1984	National High Altitude Photography Program (NHAP)	1:80,000	20 to 25
1983	Arizona Department of Transportation (ADOT)	1:20,000	1 to 5
1983	NHAP	1:80,000	10 to 11
1980	National Aeronautics and Space Administration (NASA)	1:32,000	10 to 15
1980	NHAP	1:8,600	1 to 5
1979	United States Department of Agriculture (USDA)	1:24,000	40 to 45
1979	USDA	1:8,000	20 to 25
1978	Southwest Environmental Associates	1:40,000	1 to 5
1977	USDA	1:24,000	1 to 5
1977	ADOT	1:20,000	1 to 5
1976	USDA	1:8,000	1 to 5
1976	USDA	1:40,000	5 to 10
1976	USDA	1:6,600	1 to 5
1976	United States Geological Survey (USGS)	1:16,000	5 to 10
1973	NASA	1:125,000	1 to 5
1973	NASA	1:62,500	15 to 20
1972	USGS	1:24,000	5 to 10
1972	NASA	1:60,000	5 to 10
1971	NASA	1:24,000	1 to 5
1971	USGS	1:40,000	1 to 5
1971	United States Air Force	1:80,000	1 to 5
1971	NASA	1:116,047	25 to 30
1970	Agricultural Stabilization and Conservation Service (ASCS)	1:20,000	1 to 5
1969	ASCS	1:20,000	1 to 5
1969	NASA	1:80,000	1 to 5
1967	ASCS	1:20,000	1 to 5
1964	ASCS	1:20,000	10 to 15
1968	ASCS	1:20,000	5 to 10
1965	USDA/Soil Conservation Service (SCS)	1:60,000	1 to 5
1965	ASCS	1:20,000	40 to 45
1947	USGS	1:47,000	1 to 5
1945	USGS	1:40,000	5 to 10
1935	SCS	1:24,000	80 to 85
1935	SCS	1:62,500	1 to 5

(1) These values are approximate.

LAND OWNERSHIP INFORMATION

Land ownership data is obtained from the Cochise, Graham, Pima, Pinal, and Santa Cruz Counties' assessor revenue listings as reported to the Arizona Department of Revenue. Associated parcel or plat maps were obtained directly from the county offices.

The USFS and BLM Surface Management Status maps also supply information on the ownership status of public lands. These agencies, along with the Arizona State Land Department (SLD), have supplied additional information on the status of grazing, agricultural, and commercial leases on public land. DWR has integrated the land ownership information into several computer bases: the Geographic Information System (GIS) and the Adjudication Investigation System (AIS).

WATER USE INFORMATION

One of the first tasks in DWR's investigations involves collecting and analyzing all pertinent notices of appropriation, old rights, claimed rights, water rights filings, certificates, registrations, or court decrees. DWR has direct access to all physical copies of water rights filings. The filings and registrations are also accessed through several DWR computer data bases: the Surface Water Registration system, the Statement of Claimant Registry, and the Well Registration system. Notices of appropriation are obtained from each county where the notices have been filed. Court decrees are obtained through the Cochise, Graham, Pima, Pinal, or Santa Cruz County Superior Court clerks. Chapter 1 contains a description of each category of water right filing.

Water consumption figures and customer information for franchised water companies was obtained from annual reports submitted by the companies to the Arizona Corporation Commission (ACC). Municipal water systems and domestic water improvement districts/co-ops are not regulated by the ACC. Therefore, water consumption figures and customer base information from these water providers were obtained directly from the town, city, organization, or their water rights filings.

Industrial water use figures for the Apache Nitrogen Company, ASARCO, Inc. Well Fields, and the Magma Copper Company's San Manuel Operation were obtained from these respective operations during the course of DWR's investigations.

Water use investigations for domestic and stockwatering facilities are conducted initially through map and aerial photo interpretation. The larger stockponds, those that appear to be over two surface acres in size, were inspected in the field. If the field investigation determined that the pond could store water (i.e., not a flood control impoundment with an open outlet pipe at the bottom of the dam), it was surveyed for the area (acres) and capacity (acre-feet) at its spillway crest elevation. In the early stages of DWR's investigations for the San Pedro River watershed, prior to entry of the Court's Entitlement Decision, DWR was utilizing a threshold criteria of one acre rather than two acres to measure stockpond area and capacity. Hence, data has been collected for a number of ponds between one and two surface acres and this information is reported in the watershed file reports wherever it has been obtained. Domestic water use or other stockwatering facilities (springs and smaller stockponds) may also be verified during field inspections. Domestic water, stockwatering, and wildlife uses from wells, springs, or free flowing water courses are not quantified.

Irrigation water use information was gathered through an extensive program of field mapping and measurement. Current aerial photography of irrigated areas was enlarged for mapping purposes. All elements of the irrigation systems were mapped including: diversions (groundwater supplying greater than two acres of irrigation; surface water for all acreage), conveyance systems, reservoirs, and irrigated lands. Storage reservoirs larger than two surface acres were surveyed to determine storage capacity using the same survey method applied to measuring stockpond capacities. Surface water diversions for irrigation in the San Pedro River watershed have been measured at most sites since 1988. For more information on the quantification methodology for irrigation see APPENDIX C.

8.2 GENERAL CRITERIA

The following sections describe the general criteria utilized by DWR in its investigations. These criteria were established to evaluate the many complex and varied water use situations that DWR encounters in the field. The criteria were also developed to provide the information requested by the Court in its applicable Pre-Trial Orders and Decisions.

WATER USE CLASSIFICATIONS

The different types of water uses reported and investigated are described below with their abbreviations in parentheses. DWR devised the type of use classification for reporting water uses for the adjudication; the classification does not have any legal standing.

Agricultural Irrigation (IR) - water used to produce plants for human or animal consumption or for sale such as nursery stock or pine trees.

Domestic (DM) - water used for household needs and small commercial establishments including small businesses and restaurants. Trailer parks are also included in the domestic use category. Associated irrigation of less than two acres supplied by groundwater or less than 0.1 acres supplied by surface water or less than 0.5 acres supplied by Zone 1 groundwater is included in a domestic use.

Diversion (DV) - a surface water diversion or water export. This classification is given primarily to irrigation water providers or large surface water divertors and to divertors who export water out of a watershed.

Industrial (ID) - water used by a commercial operation or business such as dairies, sand and gravel operations, and fish farming.

Mining (MI) - water used for mineral extraction or the processing of ore. Dust control, drinking water, and other associated uses may be included in this type of water use.

Municipal (MU) - water supplied by a city, town, or private water company through its distribution system for any use. Cooperatives or joint ventures involving four or more users are also included in this category.

Other Irrigation (OT) - water used to produce plants used primarily for landscaping, aesthetic value, erosion control, and similar purposes. Common examples of other irrigation include cemeteries and landscaping around businesses and along highways. Also included in this category is irrigation of land associated with a domestic use by surface water sources less than two acres and greater than or equal to 0.1 acres or greater than or equal to 0.5 acres and less than two acres when supplied by Zone 1 groundwater.

Primary Storage (PS) - an impoundment which stores surface water or groundwater and has a maximum storage capacity greater than fifteen acre-feet. The primary use of the water must be other than stockwatering or wildlife watering.

Recreational Irrigation (RC) - water used to produce plants which are an integral part of a recreation facility. Common examples of recreational irrigation include golf courses, parks, and ball fields.

Small Reservoir (SR) - an impoundment which stores surface water or groundwater and has a maximum storage capacity equal to or less than fifteen acre-feet. The primary use of the water must be other than stockwatering or wildlife watering.

Stockpond (SP) - an impoundment which stores surface water for the primary purpose of watering livestock and/or wildlife.

Stockwatering (SW) - water used primarily for watering livestock. The source may be a spring, cienega, seep, natural lake, natural depression, sink, bog, or intermittent or perennial drainage. Stockwatering does not include stockponds.

Wildlife (WL) - water used primarily for watering wildlife. The source may be a spring, cienega, seep, natural lake, natural depression, sink, bog, or intermittent or perennial drainage.

POTENTIAL WATER RIGHT

A PWR is defined to be a water use which eventually may need to be recognized as a separate and distinct right. They are identified on the basis of DWR's technical evaluation of actual uses and records of rights and claims.

They represent the end product of the investigation process. Categorizing water uses as PWRs is not, however, a presumption or recommendation of a right by DWR.

More specifically, a PWR is a water use with an independent purpose. It is supplied in its entirety by the same source(s) of water and has the same apparent date of first use for the entire period of use. For example, some water uses and claims have been classified as incidental to a more primary use, i.e., not having an independent purpose and, therefore, are not reported as PWRs. Other water uses, such as an irrigation operation, may have several PWRs reflecting different sources of water or dates of first use for the various irrigated land parcels. Each PWR is assigned a unique number that describes the location of the PWR within the watershed, the type of use, and specific lands or facilities. The data elements encompassed by the PWR number are described in detail in Section 8.5 of this chapter.

All statements of claimant, previous water rights filings including notices of appropriation, old rights, claimed rights, or decreed rights that have been associated with a particular PWR by DWR's investigation are placed in that PWR's watershed file report. These filings and rights provide data such as the location of a water use, the location of the source of water for a water use (i.e., point of diversion), a claimed or established date of first beneficial use, the volume of water used, etc. This data may be used by the Court to establish a water right and to assign an entitlement and priority date to that right. Therefore, it is important that all of these filings and decrees are shown in the HSR and matched to PWRs when applicable.

Water rights are presumed to be appurtenant to the land on which the use occurs, therefore the ownership history of that land is not assumed to be critical to the establishment of a water right. DWR has assigned filings to actual water uses on the basis of the location and type of use claimed rather than on the basis of the claimant name shown on these filings. All land areas potentially covered by a claim will be included in the HSR. Criteria for matching claims to inventoried water uses and diversions follow a similar philosophy. Data included in a claim are broadly interpreted when matching claims to PWRs.

The following outline describes specific criteria involving statement of claimant filings and previous filings/decrees.

A. Assignment to an Adjudication Watershed File Report

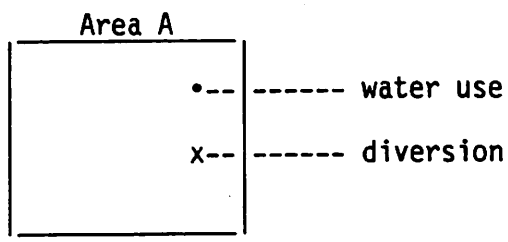
1. All previous filings/decrees and/or statements of claimant will be in a watershed file.

2. A previous filing/decree or statement of claimant listing water uses or diversions on privately owned land with multiple owners or on public land with multiple lessees/allottees is assigned only to those areas of land which contain the uses or the diversions (see Example 8-1).

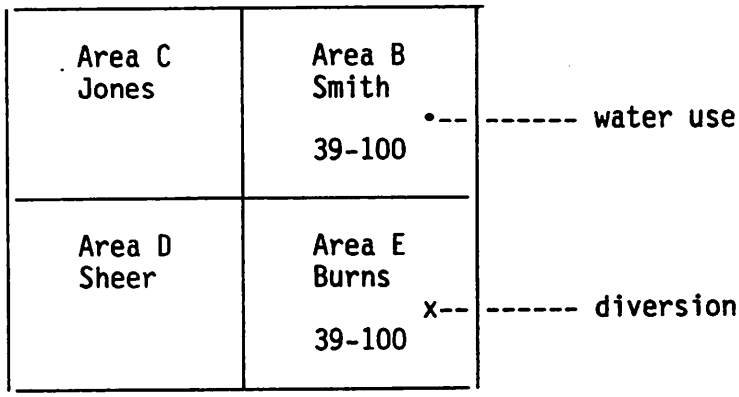
Example 8-1:

Statement of Claimant Number 39-100

filed by Smith claiming all of Area A



Area A (subdivided since time of original filing)



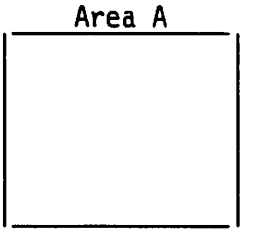
Filing number 39-100 is assigned to the investigation files created for Area B (Smith) and Area E (Burns). Areas C and D have no investigation file created for them because no water use was found.

3. Designation is independent from who filed the claim (see Example 8-1); the PWR is presumed appurtenant to the land on which it is located.

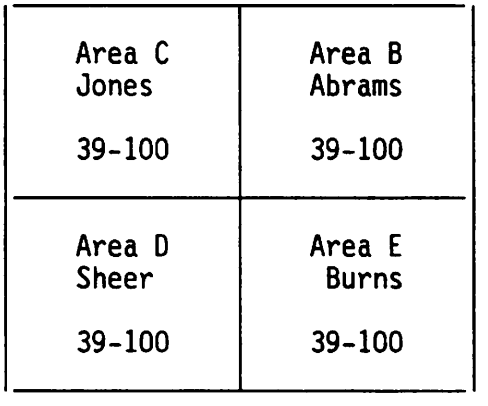
4. If land ownership has been split since a claim was filed and no PWRs exist, all parcels of land will be covered (see Example 8-2).

Example 8-2:

39-100
filed by Smith
on Area A



no water uses or diversions found



no water uses or diversions found

Four watershed files are created each containing 39-100 because it is not apparent what land areas are covered by 39-100. Therefore, all possible areas are accounted for.

5. Claims filed on a particular watershed which are investigated and found to list water uses or diversions located outside the watershed will be assigned to the correct watershed and reported in that HSR.

B. Creation of PWRs on the Basis of Filings

Two types of PWRs: stock or wildife watering from a spring and instream stockwatering may be created based solely upon the existence of filings rather than upon the identification of actual water uses from aerial photography or on site inspection. Either type of filings (statements of claimant and previous filings) can exist in order to create a PWR. Table 8-2 illustrates the criteria used to establish these PWRs.

TABLE 8-2

CRITERIA USED TO ESTABLISH STOCK OR WILDLIFE WATERING PWRS

STATEMENT OF CLAIMANT	PREVIOUS FILING/DECREE	CLAIMED USE	PWR
yes	yes	stock spring (may include wildlife)	SW
yes	yes	wildlife only spring	WL
no	yes	stock or wildlife	none
yes	no	stock or wildlife	none
no	no	stock or wildlife	none
yes	yes	instream stockwater	SW (1)
yes	no	instream stockwater	SW (1)
no	yes	instream stockwater	SW (1)

(1) In some cases, a filing may claim a stockpond and an instream stockwatering use which occurred prior to the construction of the stockpond. In these cases, DWR will create a stockpond (SP) PWR, and explain that an instream stockwatering use was claimed prior to the stockpond's construction.

C. Claimed Uses with no PWR Created

1. Stockwatering from a well will not be assigned a PWR when the well is used solely for stockwatering and/or wildlife purposes.

2. Rainfall retention, flood control, erosion control, or any collection of sheetflow will not be assigned a PWR. These uses are reported as "nonappropriable" based on the criteria describing appropriable water in A.R.S. § 45-141.

3. Any claimed use that is secondary to a primary verified use is not assigned a PWR; the claim status is reported as "incidental." For example, a claim is made for irrigation and stockwatering from a well. The water from the well is applied to a field of pasture in which the irrigation runoff is collected in tailwater reservoir. The water collected in the tailwater reservoir is used to water the stock which grazes on the pasture grasses. The primary use of the well water is for irrigation use; the incidental water use is for stockwatering (also see Section 8.3, Water Use Criteria, Incidental Water Uses).

4. Any claimed use that cannot be verified using DWR's criteria.

D. Matching Filings to PWRs

Previous filings/decrees and statements of claimant are matched to water uses based on the following criteria:

1. A point of diversion listed in a filing/decree or claim is found to supply water to a PWR.
2. The location of a water use listed on a filing/decree or claim or shown on a map attached to the filing/decree or claim matches the location of a PWR determined during the investigation process.
3. For stockponds the size and shape indicated in a filing/decree or claim may be used to match the filing/decree or claim to a verified stockpond location, if the legal description agrees at least to the section number.
4. For springs which are not field investigated, locations may be matched by USGS, USFS, and BLM maps.
5. For domestic uses, filings may be matched by name only unless the filing/decree or claim identifies a parcel number or an accurate map is provided.
6. Facility name of a claimed water source.

APPARENT DATE OF FIRST USE

The apparent date of first use represents DWR's technical evaluation of the date of first water use based upon the information evaluated by DWR. Apparent dates of first use have not been reported for all types of use. For those that are reported, much more effort and detail is applied for certain types of use than for others. The methods and criteria used to assign apparent dates of first use are described below and in Table 8-3.

Previous Filings/Rights/Decrees and Statements of Claimant

The apparent dates of first use are generally taken from the water rights filings unless refuted by historical aerial photography. These filings are: notices of appropriation, old rights, claimed rights, filings made under the State Water Code, claims made under one of the water rights registration acts,

TABLE 8-3

CRITERIA FOR ESTABLISHING APPARENT DATES OF FIRST USE

EXAMPLE	WATER USE TYPE	WATER SOURCE	APPLICABLE STATEMENT OF CLAIMANT	APPLICABLE PREVIOUS FILING/DECREE	APPARENT DATE OF FIRST USE ESTABLISHED	BASIS FOR ESTABLISHMENT OF APPARENT FIRST USE DATE
1	Irrigation (IR, RC, OT)	Surface water and/or groundwater	Yes	Yes	Yes	a) May be local historical analysis. b) May be earliest previous filing/decree not refutable by historical aerial photo. c) May be first historical aerial photo date if other than previous filing/decree date or if previous filing/decree date is refuted and photo date is the next evidence of use. d) May be certificated water right.
2	Irrigation	Groundwater	Yes	Yes	Yes	Same as example #1 except "b" may be based on "39" date if that is earlier than previous filing/decree when use supplied solely by wells and acreage is less than or equal to ten acres.
3	Irrigation	Surface water and/or groundwater	No	Yes	Yes	Same as example #1.
4	Irrigation	Groundwater	No	Yes	Yes	Same as example #1.
5	Irrigation	Groundwater and/or surface water	No	No	Yes	See a and c in example #1.
6	Irrigation	Groundwater	No	No	Yes	See c in example #1.
7	Irrigation	Any	Yes or No	Yes or No	Yes	Same as examples 1-6, but if acreage is less than or equal to ten acres, date of first use is based on information obtained from claimant interview or from the statement of claimant if there are no previous filings or no interview. Must be reasonable.

TABLE 8-3 (cont'd)

EXAMPLE	WATER USE TYPE	WATER SOURCE	APPLICABLE STATEMENT OF CLAIMANT	APPLICABLE PREVIOUS FILING/DECREE	APPARENT DATE OF FIRST USE ESTABLISHED	BASIS FOR ESTABLISHMENT OF APPARENT FIRST USE DATE
8	SP, PS, SR	Surface water and/or groundwater	Yes or No	Yes	Yes	a) Use must exist on current aerial photo. b) Earliest previous filing/decree. c) Earliest historical aerial photo.
9	SP, PS, SR	Surface water and/or groundwater	Yes or No	No	Yes	a) Use must exist on current aerial photo. b) Earliest historical aerial photo.
10	SW, WL (Both from spring)	Surface water	Yes	Yes	Yes	a) Earliest previous filing/decree.
11	SW, WL	Groundwater	Yes or No	Yes or No	No	
12	SW, WL (Instream use)	Surface water	Yes	Yes	Yes	a) Earliest previous filing/decree. b) Must be filed by owner/lessee/allottee or by documented successor- or predecessor-in-interest. c) Current aerial photo must show drainage at the claimed location.
13	SW, WL (Instream use)	Surface water	No	Yes	No	
14	SW, WL (Instream use)	Surface water	Yes	No	No	
15	Municipal	Any	Yes or No	Yes or No	Yes	a) May be based upon start of service as documented by previous filing/decree; 39 filing, Arizona Corporation Commission, historical analysis, or claimant information.

TABLE 8-3 (cont'd)

EXAMPLE	WATER USE TYPE	WATER SOURCE	APPLICABLE STATEMENT OF CLAIMANT	APPLICABLE PREVIOUS FILING/DECREE	APPARENT DATE OF FIRST USE ESTABLISHED	BASIS FOR ESTABLISHMENT OF APPARENT FIRST USE DATE
16	Industrial	Any	Yes or No	Yes or No	Yes	a) May be based on earliest historical photo, earliest previous filing/decree, earliest 39, historical analysis, or claimant interview. All documentation is evaluated.
17	Mining	Any	Yes or No	Yes or No	Yes	a) Same as in example #16. b) Large mines require field check and claimant interview to establish the apparent date of first use.
18	Domestic	Any	Yes or No	Yes or No	No	

upon decreed dates, or upon dates claimed in statements of claimant. The statement of claimant information is generally not used for any surface water uses except for irrigation of less than ten acres.

Historical Analysis

A historical analysis is performed for surface water irrigation users sharing a common delivery system (irrigation district or canal company) or privately owned ditches in local areas where they are numerous. The purpose of the analysis is to determine the general dates of initial settlement in the area, the initial installment of the diversion and conveyance facilities, and subsequent additions or deletions of lands served by the canal systems. For these cases, dates of first use may be assigned on the basis of historical information rather than the dates claimed even though the historical analysis dates may be earlier than claimed dates. A historical analysis may also be performed for municipal water providers and industrial and mining uses to establish the start-up of the water uses and to verify the claimed dates of first use.

Historical Aerial Photography

Another method for determining apparent dates of first use in the HSR is the use of historical aerial photography to verify past water use activity. When there are no previous filings, decrees, or statements of claimant that pertain to a particular water use, the reported apparent date of first use is the date of the earliest historical aerial photograph on which the activity appears. If there are previous filings/decrees that pertain to a PWR, then the apparent date of first use is taken from the applicable right or filing so long as historical aerial photographic evidence cannot refute that continual use has occurred from that date to the present. If aerial photographs taken subsequent to the date in the right or filing show no evidence of the use, then the apparent date of first use is based upon the earliest historical aerial photograph on which the use appears. Examples of these circumstances are shown in Table 8-4.

TABLE 8-4

ESTABLISHMENT OF APPARENT FIRST USE DATE BASED UPON HISTORICAL AERIAL PHOTOGRAPHY (PRIMARILY FOR IRRIGATION USES)

	DATE CLAIMED	AVAILABLE HISTORIC PHOTO DATE	USE VERIFIED DATE	APPARENT FIRST USE DATE ASSIGNED
Example 1	1919	1935	yes	1919
		1985	yes	
Example 2	1919	1935	no	1955
		1955	yes	
		1985	yes	
Example 3	1940	1935	no	1940
		1945	yes	
		1985	yes	
Example 4	1950	1935	no	1985
		1955	no	
		1985	yes	
Example 5	1940	1935	yes	1985
		1945	no (1)	
		1955	no (1)	
		1985	yes	

(1) Aerial photography must clearly show that no irrigation had been taking place.

For some types of uses, historical aerial photography has not been utilized by DWR to determine apparent dates of first use. These uses are primarily stockwatering type uses and the first use dates are based solely upon previous filings/decrees.

Historical Maps

Maps prepared by the State Water Commissioner in support of the Gila River determination (Figure 8-1), the United States General Land Office plat maps (Figure 8-2), or other types of historical maps obtained by DWR may be used to determine apparent dates of first use, primarily for irrigation uses.

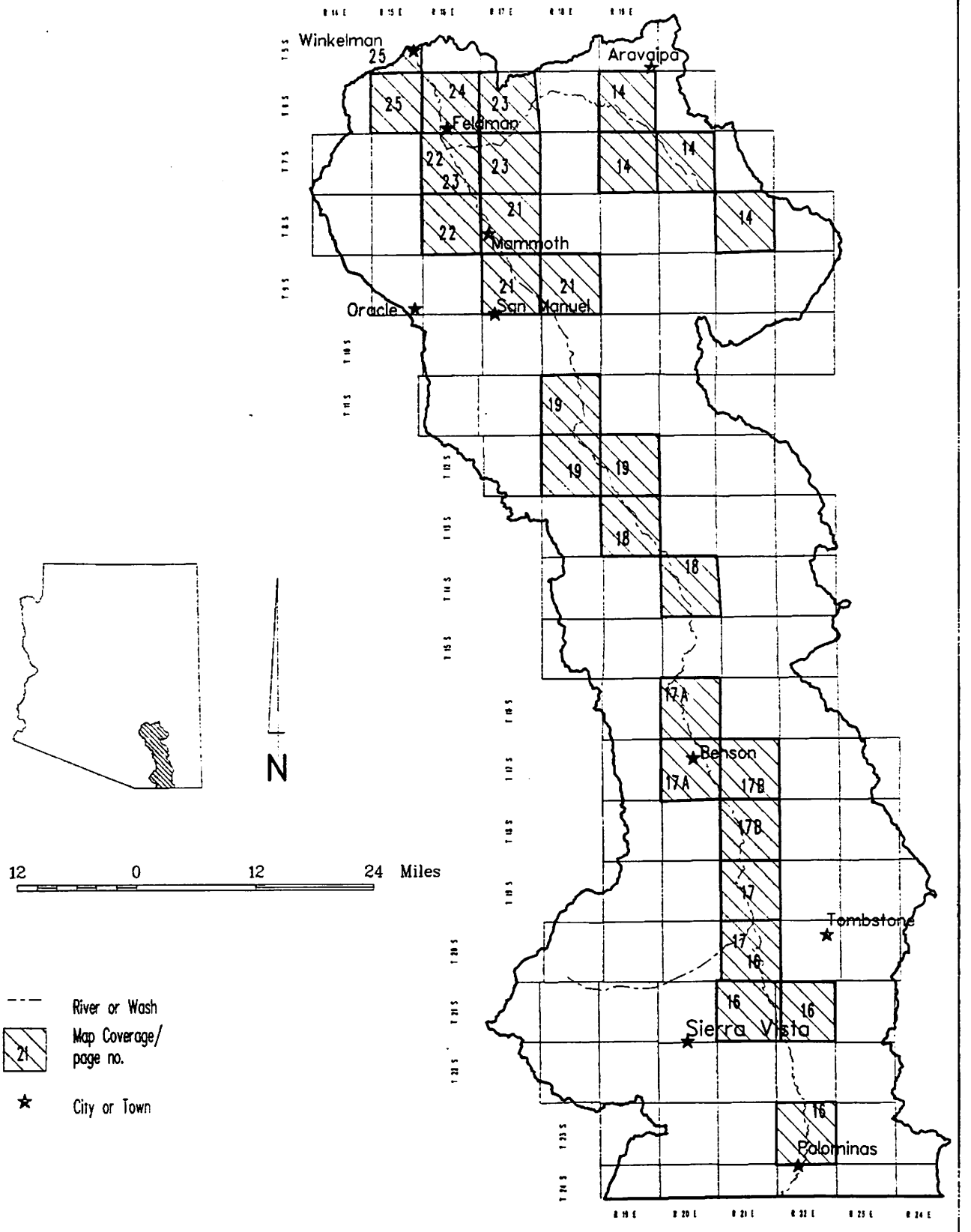


Figure 8-1. Map showing State Water Commissioner map coverage within the San Pedro River watershed.

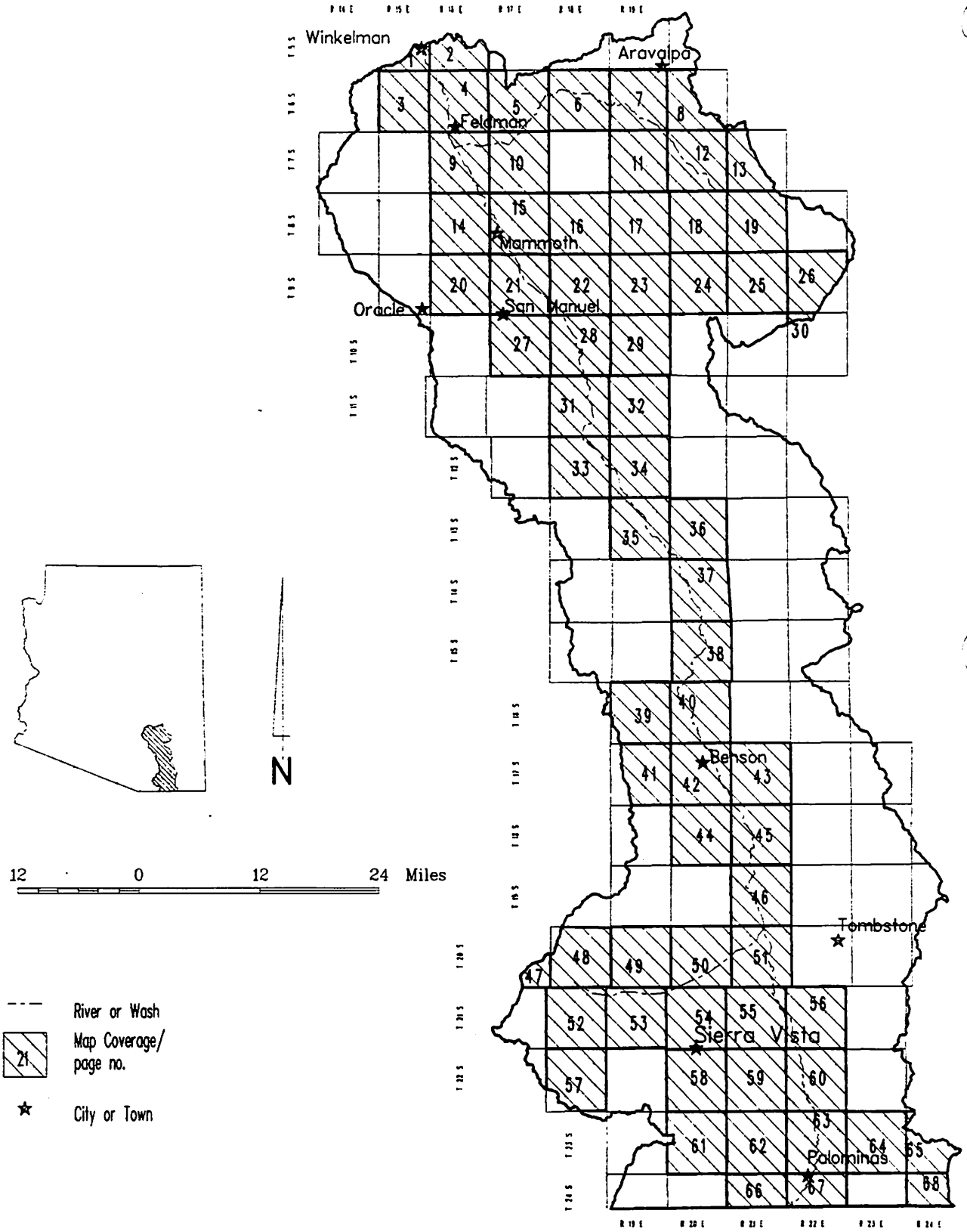


Figure 8-2. Map showing General Land Office plat map coverage within the San Pedro River watershed.

Additional Claimant Information

For irrigation uses of no more than ten acres industrial and mining uses, information obtained from interviews with the claimants may be used as the basis for the apparent date of first use only when the information appears to be reasonable.

DISCONTINUED USE AND NO USE FOUND (REPORTED AS "NONE")

Water uses which are claimed on previous water rights filings, statements of claimant, or decreed rights and which have not been used for at least the most recent five consecutive years but have been used within the past ten years, are classified as a "Discontinued" use. The use of this term does not presume a loss of right by DWR. It is only a classification of water use history and is applied regardless of whether the source of supply is groundwater, surface water, or both sources. If water has not been used for at least ten consecutive years or DWR cannot verify that a water use has ever existed at a claimed location, it is reported as "None."

The evidence required to classify a claimed water use as discontinued consists primarily of field investigations and when possible consultation with the land owner. The water use types for which the date of last water use is determined are irrigation, municipal, industrial, and major mining uses.

The criteria used to classify claimed water use types as "Discontinued" use or "None" is given in Table 8-5.

TABLE 8-5

CRITERIA TO ESTABLISH DISCONTINUED USE OR NO USE FOUND

WATER USE TYPE	DISCONTINUED USE	NO USE FOUND (REPORTED AS "NONE")
Irrigation	Owner information, field investigation, adjudication filings, aerial photography	Owner information, field investigation, adjudication filings, aerial photography
Domestic	Not considered	Aerial photography, field investigation
Stockpond (1)	Not considered	Aerial photography, field investigation
Stockwatering (Springs)	Not considered	Adjudication and previous filings
Stockwatering (Instream Use)	Not considered	Aerial photography, ownership status, field investigation
Wildlife (Springs)	Not considered	Adjudication and previous filings
Municipal	Owner information, field investigation, Arizona Corporation Commission Data, adjudication filings	Aerial photography, ownership status, field investigation
Commercial/Industrial Mining	Owner information, field investigation, Arizona Corporation Commission Data, adjudication filings	Owner information, field investigation
Small Reservoir (1)	Not considered	Field investigation, aerial photography
Primary Storage Reservoir	Not considered	Field investigation, aerial photography

(1) Field investigation conducted if a stockpond or small reservoir is greater than or equal to two surface acres.

REPORTING WATER SOURCES AND THEIR CLASSIFICATION

The Court has directed DWR to report all water uses supplied by surface water sources which include surface flow, springs, or seeps. The Court in its order dated September 9, 1988 pertaining to groundwater and surface water interrelationships directed DWR to provide additional information on

groundwater that is withdrawn by wells. Section 4.6, Chapter 4 of this volume of the HSR describes in detail DWR's technical interpretation of the Court's directives and the methodology used to implement them. DWR has established three reporting zones for water withdrawn from wells. Zone 1 delineates the area in which water withdrawn from wells is considered, for purposes of the HSR, to be pumping appropriable subflow according to the criteria provided by the Court's order. The boundaries of Zone 1 are referred to as "brightlines" in this report. The source of supply of these wells are reported as "Groundwater: Zone 1."

Zone 2 describes an area in which wells (supplying uses other than stockwatering, domestic, or irrigation of less than two acres) have the potential to diminish the sources of supply (surface and/or groundwater) available to satisfy federal reserved water right claims. Wells supplying other than the three exempted uses and withdrawing groundwater from Zone 2 are reported as "Groundwater: Zone 2."

Zone 3 is an area in which groundwater withdrawn from wells is determined to have no significant effect on diminishing the water supply available to satisfy water rights established under either state or federal law. Wells located in Zone 3 and the exempted wells in Zone 2 are reported as "Groundwater: Catalogued." Section 3.2, Chapter 3 gives examples of the possible combinations of the water sources and the manner in which DWR reports uses supplied by these sources.

In summary, DWR is reporting the following sources of water and their classification:

1. Surface Water
2. Groundwater: Zone 1
3. Groundwater: Zone 2
4. Groundwater: Catalogued
5. Combinations of the above sources.

DWR also reports when a change in water source has occurred. For example, an irrigation use has been historically supplied by a surface water source, but it is now supplied by well water based upon DWR's investigations. DWR would report this as a water source change in the watershed file report in which the irrigation use occurs.

EFFLUENT

Based upon the APS v. Long wastewater effluent decision by the Arizona Supreme Court (April 1989), certain criteria changes concerning DWR's investigation of uses supplied by effluent have resulted. The Court concluded that sewage effluent is neither groundwater nor appropriable surface water. Therefore, uses supplied by effluent will not be given a potential water right, assigned an apparent date of first use, or given a water duty by DWR.

Water uses supplied by wastewater effluent will continue to be investigated, but no watershed file report will be created. Those uses supplied by effluent are reported in Major Users Reports in Chapter 5.

CONVEYANCE SYSTEMS

Conveyance systems are canals, ditches, or pipelines which transport water from the point of diversion to the place of use. Generally, conveyance systems are mapped only when they are carrying surface water or mixed sources and normally only the conveyance system external to the place of use is shown. For example, the conveyance system from a diversion dam to the point of first use on the fields would be shown, but the internal system of laterals to transport water within the fields normally is not. The only time that an internal distribution system is shown is when it is important in identifying the particular lands susceptible to irrigation from surface or mixed sources supplying the conveyance system.

NAMES OF DIVERSIONS, FACILITIES, AND RESERVOIRS

Names are taken primarily from the statement of claimant and secondly from the previous filings or decrees. However, if multiple filings exist, the name shown on the filing by the owner of the land in question will be used. When the name of a diversion, facility, or reservoir is not available from filings, the name may be taken from a USGS topographic map if it has been identified.

SHARED WATER USES

A shared use occurs when water is conveyed across ownership or lease boundaries. Common examples are a well supplying irrigation water to the well owner's land and also to an adjoining neighbor's land. Shared uses are discovered and described using information contained in the adjudication filings and previous filings. Shared uses may be field verified during the normal course of a stockwatering, irrigation, or special use field investigations, but do not qualify for a field check in and of themselves. The watershed file report always indicates any nondomestic shared uses that are occurring.

LOCATION OF WATER USES

Water use locations for all types of uses on privately owned land are generally reported using section, township, and range. Water use locations for BLM, USFS, and state lands are reported according to section, township, and range. Quartering of sections are to ten acres whenever practical. Locational reference for USGS topographic map corners (UTM coordinates) and section lines are acquired from SLD computer files. In the cases of unsurveyed lands, section lines are acquired from BLM protraction diagrams and incorporated into SLD computer files. The USGS topographic maps and USFS hydrology maps are used for general location orientation and to assist in site-specific determinations.

PROPERTY OWNERSHIP

Water uses are generally organized by the land owner or water supply service areas where water is being used. Water uses on public lands are aggregated into lease or allotment areas. The land owner may be an individual, partnership, corporation, municipality, the State of Arizona or any political subdivision, the United States or one of its agencies. Land ownership data is acquired from the most recent county assessor property ownership roles on file with the Arizona Department of Revenue, county assessor maps, BLM land ownership and lease maps, USFS ownership and allotment maps, or SLD legal descriptions of lease property.

WATER PROVIDERS

The types of water supply organizations that occur in the watershed include municipal water providers and irrigation water providers. Municipal use is water supplied by a town, city, private water company, or a cooperative water organization through its distribution system for any beneficial purpose. Water uses in this category include all those commonly associated with urban development and may include commercial, industrial, parks, and residential uses. Four or more service connections on separate properties sharing a common water source is categorized as a private water company. An irrigation supplier is an association or company that owns or operates an existing irrigation distribution system consisting of a system of diversions, canals, flumes, ditches, pipes, or other works to deliver surface/groundwater for irrigation use.

The investigation criteria for water supply organizations require field verification of water uses and sources, location of points of diversions (e.g., wells and springs) and storage reservoirs, methods of water collection and conveyance, and methods of wastewater disposal or treatment facilities. Annual water use and amounts diverted are documented from available information including the Arizona Corporation Commission, water supply organizations, USGS, DWR, and other sources.

In addition to the watershed file reports for each water provider, reports are written that describe a general history of the formation of the water supplier, water supply system and method of operation, recent water use trends, and changes in service area boundaries. Reports for irrigation providers include more information involving detailed descriptions of facilities, shareholders/customers, irrigated lands, and apparent dates of first water use.

The service area boundaries, points of diversions, and storage reservoirs for municipal organizations are mapped on the same maps that depict stockwatering uses (regional water use maps). These maps are found in Volume 9 of this HSR. Figure 5-1 shows the general location of municipal service areas in the San Pedro River watershed. Irrigation company/district systems are shown on special maps that are referenced in the major user reports in Chapter 5 of this HSR. Individual properties supplied by these systems are

shown on the subregional water use maps in Volume 9 of this HSR. The mapped facilities include points of diversions, conveyance systems, reservoirs, and other associated information.

Within the municipal or irrigation water supply service areas, irrigation uses greater than or equal to two acres from privately owned wells or with mixed or surface water for any acreage greater than or equal to 0.1 acres, are verified as water uses and are documented separately in individual watershed file reports. However, irrigation uses and other uses supplied by a municipal supplier are not categorized as a separate use, but considered part of the municipal system.

Water users within service areas with private water supplies involving stockwatering, industrial, and mining operations are verified and investigated individually and reported in their own watershed file report.

Irrigation uses or claims supplied either partially or entirely by an irrigation company/district are field verified and reported individually in their own watershed file report even though these uses are referenced in major user reports for the irrigation water provider.

All claimed domestic uses within either a municipality or an irrigation water supply service area are investigated and reported in separate watershed file reports.

PROTESTED PREVIOUS FILINGS

Protested previous filings are listed in the watershed file report, but not given a status and are not used to establish an apparent date of first use. They are also not matched to a point of diversion or place of use. The data contained in the protested filing is utilized by DWR in its evaluation of the claimed water uses and dates of first beneficial use.

AMENDMENTS TO STATEMENTS OF CLAIMANT

Amendments to statements of claimant are evaluated and the information is included in the watershed file report and the statement of claimant record.

8.3 WATER USE CRITERIA

DWR has developed criteria to be used in the reporting of PWRs within each watershed file report. This section describes the reporting criteria to be used for each water use classification.

IRRIGATION (IR, OT, AND RC)

Irrigation PWRs are reported on the basis of water source (surface water, Zone 1, Zone 2, or Zone 3 groundwater), date of first use, acreage, and association with a domestic use. The criteria used is outlined in Table 8-6. It should be noted that in some special situations, DWR may also create irrigation PWRs based on crop types and irrigation systems even though the sources and apparent dates of first use are the same. The reason is to aid in the quantification of irrigation water uses.

For example, a field may be supplied by a surface water diversion and have an apparent date of first use of 1920. During the course of DWR's field investigations and crop surveys, it is found that one part of the field is cotton irrigated by furrows and the other part of the field is permanent pecan trees using border flood irrigation. DWR would create two distinct PWRs for this case to account for the different crops and irrigation systems.

TABLE 8-6

CRITERIA TO ESTABLISH IRRIGATION PWRS

1. IRRIGATION WITHIN THE ZONE 1

WATER SOURCE TYPE	TOTAL LAND AREA UNDER IRRIGATION	DOMESTIC USE PRESENT	IRRIGATION WATER USE TYPE CREATED	MAPPED	COMMENT
Surface/ Zone 1, Zone 2, or Zone 3 Well	greater than or equal to 0.1 acres	no	IR, OT, RC	yes	Source is a direct surface water diversion not supplied by a water company or municipal distribution system. PWR type depends upon irrigation purpose.
Surface/ Zone 1, Zone 2, or Zone 3 Well	greater than or equal to 0.1 acres, but less than two acres	yes	OT	yes	Source is a direct surface water diversion not supplied by a water company or municipal distribution system. When associated with a domestic use, all outside irrigation is reported as OT. DM PWR may be created.
Zone 1 Well	less than 0.5 acres	yes	none	no	DM PWR created, if supplied by a Zone 1 well. No separate irrigation PWR is reported.
Zone 1 Well	less than 0.5 acres	no	none	no	
Zone 1 Well	greater than or equal to 0.5 acres, but less than two acres	yes	OT	yes	DM PWR created for inside use if the domestic use is supplied by a Zone 1 well. All outside irrigation reported as OT.
Zone 1 Well	greater than or equal to two acres	yes	IR, OT, RC	yes	DM PWR also created, if the domestic use is supplied by a Zone 1 well.
Zone 1 Well	greater than or equal to 0.5 acres	no	IR, OT, RC	yes	
Effluent	any size	yes or no	none	yes	Lands irrigated by effluent are not assigned a PWR unless the effluent is mixed with a groundwater or surface water source supplying a mapped PWR. Lands irrigated solely by effluent will be mapped on special water use map and described in the Major Users Reports or Unusual Circumstances sections of Volume 1.

TABLE 8-6 (cont'd)

II. IRRIGATION WITHIN ZONE 2

WATER SOURCE TYPE	TOTAL LAND AREA UNDER IRRIGATION	DOMESTIC USE PRESENT	IRRIGATION WATER USE TYPE CREATED	MAPPED	COMMENT
Surface/ Zone 2 Well	greater than or equal to 0.1 acres	no	IR, OT, RC	yes	Source is a direct surface water diversion not supplied by a water company or municipal distribution system.
Surface/ Zone 2 Well	greater than or equal to 0.1 acres, but less than two acres	yes	OT	yes	DM PWR created for inside use, if the domestic use is supplied by an outside irrigation reported as OT.
Zone 2 Well	less than two acres	yes or no	none	no	Well is catalogued.
Zone 2 Well	greater than or equal to two acres	yes or no	IR, OT, RC	yes	DM PWR may also be created, if the domestic use is supplied by an independent well.

III. IRRIGATION OUTSIDE BOTH ZONES (ZONE 3)

SOURCE TYPE	TOTAL LAND AREA UNDER IRRIGATION	DOMESTIC USE PRESENT	IRRIGATION WATER USE TYPE CREATED	MAPPED	COMMENT
Surface/ Zone 3 Well	greater than or equal to 0.1 acres	no	IR, OT, RC	yes	
Surface/ Zone 3 Well	greater than or equal to 0.1 acres, but less than two acres	yes	OT	yes	DM well catalogued. All outside irrigation reported as OT.
Zone 3 Well	any size	yes or no	none	no	Well is catalogued.

DOMESTIC (DM)

Domestic use PWRs are reported for all residences and small commercial establishments with an independent water supply, usually a domestic well. Trailer parks, small businesses, and restaurants fall within this category. Associated irrigation of less than two acres from a domestic well is included in a domestic use PWR unless the domestic well is located within Zone 1, then the acreage is less than 0.5 acres.

MUNICIPAL (MU)

Municipal use PWRs are reported for all municipal water systems, private water companies, and all domestic water improvement districts or cooperatives supplying four or more users. All water uses supplied through a municipal distribution system are reported as a part of the municipal PWR.

Example 8-3 Water delivered to a city golf course through a municipal water system. The golf course uses the water for turf irrigation and domestic uses at the clubhouse. No PWRs are assigned to the golf course. The water use is all reported as part of the MU PWR for the city supplying the water.

Example 8-4 Water delivered by a residential subdivision water improvement district to twenty-five homes for domestic use. The district which was formed by the homeowners will receive an MU PWR for its water system. The individual homeowners will not be assigned a domestic use PWR. For water use at the residences, however, they may receive a PWR for any other independently supplied water uses.

Separate municipal PWRs will be reported for municipal providers where DWR can determine that there are distinct sources of supply and appurtenant distribution systems within the provider's service area. For example, the City of Sierra Vista municipal supply is provided by three wells which have separate distribution systems and service areas. Three MU PWRs have been reported for this situation.

INDUSTRIAL/COMMERCIAL AND MINING (ID AND MI)

Industrial/commercial or mining PWRs are reported for all commercial, industrial, or mining operations with independent water sources. Some examples of industrial/commercial operations within this classification are: sand and gravel companies, dairies, industrial plants or factories, nurseries or greenhouses, commercial fish farms, and commercial livestock feedlots. Small businesses such as a motel or restaurant with an independent water supply may be classified as a domestic use (DM).

Mining PWRs will be reported for all operations that have developed an independent water supply used for mineral or coal extraction, the processing of ore, or the transportation of mined materials through a slurry pipeline.

IMPOUNDMENTS (SP, SR, AND PS)

Any impoundment that stores surface water or groundwater for beneficial use is assigned a PWR. If the impoundment is not constructed on a natural drainage channel or stream, then it must receive water from a groundwater or surface water point of diversion (POD) to be assigned a PWR. Impoundment classifications are shown in Table 8-7 and described below.

Stockpond (SP)

A stockpond is an impoundment which stores surface water for the primary purpose of watering livestock and/or wildlife. A stockpond can also be supplied supplementally from groundwater.

A typical stockpond in the San Pedro River watershed usually consists of a small earthen dam pushed up along an ephemeral drainage channel. These impoundments are normally constructed without any outlet controls other than a spillway. Surface area size (acres) and capacity (acre-feet) are not considerations in the classification of an impoundment as a "stockpond," however, 93 percent of all stockponds in the San Pedro River watershed are less than two surface acres in size while 97 percent of the stockponds in the watershed are less than fifteen acre-feet in capacity.

Groundwater from a windmill well or stock well that is pumped into an off channel pond or metal tank for the purpose of watering stock or wildlife is not assigned a PWR, but is reported in the watershed file report if it is claimed.

Small Reservoir (SR)

A small reservoir is an impoundment which stores surface water or groundwater that has a maximum storage capacity equal to or less than fifteen acre-feet. The primary use of the water must be other than stockwatering or wildlife watering.

These impoundments are generally multi-purpose in nature. An example of an impoundment within this classification would be an off channel reservoir supplied by an irrigation district canal. Typical water uses for such a reservoir may include irrigation storage, stockwatering, and recreation/fish and wildlife uses.

TABLE 8-7

IMPOUNDMENT CLASSIFICATIONS

IMPOUNDMENT CLASSIFICATION	CONSIDERED A POTENTIAL WATER RIGHT	METHODS OF VERIFICATION	FIELD SURVEY REQUIRED TO MEASURE CAPACITY	MAPPED
Stockpond	Yes	Aerial photography, field investigation	Yes, only if surface area is greater than or equal to two acres	Yes
Small Reservoir	Yes	Aerial photography, field investigation	Yes, only if surface area is greater than or equal to two acres	Yes
Primary Storage Reservoir	Yes	Aerial photography, field investigation	Yes, only if surface area is greater than or equal to two acres	Yes
Stockpond served by a stockwell	No	Not verified	No	No
Tailwater	No	Aerial photography, field investigation	No	Yes
Regulatory	No	Aerial photography, field investigation	No	Yes

Impoundments that serve as an integral part of an irrigation PWR delivery system are termed "regulatory reservoirs." These reservoirs are normally used as a temporary holding system for pumped water. The water held in these temporary impoundments is released at a set rate to irrigate a crop. Regulatory reservoirs are singular in purpose and result in little consumptive water use other than normal irrigation delivery system seepage or evaporation losses. For this reason, regulatory reservoirs are not assigned a PWR, but are considered a part of the conveyance system for an irrigation (IR, OT, or RC) PWR.

Tailwater ponds collect excess water at the downslope end of irrigated fields. These impoundments are not assigned a PWR because the water collected is actually a portion of the water use assigned to the irrigation PWR.

Impoundments that have been constructed on a drainage for flood or erosion control purposes usually have an open outlet pipe at the base of the dam to release floodwater flows at a controlled rate. These impoundments have no permanent water storage capability and are not assigned a PWR. If the impoundment has an outlet gate or valve that can be closed to store water or if the open outlet pipe is above the bottom of the dam with some amount of dead storage below the pipe, then a PWR will be created for the impoundment based on its storage purpose and permanent storage capacity.

Primary Storage Reservoir (PS)

A primary storage reservoir is an impoundment which stores surface water or groundwater that has a maximum storage capacity greater than fifteen acre-feet. The primary use of the water must be other than stockwatering or wildlife watering.

The only criteria that separates this PWR classification from the small reservoir (SR) classification is storage capacity.

STOCKWATERING/WILDLIFE (SW AND WL)

These types of water uses are utilized primarily for watering livestock (SW) or wildlife (WL). The source may be a spring, cienega, seep, natural lake, natural depression, sink, bog, or flowing stream. If stockwatering and

wildlife water uses are both claimed, a stockwatering (SW) PWR is created due to the larger consumptive use associated with livestockwatering.

Stockwatering or wildlife water use from seeps or springs is generally not verified during field investigations (only if the spring is a diversion point for some other use, such as an irrigated field), and springs are almost never verifiable from aerial photographs. To obtain a stockwatering (SW) or wildlife (WL) PWR on a spring, the land owner or lessee must have filed a statement of claimant (39) and a previous filing or decree (10, 20, 3R, 33, 36, 38, or 4A).

Stockwatering or wildlife water use from streams, rivers, natural lakes, or natural depressions is verified by identifying that the claimant owns or leases land at the site of the natural lake or depression or along the claimed water course. A statement of claimant or a previous filing must be filed by the land owner or lessee to obtain a stockwatering or wildlife PWR from this source.

The legal location for stockwatering or wildlife water use from creeks, streams, rivers, or ephemeral drainages is given a ¼ ¼ ¼ section-township-range designation where the water course enters the property or lease allotment boundary.

For stock or wildlife water use from seeps, springs, bogs, natural lakes, or natural depressions, the legal location is given a ¼ ¼ ¼ section-township-range designation at the location of the seeps, spring, bog, etc. Table 8-8 lists the criteria to establish stockwatering PWRs.

DIVERSIONS (DV)

A diversion (DV) PWR is reported for large surface water diversions serving many users or irrigating large acreages and for diversions which export water out of a watershed. The purpose of a DV PWR is for the quantification of the amount of water diverted and to assess the impacts on downstream users. For example, DV PWRs are reported for the St. David Irrigation District, the Pomerene Water Users Association, and ASARCO's well fields which export water to ASARCO's Hayden and Ray Units located in the Upper Gila River watershed. A single divertor on an isolated tributary may or may not have a DV reported for the diversion.

TABLE 8-8

CRITERIA TO ESTABLISH STOCKWATERING PWRS

TYPE OF FACILITY	CRITERIA FOR VERIFICATION OF A POTENTIAL WATER RIGHT	WATER USE TYPE CLASSIFICATION	MAPPED
Springs	A matched set of filings consisting of an adjudication claim along with a previous filing/decree. (2)	SW (1)	Yes
Instream use	Aerial photography along with an adjudication claim or previous filing/ decree filed by the current owner or lessee of land having proven access to the stream in question. (3)	SW	No
Stockponds less than two surface acres	Aerial photography.	SP	Yes
Stockponds greater than or equal to two surface acres	Aerial photography and on site inspection.	SP	Yes
Stockwells	Generally not field verified. Groundwater supplied reservoirs associated with an irrigation use may be mapped, though no potential water right is assigned.	None (4)	No

(1) A WL use type may be substituted for SW if the use is found to serve only wildlife.
(2) Springs that also serve as a point of diversion for irrigation uses are inspected on site.
(3) Filings by a previous owner or lessee may be used if the transfer of ownership or lease status can be readily documented.
(4) No PWRs are created for stockwatering uses supplied by wells.

INCIDENTAL WATER USES

An incidental water use is a type of secondary use associated with a more primary water use PWR.

Example 8-5 Seventy (70) acres of irrigated pasture land for cattle grazing is supplied by a well. An irrigation (IR) PWR is created. The well also supplies several watering troughs for the cattle. The use of water for stockwatering is incidental to the use of water for irrigation from the same source.

Example 8-6 A stockpond is located on a small wash. The land owner claims stockwatering and wildlife water use from the pond. A stockpond (SP) PWR is created. The stockpond's primary use is to water the owner's livestock. Any use of the water by wildlife is considered incidental to the stockwatering use.

REPORTING NON-INDIAN FEDERAL LAW CLAIMS

This section addresses non-Indian federal reserved rights (FRR) claims. The legal basis of an FRR is markedly different from the basis of a water right under state law. As a result, the process used to investigate and report potential FRRs is different from "state rights" investigations. Furthermore, the unique nature of an FRR requires flexibility in the investigation procedures and in the reporting scheme.

The following outline details investigation criteria for an FRR.

1. All non-Indian FRR claims within the San Pedro River watershed are addressed in the San Pedro River watershed HSR.
2. All non-Indian claims which base a water right on a federal reserved right are included in a watershed file report.
3. All potential non-Indian FRRs are included in the HSR whether a claim has been filed or not.
4. Investigation criteria which apply to PWRs under state law are utilized when inventorying current water uses on a federal reservation, with the following exceptions:
   a. No investigation period is considered.
   b. All uses claimed on a statement of claimant are assigned a water use number unless DWR's evidence refutes the claim.
   c. Apparent dates of first use are not assigned to the water uses.
5. Information unique to a potential FRR such as the date of establishment of a federal reservation, the boundaries of a reservation, and claimed future water uses is reported.

8.4 INVESTIGATION PROCEDURES

This section describes the investigation procedures utilized by DWR to document water use claims or activities. The methods were established by DWR to provide an efficient yet accurate way of investigating the thousands of different water use situations that occur within the river system. Table 8-9 shows the method of investigation for each type of use.

IRRIGATION WATER USES

Irrigation water uses receive the most thorough and detailed investigation of all the water use categories reported in the HSR. The reasons for this are clear: irrigation water use accounts for the overwhelming majority of water consumption within the Gila River system and many of the irrigation activities within the Gila River system were established in the late 1800s and thus would appear to have senior water rights.

The primary investigative tool employed by DWR is the on site field inspection. During the course of the inspection the following items are located and mapped on current aerial photography: water sources and points of diversion, conveyance systems, irrigated areas and all associated reservoirs, and type of crops being grown. As part of this inspection, the current land owner is interviewed (if possible) concerning past and present irrigation activity. The above information is then transferred to the subregion water use maps depicted in Volume 9 of this HSR.

In order to establish apparent dates of first use for irrigation water uses, historical aerial photography is utilized to evaluate the past water use history of a particular irrigated parcel. The 1935 aerial photography is the earliest that can be obtained and utilized in the historical analysis. DWR strives to have, at a minimum, aerial photography covering each ten year period up to the present. The aerial photography is used to verify or refute the claimed first use date and to determine if there has been a period of continuous water use for the irrigated parcel.

As mentioned in Section 8.2, a historical analysis is undertaken of an area or region to determine the approximate dates of settlement and when water

TABLE 8-9

METHOD OF INVESTIGATION BY TYPE OF USE

TYPE OF USE	METHOD OF INVESTIGATION
I. Irrigation	On site inspection, aerial photography, claimant interviews, and historical analysis.
II. Domestic	Aerial photography. (1)
III. Stockwatering and Wildlife	
A. Springs	A matched set of filings consisting of an adjudication claim along with a previous filing/decree. (2)
B. Instream use	Aerial photography along with an adjudication claim or previous filing/decree filed by the current owner or lessee of land having proven access to the stream in question. (3)
C. Stockponds less than two surface acres	Aerial photography.
D. Stockponds equal to or greater than two surface acres	Aerial photography and on site inspection.
E. Stockwells	Generally not investigated. Reported only if claimed. Groundwater supplied reservoirs associated with an irrigation use may be mapped though no potential water right is assigned.
IV. Water Supply Organization (Municipal Use)	On site inspection, Arizona Corporation Commission maps, claimant interview and information. (4)
V. Mining and Industrial	Aerial photography, records, on site inspection, and claimant interview and information.
VI. Reservoirs	
A. Less than two acres	Aerial photography.
B. Equal or greater than two surface acres	Aerial photography and on site inspection.

(1) Occasionally a domestic use may be identified during the course of stockwatering or irrigation field investigations that was not visible on an aerial photograph.
(2) Springs that also serve as a point of diversion for irrigation, municipal, industrial, or mining uses are inspected on site.
(3) Filings by a previous owner or lessee may be used if the transfer of ownership or lease status can be readily documented.
(4) Self-supplied nonirrigation uses located within the service area of a municipal water provider are not investigated unless a statement of claimant or previous filing has been filed.

development began to occur. This information can be used to verify claim dates that are earlier than the available historical aerial photography.

DOMESTIC WATER USES

Current aerial photography is utilized to verify the existence of a domestic water use. During the course of an on site investigation, a domestic water use may be discovered that was not apparent or visible on an aerial photograph. Domestic water uses without any water rights claims or filings and which are located within a municipal water provider service area are not verified and are included in the municipal PWR.

STOCKWATERING AND WILDLIFE WATER USES

There are four types of stockwatering/wildlife facilities that require some form of investigation. These are:

1. Springs - Generally, springs are not field verified, unless they supply a water use which requires an on site inspection.

2. Instream Stockwatering Uses - These water uses are investigated and verified utilizing current aerial photography and USGS topographic maps to verify the existence of the watercourse. Statements of claimant and/or previous filings are also evaluated in the verification process. It should be noted that the land must have proven access to the watercourse under investigation in order for an instream stockwatering use to be given a PWR.

3. Stockponds - Stockponds less than two surface acres are verified using aerial photography. Stockponds greater than or equal to two surface acres are verified using aerial photography and on site inspection. The on site inspection consists of determining the location of the spillway and measuring the area and capacity of the pond at spillway elevation employing standard surveying techniques.

4. Stockwells - These are generally not field investigated and not given a PWR. They are reported only if claimed.

WATER SUPPLY ORGANIZATIONS

Water supply organizations are investigated through the use of on site inspections and claimant interviews. Arizona Corporation Commission maps and use figures are utilized to map the water service area for franchised water companies and to provide an estimate of yearly water usage. All points of diversion, impoundments, and water storage facilities are inspected. Points of diversion and impoundments are mapped. All water supply organizations have a report prepared which describes the history of the development of the organization, current facilities, and water use data.

INDUSTRIAL AND MINING WATER USES

Industrial and mining water uses are investigated in a manner similar to that required for water supply organizations. The facility is inspected on site and all points of diversion, impoundments, and places of use are mapped. A report is prepared describing the activity and its water use.

IMPOUNDMENTS

Impoundments include small reservoirs and primary storage reservoirs. The existence of an impoundment is verified using aerial photography. If the impoundment is two surface acres or larger, it is field investigated including measurement of its maximum controlled area and capacity.

8.5 HSR REPORTING FORMAT

HSR FORMAT

The HSR consists of the following volumes:

Volume 1: General Assessment
Volume 2: Comprehensive Indices
Volumes 3-6: Watershed File Reports
Volume 7: Zone 2 Well Reports (formerly Wells Subject to Federal Claims)
Volume 8: Catalogued Wells
Volume 9: Water Use Maps.

Each of these volumes is described below.

Volume 1: General Assessment

The purpose of the general assessment is to provide pertinent information about the watershed. The history of the adjudication proceeding is described as are the various types of water rights claims and decrees. An overview of the geography, geology, climate, vegetation, economy, and history of the area is presented. A major focus of the general assessment is an in-depth hydrologic analysis of water resources, water uses, and their interactions. The discussion of water resources concerns the quantity and quality of the water supply available from surface sources, groundwater sources, and trans-river system exports (e.g., ASARCO inter-basin transfer). Water uses are described in terms of natural uses such as phreatophytes (riparian plants) and cultural uses such as irrigation, municipal, industrial, mining, stockwatering, and reservoir evaporation. The quantities of water usage for the two categories are determined and depicted in both tabular and graphical forms. The hydrologic analysis consists of describing the interaction of surface water and groundwater systems and the effect of natural, cultural, and transmission losses and gains on these systems. Undepleted flow characteristics are estimated and a water budget for the watershed is developed.

The remaining portions of the general assessment provide additional information on major water users (municipal water providers, irrigation water providers, large industrial/mining users, and non-Indian federal law claims)

and unusual water rights or water using circumstances that occur within the watershed. DWR's water use investigation criteria, procedures, and reporting format are also explained. The final section of the general assessment is an explanation of the methodologies employed to estimate quantities of water use. Volume 1 also contains maps of the hydrologic determinations.

Volume 2: Comprehensive Indices

This volume contains nine different indices that provide an efficient way of locating specific watershed file reports for evaluation by the Court/Master and the parties to the adjudication proceedings. These indices are listed below:

Index #1 - Relates a land owner to a watershed file report.
Index #2 - Relates a watershed file report to a land owner.
Index #3 - Relates a statement of claimant to a watershed file report and land owner.
Index #4 - Relates the location of a potential water right to a land owner.
Index #5 - Relates the location of a point of diversion to a land owner.
Index #6 - Relates the water source to a PWR and land owner.
Index #7 - Relates the water source to a POD and land owner.
Index #8 - Relates the apparent date of first use to a PWR and land owner.
Index #9 - Relates a decree to a watershed file report and land owner.

Volumes 3 through 6: Watershed File Reports

DWR developed a computerized inventory and reporting system known as the Adjudication Investigation System (AIS) to report all the pertinent water use information associated with water uses investigated in a watershed. Data such as: notices of appropriation, old rights, claimed rights, water rights claims, certificated water rights, decreed water rights, quantities claimed, location of uses and/or diversions, apparent dates of first use, or estimated quantities of use can be retrieved and displayed in a tabular format. This tabular format is called the watershed file report and its basis is the watershed file. Every water use or claim investigated by DWR is on file in the AIS and reported in the HSR. There are two types of reports produced from the AIS: 1) a domestic watershed file report which contains only domestic

uses supplied by groundwater and for which no claims were filed; and 2) a watershed file report which contains all other watershed files created from the investigations.

A watershed file is created in the AIS for: 1) each water use discovered during the investigations that was of a type included within the scope of the investigations, and 2) each notice of appropriation (10), "3R," "33," "36," "38," "39," "4A," "0," and "C" on file with DWR and each decreed right (assigned a number with "20") known to exist by DWR and not matched to a water use during the investigation process. Using this approach, all water uses of the type investigated by DWR, all rights, and all claims are reported through the AIS.

For the first situation described above, water use is the basis for the creation of a watershed file in the AIS. All other information gathered during the course of the investigation such as land ownership, source of water, and filings become attributes of the watershed file rather than the basis for the creation of the file. All rights and claims of record that are not matched to a water use are accounted for in watershed files which are created to report their status.

The information that is included in the two types of watershed file reports is described below. Not all watershed files contain all of the information outlined. Some of the information may not be available or pertinent to a given watershed file.

Domestic Use Watershed File Report

(1) the land owner, lessee, or allottee of record for the land area included

(2) the watershed file report number

(3) the location of one domestic use

  (a) shown by county assessor's description

  (b) shown by legal description

An example domestic use watershed file report is shown as follows.

EXAMPLE DOMESTIC USE WATERSHED FILE REPORT

LAND OWNER	WATERSHED FILE REPORT NUMBER	CO	BK	MAP	PRCL	SUBDIV	SC	TWNP	RNGE
ADAMS, JOHN C.	111-20-AA-001	02	106	034	013C	NENENE	24	200S	200E
BAKER, A.	111-23-BBB-001	02	105	052	0022	NWNWNW	12	230S	200E
JONES, A.D.	111-24-CCC-001	02	102	010	0030	SWSWSW	34	230S	230E
SMITH, K.P.	111-20-DDDD-001	02	106	027	0021	SESESE	23	200S	200E
WASHINGTON, G.	111-24-AAA-001	02	110	057	0014	NENENE	35	220S	230E

Watershed File Report

(1) (a) all land owner(s) of record for the land area included

(b) the watershed file report number

(c) the lessee or allottee of record for the land included

(d) an identification of the lease or allotment by name or number

(2) applicable filings and decrees

(a) the filing number of the applicable filing (10, 20, 3R, 33, 36, 38, 39, 3A, 4A, "0," and "C")

(b) the filing status of all claims such as certificated, permitted, protested, amended, or questionnaire received

(c) the uses claimed in the applicable filing such as: irrigation use, domestic use, or municipal use

(d) the quantity claimed in acre-feet per year for the claimed use

(e) the location of the claimed use by legal description

(f) the claimed date of beneficial use

(g) the location of the claimed point of diversion by legal description

(3) Department of Water Resources' analysis of applicable filings and decrees

(a) the filing number of the applicable filing

(b) the uses claimed or referenced in the applicable filing

(c) the uses found by DWR through its investigations

(d) the point of diversion number(s) which applies to this filing

(e) the potential water right number(s) (PWRs) which applies to this filing

(4) diversions

(a) the type and number assigned to each diversion

(b) the location of the diversion(s) by legal description

(c) the water source name and its classification such as: "Surface Water: San Pedro River," "Groundwater: Zone 2," or Groundwater: Catalogued." If the diversion is shared or unused, these are also listed in this section

(5) uses

(a) the type and number of each water use PWR

(b) the location of the use(s) by legal description

(c) the diversions that supply water to the use(s)

(d) the type of water in use such as: "Surface Water," "Groundwater: Zone 1" or "Groundwater: Zone 2"

(e) the earliest aerial photography utilized to verify the existence of the use

(f) the identification of uses which have had a change in water source such as from surface water to groundwater

(g) the name of the facility if applicable

(6) reservoirs

(a) the type and number of each reservoir PWR

(b) the location of each reservoir by legal description

(c) the diversion(s) that supply water to each reservoir

(d) the type of water source in use

(e) the earliest aerial photography utilized to verify the existence of the reservoir if applicable

(f) the name of the reservoir

(g) the purpose of the reservoir storage such as irrigation, municipal, or recreation

(7) shared uses and diversions

(a) the applicable use or diversion that is shared and the associated watershed files

(8) PWR summary

(a) the type and number of each PWR

(b) the statements of claimant which apply to each PWR

(c) the previous water rights filings or decrees which apply to each PWR

(d) the apparent date of first use and the data sources utilized to determine the apparent date of first use such as: aerial photography, claimant interview, or water rights filing or claims

(e) the type of water sources and their classification associated with each PWR such as: "Surface Water: San Pedro River," "Groundwater: Zone 2," or "Groundwater: Catalogued"

(9) quantities of use

(a) the water use types and PWR number

(b) the quantification type

(c) the applicable acreage for irrigation PWRs and the applicable surface area for reservoir PWRs

(d) the type of crop (irrigation water uses only)

(e) the efficiency of the irrigation system (irrigation uses only)

(f) the water duty (irrigation uses only)

(g) the estimated volume or storage capacity

(h) the remarks section

(i) the diversion PWR number

(j) the diversion capacity

(k) the maximum demand rate

(l) the decreed diversion rate

(m) the certificated diversion rate

(o) the estimated volume diverted

(10) explanation section of the watershed file report

The Introduction Section to Volumes 3 through 6 provides an in-depth discussion of each of the data elements of the watershed file report outlined above. An example watershed file report is shown below.

EXAMPLE WATERSHED FILE REPORT

LAND OWNER	WATERSHED FILE REPORT NUMBER
SMITH, J.E.	111-23-ADD-006

APPLICABLE FILINGS AND DECREES

CLEARLY STATED INFORMATION FROM FILINGS AND DECREES

FILING NO.	FILING STATUS	USES	QUANTITY IN AFA	USE LOCATION SECTION	TWNP	RNGE	CLAIM DATE	DIVERSION LOCATION SECTION	TWNP	RNGE
33-0000509	PERMIT	DOMESTIC	3.00	NE30	230S	210E	1930			
33-0012345	CERTIF.	IRRIGATION	500.00	NE30	230S	210E	1950	SWSW31	230S	210E
36-1000000							<1919			
36-2000000		IRRIGATION	1,000.00	NE30	230S	210E	1930	SESE30	230S	210E
		DOMESTIC	3.00							
38-0000900		STOCK	5.00	30	230S	210E	1950	30	230S	210E
39-0000100		IRRIGATION	700.00	NE30	230S	210E	1936	SWSW31	230S	210E
		DOMESTIC								
		MINING								
39-0000101		IRRIGATION	500.00	NE30	230S	210E	1950	NESW30	230S	210E
		STOCK								
		WILDLIFE								
39-0000102		IRRIGATION	200.00	NE31	230S	210E	1936	NWSESE36	230S	210E
39-0000103	QUE.RECD	STOCK	10.00	32	230S	210E		SESE31	230S	210E
39-0000104		STOCK	5.00	30	230S	210E	1950	30	230S	210E
39-0000105		IRRIGATION	25.00	SESE31	230S	210E	<1940			

EXAMPLE WATERSHED FILE REPORT
(continued)

D W R A N A L Y S I S O F F I L I N G S A N D D E C R E E S

FILING NO.	USES CLAIMED OR REFERENCED	USES FOUND BY DWR	APPLIES TO DIVERSIONS	APPLIES TO PWR NUMBERS
33-0000509	DOMESTIC	DOMESTIC		DM001
33-0012345	IRRIGATION	IRRIGATION	D01	IR003,SR001,DV001
36-1000000				
36-2000000	IRRIGATION	IRRIGATION	D01,W01	DM001,IR001,IR002
	DOMESTIC	DOMESTIC		IR003,SR001,DV001
38-0000900	STOCK	STOCK		SP001
39-0000100	IRRIGATION	IRRIGATION	W01	DM001,IR001
	DOMESTIC	DOMESTIC		
	MINING	NONE		
39-0000101	IRRIGATION	IRRIGATION	D01	IR003,SR001,DV001
	STOCK	INCIDENTAL		
	WILDLIFE	INCIDENTAL		
39-0000102	IRRIGATION	IRRIGATION	S01,W02	IR002
39-0000103	STOCK	NONE		
39-0000104	STOCK	STOCK		SP001
39-0000105	IRRIGATION	DISCONTINUED		IR090

D I V E R S I O N S

DIV #	LOCATION SECTION	TWNP	RNGE	DIVERSION NAME	WATER SOURCE AND CLASSIFICATION
D01	SWSWSW31	230S	210E	MANY FARMS I.D. DITCH	SURFACE WATER: SAN PEDRO RIVER
					SHARED
S01	SENESW30	230S	210E	BUBBLE SPRING	SURFACE WATER: SAN PEDRO RIVER
W01	NESESE30	230S	210E	UNNAMED	GROUNDWATER: ZONE 1 OF THE SAN PEDRO RIVER
W02	NWSESE36	230S	210E	UNNAMED	GROUNDWATER: ZONE 2
W03	SESESE36	230S	210E	UNNAMED	GROUNDWATER: CATALOGUED
					UNUSED

U S E S

PWR #	LOCATION SECTION	TWNP	RNGE	SUPPLIED BY DIVERSIONS	WATER SOURCES	PHOTO DATE	SOURCE CHANGE	FACILITY NAME
DM001	NENENE30	230S	210E	W01	GROUNDWATER: ZONE 1		NO	
DM002	SESESE30	230S	210E		GROUNDWATER: CATALOGUED		NO	
DV001	SWSWSW31	230S	210E	D01	SURFACE WATER		NO	
IR001	SE30	230S	210E	W01	GROUNDWATER: ZONE 1	1935	NO	
IR002	NENE31	230S	210E	S01,W02	SURFACE WATER	1935	NO	
					GROUNDWATER: ZONE 2			
IR003	30	230S	210E	D01	SURFACE WATER	1950	YES	
IR090	SESE31	230S	210E	D01	SURFACE WATER	1955	NO	
OT001	SESE31	230S	210E	W01	GROUNDWATER: ZONE 1	1986	NO	

EXAMPLE WATERSHED FILE REPORT
(continued)

RESERVOIRS

PWR #	LOCATION SECTION	TWNP	RNGE	SUPPLIED BY DIVERSIONS	WATER SOURCES	PHOTO DATE	RESERVOIR NAME	STORAGE PURPOSE
SP001	NENENE30	23OS	21OE		SURFACE WATER		SMITH TANK	STOCKWATERING
SR001	SESESE31	23OS	21OE	D01,W02	SURFACE WATER GRNDWTR: ZONE 2	1935	SMITH POND	IRRIGATION RECREATION STOCKWATERING OTHER

SHARED USES AND DIVERSIONS

** DIVERSION D01 OPERATED BY THE MANY FARMS IRRIGATION DISTRICT (FILE 111-01-XXX-0) SUPPLIES WATER TO PWRS IN THIS FILE.

PWR SUMMARY

PWR #	APPLICABLE ADJ FILINGS	APPLICABLE PRE FILINGS	*APPARENT FIRST USE DATE* DATE	BASIS FOR DATE	WATER SOURCES AND CLASSIFICATIONS
DM001	39-0000100	33-0000509 36-2000000			GROUNDWATER: ZONE 1 OF THE SAN PEDRO RIVER
DM002	NONE	NONE			GROUNDWATER: CATALOGUED
DV001	39-0000101	33-0012345 36-2000000	1930	36-2000000	SURFACE WATER: SAN PEDRO RIVER
IR001	39-0000100 39-0000102	36-2000000	1930	36-2000000	GROUNDWATER: ZONE 1 OF THE SAN PEDRO RIVER
IR002	39-0000102	36-2000000	1930	36-2000000	SURFACE WATER: SAN PEDRO RIVER GROUNDWATER: ZONE 2
IR003	39-0000101	33-0012345 36-2000000	1950	33-0012345	SURFACE WATER: SAN PEDRO RIVER
IR090	39-0000101	33-0012345	1955	1955 AERIAL PHOTO	SURFACE WATER: SAN PEDRO RIVER
OT001	39-0000102	NONE	1986	1986 AERIAL PHOTO	GROUNDWATER: ZONE 1 OF THE SAN PEDRO RIVER
SP001	39-0000104	38-0000900	1945	38-0000900	SURFACE WATER: BABOCOMARI RIVER
SR001	39-0000101	33-0012345 36-2000000	1935	1935 AERIAL PHOTO	SURFACE WATER: SAN PEDRO RIVER GROUNDWATER: ZONE 2
NONE	39-0000103	36-1000000			

EXAMPLE WATERSHED FILE REPORT
(continued)

QUANTITIES OF USE

PWR #	QUANTIFICATION TYPE	ACRES	CROP TYPE	EFF	WATER DUTY	ESTIMATED VOLUME	REMARKS
DM001							SEE VOLUME 1 - GENERAL ASSESSMENT
DM002							SEE VOLUME 1 - GENERAL ASSESSMENT
IR001	MAX. OBSERVED	130.0	ALFALFA	35%	4.6 AF/AC	598.0 AFA	
	REGIONAL	135.0	AVE. CROP		4.0 AF/AC	540.0 AFA	
	MAX. POTENTIAL	135.0	ALFALFA	35%	4.6 AF/AC	621.0 AFA	
IR002	MAX. OBSERVED	32.1	ALFALFA	35%	3.0 AF/AC	96.3 AFA	DEFICIT IRRIGATION
	REGIONAL	32.1	AVE. CROP		4.0 AF/AC	128.4 AFA	
	MAX. POTENTIAL	32.1	ALFALFA	35%	4.6 AF/AC	147.7 AFA	
IR003	CERTIFICATE	180.0	PERM. PSTR.		6.0 AF/AC	1080.0 AFA	
	MAX. OBSERVED	170.2	PERM. PSTR.	30%	4.9 AF/AC	834.0 AFA	
	REGIONAL	175.0	AVE. CROP		4.0 AF/AC	700.0 AFA	
	MAX. POTENTIAL	175.0	PERM. PSTR.	30%	4.9 AF/AC	857.5 AFA	
IR090	REGIONAL	6.0	AVE. CROP				DISCONTINUED IRRG.
OT001	REGIONAL	1.9	AVE. CROP		4.0 AF/AC	7.6 AFA	
SP001	MAX. AREA/CAP	1.5			3.5 AF		
SR001	MAX. AREA/CAP	6.0			18.0 AF		

DIVERSION PWR NOS.	DIVERSION CAPACITY	MAXIMUM DEMAND RATE	DECREED RATE	CERTIFICATED RATE	ESTIMATED VOLUME DIVERTED
DV001	40.0 CFS	35.0 CFS		45.0 CFS	10,000.0 AFA

EXPLANATION

FILINGS AND DECREES

FILING 39-103 - CLAIMS STOCKWATERING USE FROM JONES TANK. NO STOCKPOND WAS FOUND AT THE CLAIMED LOCATION. A UNIFORM QUESTIONNAIRE WAS RECEIVED WHICH PROVIDED NO ADDITIONAL INFORMATION.

FILING 36-1000000 - NO WATER USES OR LOCATIONS WERE CLAIMED. NO WATER USES WERE MATCHED TO THIS FILING.

DIVERSIONS

D1 - DIVERSION FROM THE SAN PEDRO RIVER INTO THE MANY FARMS IRRIGATION DISTRICT DITCH.
W1 - WELL PROVIDES WATER FOR IRRIGATION AND DOMESTIC WATER USES.
W2 - WELL PROVIDES WATER FOR IRRIGATION USES.
W3 - UNUSED WELL.

EXAMPLE WATERSHED FILE REPORT
(continued)

USES AND RESERVOIRS

DM1 - DOMESTIC USE.

DV1 - DIVERSION FROM THE SAN PEDRO RIVER INTO THE MANY FARMS IRRIGATION DISTRICT DITCH.

IR1 AND IR2 - IRRIGATED ALFALFA.

IR3 - IRRIGATED PASTURE.

IR90 - DISCONTINUED IRRIGATION: D.W.R. HAS DETERMINED THAT NO IRRIGATION HAS OCCURRED ON THIS PROPERTY IN THE LAST FIVE YEARS, BUT THERE HAS BEEN IRRIGATION WITHIN THE PAST TEN YEARS BASED UPON A REVIEW OF HISTORICAL AERIAL PHOTOGRAPHY AND FIELD INVESTIGATIONS.

OT1 - IRRIGATION TOTALING LESS THAN TWO ACRES ASSOCIATED WITH A DOMESTIC USE.

SP1 - SMITH TANK STOCKPOND.

SR1 - SMALL RESERVOIR, SUPPLIED BY DIVERSION D1 AND WELL W2, IS USED FOR IRRIGATION, RECREATION, STOCKWATERING, AND WILDLIFE PURPOSES.

Volume 7: Zone 2 Well Reports (formerly Wells Subject to Federal Claims)

This volume contains a listing of those wells pumping groundwater that DWR has determined may be subject to claims made by federal reservations within the Gila River system. The claims are based on federal reserved rights previously described in Chapter 1. These wells have the potential to diminish the surface water and groundwater supplies at, on, or near federal reservations that could be used to satisfy their reserved rights claims. The information contained in the reports for these wells is as follows:

(1) ownership information

  (a) the land owner of record

  (b) the report number

(2) Zone 2 groundwater wells information

  (a) the well number

  (b) the well name if applicable

  (c) the well location by legal description

(d) the water uses served by the well

(e) the remarks section

(3) water use information

(a) the water uses and numbers supplied by the well

(b) the water use location by legal description

(c) apparent dates of first use and data source

(d) the apparent annual volume used

(e) the acres irrigated (for irrigation uses only)

(4) the statements of claimant that apply to the well(s) and/or water use(s)

(5) the explanation section

The Introduction Section to Volume 7 provides an in-depth discussion of each of the data elements of the report outlined above. An example of a Zone 2 Well report is shown below.

EXAMPLE ZONE 2 WELL REPORT

LAND OWNER	ZONE 2 WELL REPORT NUMBER
SMITH, J.E.	111-23-ADD-006

		WELL LOCATION				
WELLS	WELL NAMES	SECTION	TWNP	RNGE	WATER USES SERVED	REMARKS
W02	UNNAMED	NWSESE31	230S	210E	IR002,SR001	

	WATER USE LOCATION			**APPARENT FIRST USE**		APPAR. ANNUAL	ACRES
WATER USE NUMBERS	SECTION	TWNP	RNGE	DATE	BASIS FOR DATE	VOLUME USED	IRRIGATED
IR002	NENE31	230S	210E	1930	FILING 36-2000000	128.4 AFA	32.1
SR001	SESESE31	230S	210E	1935	1935 AERIAL PHOTO	18.0 AFA	1.9

APPLICABLE STATEMENTS OF CLAIMANT	APPLIES TO: WELLS	APPLIES TO: WATER USES
39-0000101		SR001
39-0000102	W02	IR002

EXAMPLE ZONE 2 WELL REPORT
(continued)

EXPLANATION

THE APPARENT ANNUAL VOLUME FOR IR002 IS PARTIALLY SUPPLIED BY SURFACE WATER.
THE APPARENT ANNUAL VOLUME FOR SR001 IS PARTIALLY SUPPLIED BY SURFACE WATER.
W2 - WELL PROVIDES WATER FOR IRRIGATION USES.
IR2 - IRRIGATED ALFALFA.
SR1 - SMALL RESERVOIR IS USED FOR IRRIGATION, RECREATION, STOCKWATERING, AND WILDLIFE PURPOSES.

Volume 8: Catalogued Wells

This volume contains a catalogue of those wells which may not be subject to the adjudication or to federal claims as determined by DWR. This determination is based on the well location and the estimated quantity of water use. The wells listed in this report are located outside Zone 1 and serve primarily domestic or stock wells or irrigation uses of less than two acres in size. The information contained in this report is outlined below.

(1) the catalogued well number

(2) the well owner's name

(3) the well location by legal descriptions

(4) the claimed date of first beneficial use

(5) the claimed quantity

(6) the data source for the well information such as: a watershed file report, state well registration, or a statement of claimant

The Introduction Section to Volume 8 provides an in-depth discussion of each of the data elements of the Catalogued Wells listing outlined above. An example of the Catalogued Wells is shown on the next page.

EXAMPLE CATALOGUED WELLS

CATALOGUED WELL NUMBER	WELL OWNERS NAME	WELL LOCATION SECTION	TWNP	RNGE	CLAIMED DATE	QUANTITY	DATA SOURCE	TYPE
1	ADAMS, B.B.	SESESE36	230S	210E	1962	9.00 GPM	55-1000000	DOMESTIC WELL
2	BAKER, C.C.	NENENE01	230S	210E	1983		55-2000000	DOM/STK WELL
3	CHARLES, D.D.	NWNWNW01	230S	210E	1956		55-3000000	STOCK WELL
4	JOHNSON, E.E.	SWSWSW36	230S	210E	1970	1.00 AFA	111-23-AAA-100	AI FILING 39-0000106
5	SMITH, J.E.	SESESE36	230S	210E			111-23-ADD-006	AI DIVERSION W03
6	SMITH, J.E.	SESESE30	230S	210E			111-23-ADD-006	AI PLACE OF USE DM002

Volume 9: Water Use Maps

This volume contains region and subregion maps that depict water uses reported in the watershed file reports in Volumes 3 through 7 with the exception of domestic and other small uses which are not mapped. The scale of these maps varies from one inch equals 5,280 feet for region maps to as great as one inch equals 330 feet for subregion maps. The information included on these maps is discussed in Volume 9. A map index is also provided.

REFERENCES AND BIBLIOGRAPHY

Aldridge, B. N. and Hales, T.A., 1984, Flood of November 1978 to March 1979, in Arizona and West-Central New Mexico: U.S. Geological Survey Water Resource Supply Paper 2241.

Allen, R.G., Brockway, M., and Wright, J.L., 1983, Weather Station Siting and Consumptive Use Estimates: Journal of Water Resource Planning and Management, Proceedings of ASCE, v. 109, No. 2, April 1983, Paper No. 17915, p. 134-146.

Allen, R.G., and Pruitt, W.O., 1986, Rational Use of the FAO Blaney Criddle Formula: Journal of Irrigation and Drainage Engineering, Proceedings of ASCE, v. 112, No. 2, May 1986, Paper No. 20580, p. 139-155.

_____, 1988, Closure to Rational Use of the FAO Blaney-Criddle Formula: Journal of the Irrigation and Drainage Division, Proceedings of ASCE, v. 114, No. 2, p. 375-380.

American Water Resources Association, 1988, Adjudication of Water Rights: Gila River Watershed: Arizona Section, Tucson, 180 p.

Anderson, T.A. and White, N., 1979, Statistical Summaries of Arizona Streamflow Data: U.S. Geological Survey Water Resources Investigation 75-5.

Anderson, T.W. and Johnson, A.I., 1985, Regional Aquifer Systems of the United States: Southwest Alluvial Basins of Arizona: AWRA Monograph Series No. 7, 116 p.

Arizona Agricultural Statistics Service, 1966, Arizona Agricultural Statistics, 1867-1965: Arizona Crop and Livestock Reporting Service, Phoenix, Arizona, February 1966.

_____, 1988, 1987 Arizona Agricultural Statistics: USDA National Agricultural Statistics Service, and the University of Arizona, Bulletin S-23, July 1988.

Arizona Bureau of Mines, 1959, Geologic Map of Cochise County, Arizona: University of Arizona, Tucson, map scale 1:375,000.

Arizona Corporation Commission, 1988, Annual Utilities Report.

Arizona Crop and Livestock Reporting Service, 1974, Cropland Atlas of Arizona.

Arizona Department of Commerce, 1989, Community Profiles.

Arizona Department of Economic Security, 1986, Arizona Population Projections: 1985-2035.

_____, 1989, Arizona Population Statistics for 1989.

_____, 1990, Arizona Population Statistics for 1990.

Arizona Department of Water Resources, 1982, Groundwater Basin and Sub-basin Designations: Pursuant to A.R.S. § 45-404.

_____, 1984a, Channel Loss Study file data: Unpublished data.

_____, 1984b, Maps showing Groundwater Conditions in the Upper Santa Cruz Basin Area, Pima, Santa Cruz, Pinal and Cochise Counties, Arizona.

_____, 1987, Preliminary Hydrographic Survey Report for the San Pedro River watershed: January 1987, Phoenix, 6 vols.

_____, 1989, Preliminary Hydrographic Survey Report for the Silver Creek Watershed, Volume 1: General Assessment: Phoenix, 378 p.

_____, 1990a, Groundwater Site Inventory: Unpublished data.

_____, 1990b, Hydrographic Survey Report for the Silver Creek Watershed, Volume 1: General Assessment: Phoenix, 351 p.

_____, 1990c, Linear Regression Analysis for Selected Gages on the San Pedro River: Unpublished.

_____, 1990d, Preliminary Hydrographic Survey Report for the San Pedro Watershed: Phoenix, 548 p.

_____, 1990e, San Pedro River Brightline Analysis file data: p. 74.

_____, 1990f, San Pedro River Flow Net Analysis file data: Unpublished data.

_____, 1991, Draft, A Guide To Filing Applications For Instream Flow Water Rights in Arizona: Phoenix, Arizona, August 1991.

The Arizona Graphic, 1900, v. 1, No. 23, Saturday, February 7, 1900.

ASL Fort Huachuca Meterologic Team, 1990, Climatology of Ft. Huachuca: Letter to the Department of Water Resources, May 14, 1990.

Basso, K.H., 1983, Western Apache: Handbook of North American Indians, Smithsonian Institute, v. 10, Washington, D.C., p. 462-488.

Bill Stephens and Associates, P.C., 1987, Groundwater/Surface Water Interaction, A Historical Appraisal: Unpublished report, 21 p.

Blaney, H.F. and Criddle, W.D., 1950, Determining Water Requirements in Irrigated Areas from Climatological and Irrigation Data: U.S. Department of Agriculture, Soil Conservation Service, Technical Publication 96, 48 p.

Blaney, H.F., 1951, Consumptive Use of Water: Proceedings of ASCE, v. 77, No. 91.

Blaney, H.F., and Harris, K., 1951, Consumptive Use and Irrigation Requirements of Crops in Arizona: U.S Department of Agriculture, Soil Conservation Service, December 1951, Provisional.

Blaney, H.F., 1952, Determining Evapotranspiration by Phreatophytes from Climatological Data: Transactions, American Geophysical Union, v. 33, No. 1.

Bourne, E., 1967, Woman in Levis: University of Arizona Press, Tucson.

Bowden, C., 1977, Killing the Hidden Waters: University of Texas, Austin.

Bradey, W., Patton, D.R., and Paxson, J., 1985, The Development of Southwestern Riparian Gallery Forests: Riparian Ecosystems and Their Management: Reconciling Conflicting Uses, Johnson, R.R., Ziebell, D.R., Patton, P.F., and Harme, R.H., eds., First North American Riparian Conference, U.S. Department of Agriculture, Forest Service, Gen. Tech. Rept. RM-120. 523 p., April, 1986, Tucson, Arizona.

Brazel, A.J., Quinn, J.A., McQueen, J.D., Catalano, J.A., and Chico, T., 1981, Final Report, Arizona Climate Inventory, Volume 1: U.S. Department of the Interior, Bureau of Land Management, Phoenix, Arizona, December, 1981.

Brown and Caldwell, P.C., 1984, Residential Water Conservation Projects, Summary Report: U.S. Department of Housing and Urban Development, Office of Policy Development and Research, Building Technology Division, Walhut Creek, California, June 1984.

Brown, D.E. and Lowe, C.H., 1980, Biotic Communities of the Southwest: U.S. Department of Agriculture, Forest Service General Technical Report RM-78, 1 p., Rocky Mountain Forest and Range Experiment Station, Ft. Collins, Colorado.

Brown, D.E., Carmony, N.B., and Turner, R.M., 1981, Drainage Map of Arizona Showing Perennial Streams and Some Important Wetlands. Arizona Game and Fish Department Map 1, scale 1:1,000,000.

Brown, D.E., ed., 1982, Biotic Communities of the American Southwest, United States and Mexico: Desert Plants, University of Arizona at Boyce Thompson Southwestern Arboretum, v. 4, p. 4-431.

Brown, S.G., Davidson, E.S., Kister, L.R., and Thomsen, B.W., 1966, Water Resources of Fort Huachuca Military Reservation, Southeastern Arizona: U.S. Geological Survey Water Supply Paper 1819-D.

Bryan, K., Smith, G.E., and Waring, G.A., 1934, Groundwater Supplies and Irrigation in the San Pedro Valley, Arizona: U.S. Geological Survey Open File Report.

Burns, W.N., 1927, Tombstone: An Illiad of the Southwest: Doubleday, Page, and Co., Garden City, New Jersey.

Camp, P.D., 1982, Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona: U.S. Department of Agriculture, Soil Conservation Service, 158 p.

City of Sierra Vista, 1983, Summary of Design Criteria and Parameters: Sierra Vista Wastewater Management Facility, Sierra Vista, Arizona.

Comeaux, M.L., 1981, Arizona: A Geography: Westview Press, Boulder, Colorado.

Cook, K.J., 1980, Water Service Organizations of Arizona: University of Arizona Press, Tucson.

Cooke, R.U. and Reeves, R.W., 1976, Arroyo and Environmental Change in the American Southwest: Oxford University Press, London.

Cooper, J.D., 1959, Geologic Map of Cochise County, Arizona: Arizona Bureau of Mines map, scale 1:375,000.

Culler, R.C., Hanson, R.L., Myrick, R.M., Turner, R.M., and Kipple, F.P., 1982, Evapotranspiration Before and After Clearing Phreatophytes, Gila River Flood Plain, Graham County, Arizona: U.S. Geological Survey, Professional Paper 655-P.

Cummins, F. ed., 1985, Where the Waters Meet: A 13,000 Year Adventure Along the Aravaipa: Arizona Lithographers, Tucson.

Dames and Moore, P.C., 1987, Surface Water and Groundwater Relationships in Arid Alluvial Basins with Deep Water Tables: Unpublished report for Ellis, Baker, Clark and Porter, P.C., Phoenix, 7 p.

Dastane, N.G., 1974, Effective Rainfall in Irrigated Agriculture: Food and Agriculture Organization of the United Nations, Irrigation and Drainage Paper No. 25, Rome, 62 p.

Davis, S.N. and DeSiest, R.J., 1966, Hydrogeology: John Wiley and Sons, Inc., New York.

DeCook, K.J., Kreamer, D.K., Keith, S., Mack, S.F., and Hutton, J.P., 1977, Surface Water Quality Monitoring, San Pedro River Basin, Arizona: Water Resources Research Center, University of Arizona, Tucson.

DiPeso, C.C., 1951, The Babocomari Village Site on the Babocomari River, Southeastern Arizona: The Amerind Foundation Inc., Dragoon, Arizona, No. 5.

Doorenbos, J., and Pruitt, W.O., 1977, Guidelines for Predicting Crop Water Requirements: Food and Agriculture Organization of the United Nations, Irrigation and Drainage Paper No. 24, Revised.

Doorenbos, J., and Kassam, A.H., 1979, Yield Response to Water: Food and Agriculture Organization of the United Nations, Irrigation and Drainage Paper No. 33, Rome, 193 p.

Doorenbos, J., Kassam, A.H., Bentvelsen, C., and Uittenbogaard, G., 1979, Yield Response to Water: Irrigation and Agricultural Development, Johl, S.S., ed., United Nations, Pergamon Press, Oxford.

Drewes, H., 1980, Tectonic Map of Southeastern Arizona: U.S. Geological Survey Miscellaneous Investigation Series Map I-1109.

Eberhardt, S.E., 1981, San Pedro River Basin Water Quality Status Report for Period 1973-1979: Arizona Department of Health Services.

Erie, L.J., French, O.F., and Harris, K., 1965, Consumptive Use of Crops in Arizona: University of Arizona Experiment Station Technical Bulletin No. 169.

Erie, L.J., French, O.F., Bucks, D.A., and Harris, K., 1981, Consumptive Use of Water by Major Crops in the Southwestern United States: U.S. Department of Agriculture, Conservation Research Report No. 29, 42 p.

Ellingson, C.T., 1980, Hydrology of Aravaipa Creek, Southern Arizona: Masters Thesis, University of Arizona, Tucson, Arizona.

Elliot, J.G., 1979, Evolution of Large Arroyos - the Rio Puerco of New Mexico: Unpublished Masters Thesis, Colorado State University, Fort Collins, Colorado, 106 p.

Farnsworth, R.K., Thompson, E.S., and Peck, E.L., 1982, Evaporation Atlas for the Contiguous 48 United States, NOAA Technical Report NWS 33: National Weather Service, Office of Hydrology, Washington, D.C., June 1982.

Ferg, A., 1977, The Poor Canyon Scatter: A Cochise Site near Redington, Arizona: Arizona State Museum, Tucson.

_____, ed., 1987, Western Apache Material Culture: The Goodwin and Guenther Collections, University of Arizona Press, Tucson.

Foerman, B.R., 1982, Planting Vegetables, Fruits and Nuts in Southern Arizona Gardens: University of Arizona, Cooperative Extension Service, Fact Sheet MC4, Revised.

Forrest, E. R., 1929, Missions and Pueblos of the Old Southwest: Interstate Printers and Publishers, Danville; reprint, 1965, Rio Grande Press, Inc., Chicago.

Fort Huachuca Historical Museum, 1987, Document Collection 1865-1987: Fort Huachuca, Arizona.

_____, 1974, Old Fort Huachuca, Arizona.

Freethey, G.W., 1982, Hydrologic Analysis of the Upper San Pedro Basin from the Mexico-U.S. Boundary to Fairbank, Arizona: U.S. Geological Survey Open File Report 82-752.

Freethey, G.W. and Anderson, T.W., 1986, Predevelopment Hydrological Conditions in the Alluvial Basins of Arizona and Adjacent Parts of California and New Mexico: U.S. Geological Survey Hydrologic Investigations Atlas HA-664.

Freethey, G. W., Pool, D.R., Anderson, T.W., and Tucci, P., 1986, Description and Generalized Distribution of Aquifer Materials in the Alluvial Basins of Arizona and Adjacent Parts of California and New Mexico: U.S. Geological Survey Hydrologic Investigations Atlas, HA-663.

Gatewood, J.S., Robinson, T.W., Colby, B.R., Hem, J.D., and Halpenny, L.C., 1950, Use of Water by Bottom-land Vegetation in the Lower Safford Valley, Arizona: U.S. Geological Survey Water Supply Paper 1103.

Geraghty and Miller, Inc., 1987, Groundwater/Surface Water Relationships: Unpublished report.

Goldman, F.E., 1987, The Relationship of Groundwater to Surface Water: Unpublished report.

Gumerman, G.J. and Haury, E.W., 1979, Prehistory: Hohokam: Handbook of North American Indians: v. 9, Smithsonian Institute, Washington D.C., p. 75-90.

Guyton, W.F., 1987, The Effect of Groundwater Pumping on Surface Water: Unpublished report.

Hagan, R.M., and Stewart, J.I., 1972, Water Deficits - Irrigation Design and Programming: Journal of the Irrigation and Drainage Division: Proceedings of the ASCE, June 1972, 98(IR2), p. 215-233.

Halpenny, L.C., 1987, Groundwater and Surface Water Interconnection in Arizona: Unpublished report.

Hanks, R.J., and Ashcroft, G.L., 1980, Applied Soil Physics: Advanced Series in Agricultural Sciences: Springer-Verlag, Berlin, No. 8, 159 p., 55 figures.

Hanks, R.J., Gardner, H.R., and Fairbourn, M.L., 1967, Evaporation of Water From Soils as Influenced by Drying With Wind or Radiation: Soil Science Society of America Proceedings v. 31, No. 5, September-October 1967, p. 593-598.

Hanks, R.J., and Hill, R.W., 1980, Modeling Crop Responses to Irrigation In Relation to Soils, Climate and Salinity: Department of Soil Science and Biometeorology, College of Agriculture, Utah State University, Logan, Utah, Pergamon Press Inc., Elmsford, New York, 66 p.

Hargis and Associates, Inc. P.C., 1990a, Draft Study Area Survey, Apache Powder Co., Benson, Arizona: February 19, 1990.

_____, 1990b, Draft Hydrogeologic Investigation Report, Apache Nitrogen Products, Benson, Arizona: v. 1, October 31, 1990.

_____, 1991a, Draft Addendum to the Hydrogeologic Investigation Report, Apache Nitrogen Products, Benson, Arizona: 11 p. January 11, 1991.

_____, 1991b, Results of Quarterly Monitoring Program, October 1991, Apache Nitrogen Products, Benson, Arizona: 17 p., January 18, 1991.

_____, 1991c, Supplemental Hydrogeologic Investigations, Apache Nitrogen Products, Inc., Benson, Arizona: 20 p., February 19, 1991.

Hargreaves, G.H., and Samani, Z.A., 1984, Economic Considerations of Deficit Irrigation: Journal of the Irrigation and Drainage Division, Proceedings of the ASCE, December 1984, v. 110, p. 343-58.

Harshbarger and Associates, P.C., 1974, Report on Water Development in the Ft. Huachuca Area, Arizona: Report on Water Supply, Fort Huachuca and Vicinity, Arizona, U.S. Army Corps of Engineers.

Hastings, J.R. and Turner, R.M., 1965, The Changing Mile: An Ecological Study of Vegetation Change with Time in the Lower Mile of an Arid and Semi-Arid Region: University of Arizona Press, Tucson.

Heermann, D.F., and Shull, H.H., 1976, Effective Precipitation of Various Application Depths: Transactions of the ASAE, 19(4), p. 708-712.

Hein, J., 1983, Early Sierra Vista: Its People and Neighbors: Banner Printing Center, Sierra Vista, Arizona.

Heindl, L.A., 1952, Upper San Pedro Basin, Cochise County and Lower San Pedro Basin: Groundwater in the Gila River Basin and Adjacent Areas - A Summary, Halpenny, L.C., ed., U.S. Geological Survey Open File Report 29.

Hendrickson, D.A. and Minkley, D.A., 1984, Cienegas: Vanishing Climax Communities of the American Southwest: Desert Plants, University of Arizona at Boyce Thompson Southwestern Arboretum, v. 6, No. 3, p. 131-175.

Hill, R.W., Johns, E.L., and Frevert, D.K., 1983, Comparison of Equations Used for Estimating Agricultural Crop Evapotranspiration with Field Research: U.S. Department of Interior, Bureau of Reclamation, p. A-1 - A-4.

Hinton, T.B., 1983, Southern Periphery: West: Handbook of North American Indians: v. 10, Smithsonian Institute, Washington D.C., p. 315-328.

Horton, J.S., Robinson, T.W., and McDonald, H.R., 1964, Guide for Surveying Phreatophyte Vegetation: U.S. Department of Agriculture Handbook No. 266.

Howell, T., 1991, Agricultural Research Service, Texas Water Conservation Lab, Personal Interview: April 4, 1991.

International Boundary and Water Commission, 1979, Preliminary Report, Consideration of Need for Diversion of Water Resources of San Pedro River Basin, Arizona, between the United States and Mexico: 63 p.

_____, 1981, Western Boundary Water Bulletin: p. 93.

_____, 1989, Flow of the Colorado River and other Western Boundary Streams and Related Data: Western Water Bulletin 1981 to 1989.

_____, 1990, Cananea Mining Co.: Unpublished well data.

Israelsen, O.W. and Hansen, V.E., 1962, Irrigation Principles and Practices: John Wiley and Sons, Inc., New York.

Jackson, W., Martinez, T., Cuplin, P., Minkley, W., Shelby, B., Summers, P., McGlothlin, D., and VanHaveren, B., 1987, Assessment of Water Conditions and Management Opportunities in Support of Riparian Values: BLM San Pedro River Properties, Arizona Project Completion Report: U.S. Department of Interior, Bureau of Land Management, Denver, 181 p.

Jenkins, C.T., 1968, Techniques for Computing Rate and Volume of Stream Depletion by Wells: U.S. Geological Survey Open File Report.

_____, 1970, Computation of Rate and Volume of Stream Depletion by Wells: Techniques of Water Resource Investigations, U.S. Geological Survey, Book 4, Chapter D1.

Jensen, M.E., Burman, R.D., and Allen, R.G., eds., 1990, Evapotranspiration and Irrigation Water Requirements: ASCE Manuals and Reports on Engineering Practice No. 70, American Society of Civil Engineers, New York.

Jones, E.D., 1977, Calculation of Evapotranspiration Using Color-Infrared Photography: U.S. Geological Survey Professional Paper No. 655-O.

Jones, S.C., 1980, Maps showing Groundwater Conditions in the Lower San Pedro Basin Area, Pinal, Cochise, Pima, and Graham Counties, Arizona: U.S. Geological Survey Open File Report 80-954.

Kiyose, Y., 1984, The Behavior of Small Water Impoundments in Southern Arizona: Unpublished Masters Thesis, School of Renewable Natural Resources, The University of Arizona, Tucson.

Koniescki, A.D., 1980, Maps showing Groundwater Conditions in the Upper San Pedro Basin Area, Pima, Santa Cruz, and Cochise Counties, Arizona: U.S. Geological Survey Open File Report 80-1192.

Kraeger-Rovey, C., 1987, Preliminary Report: Hydrologic Investigation of the San Pedro River Basin, Southeastern Arizona: Unpublished report for Gila River Indian Community, Sacaton, Arizona, 53 p.

Kruse, E.G. and Herman, 1977, Implications of Irrigation System Efficiencies: U.S. Department of Agriculture, Agriculture Research Service.

Laboratory of Climatology, 1989 Computer Data Base ASCII Files Based on National Oceanic and Atmospheric Administration Records: Arizona State University.

Lacey, J.R., Ogden, P.R., and Foster, K.E., 1975, Southern Arizona Riparian Habitat: Spatial Distribution and Analysis: University of Arizona, Office of Arid Land Studies, Bulletin 8, 148 p.

Lemeur, R., and Zhang, L., 1990, Evaluation of Three Evapotranspiration Models in Terms of Their Applicability for an Arid Region: Journal of Hydrology, v. 114, p. 395-411, Elsevier Science Publishers, Amsterdam.

Long, M. and Erb, S., 1980, Computerized Depth Interval Determination of Groundwater Characteristics from Well Driller Logs: Hydrology and Water Resources in Arizona and the Southwest, Proceedings of the 1980 Meetings of the Arizona Section - American Water Resources Association and the Hydrology Section - Arizona - Nevada Academy of Science, April 11-12, 1980, Las Vegas, Nevada, p. 203-206.

Martin, D.D., 1951, Tombstone's Epitaph: University of New Mexico Press, Albuquerque.

Martin, D.L., Watts, D.G., and Gilley, J.R., 1984, Model and Production Functions for Irrigation Management: Journal of Irrigation and Drainage Engineering, Proceedings of the ASCE, v. 110, No. 2, June 1984, Paper No. 18949, p. 149-163.

Matthias, A.D., 1990, Simulation of Daily Energy Budget and Mean Soil Temperatures at an Arid Site: Theoretical and Applied Climatology, 42, 3-17, p. 3 figures, Springer-Verlag, Berlin.

McClintock, J.H., 1921, Mormon Settlement in Arizona: The Manufacturing Stationers, Inc., Phoenix.

McCulloch, 1955, Sprinkler Irrigation: Sprinkler Irrigation Association, Washington D.C.

McDonald, C.C. and Hughes, G.H., 1968, Studies of Consumptive Use of Water by Phreatophytes near Yuma, Arizona: U.S. Geological Survey Professional Paper 486-F.

Melton, M.A., 1965, The Geomorphic and Paleoclimatic Significance of Alluvial Deposits in Southern Arizona: Journal of Geology, Vol. 73, No. 1, pp. 1-38.

Miller, T., 1990, Climdata Utilities, Ver. 1.6: Computer Software with Climatological Data Reduction Calculations, Laboratory of Climatology, Arizona State University.

Montgomery, E.L. and Harshbarger, J. W., 1987, General Hydrogeologic Conditions, Lower San Pedro Basin, Pinal County, Arizona: Unpublished report.

Mooseburner, O., 1970, A Proposed Streamflow Data System for Arizona: U.S. Geological Survey Open File Report.

National Oceanic and Atmospheric Administration, 1982, Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951-1980, Arizona: U.S. Department of Commerce.

_____, 1982, Evaporation Atlas for the Contiguous Forty-eight United States: NOAA Technical Report NWS 33, Office of Hydrology, National Weather Service, Washington D.C.

_____, 1988, Climatological Data-Annual Summary: U.S. Department of Commerce, Tucson, Arizona: ISSN 0189-0580.

_____, 1989, Climatological Data-Monthly Summaries: U.S. Department of Commerce, Tucson, Arizona.

_____, 1989, Climatological Data-Annual Summary: U.S. Department of Commerce, Tucson, Arizona, ISSN 0145-0580.

Neuman, S.P. and Adar, E., 1983, Estimation of Recharge in a Small Southern Arizona Basin by Means of Hydrological, Hydrochemical, and Environmental Isotope Data: Completion Report: Office of Water Research and Technology, U.S. Department of the Interior, No. A-099-ARIZ. 119 p.

Oebker, N.F., 1987, Ten Steps to a Successful Vegetable Garden: University of Arizona, Cooperative Extension Service, Q95, Reprinted April 1987.

Oppenheimer, J. and Sumner, J.S., 1980, Depth to Bedrock Map: Laboratory of Geophysics, University of Arizona, Tucson.

Pair, C., Hinz, W.H., Frost, K.R., Sneed, R.E., and Schiltz, T.J., 1983, Irrigation: Irrigation Association, Silver Springs, Maryland, 658 p.

Parson, D., 1990, Climatology from Magma Copper Company: Letter to the Department of Water Resources, May 25, 1990.

Patch, J.D., 1962, Reminiscences of Fort Huachuca, Arizona: J.J. Lipsey, Western Books, Colorado Springs.

Paxon, J.K., 1981, Temporal and Spatial Relationships in the Development of the Southwestern Riparian Gallery Forests: Unpublished Masters Thesis, Arizona State University, Tempe, 56 p.

Putman, F., Mitchell, K., and Bushner, G., 1988, Water Resources of the Upper San Pedro Basin, Arizona: Arizona Department of Water Resources, Phoenix.

Reents, J.W., 1985, St. David Area Nitrates Study: Southeastern Arizona Governments Organization, Bisbee, Arizona.

Renard, K.G., Hickey, J.J., and Wallace, D.E., 1964, Performance of Local Aquifers as Influenced by Stream Transmission Losses and Riparian Vegetation: Transactions of the ASAE.

Ritchie, J.T., 1972, Model for Predicting Evaporation from a Row Crop with Incomplete Cover: Water Resources Research, Vol. 8, No. 5, October 1972.

Robinson, T.W., 1965, Introduction, Spread, and Areal Extent of Saltcedar in the Western United States: U.S. Geological Survey Professional Paper 491-A.

Roeske, R.H. and Werrell, W.H., 1973, Hydrologic Conditions in the San Pedro River Valley, Arizona, 1971: Arizona Water Commission Bulletin No. 4.

Rolak, B. J., 1974, History of Fort Huachuca: The Smoke Signal, Spring Edition No. 29.

Salt River Project, 1990, Salt River Project Comments - San Pedro River Preliminary HSR: November 14, 1990.

Self, O., 1987, Water Quality of the Upper San Pedro Basin, Cochise County, Arizona: Evaluation of Water Management Alternatives for the Upper San Pedro Basin, Arizona: Water Research Center, University of Arizona, Tucson.

Sellers, W.D., and Hill, R.H., eds., 1974, Arizona Climate 1931-1972: University of Arizona Press, Tucson, 2nd Edition, 616 p.

Sellers, W.D., Hill, R.H., and Sanderson-Rae, M., Eds., 1985, Arizona Climate - The First Hundred Years: The University of Arizona, 143 p.

Smith, C., 1976, Fort Huachuca: Story of a Frontier Post: Fort Huachuca, Arizona.

Stetson Engineers, Inc., P.C., 1987, The Interrelationships of Basin Ground Water and Surface and Subsurface Flow on the San Pedro River Basin, Arizona: Unpublished report for U.S. Department of Justice.

Stewart, J.I., and Hagan, R.M., 1969, Predicting Effects of Water Shortage on Crop Yield: Journal of the Irrigation and Drainage Division, Proceedings of the ASCE, March 1969, 95(IR1), p. 91-104.

_____, 1973, Functions to Predict Effects of Crop Water Deficits: Journal of the Irrigation and Drainage Division, Proceedings of the ASCE, December 1973, 99(IR4), p. 421-439.

Stewart, J.I., Hagan, R.M., and Pruitt, W.O., 1974, Functions to Predict Optimal Irrigation Programs: Journal of the Irrigation and Drainage Division, Proceedings of the ASCE, June 1974, 100 (IR2), p. 179-196.

Stewart, J.I., 1979, Planning and Managing Irrigation Projects for Optimal Water Use Efficiency: Irrigation and Agricultural Development, Johl, S.S., ed., United Nations, Pergamon Press, Oxford.

Sulphur Springs Valley Electrical Cooperative, Inc., 1988, Final Report for the Arizona Energy Office: Technical Assistance in Energy Management.

Sumner, J.S. and Halverson, P.F., 1983, Geophysical Exploration: Surveys for Groundwater in the San Pedro Basin, Arizona: University of Arizona Research Project Technical Completion Report, A-108-ARIZ, 28p.

Theis, C.V., 1941, The Effects of a Well on the Flow of a Nearby Stream: American Geophysical Union Transaction, v. 22, part 3, p. 734-738.

Theis, C.V. and Conover, C.S., 1963, Chart for Determining the Percentage of Pumped Water being Diverted from a Stream or Drain: Shortcuts and Special Problems in Aquifer Tests: Bental, R., ed., U.S. Geological Survey Water Supply Paper 1545-C.

Thompson, T.H., Nuter, J., and Anderson, T.W., 1984, Map showing Distribution of Dissolved Solids and Dominant Chemical Type in Groundwater, Basin and Range Province, Arizona: U.S. Geological Survey Water Resource Investigations 83-4114-C.

Tilton, R.G., 1970, Handwritten History of St. David, Arizona.

Traywick, B.T., 1972, Thunder Fort: The Story of Fort Huachuca: published by author.

Tromble, J.M., 1972, Use of Water by a Riparian Mesquite Community: National Symposium on Watersheds in Transition, p. 267-270.

Turner, S.F., 1945, Groundwater Pumpage in Southern Arizona: U.S. Geological Survey Open File Report.

U.S. Army Corps of Engineers, 1974, Report on Water Supply: Fort Huachuca and Vicinity, Arizona: U.S. Army Corps of Engineers, Los Angeles District.

_____, 1987, Fort Huachuca Groundwater Modeling Study, Southeastern Arizona: U.S. Army Corps of Engineers, Los Angeles District.

U.S. Department of Agriculture, Soil Conservation Service, n.d., Consumptive Use and Effective Rainfall for Arizona, Based on TR-21.

_____, 1970, Irrigation Water Requirements, Technical Release No. 21: Revised September 1970.

_____, 1971, General Soil Map, Cochise County, Arizona.

_____, 1971, General Soil Map, Pinal County, Arizona.

_____, 1972, National Experimental Handbook, Section 4, Hydrology.

_____, 1973, General Soil Map, Graham County, Arizona.

_____, 1974, General Soil Map, Pima County, Arizona.

_____, 1975, Hydrologic Data for Experimental Agricultural Watersheds in the United States, 1967 through 1975.

_____, 1979, Soil Survey of Santa Cruz and parts of Cochise Counties, Arizona.

_____, 1984, Irrigation - Furrow Irrigation: National Engineering Handbook, Section 15, Chapter 5, 2nd Edition, October 1984.

U.S. Department of Commerce, Bureau of Census, 1980, The 1980 Census.

U.S. Department of the Interior, Bureau of Land Management, 1989, San Pedro River Riparian Management Plan and Environmental Impact Statement: Safford District.

U.S. Environmental Protection Agency, 1979, National Secondary Drinking Water Regulation: EPA #570/9-76-00.

_____, 1985, Finding of Violation Against Phelps-Dodge Corporation, Bisbee, Arizona: Region 9, Docket No. IX-FY86-44.

_____, 1986, Quality Criteria for Water, 1986: EPA #440/5-86-001.

U.S. Geological Survey, 1921, Surface Water Supply of the United States, 1918, Part 9, Colorado River Basin: Water Supply 479, 189 p.

_____, 1925, Surface Water Supply of the United States, 1919-1920, Part 9, Colorado River Basin: Water Supply Paper 509, 269 p.

_____, 1972, Water Resource Data for Arizona 1968-1972, Part 1, Surface Water Records.

_____, 1973, Administrative Report.

_____, 1982, Water Resources Data for Arizona, Water Year 1982, U.S. Geological Survey Water Data Report AZ-82-1.

_____, 1985, Upper San Pedro Basin 1984 Groundwater Summary.

_____, 1986, Landsat MSS Scenes 36/38, 5083817215, 6/17/86 and 37/37, 5082917275, 8/8/86: EROS Data Center, Sioux Falls, SD.

_____, 1990, Daily Streamflow Measurements for Palominas Gage: Unpublished data report.

_____, 1991a, Basin Characteristics and Streamflow Statistics in Arizona as of 1989: Water Resources Investigations Report 91-4041, 612 p.

_____, 1991b, Streamgage Records, San Pedro River watershed, Computerized Data Source.

University of California, Cooperative Extension, Division of Agriculture and Natural Resources, n.d., Using Reference Evapotranspiration (ETo) and Crop Coefficients to Estimate Crop Evapotranspiration (ETc) for Trees and Vines: Leaflet 21428.

_____, n.d., Using Reference Evapotranspiration (ETo) and Crop Coefficients to Estimate Crop Evapotranspiration (ETc) for Agronomic Crops, Grasses, and Vegetable Crops: Leaflet 21427.

Van Dielen, R., Division Manager, Arizona Water Compnay, Oracle System, 1990, Personal Communication.

Walker, H.P. and Bufkin, D., 1986, Historical Atlas of Arizona: University of Oklahoma Press, Norman, Oklahoma.

Walton, W., 1979, Groundwater Resource Evaluation: McGraw-Hill.

Warrick, A.W., and Yates, S.R., 1987, Crop Yield as Influenced by Irrigation Uniformity: Advances in Irrigation, Volume 4, Academic Press, Inc.

Warrick, A.W., Hart, W.E., and Yitayew, M., 1989, Calculation of Distribution and Efficiency for Nonuniform Irrigation: Journal of Irrigation and Drainage Engineering, Proceedings of ASCE, v. 115, No. 4, August 1989, Paper No. 23791.

Wetzel, P.J., and Chang, J., 1987, Concerning the Relationship between Evapotranspiration and Soil Moisture: Journal of Climate and Applied Meteorology, American Meteorlogical Society, v. 26, No. 1, January 1987.

White, N.D., Stulik, R.S., Morse, E.K., and others, 1963, Annual Report on Groundwater in Arizona, Spring 1962 to Spring 1963: Arizona State Land Department of Water Resources Report Number 15, 136 p., Phoenix.

Wilkin, D.C. and Galante, J.C., 1987, Land Use History: Upper San Pedro River Valley: U.S. Department of the Interior, Bureau of Land Management, Arizona State Office.

Wilson, E.D. and Moore, R.T., 1958, Geologic Map of Graham and Greenlee Counties, Arizona: Arizona Bureau of Mines Map, scale 1:375,000.

_____, 1959, Geologic Map of Pinal County, Arizona: Arizona Bureau of Mines Map, scale 1:375,000.

Wilson, E.D., Moore, R.T., and O' Haire, R.T., 1960, Geologic Map of Pima and Santa Cruz Counties, Arizona: Arizona Bureau of Mines Map, scale 1:375,000.

Wilson, E.D., Moore, R.T., and Peirce, W.T., 1959, Geologic Map of Gila County, Arizona: Arizona Bureau of Mines Map, scale 1:375,000.

Winika, C.C., and Durrenberger, R.W., n.d., A Cloud Atlas of the American Southwest: Laboratory of Climatology, Arizona State University, Tempe, Arizona.

Winship, G.P., ed., 1896, Journey of Francisco Vasquez de Coronado, 1540-1542: U.S. Bureau of American Ethnology, Annual Report, No. 14, reprint 1964, Rio Grande Press, Inc., Chicago.

Young, D.W., 1987, An Overview of Groundwater/Surface Water Interrelationships, A Practical Perspective: Unpublished report for Water Rights Litigation Team, Office of the Arizona Attorney General, 17p.

APPENDICES

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APPENDIX A: PROCEDURES FOR ESTIMATING GROUNDWATER STORAGE

The amount of usable groundwater in storage in the San Pedro River watershed was estimated for the regional and floodplain aquifers for the Upper San Pedro groundwater basin (USP) and the Lower San Pedro groundwater basin (LSP) (see Figure 2-2). This distinction is made because of the difference in aquifer characteristics between the groundwater basins and between the two aquifers. The USP basin is equivalent to the Sierra Vista and Benson subwatersheds (see Figure 2-6) and the LSP basin is equal to the Redington and Winkelman subwatersheds (see Figure 2-7).

The amount of water held in storage in an aquifer is equal to the volume of the saturated aquifer multiplied by the average specific yield of the aquifer material. The total amount of groundwater in storage within the San Pedro River watershed is the sum of the amount held in the regional and floodplain aquifers. The aerial extent of the floodplain and basin fill alluvium, which comprise the floodplain and regional aquifers, respectively, were obtained from geographic information (Table A-1). The estimated amounts of stored groundwater contained within the floodplain and regional aquifers of each groundwater basin is further broken down by subwatershed and is summarized in Table A-2.

TABLE A-1

SURFACE AREA IN ACRES FOR SUBWATERSHEDS OF THE SAN PEDRO RIVER WATERSHED

WATERSHED NAME	FLOODPLAIN ALLUVIUM	BASIN FILL	HARD ROCK	TOTAL AREA
Upper San Pedro				
Sierra Vista	22,167.6	464,554.6	176,140.8	662,863.0
Benson	17,170.8	398,416.7	69,681.9	485,269.4
Lower San Pedro				
Redington	36,893.7	338,782.2	323,435.2	699,111.1
Winkelman	64,745.9	47,984.2	107,353.9	220,084.0
Aravaipa	30,329.5	138,936.8	174,401.9	343,668.2

TABLE A-2

SUMMARY OF ESTIMATED GROUNDWATER STORAGE IN THE SAN PEDRO RIVER WATERSHED

WATERSHED NAME	FLOODPLAIN AQUIFER STORAGE (ACRE-FEET)	REGIONAL AQUIFER STORAGE (ACRE-FEET)	TOTAL STORAGE BY WATERSHED (ACRE-FEET)
Upper San Pedro			
Sierra Vista	159,609	31,753,242	31,912,851
Benson	123,681	27,064,683	27,188,364
TOTAL	283,290	58,817,925	59,101,215
Lower San Pedro			
Redington	265,636	13,025,149	13,290,785
Winkelman	466,171	5,368,451	5,834,622
Aravaipa	218,368	6,241,461	6,459,829
TOTAL	950,175	24,635,061	25,585,236
Watershed Total	1,233,465	83,452,986	84,686,451

UPPER SAN PEDRO GROUNDWATER BASIN

Floodplain Aquifer

The thickness of the floodplain alluvium ranges from forty feet to over 100 feet (Roeske and Werrell, 1973). An average thickness of sixty feet was used for this estimate and was considered to be fully saturated. The specific yield for the floodplain alluvium is estimated at about 0.12 (Putman et al., 1988). The total amount of groundwater stored in the floodplain aquifer in the USP basin is estimated to be approximately 283,000 acre-feet. This volume is based on a floodplain alluvium area of 39,338 acres.

Regional Aquifer

Storage coefficient estimates for the unconfined portion of the regional aquifer of the USP basin are 0.12 to 0.15 (Harshbarger and Associates, 1974), 0.05 to 0.10 (U.S. Army Corps of Engineers, 1974), and 0.08 (Freethey, 1982). Freethey's estimated value of 0.08 was used for this estimate. The entire regional aquifer was considered unconfined for this estimate, therefore, the storage coefficient equals the specific yield.

The thickness of the basin fill alluvium was estimated at 1200 feet using depth to bedrock maps constructed from gravity data (Oppenheimer and Sumner, 1980). Water level contour maps (Roeske and Werrell, 1973) were compared with the depth to bedrock maps to arrive at an estimate of the average saturated thickness of the basin fill alluvium. An average of 400 feet of unsaturated alluvium lies between the land surface and the water table in the regional aquifer, therefore, an average saturated thickness of 800 feet was used for the regional aquifer. The total amount of groundwater stored in the regional aquifer of the USP basin is estimated to be approximately 58,818,000 acre-feet based on an area of 862,971 acres.

LOWER SAN PEDRO GROUNDWATER BASIN

Floodplain Aquifer

The total volume of groundwater held in storage in the LSP groundwater basin is estimated to be approximately 950,000 acre-feet based on an area of 131,969 acres. This estimated volume is based, as in the USP groundwater basin, on a saturated thickness of sixty feet and a specific yield of 0.12.

Regional Aquifer

The total amount of groundwater in storage in the regional aquifer in the LSP groundwater basin is estimated to be approximately 24,635,000 acre-feet based on an area of 525,703 acres. An average specific yield value of 0.08 was assumed for the regional aquifer. The average thickness of the basin fill was estimated to be 800 feet, of which 400 feet is saturated.

APPENDIX B: PROCEDURES FOR DETERMINING NATURAL USES OF WATER WITHIN THE SAN PEDRO RIVER WATERSHED

Natural use of water within the San Pedro River watershed is specifically that quantity of water, assessed in acre-feet per year, consumed through atmospheric losses from vegetative transpiration or direct evaporation. Factors that influence these losses are interactive and principally climatic: temperature, vegetative growing season, and surface areas of exposure. That water which returns to the system through reinfiltration or overland flow is not consumed and, hence, not considered as a component of natural use.

Determination of an overall quantity of loss is based upon extrapolation from values of specific use which are derived by empirical measurement of representative samples. The literature provides such measurements for areas of similar terrain, vegetative cover, and climate. Subsequent estimation is derived from components of nonvegetated bare soil evaporation, natural vegetative use (riparian evaporation/transpiration), and direct evaporation from water surfaces of perennial reaches of the stream channel. These are in turn discussed below.

To assess vegetative transpiration and evaporative losses from alluvial soils, the following information is needed: 1) the areal extent of the floodplain; 2) the extent, density, and species composition of the phreatophytic community; 3) the factors of climate relevant to evapotranspirative use; and 4) potential water use of phreatophytes. Specific losses are extrapolated from adjusted values of consumptive use.

FLOODPLAIN DELIMITATION

A fundamental assumption in this determination is that significant natural water loss will be limited to the general area of the floodplain, or younger alluvial surface. The characteristically deep groundwater outside of the floodplain precludes the availability of moisture near the surface for evaportion or transpiration by plant cover. This is readily evidenced by the absence of dense or moderately dense vegetative cover on the older alluvial

surfaces. The presence of xerophytic associations on these upslope surfaces is supported by direct interception of precipitation and its immediate infiltration to the soil horizon.

The areal extent of the younger alluvial surface was determined using the largest-scale aerial photography available depicting post-flood (1983) conditions. Interpretation of the floodplain was based on several factors: 1) relative absence of developed vegetative cover for areas showing recent flood scour; 2) prior channel bank relicts adjacent to the current channel; and 3) alignment of developed vegetative species indicating a previous near-channel bank growth. In many cases, the floodplain is substantially broader than the current channel, indicating a large area of dynamic fluctuation and relative absence of bedrock control on channel migration. Areas of the younger alluvium that run up side tributaries to the San Pedro River, Babocomari River, and Aravaipa Creek were excluded from this area resulting in a delineation of that portion of the younger alluvium within the San Pedro River watershed that corresponds to the floodplain alluvial aquifer.

RIPARIAN MAPPING

Species composition, extent and density for phreatophytic communities comprising the riparian vegetation of the San Pedro River watershed were determined from a combination of four techniques: 1) review of existing maps of riparian communities within the area of interest; 2) multispectral classification of vegetation using satellite digital data; 3) interpretation of large-scale color aerial photography to refine the satellite multispectral classification; and 4) field verification of species predominance and classification accuracy.

Several studies of the riparian vegetative communities within the San Pedro River watershed have been performed by the University of Arizona. A 1975 study by the Office of Arid Lands Studies (Lacey et al., 1975) utilized a combination of field site examinations and interpretation of high-altitude color infrared aerial photography to delineate homogeneous communities along the river. This preliminary mapping effort was confined to that portion of the San Pedro River watershed within Cochise County. Interpretive parameters were largely subjective, and provide no data on relative abundance or density. A 1978 follow-up study provided more detailed mapping units, along

with field-transect data averages of abundance characterizing the communities. More recent mapping has been performed specifically within the administrative boundaries of the San Pedro Riparian National Conservation Area (SPRNCA) under guidance of the Bureau of Land Management; however, these data cannot be projected readily outside the boundaries.

To provide a consistent and contemporaneous view of vegetative cover within the watershed, Landsat satellite image data were acquired for the dry season month (June) of 1986. Because of the scale and alignment of the satellite images, two adjacent scenes were selected with proximal dates to produce a scene composite covering the entire watershed. The resulting image data set was subjected to unsupervised multispectral classification producing approximately 100 distinct spectral classes, which then were consolidated and labeled according to existing information of vegetative species assemblages within the map area. Classification accuracy was assured through field site examination at five points within the watershed. Class density was assessed using both field and large-scale aerial photographic interpretation. The resulting classification produced six categories combining factors of species composition as summarized in Table B-1.

TABLE B-1

AREA OF RIPARIAN VEGETATION
(ACRES)

	COTTONWOOD/ SYCAMORE	TAMARISK/ MESQUITE	DENSE MESQUITE	MEDIUM DENSE MESQUITE	WILLOW	CIENEGA/ DENSE GRASS	TOTAL
Sierra Vista	1,337	---	1,556	2,875	42	84	5,894
Benson	275	1,836	2,338	1,156	---	440	6,045
Redington	431	176	3,877	46	---	379	4,909
Winkelman	99	196	1,098	1,898	---	---	3,291
Aravaipa	290	---	34	129	---	---	453
TOTALS	2,432	2,208	8,903	6,104	42	903	20,592

Because dense natural vegetation is essentially indistinguishable from irrigated vegetation such as field cultivation, those areas of active agriculture identified through field survey and aerial photographic interpretation in 1986 were superimposed on the satellite map to eliminate misclassification as natural vegetation. Subsequent areal tabulation

involving irrigated land estimates were based on this class, rather than the 1989-90 revised areas, because of the necessary interaction with mapped riparian area tabulations.

RIPARIAN CONSUMPTIVE USE

Water consumption by vegetation is a function of the effective energy available to the plant, as well as the overall density of plant cover. The climatic factors of greatest significance for estimation of evaporative and evapotranspirative loss are average air temperature and the amount of daylight within the growing season for the vegetative communities involved. These factors are consolidated in the Blaney-Criddle method of consumptive use determination into a single factor (F) that is the sum of the products of mean monthly temperature and the percentage of daytime hours of the year for the growing season.

The average temperature data for the San Pedro River watershed were derived from National Weather Service (Laboratory of Climatology, 1989) recording stations selected to represent conditions for each of the five subwatersheds. The absence of a station in the Aravaipa subwatershed necessitated an approximation of monthly average temperatures based on averaging of values from two adjacent stations: Cascabel and Winkelman.

The annual distribution of the growing season is based on the percent of daylight on a monthly average, and is a function of latitude. For the Winkelman subwatershed, a distribution for thirty-three degrees north latitude was applied; the remaining subwatersheds were estimated from a distribution for 32 degrees north latitude (Blaney and Harris, 1951). Average monthly temperature and growing season distribution values are provided for each subwatershed in Table B-2. F-factors for the subwatersheds were calculated as the sum of the products of average monthly temperature (T) and the percent of growing season. These values are summarized in Table B-3.

The estimation of consumptive use employed here is based on an extension of the Blaney-Criddle method applied to natural vegetation within the Gila River riparian communities (Gatewood et al., 1950). In this method, consumptive use is a product of a vegetative use coefficient (K) and the climate factor (F) described above. For the Gila River studies, these

TABLE B-2

MONTHLY AVERAGE TEMPERATURE AND PERCENT OF SEASONAL DAYLIGHT DISTRIBUTION
F = (Avg.Temp) x (% Season)

SIERRA VISTA SUBWATERSHED-TOMBSTONE (~32°N)

MONTH	AVG TEMP	% SEASON	F
Jan	46.24	.0720	3.33
Feb	49.54	.0697	3.45
Mar	54.06	.0837	4.52
Apr	60.61	.0875	5.30
May	68.22	.0963	6.57
Jun	77.68	.0960	7.46
Jul	82.37	.0977	8.05
Aug	80.05	.0928	7.43
Sep	74.85	.0834	6.24
Oct	64.49	.0793	5.11
Nov	52.96	.0711	3.77
Dec	46.51	.0705	3.28
		TOTAL	64.51

WINKELMAN SUBWATERSHED-WINKELMAN (~33°N)

MONTH	AVG TEMP	& SEASON	F
Jan	46.50	.0715	3.32
Feb	49.77	.0694	3.45
Mar	54.20	.0836	4.53
Apr	60.74	.0878	5.33
May	68.48	.0968	6.63
Jun	78.06	.0964	7.52
Jul	82.96	.0983	8.15
Aug	80.60	.0931	7.50
Sep	75.37	.0834	6.29
Oct	64.90	.0792	5.14
Nov	53.18	.0706	3.75
Dec	46.69	.0699	3.26
		TOTAL	64.87

BENSON SUBWATERSHED-APACHE POWDER (~32°N)

MONTH	AVG TEMP	% SEASON	F
Jan	45.49	.0720	3.28
Feb	48.93	.0697	3.41
Mar	53.74	.0837	4.50
Apr	60.37	.0875	5.28
May	67.50	.0903	6.10
Jun	76.64	.0960	7.36
Jul	80.58	.0977	7.87
Aug	78.37	.0928	7.27
Sep	73.30	.0834	6.11
Oct	63.24	.0793	5.01
Nov	52.37	.0711	3.72
Dec	46.04	.0705	3.25
		TOTAL	63.16

ARAVAIPA SUBWATERSHED (~33°N)
MEAN TEMPERATURES OF CASCABEL/WINKELMAN

MONTH	AVG TEMP	% SEASON	F
Jan	46.51	.0720	3.35
Feb	49.76	.0697	3.47
Mar	54.16	.0837	4.53
Apr	60.68	.0875	5.31
May	68.47	.0903	6.18
Jun	78.06	.0960	7.49
Jul	83.06	.0977	8.11
Aug	80.68	.0928	7.49
Sep	75.44	.0834	6.29
Oct	64.95	.0793	5.15
Nov	53.16	.0711	3.78
Dec	46.67	.0705	3.29
		TOTAL	64.44

REDINGTON SUBWATERSHED-CASCABEL (~32°N)

MONTH	AVG TEMP	% Season	F
Jan	46.42	.0720	3.34
Feb	49.70	.0697	3.46
Mar	54.14	.0837	4.53
Apr	60.69	.0875	5.31
May	68.40	.0903	6.18
Jun	77.94	.0960	7.48
Jul	82.80	.0977	8.09
Aug	80.44	.0928	7.46
Sep	75.22	.0834	6.27
Oct	64.78	.0793	5.14
Nov	53.11	.0711	3.78
Dec	46.63	.0705	3.29
		TOTAL	64.33

TABLE B-3

CLIMATIC FACTOR (F) COEFFICIENT BY SUBWATERSHED
(AVERAGE MONTHLY TEMPERATURE X PERCENT SEASON)

Sierra Vista	64.51
Benson	63.16
Redington	64.33
Winkelman	64.87
Aravaipa	64.44

estimates were based on relatively pure stands of high density riparian vegetation, with no allowance for intervening unvegetated land surface evaporation. Table B-4 provides the K-factors employed for this study (Gatewood et al., 1950). Because the Gila River riparian study did not provide a consumptive use estimate for sycamore in particular, the consumptive use for cottonwood was used with the assumption that the similar structure and growth characteristics approximate cottonwood species. To adjust for the mix of tamarisk and mesquite, the community was estimated to consist of 75 percent tamarisk and 25 percent mesquite throughout the watershed.

TABLE B-4

K-FACTORS BY RIPARIAN VEGETATION CLASSES
(UNADJUSTED)

Cottonwood/Sycamore	1.131
Tamarisk/Mesquite	1.173
Tamarisk (75%)	1.357
Mesquite (25%)	0.622
Dense Mesquite	0.622
Medium-Dense Mesquite	0.622
Willow	1.131
Cienega/Dense Grass	0.660
Unvegetated	0.210

To adjust these estimates to conditions found in the San Pedro River watershed, consumptive use was determined for the percentage of riparian cover (T) and nonvegetated cover (E) as shown in Table B-5. Consumptive use for the nonvegetated area was based on coefficient determinations made in the Gila River case by Culler et al., (1982) of 0.21 for cleared areas. The adjusted

TABLE B-5

RELATIVE EVAPORATION/TRANSPIRATION FACTORS
FOR RIPARIAN VEGETATION CLASSES

ASSOCIATION	EVAPORATION (E) (UNVEGETATED)	TRANSPIRATION (T) (VEGETATED)
Cottonwood/Sycamore	0.30	0.70
Tamarisk/Mesquite	0.30	0.70
Dense Mesquite	0.20	0.80
Medium-Dense Mesquite	0.60	0.40
Willow	0.35	0.65
Cienega/Dense Grass	0.00	1.00
Unvegetated	1.00	0.00

TABLE B-6

CONSUMPTIVE USE (CU) FOR RIPARIAN VEGETATION CLASSES
(FEET PER ACRE)

	COTTONWOOD/ SYCAMORE	TAMARISK/ MESQUITE	DENSE MESQUITE	MEDIUM DENSE MESQUITE	WILLOW	CIENEGA/ DENSE GRASS
Sierra Vista	4.59	---	2.90	2.01	4.35	3.55
Benson	4.50	4.65	2.84	1.97	---	3.47
Redington	4.58	4.74	2.89	2.01	---	3.54
Winkelman	4.62	4.78	2.92	2.03	---	---
Aravaipa	4.59	---	2.90	2.01	---	---

Consumptive Use = Climatic factor for subwatershed (F) x [(vegetative class K-Factor) x (T)] + (F) x [(bare soil K-Factor) x (E)]/12

Weighted watershed CU = 3.05 feet/year
(by area acreage)

consumptive use coefficients are given in Table B-6. The application of Blaney-Criddle to consumptive use for the resulting classification utilized areal estimates of vegetative cover. Table B-7 provides the results of this application. The consumptive use values take into account effective precipitation of five inches (0.42 feet) per year which is assumed uniform throughout the watershed.

TABLE B-7

CONSUMPTIVE USE QUANTITIES BY RIPARIAN VEGETATION CLASSES
(ACRE-FEET PER YEAR)

	COTTONWOOD/ SYCAMORE	TAMARISK/ MESQUITE	DENSE MESQUITE	MEDIUM DENSE MESQUITE	WILLOW	CIENEGA/ DENSE GRASS	TOTAL
Sierra Vista	5575	----	3860	4585	165	263	14,448
Benson	1122	7772	5658	1795	---	1344	17,691
Redington	1794	760	9587	73	---	1182	13,396
Winkelman	416	854	2742	3048	---	----	7,060
Aravaipa	1209	----	84	205	---	----	1,498
TOTALS	10,116	9,386	21,931	9706	165	2789	54,093

Annual consumptive use = [(value from Table B-6) - 0.42] x value from Table B-1 where 0.42 is annual effective precipitation.

WATER SURFACE EVAPORATION

Direct channel evaporation from the perennial and flowing intermittent reaches along the San Pedro River, Aravaipa Creek and Babocomari River was estimated by calculating the net evaporation from an open water surface. An average evaporation rate along the river channel was estimated to be sixty-five inches per year (National Oceanic and Atmospheric Administration, 1982). With an average precipitation of 13.8 inches per year, the net evaporative loss from a free water surface would be approximately fifty-one inches or 4.3 feet.

Average perennial channel widths were estimated from Arizona Department of Water Resources gaging records and field observations. Perennial and intermittent channel reaches and lengths were identified from aerial photography, U.S. Geological Survey topographic maps, Brown et al., (1981) and field investigation. For purpose of this analysis, average stream reaches for intermittent (perennial prior to development) and intermittent streams are assumed equal to the average width of perennial reaches for the given subwatershed. However, intermittent (perennial prior to development) and intermittent reaches only flow for a portion of the year. They are assumed to be flowing for two-thirds and one-third of the year, respectively. Channel widths and lengths for each channel by subwatershed is provided in Table B-8,

TABLE B-8

PERENNIAL REACH CONSUMPTIVE USE
(ACRE-FEET PER YEAR)

SUBWATERSHED	REACH	STREAM CONDITION	(1) STREAM LENGTH (MILES)	(2) AVERAGE STREAM WIDTH (FEET)	(3) FLOW REDUCTION FACTOR	(4) STREAM REACH AREA (ACRES)	(5) SUBWATERSHED TOTAL AREA OF FLOWING WATER (ACRES)	(6) EVAP. LOSS (AC-FT/YR)*
Sierra Vista	San Pedro	Per	23.97	12	1	34.87	63.70	270
		Inter (Per)	16.17	12	0.66	15.53		
	Babocomari	Per	7.96	6	1	5.79		
		Inter (Per)	15.66	6	0.66	7.52		
Benson	San Pedro	Inter (Per)	35.39	12	0.66	33.98	33.98	150
Redington	San Pedro	Per	3.96	12	1	5.76	43.56	190
		Inter (Per)	28.74	12	0.66	27.59		
		Inter	21.26	12	0.33	10.21		
Winkelman	San Pedro	Inter (Per)	15	12	0.66	14.40	21.10	90
		Inter	11.37	12	0.33	5.46		
	Aravaipa	Per	0.68	15	1	1.24		
Aravaipa	Aravaipa	Per	22.88	15	1	41.61	41.61	180

Total evaporation from flowing channels for San Pedro River watershed = 880

Formulas:
(4)=[[(1)X5280]X(2)X2.296E-05]X(3)
(6)=(5)X4.3
where (#) represents column value.

Stream conditions:
Per = Perennial
Inter (Per) = Intermittent but perennial before development
Inter = Intermittent

*Values rounded to nearest tens.

along with the calculated area of open water. These areas were in turn multiplied by the net evaporative loss of 4.3 feet to obtain the evaporative loss from flowing reaches.

NONVEGETATIVE EVAPORATIVE LOSS

Determination of evaporative loss from nonvegetated areas of the watershed was similarily based on the Blaney-Criddle method of estimation. The established coefficient K of 0.21, as determined for the Gila River

studies and applied elsewhere in the state, was used for all nonvegetated (riparian or irrigated) land area within the boundaries of the principal river channel. An assumption of negligible evaporative loss outside of this channel is based on the substantial depth to groundwater evidenced away from the immediate active floodplain; hence, evaporative losses from nonvegetated surfaces outside of the channel were calculated only for those areas estimated within phreatophytic communities. Table B-9 provides areas of the channel without vegetative cover. After removal of the areas calculated for perennial and intermittent loss, consumptive use was calculated for the remainder. Table B-10 provides areas and estimates of consumptive use for these surfaces. The consumptive use values take into account effective precipitation of five inches (0.42 feet).

TABLE B-9

NONVEGETATED AREA OF RIVER CHANNEL IN ACRES
(INCLUDES PERENNIAL REACH AREA)

Sierra Vista	1,020.0
Benson	872.1
Redington	2,876.4
Winkelman	2,197.2
Aravaipa	1,103.7
TOTAL	8,069.4

NATURAL USE SUMMARY

Table B-11 provides a summary of consumptive use by subwatershed for the overall San Pedro River watershed. Of note, phreatophytic consumptive use represents approximately 90 percent of the total natural use within the watershed.

TABLE B-10

NONVEGETATED (BARREN) SURFACE EVAPORATION
(ACRE-FEET PER YEAR)

SUBWATERSHED	AREA (1) (ACRES)	CONSUMPTIVE (2) USE (FEET/LAKE)	ANNUAL (3) EVAPORATION (ACRE-FEET)
Sierra Vista	956.3	0.715	680
Benson	838.1	0.738	620
Redington	2,832.8	0.716	2,030
Winkelman	2,176.1	0.731	1,590
Aravaipa	1,062.1	0.746	790
TOTAL	7,865.4		5,710

(1) Nonvegetated area (Table B-9) minus perennial reach area.

(2) Based on climatic F-factor for each subwatershed (Table B-3) times unvegetated K-factor (Table B-4) minus an assumed effective precipitation of five inches divided by twelve inches per foot.

(3) Values rounded to nearest tens.

TABLE B-11

WATERSHED NATURAL CONSUMPTIVE USE TOTALS
(ACRE-FEET PER YEAR)
ALL VALUES ROUNDED TO NEAREST 10

	RIPARIAN	FLOWING STREAM EVAPORATION	BARREN CHANNEL SOIL EVAPORATION	TOTAL
Sierra Vista	14,450	270	680	15,400
Benson	17,690	150	620	18,460
Redington	13,400	190	2,030	15,620
Winkelman	7,060	90	1,590	8,740
Aravaipa	1,500	180	790	2,470
TOTALS	54,100	880	5,710	60,690
% TOTAL	90%	1%	9%	100%

APPENDIX C: QUANTITIES OF USE DETERMINATIONS

This appendix describes the procedures and criteria utilized by the Arizona Department of Water Resources (DWR) for determining the quantity of water use for a potential water right (PWR) such as irrigation or stockwatering. There are two primary objectives for quantifying water use: 1) to provide the Court and master with the information needed to determine an appropriate entitlement for each PWR and 2) to provide DWR with information on cultural water uses occurring within a watershed for water budget determinations. The Water Rights Entitlement Issue Decision dated March 17, 1989, specified the types of uses and quantities to be reported in the hydrographic survey reports (HSR) for the Gila River System General Adjudication. This order also approved DWR's description of quantification procedures which are outlined below:

A. The amount of water claimed to be used by each claimant.

B. Irrigation

1. Report the quantities of use specified by existing decrees which pertain to water uses reported in the HSRs.

2. Report the estimated maximum observed use during the last five year period of DWR's investigations, identifying any such quantities that represent wasteful or excessively inefficient practices.

3. Report a regional use by application of uniform water duties within regional farming conditions that are derived from average cropping patterns and efficiencies within those areas.

C. Domestic

Domestic uses reported in the HSRs will pertain only to the uses inside the residence. In order to accurately account for all uses, outside uses (lawns, gardens, pasture, etc.) will be reported as other irrigation (OT) in order to provide maximum flexibility to the Master and Court in their determination of domestic rights. The estimated quantities associated with inside domestic uses will be described in a report which appears in Volume 1 of the HSR.

D. Industrial, Mining, and Municipal

DWR includes a separate report for each of these uses in Volume 1 of the HSRs. Those reports list all quantification information which DWR has been able to gather relative to these uses.

E. Large Stockponds and Reservoirs

For those stockponds and reservoirs which exceed two acres of maximum controlled surface area, DWR will report the applicable maximum surface area and capacity for each facility.

F. Small Stockponds and Reservoirs

For these facilities, DWR shall report that they have been found to be less than two surface acres in maximum controlled surface area and less than or equal to fifteen acre-feet in maximum capacity.

G. Stockwatering and Wildlife

For these instream uses and uses from springs and small diversions to stockwatering facilities, DWR will report and describe the normal water using practices and relative amounts of water use associated with these facilities.

H. Diversions

For direct surface water diversions from streams into canal systems, DWR will report the capacity of the diversion and canal system, any applicable decreed rates for the diversion/canal system, and the maximum rate needed to meet the irrigation requirement for the lands served during the peak demand periods of the year. These peak demand calculations can be made assuming an average cropping pattern and efficiency for the lands being served.

In response to comments received on the preliminary San Pedro River HSR, DWR has decided to include an additional determination of water use that goes beyond the directives of the above described court order. The Maximum Potential quantity of water use for irrigation is included in the watershed file report (WFR) based on the highest water using crop that can reasonably be grown in the region.

As indicated in Chapter 8, DWR has integrated the amount of water claimed as well as the claimed uses, locations, points of diversions, and dates into each WFR, which also displays the results of DWR's investigations. Information pertaining to water right certificates or decrees is also shown in the WFRs. This information is displayed under the "Applicable Filings and Decrees" section of each WFR. Information relating to certificated and decreed water duties and acreage for irrigation PWRs will also be listed in the "Quantities of Use" section along with the other types of quantities to be reported as directed by the Court.

The remainder of this chapter will describe the criteria and procedures to estimate quantities for the different types of water uses investigated and reported by DWR.

C.1 IRRIGATION WATER USES

The types of irrigation uses for which quantities are reported in the HSR are agricultural irrigation (IR), recreational irrigation (RC), and other irrigation (OT). The types of quantities reported for these irrigation uses are Maximum Observed, Regional, Maximum Potential, decreed, and certificated. The irrigation uses are determined by multiplying the applicable irrigated acreage by the estimated water duty which yields the total estimated irrigation volume in acre-feet per year.

The method utilized by DWR to quantify and describe agricultural water usage can be summarized in three major steps: 1) Estimate irrigation water usage by employing various procedures, 2) compile irrigation water usage into PWR specific water duties, and 3) describe the effects of irrigation water usage on the watershed. The first two of these steps are discussed in this section of the appendix while step 3 is discussed in Appendix F.

Although discussed in further detail later on, the general procedure utilized in estimating irrigation water usage involves initializing data and computational procedures (models), computing crop consumptive use and irrigation efficiencies for both normal and deficit irrigation practices, and deriving water duties from these values. An overview of the entire procedure can be found in Figure C-1. This discussion will follow the format outlined in Figure C-1. Similar flow diagrams are included in this discussion which stem either directly from this main model or from one of the sub models. The figure numbers listed on Figure C-1 and on other figures refer to a more specific description of that portion.

Compiling quantities of irrigation water usage into irrigation water duties involves analyzing crop types, irrigation systems, farming practices, and field quality for each irrigation PWR. Three different water duties are computed from the estimated irrigation water usage on each PWR. They depict the quantity of irrigation water used per acre on a PWR specific basis, on a region wide basis, and on a maximum water use basis.

To aid in clarification, a list of abbreviations and symbols as well as some definitions of terms pertinent to this discussion are provided at the end of this appendix. It should be noted here that the water duty and applicable

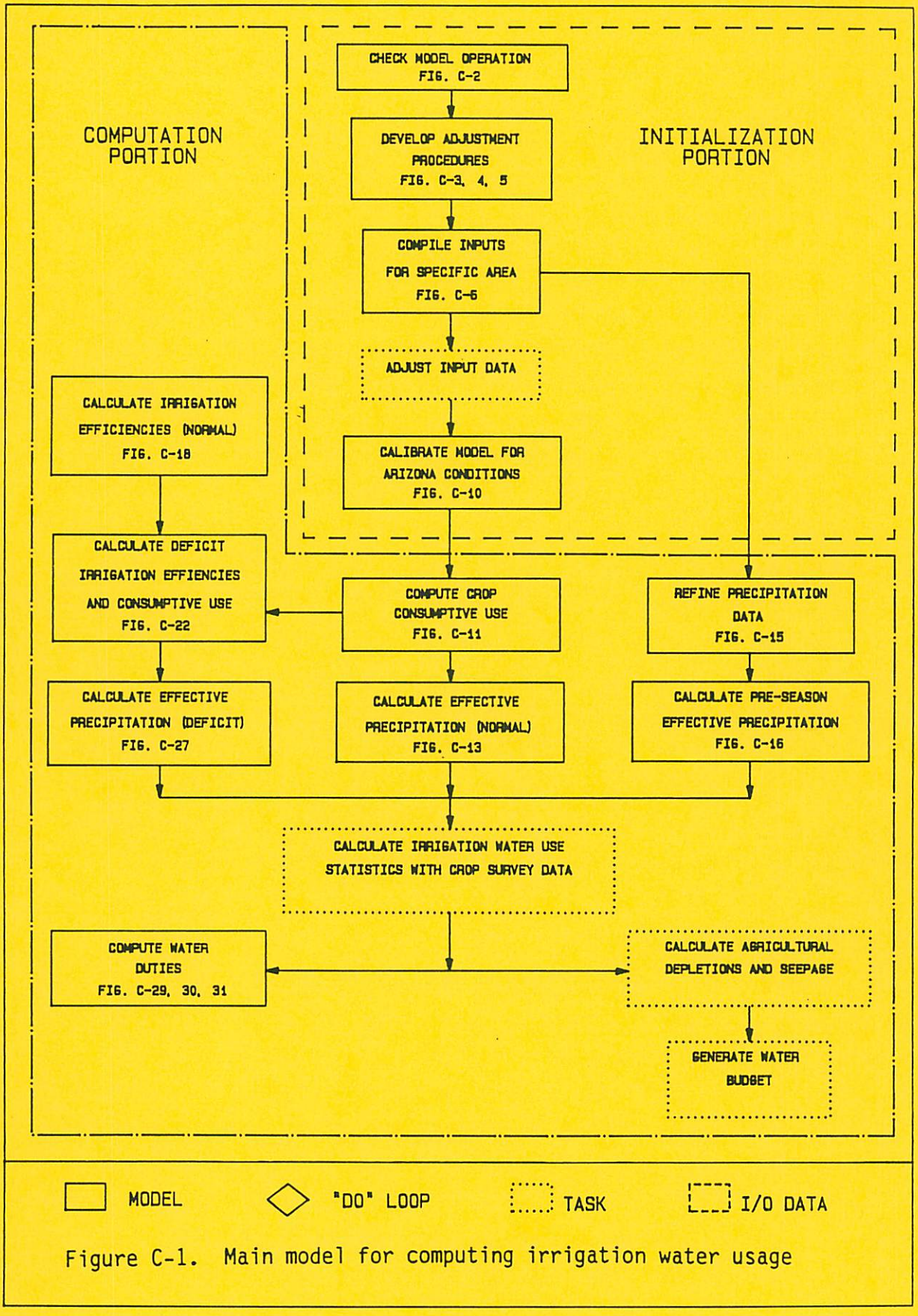


Figure C-1. Main model for computing irrigation water usage

acreage information for the decreed and certificated water duties are derived directly from the documentation obtained by DWR such as statements of claimant.

INITIALIZATION PROCEDURES

Model Verification

One of the most important quantification procedures employed by DWR is estimating crop water requirements. The model used by DWR, the FAO-24 Modified Blaney-Criddle method (Doorenbos and Pruitt, 1977), utilizes inputs such as weather data and crop characteristics to estimate crop evapotranspiration. A computerized version of FAO-24 was developed by DWR to aid in the calculation process. This computerized version of the FAO-24 computer model was verified for correct operation by comparing the output against a computerized version of the FAO-24 model developed by Utah State University (REF-ET ver 2.0, 1989). With identical input data, both models predicted nearly the same value of reference evapotranspiration (ETo). The slight difference noted was due to different methods of rounding values and the method in which percent daylight hours was computed from latitude. The DWR developed program was selected for use over the Utah State University program since, in addition to computing ETo, the DWR model also calculates crop consumptive use from crop coefficient computations. The procedure employed to verify model operation is illustrated in Figure C-2.

Deriving Adjustment Procedures

Although the FAO-24 model has been widely accepted, caution must be exercised when computing crop consumptive use. FAO-24 does not inherently predict the correct consumptive use values. Jensen, Burman, and Allen (1990) in a comparison of different consumptive use prediction models state that "The FAO-24 Blaney-Criddle method was the best performing temperature method over all locations . . . ." Although this model has been proven accurate at predicting crop consumptive use at many locations, FAO-24 tends to over predict at locations where the weather data is not measured within an irrigated environment. Doorenbos and Pruitt (1977) state that the climatic data used in the model "are often collected prior to irrigation development in stations located in rain fed or uncultivated areas . . . . Irrigated fields

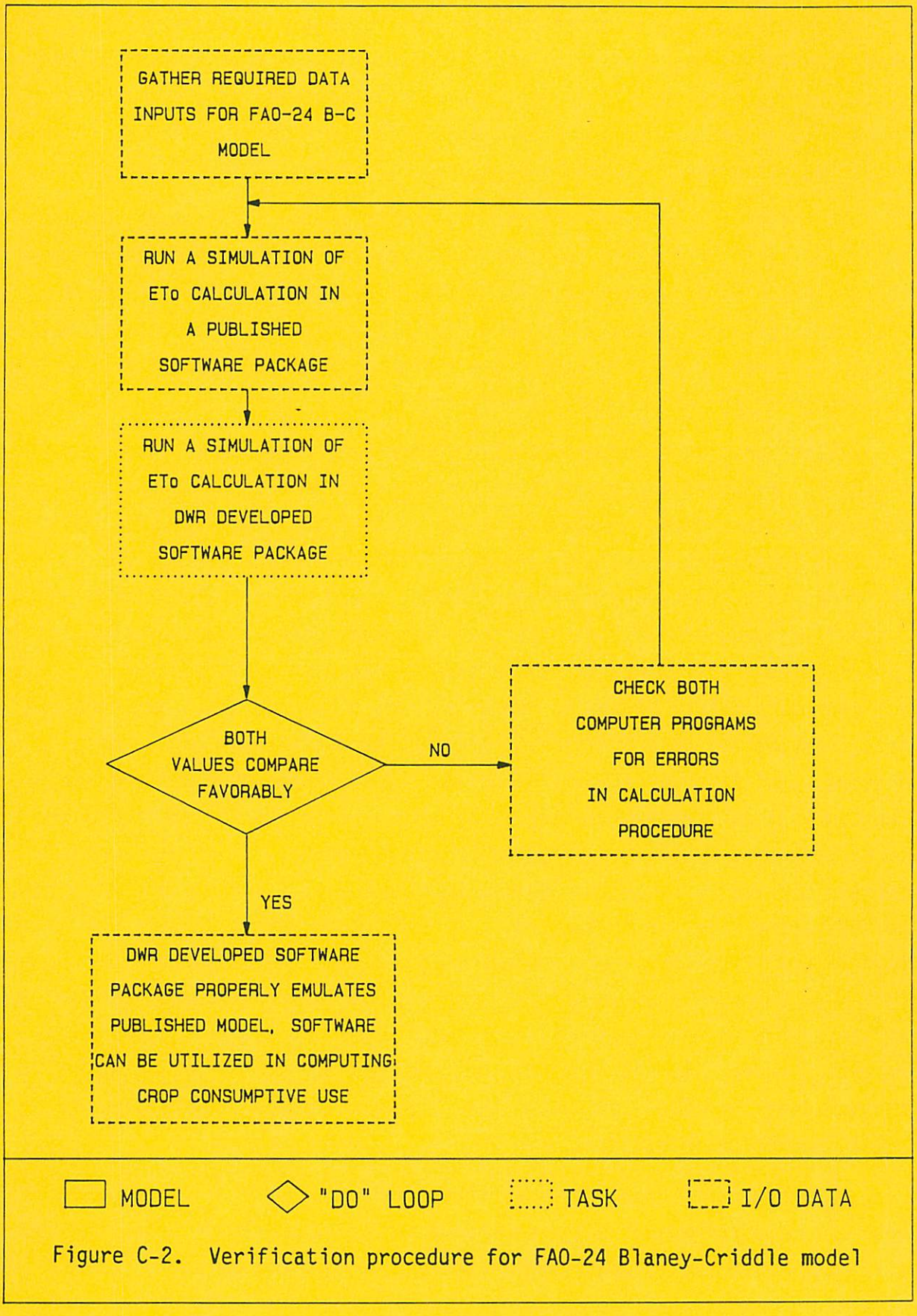


Figure C-2. Verification procedure for FAO-24 Blaney-Criddle model

will produce a different micro-climate and ETcrop may not be equal to predicted values based on these data." Allen, Brockway, and Wright (1983) state, "Irrigation of arid regions contributes to substantial modification in local climate, resulting in cooling and humidification, and reduced turbulence of air masses advancing from nonirrigated to irrigated areas."

On this basis, many of the various inputs to the FAO-24 model were analyzed for their ability to accurately represent an irrigated environment in the San Pedro River watershed. This type of analysis has been termed a "rational use approach" by Allen and Pruitt (1986) and has been interpreted by DWR to be a method of selecting and adjusting (if necessary) all of the inputs necessary for the FAO-24 model and correctly interpreting the results.

Allen, Brockway, and Wright (1983) recommend that local studies on the effect of irrigated environments on air temperature data be conducted before applying weather data in consumptive use estimates. Since very few weather stations in Arizona with long term data are located in an irrigated environment, a relationship between irrigated and nonirrigated environments in Arizona was developed. The first step involved locating weather stations in an irrigated environment that would have a companion "nonirrigated environment" station nearby to use as a basis of comparison. DWR compared data from the Tucson University of Arizona Campbell Avenue Farm, the University of Arizona campus station and the Tucson Airport weather station. The Campbell Avenue farm station is located in an irrigated environment which is bounded by a mostly nonirrigated urban environment. Also used was the Safford University of Arizona Agricultural Experiment Farm, which was compared to the weather station in Safford. The Safford University of Arizona Agricultural Experiment Farm is located in an area that is approximately one-half mile downwind from an arid environment. In both instances, the weather stations were within fifteen miles of each other and had a long period of record. The results show that the mean temperature at the irrigated weather stations was 2 to 4 percent lower than the mean temperature measured at the nearby nonirrigated stations.

Within the San Pedro River watershed, all weather stations are located in what could be termed an "arid" environment. The temperature data from these stations is subject to adjustment based on the findings mentioned above. DWR utilized an adjustment factor for all temperature data based on an average temperature departure between the arid and nonarid weather stations. This

adjustment varied from month to month and was a simple percentage reduction in the mean temperature measured over an "arid" area. The average percentage decrease in temperatures is displayed in Table C-1. The method used to adjust temperature data is illustrated in Figure C-3.

TABLE C-1

PERCENTAGE DECREASE IN MEAN TEMPERATURE
IRRIGATED AREAS VERSUS NONIRRIGATED AREAS

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
3.2	3.5	3.0	3.3	3.3	2.6	1.8	1.9	2.4	2.7	2.7	3.6

Minimum relative humidity (RH) data from Arizona Climate (Sellers and Hill, 1972) for the San Pedro River watershed were used. These relative humidity values were estimated by comparing measured relative humidity and temperature at one station and computing the relative humidity at another location based upon measured temperature at that site. DWR adjusted this estimated relative humidity based on the reduction in temperature found over irrigated areas. This adjustment was based on the thermodynamic principle that when air moisture remains the same and the temperature decreases, the relative humidity will increase. DWR utilized a psychrometric chart (Henderson and Perry, 1982) to determine the change in relative humidity based on the change in temperature. In this analysis, the point where temperature and relative humidity meet was found for the unadjusted station, then the new relative humidity was found by moving horizontally to the adjusted temperature (Henderson and Perry, 1982). This provided an increase in relative humidity of approximately 10 percent, all relative humidity values from Sellers and Hill (1972) were then adjusted upward by 10 percent (Figure C-3).

Wind speed data must also be adjusted within the rational use concept of the FAO-24 Blaney-Criddle model. Some wind speeds are measured at elevations other than those specified in the consumptive use model. For use in the FAO-24 model the wind data must be adjusted to an anemometer elevation of two meters above the ground. This can be accomplished through the use of Equation C-1 (Jensen, Burman, and Allen, 1990):

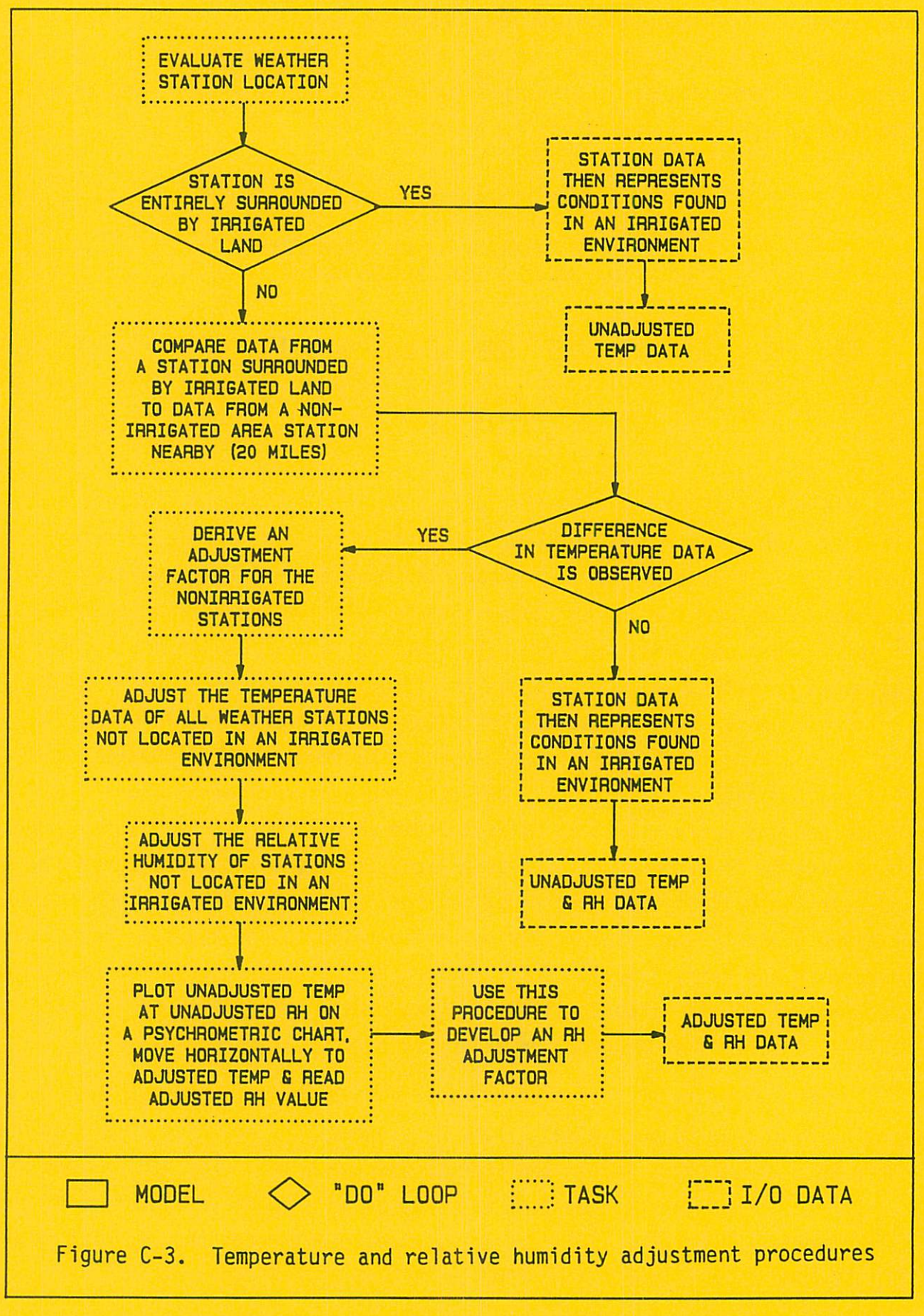


Figure C-3. Temperature and relative humidity adjustment procedures

EQUATION C-1

$$W2=W1[z2/z1]^{a}$$

Where:

W2 = Wind speed at desired elevation
W1 = Measured wind speed
z2 = Desired anemometer elevation (2 meters).
z1 = Measured anemometer elevation.
a = 0.17 when z1 >z2 and 0.22 when z1 < z2.

The daytime wind speed must also be computed when only 24 hour wind speed is available. DWR computed a ratio of daytime to nighttime wind speed at Tucson (Sellers and Hill, 1972) and then converted this ratio to a daytime verses 24 hour wind speed ratio. The ratio factor of daytime to 24 hour wind speed is 1.12. All 24 hour wind speed values were multiplied by this factor to obtain daytime wind speed (Figure C-4).

Elevation has also been found to have some effect on the ability of the FAO-24 model to accurately predict crop consumptive use. Allen, Brockway, and Wright (1983) and Doorenbos and Pruitt (1977) suggest an adjustment for elevation of 10 percent upwards for every 1,000 meter increase in elevation above mean sea level. DWR tested this relationship by comparing the predicted evaporation from a free water surface computed from evaporation pan data and National Weather Service Publication 33 (NWS-33) verses the predicted evaporation from a free water surface as predicted by FAO-24 with the rational use approach. The free water surface evaporation predicted by NWS-33, although not necessarily a correct estimation, was considered to not be influenced by the same factors that may cause the FAO-24 model to improperly predict evaporation at higher elevations. If the FAO-24 model actually exhibits characteristics of over or under prediction as a function of elevation, the difference between the NWS-33 prediction and the FAO-24 prediction would increase with increasing elevation (Figure C-5). Free water surface evaporation was predicted at six weather stations throughout Arizona that provide evaporation pan data, station elevation, and the usual inputs for the FAO-24 model. The stations ranged in elevation from 1,230 feet (375 meters) above mean sea level to almost 3,800 feet (1158 meters). The departure between the two methods of prediction did not conclusively increase with increasing elevation. For this reason, DWR did not include an elevation correction factor in the crop consumptive use estimates.

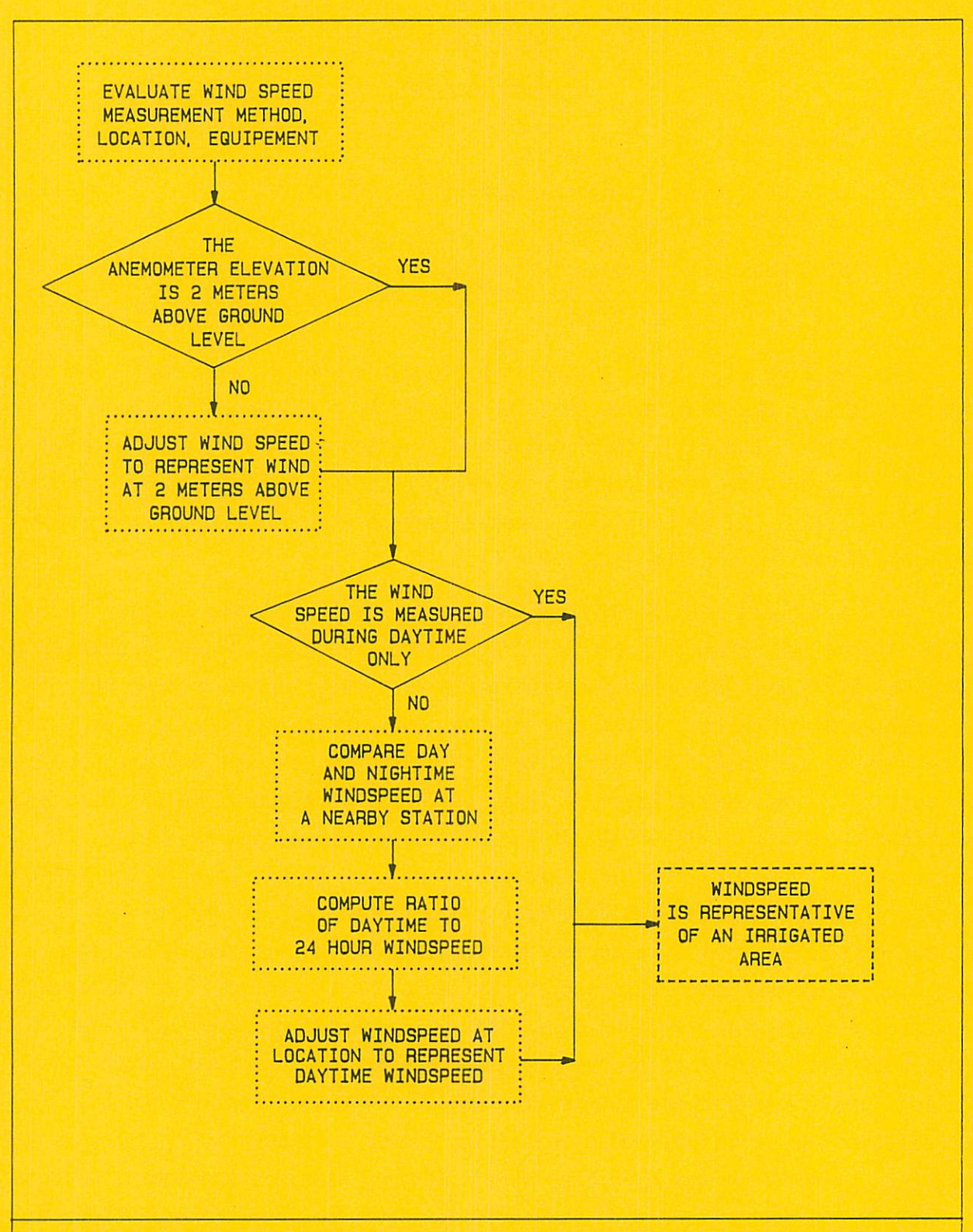


Figure C-4. Wind speed adjustment procedure

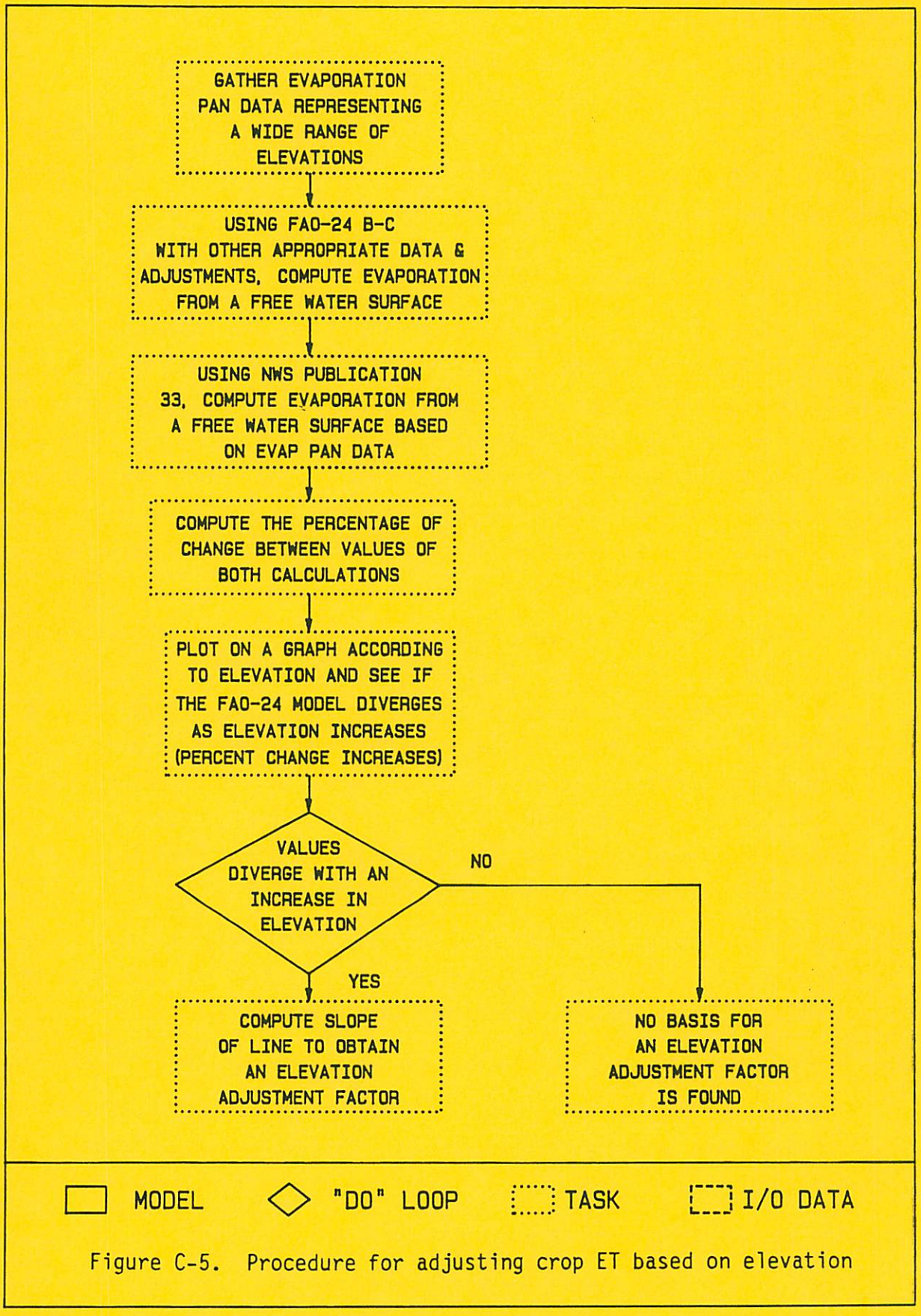


Figure C-5. Procedure for adjusting crop ET based on elevation

SELECTING INPUT DATA

The amount of data required to compute irrigation water duties is extensive and is not presented in this discussion. The data involved includes weather data, crop types, crop water use dates, irrigation frequencies and net depth of irrigation, and soil information. The methods by which this data was obtained or computed is discussed below and outlined in Figure C-6.

Selection of Weather Data

The selection of proper weather data inputs into the FAO-24 model as well as other models is considered an important step in the process of computing consumptive use requirements. This data then may or may not be adjusted prior to use. A set of criteria was generated to aid in this process. Since all of the data required for the FAO-24 model were not available from stations within the watershed, some information had to be gathered from stations outside of the watershed. The list of selection criteria follows and the selection process is illustrated in Figure C-7.

1) The period of record is very important in the selection process, a long period of record is necessary to even out the variability in annual cycles. However, the period of record should not be so long as to not reflect current trends in the overall weather cycle. When available, a thirty year period of record was used, 1960-1989. If a weather station with a 30 year period of record could not be found, 20 years of data is considered acceptable. Some watersheds may have more limiting constraints on the availability of data.

2) The consistency of data must also be high. If the station moved, the reporting format changed or there were large gaps in the record, data from that station was not considered to be consistent.

3) The data must be from a dependable source and it must be accurate.

4) The data must be available for use. Data was not used that was either not available to the public or was not in a format that could be utilized.

5) The station should be representative of the irrigated areas.

Weather data requirements for the FAO-24 model includes mean monthly temperature (Tm), percentage of daylight hours (P), mean monthly minimum

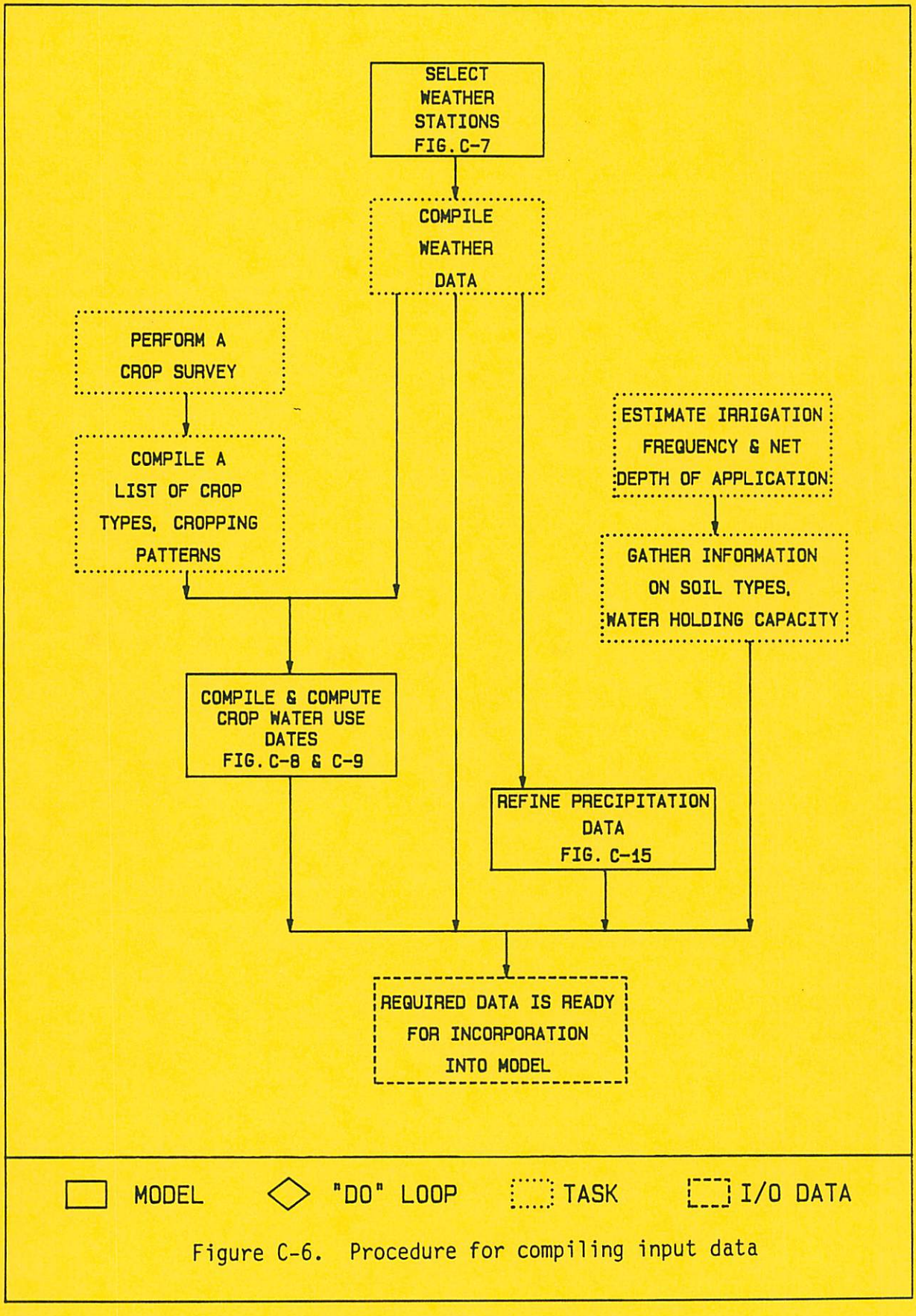


Figure C-6. Procedure for compiling input data

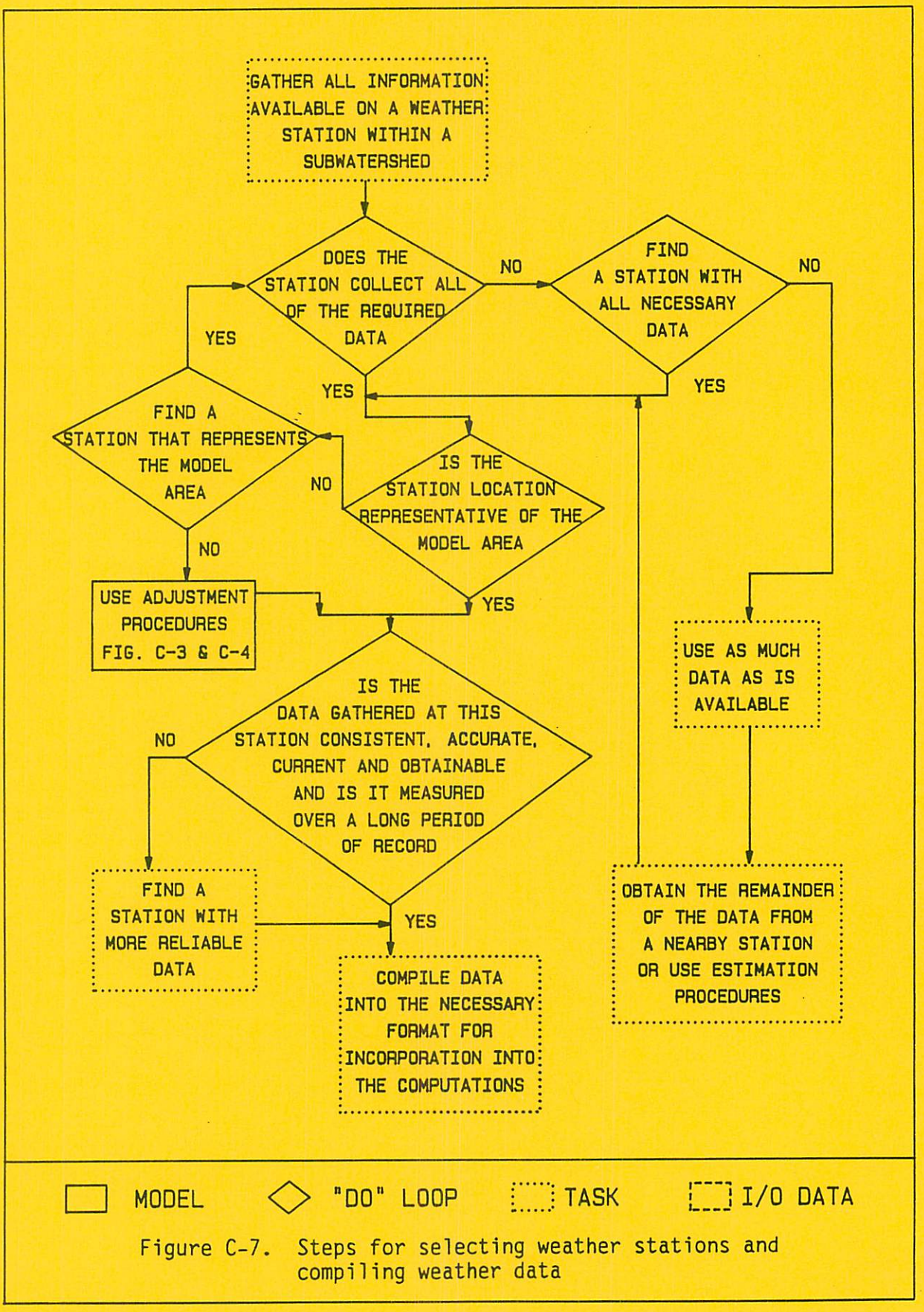


Figure C-7. Steps for selecting weather stations and compiling weather data

relative humidity (RH), mean monthly daytime wind speed (Wd), and percent of possible sunshine (n/N). Daily and monthly precipitation data is required to compute effective precipitation. Mean daily and minimum daily temperatures are needed to aid in selecting crop water use dates. A list of stations selected to provide this information is provided below. DWR first computed consumptive use values on a subwatershed basis, for this reason weather data within each subwatershed was obtained when available.

A) Selection of Stations to Provide Data for the FAO-24 Model

1) Mean Monthly Temperature

Sierra Vista subwatershed - Tombstone weather station
Benson subwatershed - Apache Powder weather station
Redington subwatershed - Cascabel weather station
Winkelman subwatershed - Winkelman weather station
Aravaipa subwatershed - Average of Cascabel and Winkelman data

2) Percent Daylight Hours.

Sierra Vista subwatershed - Tombstone weather station
Benson subwatershed - Apache Powder weather station
Redington subwatershed - Cascabel weather station
Winkelman subwatershed - Winkelman weather station
Aravaipa subwatershed - Average of Cascabel and Winkelman data

3) Minimum Relative Humidity.

Sierra Vista subwatershed - Tombstone weather station
Benson subwatershed - Apache Powder weather station
Redington subwatershed - Cascabel weather station
Winkelman subwatershed - Winkelman weather station
Aravaipa subwatershed - Average of Cascabel and Winkelman data

4) Wind Speed

Sierra Vista subwatershed - Nogales
Benson subwatershed - Nogales
Redington subwatershed - Nogales
Winkelman subwatershed - Nogales
Aravaipa subwatershed - Nogales

5) Solar Radiation (% Possible Sunshine)

Sierra Vista subwatershed - Cloud Atlas of the American Southwest
Benson subwatershed - Cloud Atlas of the American Southwest
Redington subwatershed - Cloud Atlas of the American Southwest
Winkelman subwatershed - Cloud Atlas of the American Southwest
Aravaipa subwatershed - Cloud Atlas of the American Southwest

B) Selection of Mean Monthly Precipitation Data for Calculating the Effective Precipitation and Pre-season Effective Precipitation

Sierra Vista subwatershed - Y-Lightning Ranch weather station
Benson subwatershed - Apache Powder weather station
Redington subwatershed - Cascabel weather station
Winkelman subwatershed - Winkelman weather station
Aravaipa subwatershed - Klondyke weather station

C) Selection of Temperature data for calculating Water Use Dates.

Sierra Vista subwatershed - Tombstone weather station
Benson subwatershed - Apache Powder weather station
Redington subwatershed - Cascabel weather station
Winkelman subwatershed - Winkelman weather station
Aravaipa subwatershed - Average of Cascabel and Winkelman data

The procedures and stations mentioned above provide adequate data for an initial computation of consumptive use in the San Pedro River watershed. Some station data from other stations in Arizona was also used to aid in the developement of correction and/or calibration factors for the various models. Data from these stations allow for a comparison of effects that different factors may have on the results. Stations used for these various analyses are: Safford Agricultural Experiment Station, Safford, Tucson, Tucson Campbell Avenue Farm, Tucson University of Arizona, Mesa Agricultural Experiment Station, Mesa, Phoenix, Bartlett Dam, Yuma Citrus Station, San Carlos Reservoir, Roosevelt, and Nogales.

Crop Types

The list of crop types and cropping patterns is composed from recent crop surveys. DWR conducted a crop survey in the spring and again in the fall of 1990 in the San Pedro River watershed. These crop surveys were instrumental

in describing crop types and cropping patterns in the watershed. Table C-2 lists the crop types found in the San Pedro River watershed during the 1990 crop survey.

TABLE C-2

CROP TYPES FOUND IN THE SAN PEDRO RIVER WATERSHED

DOUBLE CROPPED

Alfalfa and small grains
Alfalfa and summer pasture
Alfalfa and sorghum
Alfalfa and winter pasture
Winter pasture and summer pasture
Winter pasture and corn
Winter pasture and sorghum
Winter pasture and mixed vegetables
Small grains and okra
Small grains and summer pasture
Small grains and sorghum
Small grains and cotton
Small grains and pinto beans
Small grains and corn
Fruit trees and vegetables

SINGLE CROPPED

Alfalfa
Winter pasture
Summer pasture
Permanent pasture
Corn
Small grains
Cotton
Sorghum
Hay
Pecans without ground cover
Pecans with ground cover
Orchard without ground cover
Orchard with ground cover
Pinto beans
Mixed vegetables
Grapes
Turf
Pine trees
Melons
Landscaping
Unknown crop

DEFICIT IRRIGATED

Alfalfa
Orchard without ground cover
Small grains
Grapes
Landscaping
Orchard with ground cover
Permanent pasture
Pecan without ground cover
Pecan with ground cover
Pine trees
Summer pasture
Turf
Winter pasture

DOUBLE CROPPED AND DEFICIT IRRIGATED

Deficit Summer Pasture and Small Grains
Deficit Summer Pasture and Alfalfa
Deficit Winter Pasture and Okra

Selection of Water Use Dates for Various Crops

Selection of water use dates depends upon weather data and has a direct influence upon the consumptive use of crops. A water use date is defined as the date when plant matter in the form of a cultivated crop begins or ceases to utilize water for the purpose of plant growth and cooling. A water use date can be either the beginning or end of this period. The water use period is considered to be the time between the first use of water and the last use of water. Three procedures were used in determining these dates. The most reliable source of information was considered to be actual water use dates observed in the field. Published planting and harvest dates or growing season dates for the general vicinity were also used. In the absence of any of this information and for verification of this information, the Soil Conservation Service Technical Release 21 (TR-21) method (1970, revised) of selecting water use dates was used.

When water use dates from several sources are available, a consensus between all of the sources was obtained when possible. When only one date, such as the planting or harvest date, is known from field research, DWR added or subtracted the published length of growing season from the known planting or harvest date. The known date is checked to see if it concurs with another published date. Finally, the dates are checked to see if they fall within the range allowed by the TR-21 method. If all methods concur to provide a range of dates within one or two weeks apart, then the average date is chosen. If the different sources do not concur, DWR uses the date that is most reliable based upon the hierarchy mentioned above (Figure C-8).

The TR-21 method of selecting water use dates simply involves a table of temperature limits within which a certain crop category begins to use water or ceases to use water. These temperature limits are either in the form of mean daily temperature or minimum daily temperature. To use this method, DWR calculated averages of both mean daily and minimum daily temperatures over thirty years of record or the length of record of the station (whichever was smallest) and determined the dates on which the published limits were exceeded (Figure C-9).

Daily temperature data from the four stations which provide temperature data for the San Pedro River watershed were retrieved from computerized ASCII files from the Arizona Climate Lab with the aid of the Climdata Utilities

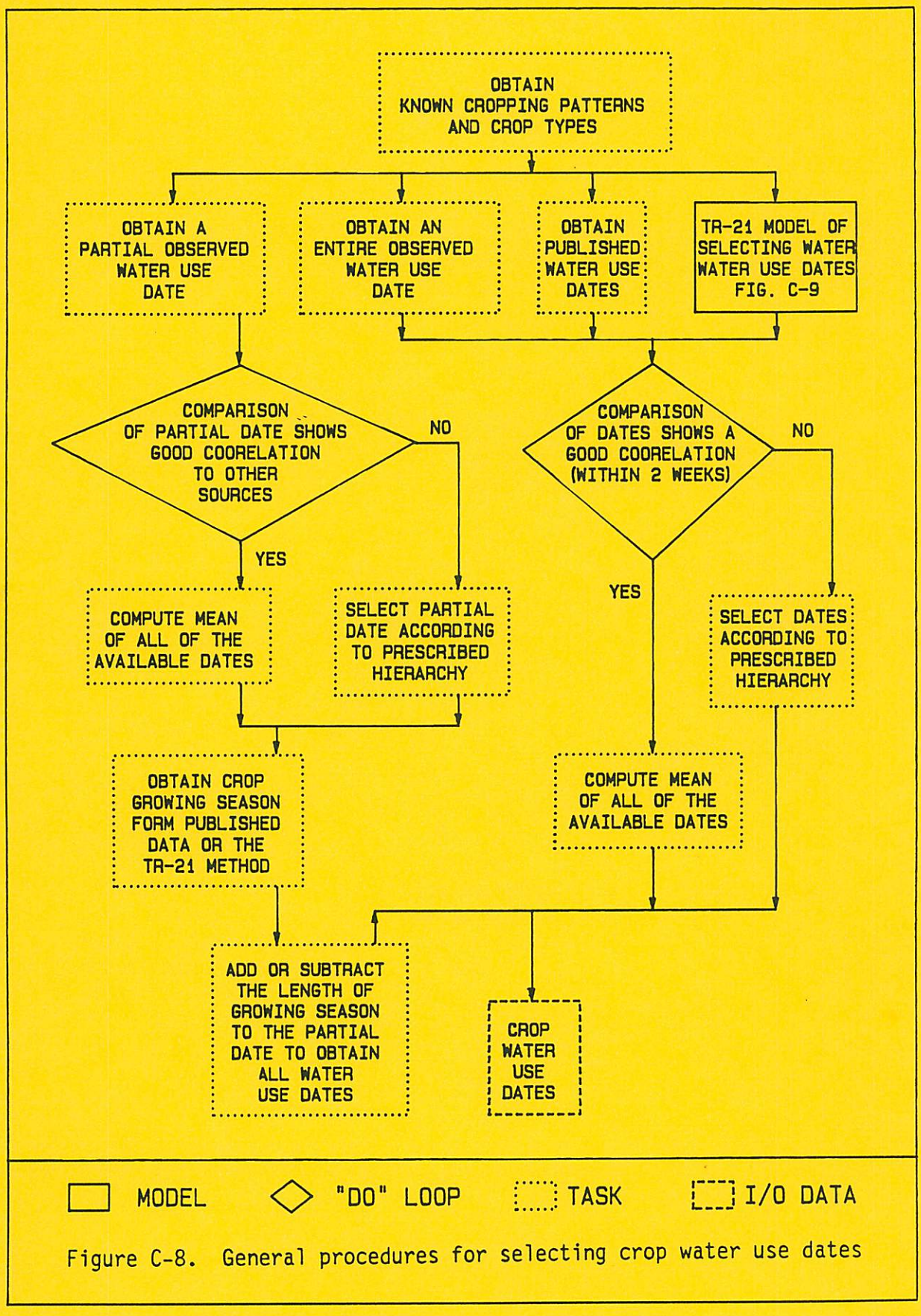


Figure C-8. General procedures for selecting crop water use dates

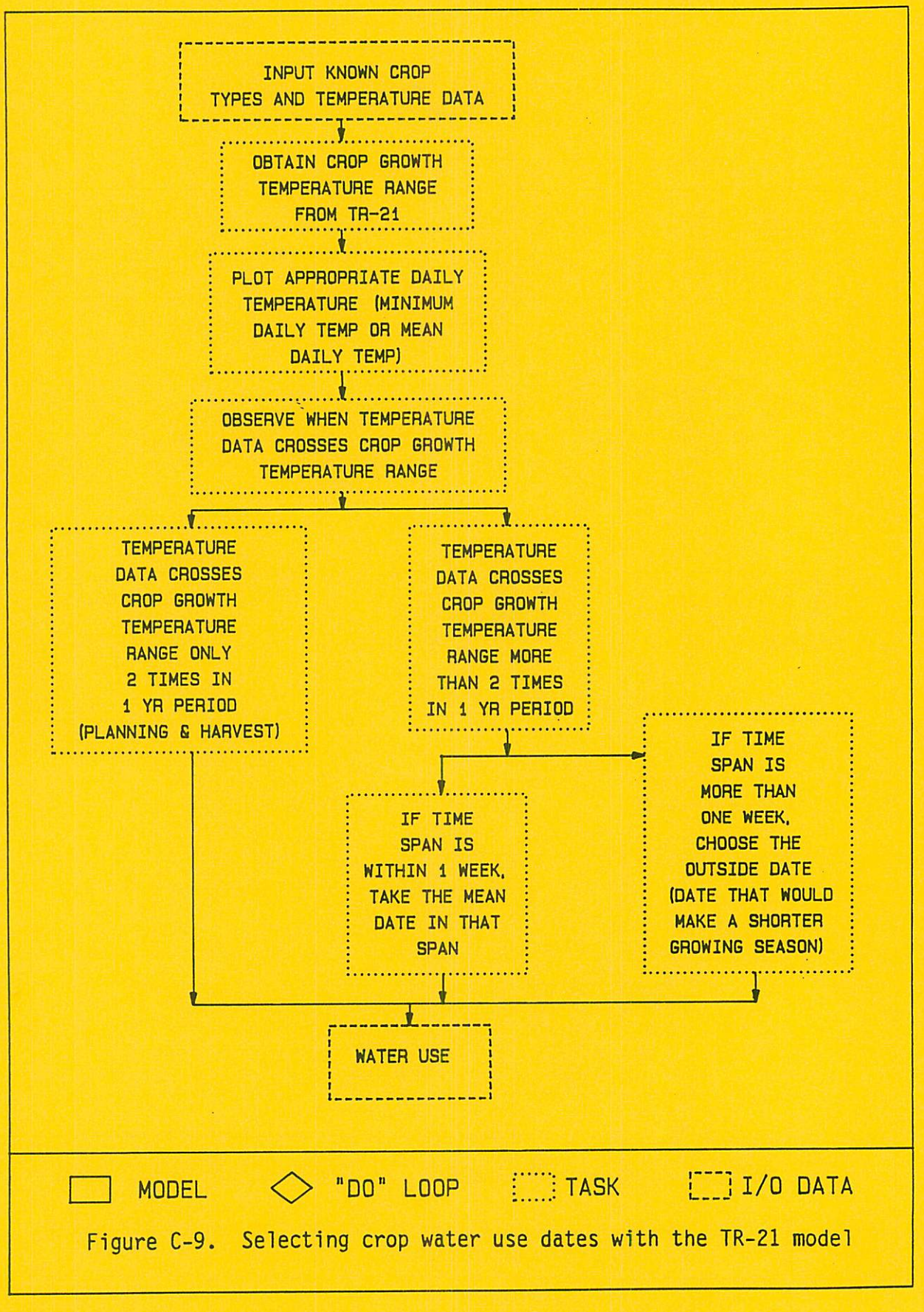


Figure C-9. Selecting crop water use dates with the TR-21 model

program (Miller, 1990, ver. 1.0). The five day floating average of mean daily temperature data were plotted to determine at what date, on average, the mean temperature was above or below the limit set by TR-21. Freeze dates were calculated by finding the first and last date of occurrence for each year. These dates were then averaged. The dates derived by this method were tabulated for each weather station (Table C-3). Only the dates for the Tombstone weather station were outside of a one week time span shown by the other three weather stations. Dates for Apache Powder, Cascabel, and Winkelman were averaged to obtain one set of dates for the entire watershed. The dates derived from this method were used only as a range within which to compare published and observed water use dates and for establishing water use dates for crops on which no information was available.

In a number of instances involving double cropping patterns, two crops had overlapping water use dates. For example, alfalfa which has a water use period from 2/19 to 11/12 was seen to be double cropped with sorghum which has a water use period from 6/1 to 10/1. In situations such as this, it was assumed that the alfalfa crop was being rotated out of production and had a water use period, in this instance, from 2/19 to 5/31, with a consumptive use commensurate with these months. Field preparation time was considered negligible.

TABLE C-3

DATES OF AVERAGE OCCURRENCE OF MEAN TEMPERATURES
AND DATES OF FIRST AND LAST OCCURRENCE OF FROST TEMPERATURES
IN THE SAN PEDRO RIVER WATERSHED

WEATHER STATION	AVERAGE OCCURRENCE OF MEAN TEMPERATURES							AVERAGE OCCURRENCE OF FROST TEMPERATURES			
DEGREE FAHRENHEIT	45		50		55	60	62	32		28	
	1st	last	1st	last	1st	1st	1st	1st	last	1st	last
Tombstone	12/31	1/5	1/6	2/11	3/19	4/6	4/22	11/22	3/27	12/9	2/27
Apache Powder	12/28	1/13	11/20	2/24	3/22	4/11	4/26	11/2	4/23	11/11	3/28
Cascabel	12/30	1/5	11/23	2/11	3/22	4/10	4/23	11/1	4/24	11/9	4/9
Winkelman	12/31	1/6	11/28	2/23	3/16	4/3	4/14	11/5	4/11	11/17	3/21
Average of Apache, Cascabel, and Winkelman	12/30	1/8	11/24	2/19	3/20	4/8	4/21	11/3	4/19	11/12	3/30

Several dates of crop water use have been observed in the San Pedro River watershed. Summer pasture was seen irrigated from 4/15 until 10/15. Winter pasture was seen irrigated from 10/15 until 4/15. Cotton has been observed planted on about April 15 and harvested on about October 30. Pinto beans were harvested on about October 15 and small grains were observed planted on this date as well. Sorghum is planted on June 1 and permanent pasture has often been observed growing and being irrigated during the coolest winter months (all year).

The water use dates selected for the San Pedro River watershed are presented in Table C-4.

TABLE C-4

SELECTED WATER USE DATES FOR THE SAN PEDRO RIVER WATERSHED

CROP	WATER USE DATE	JULIAN DATE*
Permanent pasture	1/8-12/30	8-365
Winter pasture	10/15-4/30	289-121
Summer pasture	4/30-10/15	121-289
Small grains	10/15-12/30 and 1/8-4/31	289-365 and 8-121
Turf	4/30-10/15	121-289
Cotton	4/21-11/3	112-308
Corn	6/1-10/1	153-275
Sorghum	6/1-10/1	153-275
Vegetables	5/20-9/12	141-256
Okra	5/15-9/30	136-274
Dry beans	6/30-10/15	182-289
Orchard with cover	3/19-11/3	79-308
Orchard without cover	4/19-11/3	110-308
Pecans with cover	3/19-11/3	79-308
Pecans without cover	4/19-11/3	110-308
Pine trees	1/1-12/31	1-366
Grapes	5/1-10/31	122-305
Melons	5/31-10/1	152-275
Alfalfa	2/19-11/12	50-317

* All calculations are based on Julian leap year of 366 days.

Irrigation Frequency and Net Depth of Application

Irrigation frequency was required for input into the FAO-24 model for computing the initial crop coefficient value. The irrigation frequency only needs to be estimated for this phase of the computation. An average gross

irrigation requirement (GIR) of 5.5 feet per year, net depth of application of 3 inches per irrigation, efficiency of 50 percent and growing season of 260 days were estimated based on the best information available at that time. The irrigation interval was calculated as follows: (3 inch net application) / (0.50 efficiency) x 1 foot / 12 inches = 0.5 feet gross application per interval. The average amount of water needed to be supplied per day is (5.5 feet per year) / (260 growing days per year) = 0.021 feet per day of required application. Therefore, 0.5 feet applied per irrigation / 0.021 feet/day = 23.6 days per irrigation interval. The closest interval accepted by the FAO-24 model is 20 days between irrigations.

Soils

The soil types and water holding capacity were found in the general soil maps of the counties which the San Pedro River flows through. Since the majority of the irrigation within this watershed can be found in close proximity to the river, the soil type along this narrow band was considered to be representative of the irrigated areas in the watershed. The General Soil Map for Cochise County (Soil Conservation Service, 1971) describes these soils as "Deep, well drained, nearly level, medium and . . . coarse textured soils." The representative soils are the Comoro-Anthony-Grabe Association and the Vinton-Gila Association. The water holding capacity is from 3.5 to 10.5 inches with surface runoff from slow to medium. The parameters chosen for this analysis are a loamy soil with a water holding capacity of 8.0 inches over a 4 foot profile, a rapid intake and permeability rate, and slow surface runoff.

ADJUSTMENT OF INPUT DATA

The weather data compiled for calculating irrigation water usage in the San Pedro River watershed was adjusted according to the procedures described earlier. Mean temperature data for the FAO-24 model was adjusted according to Table C-1. Relative humidity was increased by 10 percent, wind speed from Nogales was adjusted to a 6.5 foot (2 meter) anemometer height from a 2 foot height according to equation C-1 and adjusted for daytime wind speed by multiplying by a factor of 1.12. No correction for elevation was included.

CALIBRATION OF FAO-24 MODEL

An attempt was made to check, and if necessary, to calibrate the FAO-24 model for correct operation for Arizona conditions. DWR determined that the model could be calibrated in two different ways. One method would be to change the input data adjustment procedures discussed previously. The other method would involve the development of new crop coefficients (Kc). The procedure used to check the output of the model utilized crop consumptive use values found in USDA Agricultural Research Service Conservation Research Report No. 29 (CRR-29, 1983). The method involved using FAO-24, including all of the adjustment procedures mentioned earlier, to predict a specific crop consumptive use at the same location and for the same growing season and time period as reported in CRR-29. The comparison between values predicted by FAO-24 and those reported in CRR-29 was inconclusive. Based on CRR-29 values, FAO-24 over predicted consumptive use for some crops and under predicted for others (see Figure C-10).

DWR did not consider the results of this analysis conclusive enough to prove that FAO-24 requires calibration in order to correctly predict crop consumptive use in Arizona. The consumptive use values presented in CRR-29 were developed by using soil moisture balance methods which are subject to much error and are not as accurate as lysimeter measurements. The values presented in this report are also derived from the one test field with the highest crop yield. This was most likely the field with the wettest treatment of irrigation water. Some of these yield values were obtained by DWR and compared to the county wide average yield for that time period. The yield value for cotton was found to be approximately 18 percent higher than other yields of that same time period (1955-1964) and 21 percent higher than the average yield of that same year (1960). Since yield can be closely related to consumptive use of water, DWR did not find the values presented in CRR-29 to be necessarily an accurate portrayal of actual crop water use. DWR decided not to force the internationally accepted FAO-24 model to be calibrated to these values.

IRRIGATION WATER USE

The water duty is defined as the total amount of water that must be applied to a portion of irrigated acreage to successfully produce a crop based

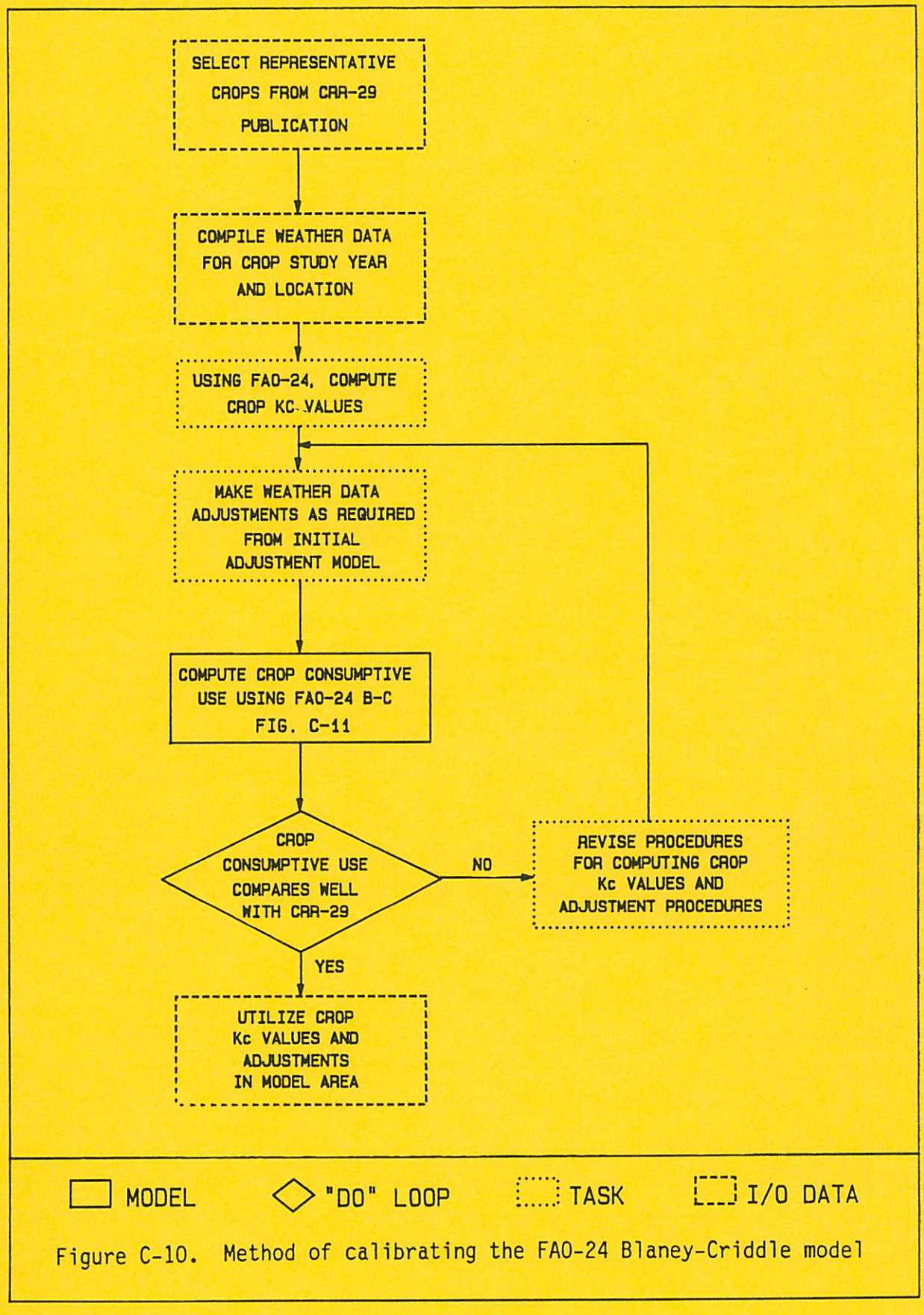


Figure C-10. Method of calibrating the FAO-24 Blaney-Criddle model

on the crop type and the effectiveness of water management and application utilized to meet the needs of the crop. In general terms, the irrigation water needs of a crop are known as the Net Irrigation Requirement (NIR) while the effectiveness of water management and application is called the efficiency. Dividing the NIR by the efficiency (expressed as a fraction of one) produces the water duty. The parameters which make up the NIR and efficiency are described below.

Net Irrigation Requirement

Under ideal conditions, the net irrigation requirement is comprised of five components and can be determined by Equation C-2.

EQUATION C-2

NIR = (Consumptive Use Requirement + Leaching Requirement + Other Water Needs) - Subbed Water - Annual Effective Precipitation

These five components are defined below.

Consumptive Use Requirement

The consumptive use requirement is the amount of water used by the vegetative growth in transpiration and building of plant tissue and water evaporated from the adjacent soil from the time of first plant water use to the time when plant water use ceases. Consumptive use is also known as evapotranspiration (ET), although ET does not include the water stored in the plant tissue. ET and consumptive use requirement (CU) will be utilized interchangeably in this discussion since the differences are negligible. DWR utilized the Food and Agricultural Organization of the United Nations Paper No. 24 Modified Blaney-Criddle (FAO-24) method (Doorenbos & Pruitt, 1977) for determining the ET for various crops in the San Pedro River watershed. The FAO-24 methodology employed by DWR also included a "rational use approach" to the use of this method, i.e., using rational judgment in the gathering and modification of input data. This methodology employs crop specific characteristics as well as local weather conditions to estimate the consumptive use of the crop. The general form of the equation is presented in Equation C-3.

EQUATION C-3

$$ETm = Kc \times ETo$$

Where:

ETm = evapotranspiration of the crop considered
Kc = specific crop coefficient
ETo = reference crop evapotranspiration

The "Kc" portion of Equation C-3 represents a specific crop's water use characteristic while the "ETo" portion of Equation C-3 represents the effects that local weather conditions have on crop consumptive use. FAO-24 considers factors such as measured temperature data as well as general levels of humidity, sunshine, and wind to predict the effects of local weather conditions. Values of ET and NIR for the various crops grown in the San Pedro River watershed can be found at the end of the Pre-season Effective Precipitation subsection under the Net Irrigation Requirements section. This relationship is expressed in the following equations. Figure C-11 provides a schematic of the procedure.

EQUATION C-4

$$ETo = a1 + b(f)$$

Where:

a1 = Blaney-Criddle "a" term computed in Equation C-5
b = Blaney-Criddle "b" term computed in Equation C-6 (Jensen, 1990)
f = Blaney-Criddle "f" term computed in Equation C-7

EQUATION C-5

$$a1 = ((0.0043)\ (X1)) - (X2) - (1.41)$$

Where:

X1 = Mean monthly minimum relative humidity (RH) in percent where X1 is greater than or equal to 0 and less than or equal to 100%.
X2 = Mean monthly fraction of sunshine (n/N) where X2 is greater than or equal to 0 and less than or equal to 1.0.

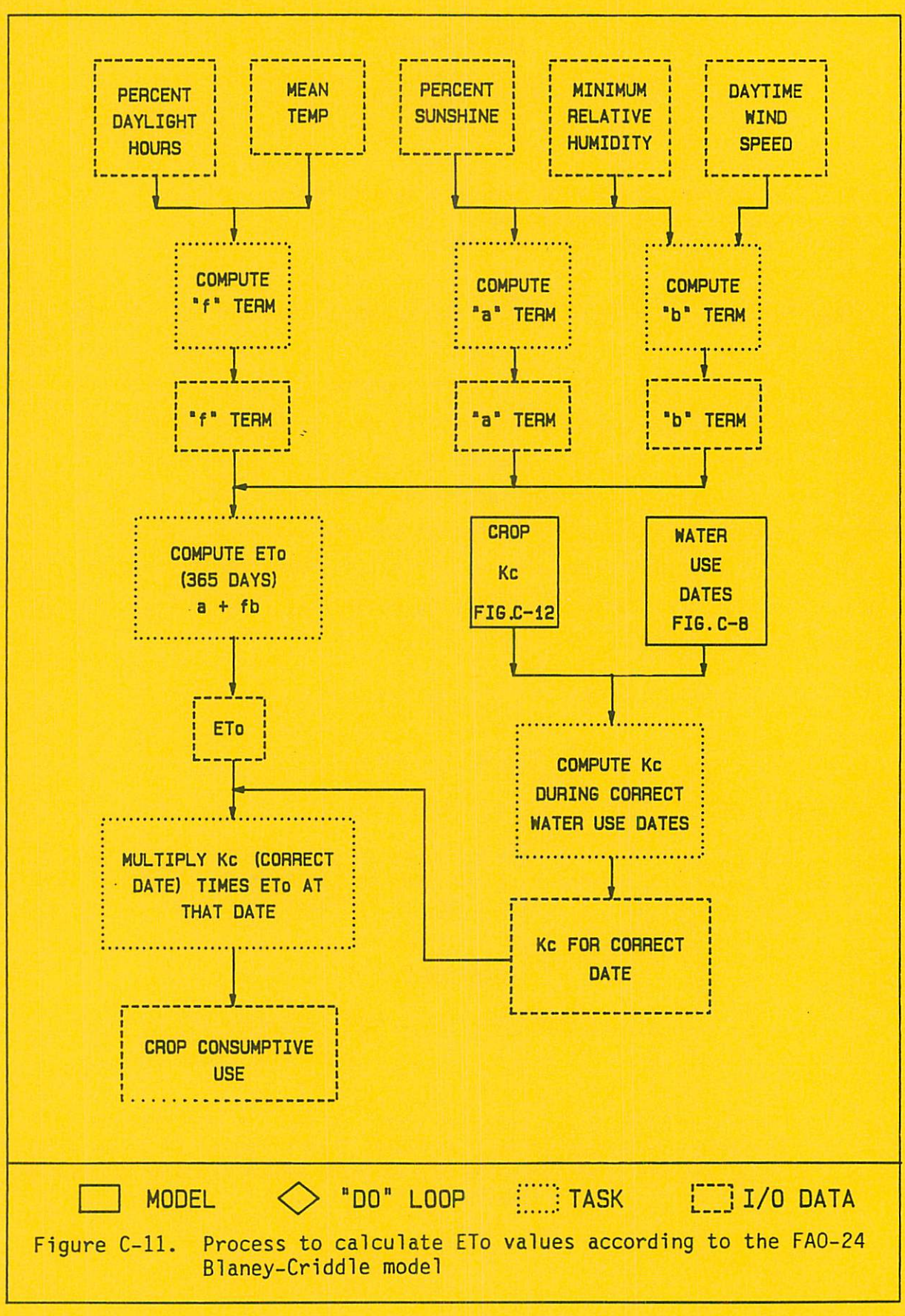


Figure C-11. Process to calculate ETo values according to the FAO-24 Blaney-Criddle model

EQUATION C-6

$$b = 0.908 - (0.00483)(X1) + (0.7949)(X2) + (0.0768)[(Ln(X3 + 1))^2] - (0.0038)(X1)(X2) - (0.000443)(X1)(X3) + (0.281)[Ln(X3 + 1)][Ln(X2 + 1)] - (0.00975)[Ln(X3 + 1)]([Ln(X1 + 1)]^2)[Ln(X2 + 1)]$$

Where:

X3 = Mean monthly daytime wind speed (U) in meters per second where X3 is greater than or equal to 0 and less than 10 meters per second

EQUATION C-7

$$f = P[(0.46Tm) + 8.13]$$

Where:

P = mean daily percent of total annual daytime hours
Tm = mean monthly temperature in degrees C

The method used in computing crop Kc factors is essentially the same as those outlined in FAO-24. Some other sources of information for computing crop Kc factors was also utilized, namely University of California Cooperative Extension Leaflets 21427 and 21428. Suggestions for selecting initial, peak, and final Kc values that best approximate conditions and practices in the San Pedro River watershed were followed (Figure C-12). In some instances, crop coefficients from two crops were combined to approximate conditions not represented in the above sources. For example, in the San Pedro River watershed, it is common practice to pasture livestock on an alfalfa crop in the beginning and the final months of the growing season. In this case, pasture Kc values were used in the first and final months of the growth period and alfalfa Kc values were used for the months between. Some other assumptions also had to be made about the use of Kc values. Okra was considered to have the same growth characteristics of chili peppers, mixed vegetables were considered to have a growth stage equal to an average of several vegetable crops such as beets, celery, cucumber, egg plant, lettuce, onion, peas, radish, spinach, squash and tomato. Turf was modeled after grass cut for hay.

Once the Kc value has been determined for a crop, it then can be multiplied by the ETo to obtain ET. Monthly ETo may be prorated depending

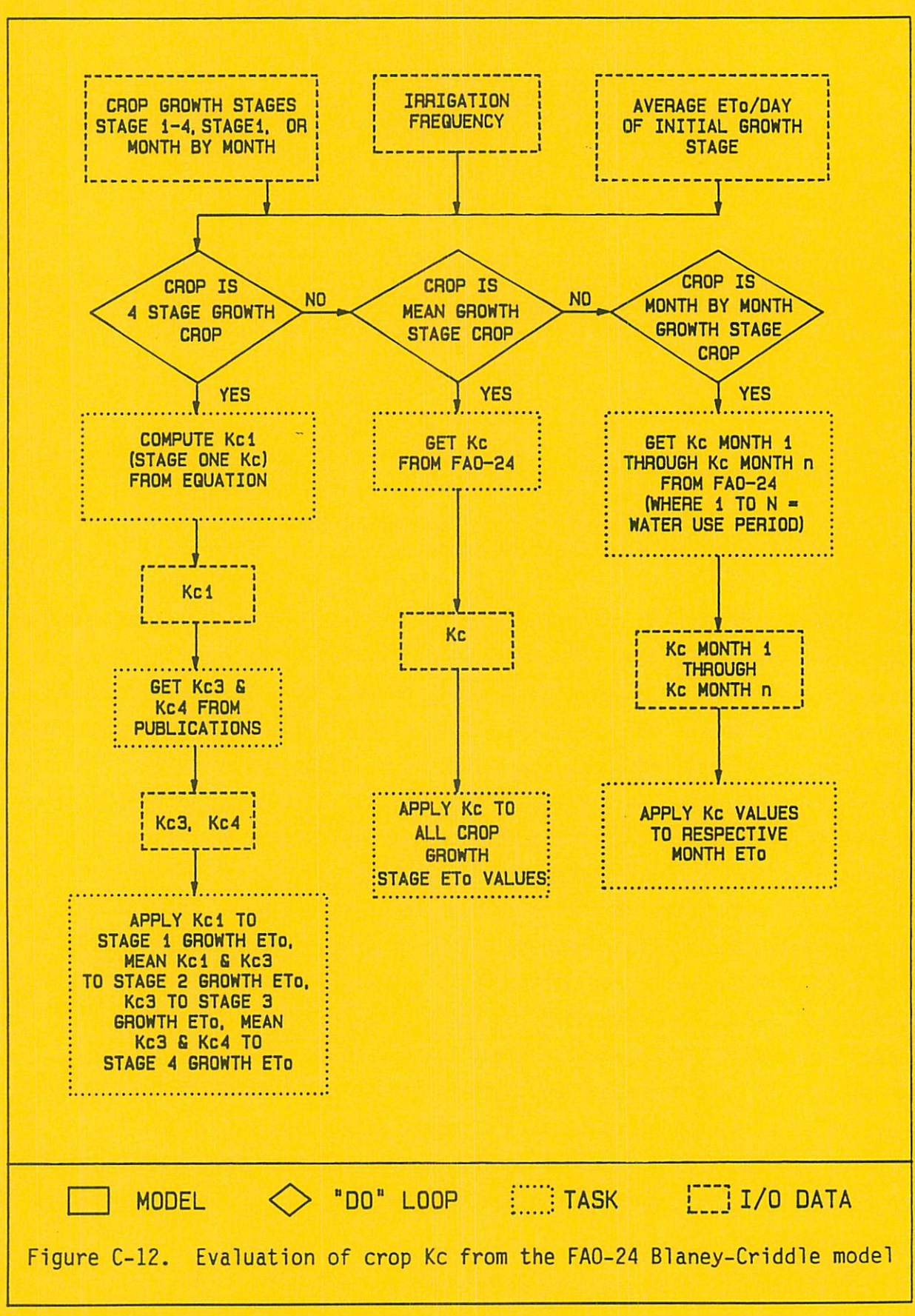


Figure C-12. Evaluation of crop Kc from the FAO-24 Blaney-Criddle model

upon the length of growth stage or the growth stage methodology. There are three basic growth stage methods employed which are dependent upon crop type.

The first growth stage method uses only one Kc value for each monthly ETo. This method is reserved for permanent crops such as permanent pasture. The prorating of monthly ETo is done only in beginning or end of the growth cycle where the entire month may not be utilized. Table C-5 gives the type of crops included in this method along with the Kc which is associated with each crop.

TABLE C-5

CROPS AND Kc VALUES USED IN FIRST GROWTH STAGE METHOD

CROP TYPE	Kc
Permanent Pasture	0.8
Winter Pasture	0.8
Summer Pasture	0.8
Turf	1.0
Pine Trees	1.2
Hay	0.9

The second growth stage method uses four Kc values and for each Kc there is a corresponding growth period associated with it. This method usually is employed for annual crops such as corn. Prorating the monthly ETo is dependent upon where the growth period begins and ends in each month or overlapping months. Table C-6 shows the type of crop, growth periods per Kc, Kc3, Kc4, and in some cases Kc1 or initial Kc. Kc is calculated using the equation developed in Cooperative Extension University of California Leaflet 21427. Initial Kc (Kc1), in most cases, was calculated but some exceptions were made due to the calculated values being too high or low. Kc2 is not listed since it is a value calculated from the methods described in FAO-24 and is a midpoint of the Kc1 and Kc3 values.

The final growth stage method employs a monthly Kc for each month of growth. This method is used mostly for orchard type crops such as pecans. Each month will have a different Kc assigned to it, so proration of the monthly ETo will come at the beginning or the end of the growth cycle where the entire month may not be used. Table C-7 shows the monthly Kc by crop type.

TABLE C-6

CROPS AND Kc VALUES USED IN SECOND GROWTH STAGE METHOD

CROP TYPE	Kc1	Kc3	Kc4	DAYS/GROWTH STAGE 1	2	3	4
Small Grains		1.10	0.25	19	38	82	50
Cotton	0.20	1.20	0.40	33	54	60	49
Sorghum		1.10	0.55	20	31	41	30
Mixed Vegetables		1.03	0.86	23	32	43	17
Okra		1.05	0.85	29	40	46	23
Pinto Beans		1.15	0.25	19	29	39	20
Grapes	0.27	0.82	0.32	30	36	60	57
Melons	0.18	1.10	0.10	23	44	28	28
Corn		1.15	0.60	20	31	41	30

TABLE C-7

CROPS AND Kc VALUES USED IN THIRD GROWTH STAGE METHOD

CROP TYPE	Kc BY MONTH FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
Alfalfa	0.80	0.85	0.95	0.95	0.95	0.95	0.95	0.95	0.90	0.85
Orchard with cover		0.85	1.00	1.15	1.25	1.25	1.20	0.95	0.85	0.79
Orchard without cover			0.75	0.95	1.00	1.00	0.95	0.90	0.85	0.71
Pecans with cover		0.85	0.95	1.05	1.15	1.15	1.15	1.10	0.90	0.86
Pecans without cover			0.70	0.85	0.90	0.90	0.90	0.80	0.70	0.81

To calculate the consumptive use of permanent pasture for the area, the calculations in Example C-1 through C-3 must be performed.

EXAMPLE C-1

ETo CALCULATION
SIERRA VISTA
MAY (31 DAYS)

Given:

Temperature:	18.89°C
Relative humidity:	18.70%
Wind (corrected):	1.45 meters per second
Sunshine ratio:	0.94
Percent daylight:	0.31

EXAMPLE C-1 (cont'd)

Solve "a1" term

Equation C-5 and substitute

$a1 = [(0.0043)\ (18.7)] - (0.94) - (1.41)$

$a1 = -2.27$

Solve "b" term

Equation C-6 and substitute

$b = 0.908 - [(0.00483)\ (18.7)]$
$+ [(0.7949)\ (.94)]$
$+ (0.0768)\ [Ln(1.45 + 1)]^2$
$- (0.0038)\ (18.7)\ (0.94)$
$- (0.000443)\ (18.7)\ (1.45)$
$+ (0.281)\ [Ln(1.45 + 1)]\ [Ln(0.94 + 1)]$
$- (0.00975)\ [Ln(1.45 + 1)]\ [(Ln[18.7 + 1])^2]\ [Ln(.94 + 1)]$

$b = 1.66$

Solve "f" term

Equation C-7 and substitute

$f = P[(0.46 \times Tm) + 8.13]$

$f = 0.31\ [(0.46 \times 18.89) + 8.13]$

$f = 5.21$

Solve ETo

Equation C-4 and substitute

$ETo = a1 + b(f)$

$ETo = -2.27 + (1.66)\ (5.21)$

$ETo = 6.38$ millimeters per day

convert from millimeters per day to inches per month (May)

$$ETo = \frac{6.38 \text{ millimeters per day} \times 31 \text{ days per month (May)}}{25.4 \text{ millimeters per inch}}$$

$ETo = 7.79$ inches per month (May)

EXAMPLE C-2

MONTHLY CONSUMPTIVE USE CALCULATIONS FOR MAY PERMANENT PASTURE

Given:

ETo from Example C-1 = 7.79 inches for May
Kc from Table C-5 = 0.80

Solve Equation C-3 for the month of May and for permanent pasture

EXAMPLE C-2 (cont'd)

Where:

ET = 0.80 x 7.79
ET = 6.23 inches for May

Example C-3 shows the annual consumptive use of permanent pasture. Note that results of Example C-2 are incorporated into Example C-3 for the month of May.

EXAMPLE C-3

ANNUAL CONSUMPTIVE USE CALCULATIONS
PERMANENT PASTURE

MONTH	Kc1		ETo (INCHES)		ET (INCHES)
January	0.8	x	1.69	=	1.35
February	0.8	x	2.56	=	2.05
March	0.8	x	4.14	=	3.31
April	0.8	x	5.69	=	4.55
May	0.8	x	7.79	=	6.23
June	0.8	x	8.61	=	6.89
July	0.8	x	7.70	=	6.16
August	0.8	x	6.65	=	5.32
September	0.8	x	5.63	=	4.50
October	0.8	x	4.30	=	3.44
November	0.8	x	2.71	=	2.17
December	0.8	x	1.93	=	1.54
TOTAL					47.51

The total annual evapotranspiration (ET) for permanent pasture in the above example is 47.51 inches or 3.95 acre-feet.

Leaching Requirement

The leaching requirement is an additional increment of water used to prevent reductions in crop yield due to high soil salinity related to high total dissolved solids in the irrigation water. Based on DWR's field observations and the quality of water available for irrigation use, the leaching requirement is considered negligible for the San Pedro River watershed.

Other Water Needs

The other water needs component refers to the water required for purposes other than crop consumptive use. Some vegetable crops, for example, need additional water for germination and quality control. It also may include water requirements for frost protection, prevention of wind erosion, or plant cooling. The other water needs requirement for the crops grown in the San Pedro River watershed is considered negligible.

Subbed Water

Subbed water is the amount of the water available from high groundwater tables to meet crop consumptive use requirement. In the San Pedro River watershed, subbed water is considered negligible. No areas were observed during DWR's investigations that appeared to have a portion of the crop's consumptive use requirement met by high water tables. There are several cienega areas in the Babocomari River drainage where subbed water is a factor in the growth of native grasses. These cienegas do not receive any irrigation water and thus are not considered irrigated areas.

Annual Effective Precipitation

A portion of the annual precipitation falling on irrigated acreage in the San Pedro River watershed is considered to be effective in meeting the water demands of a crop. DWR makes a distinction between two types of effective precipitation based on whether the precipitation is received during or prior to the growing season. Effective precipitation (EP) is the portion of annual precipitation falling on cropped acreage during the growing season and provides some of the water consumptively used by the crop. Pre-season effective precipitation (PEP) is the amount of water that falls on fallow acreage and is held within the soil root zone for future crop use. Calculation methods for PEP are discussed later in this Appendix.

1. Effective Precipitation (EP)

DWR used the SCS TR-21 method (Soil Conservation Service, 1967) for computing effective precipitation. This empirical model, developed at twenty-two sites in the continental United States with fifty years of data, depends on four main factors, annual precipitation, crop evapotranspiration rate, net depth of application, and a percent chance of occurrence factor. Annual precipitation has an obvious influence on the amount of effective

precipitation. The crop evapotranspiration rate determines how quickly the soil moisture is depleted. In the TR-21 model, this is a measure of how much volume in the soil is available to hold precipitation. The net depth of irrigation is used to emulate the management allowed depletion (MAD) or the amount of soil water deficit allowed before the next irrigation. The net depth of application depends on the soil moisture at the start of the season and the irrigation practices. DWR assumes a 3 inch net depth of application value for the San Pedro River watershed. The fourth factor, percent chance of occurrence, is an expression of the dependable amount of rainfall for use in planning an irrigation supply. The effective precipitation model is illustrated in Figure C-13.

The percent chance of occurrence used by DWR is 50 percent. Table 7 in Soil Conservation Service Technical Release 21 (1967) lists percent chance of occurrence factors for several chances of occurrence and the average annual rainfall. DWR chose to represent values of effective precipitation at 50 percent chance of occurrence as this will represent an average amount of effective precipitation. DWR does acknowledge the variability in irrigation water supplies but is obligated to report the amount of water used on "average" and this would in part translate to the amount of water supplied on "average."

The form of the empirical relationship from SCS TR-21 is as follows:

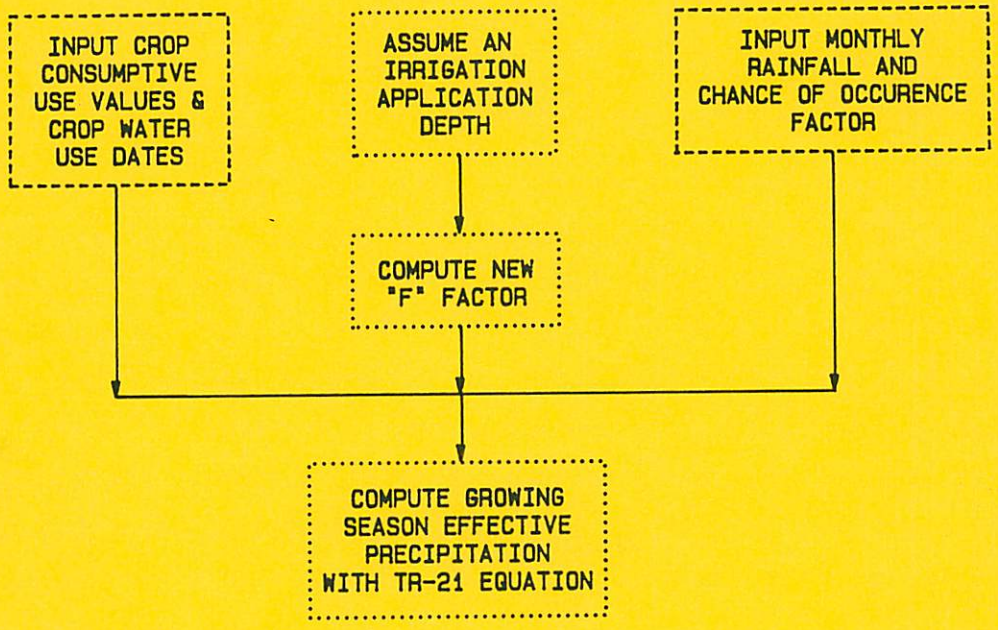
EQUATION C-8

$$EP = (0.70917\ Rt^{0.82416} - 0.11556)\ (10^{0.02426ET})\ (F)\ (cof)$$

Where:

EP = re = Effective Precipitation (inches/month)
ET = u = Crop evapotranspiration (inches/month)
Rt = Precipitation (inches/month)
F = (0.531747 + 0.295164D - 0.057697D2 + 0.003804D3)
D = Net Depth of Application (inches/application)
cof = chance of occurrence factor
Care must be taken that EP does not exceed Rt or ET.

The effective precipitation for double cropped crops can vary as a function of the crop mix. In cases where one crop overlaps another crop's regular season, the effective precipitation for only the portion of the crop's season is calculated. For instance, when alfalfa is double cropped with



MODEL "DO" LOOP TASK I/O DATA

Figure C-13. Calculating effective precipitation using the TR-21 model

sorghum, only the portion of the year in which the alfalfa was growing was used to calculate alfalfa consumptive use and effective precipitation.

The effectiveness of precipitation on deficit irrigated crops was also calculated. This is discussed in the section on Deficit Irrigation.

Effective precipitation was calculated for each crop within each subwatershed. The weighted average effective precipitation of the subwatershed values can be found at the end of the next section.

2. Pre-season Effective Precipitation

DWR also considered the effects of pre-season effective precipitation in meeting the water requirements for crops. Pre-season effective precipitation is the amount of precipitation falling on a field during the time that the field is fallow and stored in the soil profile for later use by the crop. Hanks and Ashcroft (1980) state that "In the summer fallow system, . . . about 30 percent of the fallow year precipitation is conserved for use by plants the next year." About the same percentage of precipitation is also reported to accumulate in Texas (Howell, 1991, personal communication). This amount of water can be an appreciable amount and should not be totally ignored.

DWR looked at several different methods for quantifying the amount of pre-season effective precipitation in the San Pedro River watershed. Previously published methods do not appear to be well suited to compute PEP during the summer months. Three basic models were looked at for computing PEP. Two were reported in Jensen, Burman, and Allen (1990) and are termed here as the "Jensen PEP" model and the "SCS TR-21 PEP" model. The third model is presented in FAO-24 and will be termed the "FAO-24 PEP" model. The first two models do not take into account the magnitude of evaporation from bare soils and do not seem to be suited for Arizona summer conditions. The author states that the SCS equation "may be used to estimate the effectiveness of fall and winter precipitation by . . . setting E_t (ET) to a low value." Clearly this model is not intended to estimate effectiveness of summer precipitation. The Jensen PEP model is used ". . . for approximating the effectiveness of fall-winter precipitation to replenish fall soil water deficits . . . ." This also appears to be intended for estimating the effectiveness of fall and winter precipition only.

The FAO 24 PEP model computes the evaporation from bare soils based on the water content of the soil surface and frequency and depth of rain. Although these are the main factors which should be considered in computing bare soil evaporation, this model only computes bare soil evaporation based on average precipitation frequencies. When based on average precipitation frequencies and amounts in the San Pedro River watershed, the amount of bare soil evaporation computed from this model is much higher than the average amount of rainfall. The documentation for this model is also unclear whether the model can be used to compute pre-season effective precipitation during the summer season.

To compute the pre-season effective precipitation in a way that could be considered adequate for any time of the year in the San Pedro watershed, DWR must compute how much water evaporates from the soil after an individual rainfall event. Jensen, Brockway, and Allen (1990) report that evaporation from bare soils occurs as a two stage process (Figure C-14). In the first stage, evaporation is controlled by the amount of energy input and is about 90 percent of the potential rate of evapotranspiration. The duration of this stage is influenced by the rate of evaporation, soil depth, and hydraulic properties of the soil.

The cumulative loss of water for the first stage can be calculated from Equation C-9.

The second stage evaporation is occuring below the soil surface and is limited not as much by meterological conditions as by soil characteristics. These soil characteristics define how tightly, at any given soil moisture content, each molecule of water in the soil is held. The cumulative second stage evaporation decreases with the square root of time for a given soil and evaporative demand (Figure C-14). The cumulative loss of water for the second stage of drying can be calculated from Equation C-10.

EQUATION C-9

$$We1 = \int_{t=0}^{t} 0.9(Etp)dt$$

Where:

We1 = cumulative loss of water to evaporation in the first stage of drying
t = time from precipitation to beginning of second stage
t1 = duration of first stage of drying
Etp = potential rate of evapotranspiration

EQUATION C-10

$$We2 = Ce(t-t1)^{\frac{1}{2}} \text{ for } t > t1$$

Where:

We2 = cumulative loss of water to evaporation in the second stage of drying
Ce = empirical soil constant
t = soil drying time
t1 = duration of first stage of drying

Time t is considered the amount of time until either the soil drys to the wilting point or a rainfall or irrigation event occurs. Then calculating time t1 allows the total evaporation from the soil to be computed. Consequentially, the amount of water contributed to the soil from the rain is also computed.

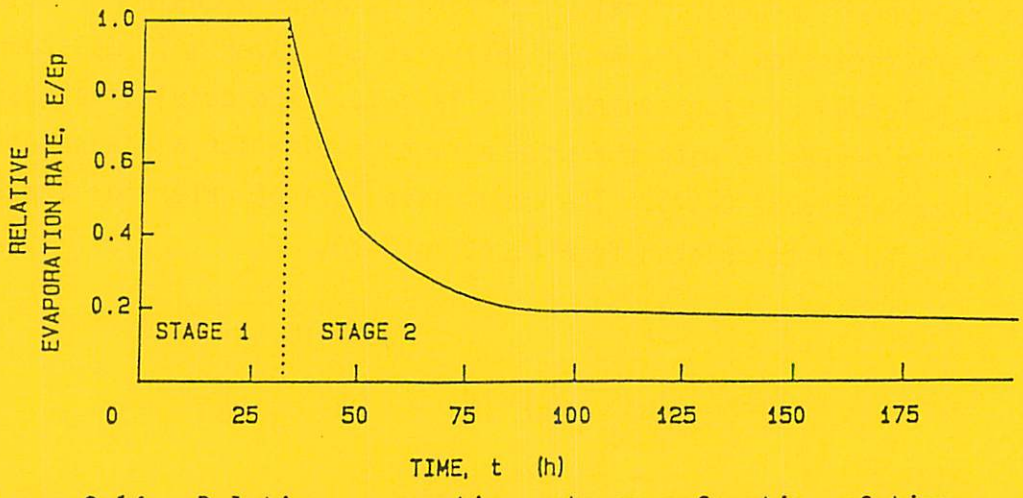


Figure C-14. Relative evaporation rate as a function of time. During stage 1, evaporation is controlled by the climate. During stage 2 the evaporation is controlled by the soil (Hanks and Ashcroft, 1980).

Hanks and Ashcroft (1980) report an equation developed by Gardner and Hillel (1962) that predicts the evaporation rate during the second stage of drying. Hanks and Ashcroft state that the time when the second stage begins and the first stage ends can be predicted from this model. Since the stage 2 rate must necessarily be less than the stage one rate, one only needs to compute the time at which the rate of drying drops below 90 percent of Etp. Hanks and Ashcroft (1980) also state that, "In the evaporation process, the gravitational gradient is so small compared to the matric potential that it can usually be ignored. Thus, horizontal flow equations can be used for vertical evaporation problems with little loss in accuracy." The rate of stage 2 drying was predicted using Equation C-11.

EQUATION C-11

$$E = \frac{Dw\ Cv\ (\pi)^2}{4Zw}$$

Where:

E = evaporation rate (cm/day)
Dw = water diffusivity (cm/day)
Cv = volume water content
Zw = depth of wetting front

Also,

$$Dw = Kw\ \frac{\triangle Mp}{\triangle Cv}$$

Where:

Kw = hydraulic conductivity (cm/s)
Mp = matric potential (cm)
Cv = volume water content

By Substitution:

$$E = Kw \frac{\triangle Mp}{\triangle Cv} \times \frac{Cv\ (\pi)^2}{4\ Zw}$$

For each selected time increment from the moment of wetting, the ability of the soil to supply water to the atmosphere can be compared with the ability of the atmosphere to take the water, or E can be compared with 0.9Etp. For

each increment of time, a new volume water content can be calculated since it is assumed that the evaporative rate is equal to 0.9Etp for each increment up to time t1. Once the new volume of water content at that time is computed, the unsaturated hydraulic conductivity and matric potential can be obtained from a table. The new variables can then be substituted back into the equation to see if E is less than 0.9Etp. When this happens, the second stage process has begun.

The depth of evaporative influence on the soil must also be assumed. The influence that evaporation has on the soil decreases with soil depth until it becomes negligible. Hanks and Ashcroft (1980) state that ". . . water that penetrates below about 25 cm (10 inches) for nonswelling (noncracking) soils has very little likelihood of being lost by evaporation." In a study by Martin, Watts, and Gilley (1984), a surface layer of 2 inches was used to control the evaporation rate. They also state that evaporation was considered to have ceased when the top two soil layers (4 inches) dropped to the air-dry soil moisture content. For DWR's purposes, a four inch layer of soil was considered to control the evaporation process. Any precipitation that can penetrate past the top four inches of soil and not percolate past the root zone was considered effective. Also, any plant available moisture in the top four inches at the time of planting was considered effective. The amount of rain necessary to penetrate the top four inches varied according to the moisture content within the top soil layer at the time of the rainfall. Runoff from the soil was said to be negligible and precipitation losses would only occur through evaporation or by deep percolation past the root zone.

The timing of precipitation events is very critical in this type of analysis. For example, if two events both measuring 0.5 inches were to occur within two days of one another and the top layer of soil required 0.5 inches to be full, it is obvious, assuming no runoff, that the first event would fill the voids in the top layer of soil and the second event would likely allow some water to penetrate past the four inch evaporative zone and be stored for later use by the crop. However, if the two events were to occur two months apart with no other moisture inputs between times, the top layer of soil would likely have evaporated all of the water received from the first event so that the second event goes only to filling the evaporative zone and is not saved for later use by a crop.

In DWR's analysis, 20 years of daily precipitation data from Cascabel was analyzed. If precipitation measured on consecutive days, the precipitation was considered as one event. If trace amounts of rainfall occurred, these were considered to have been days where the amount of precipitation equalled the amount of evaporative demand or Etp = 0. Days of significant or trace events were days where evaporative demand, or Etp, was very low, overall. Although evaporation did take place, water was said to have been evaporated equally from both the rain gage and the field. See Figure C-15.

Using the values of t1 (the time when second stage evaporation begins) and t (the time when the soil reaches the wilting point or the next rainfall event occurs), the cumulative evaporation was calculated from the four inch zone. Any moisture remaining in this zone is then considered at the time of the next event. If the top zone was at field capacity at the time of the next event, the volume of the next event was effective in suppling moisture for later plant growth. If a portion of the rainfall is used to fill the 4 inch depletion zone to field capacity, only the remaining portion is effective in supplying moisture for later plant growth. Evaporation and accumulated soil moisture was calculated for each specific event for all years of data. The evaporation was calculated from the time of one specific date of occurrence to the next specific date of occurrence or until the soil reached the wilting point. It was also assumed that no transpiration losses occurred from the soil during the off-season (Figure C-15). Refer to Figure C-16 and C-17.

DWR also limited the pre-season effective precipitation to the amount of moisture that the soil can hold at any given time. For DWR's purposes, it was assumed that all of the irrigated lands of the San Pedro River watershed consist of homogenous soil since most of the irrigated lands within the watershed are on the alluvial material of the San Pedro River. The soil parameters defined earlier in this discussion are a loamy soil with an 8 inch water holding capacity in a 48 inch profile. Hydraulic conductivities and matric potentials were obtained for a loamy soil from Hanks and Ashcroft (1980).

Once the pre-season effective precipitation for the Redington subwatershed was computed, a percentage of total precipitation per month verses effective precipitation per month was derived. This percentage value was then applied against total precipitation in other subwatersheds rather

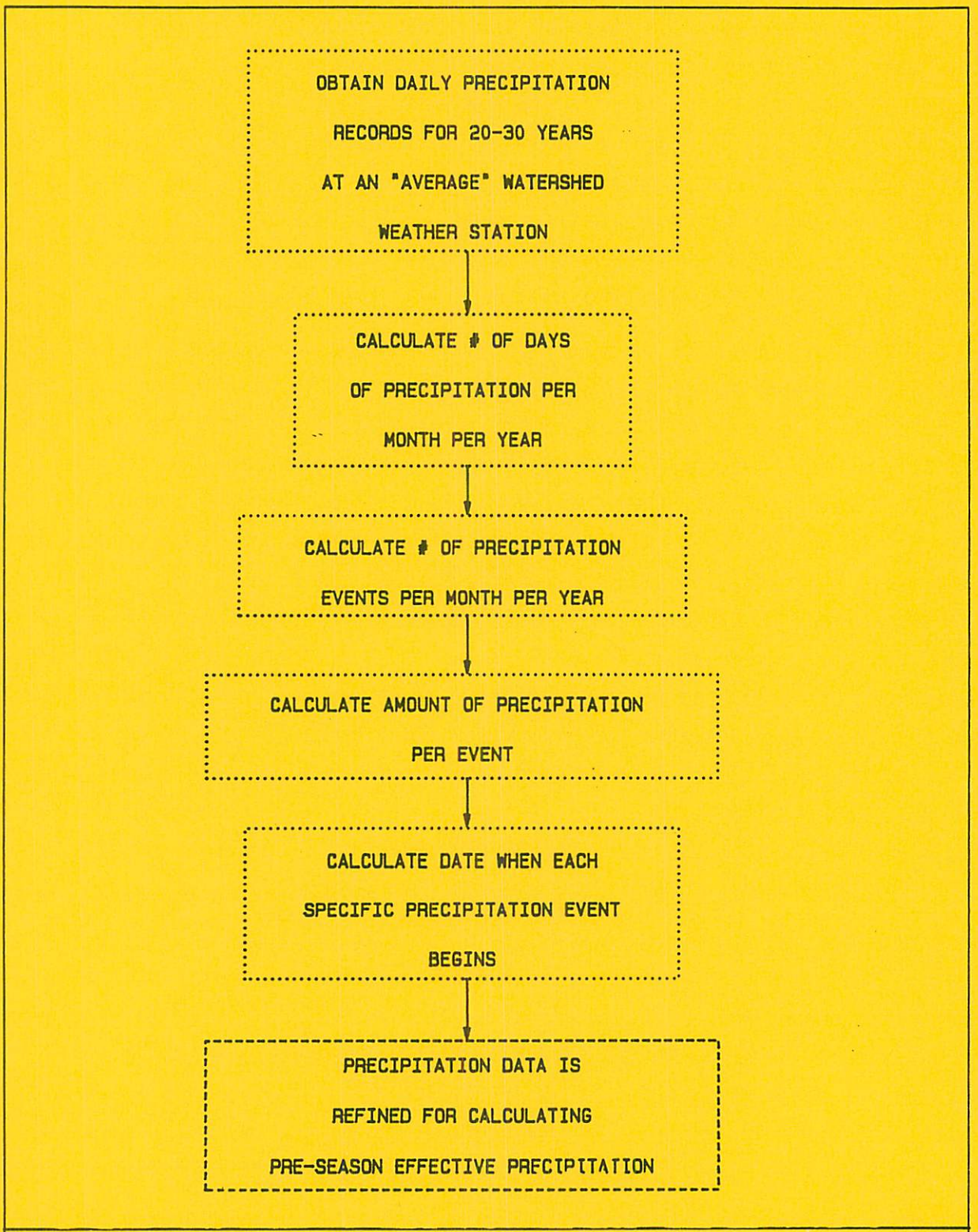


Figure C-15. Refining precipitation data for computing pre-season effective precipitation

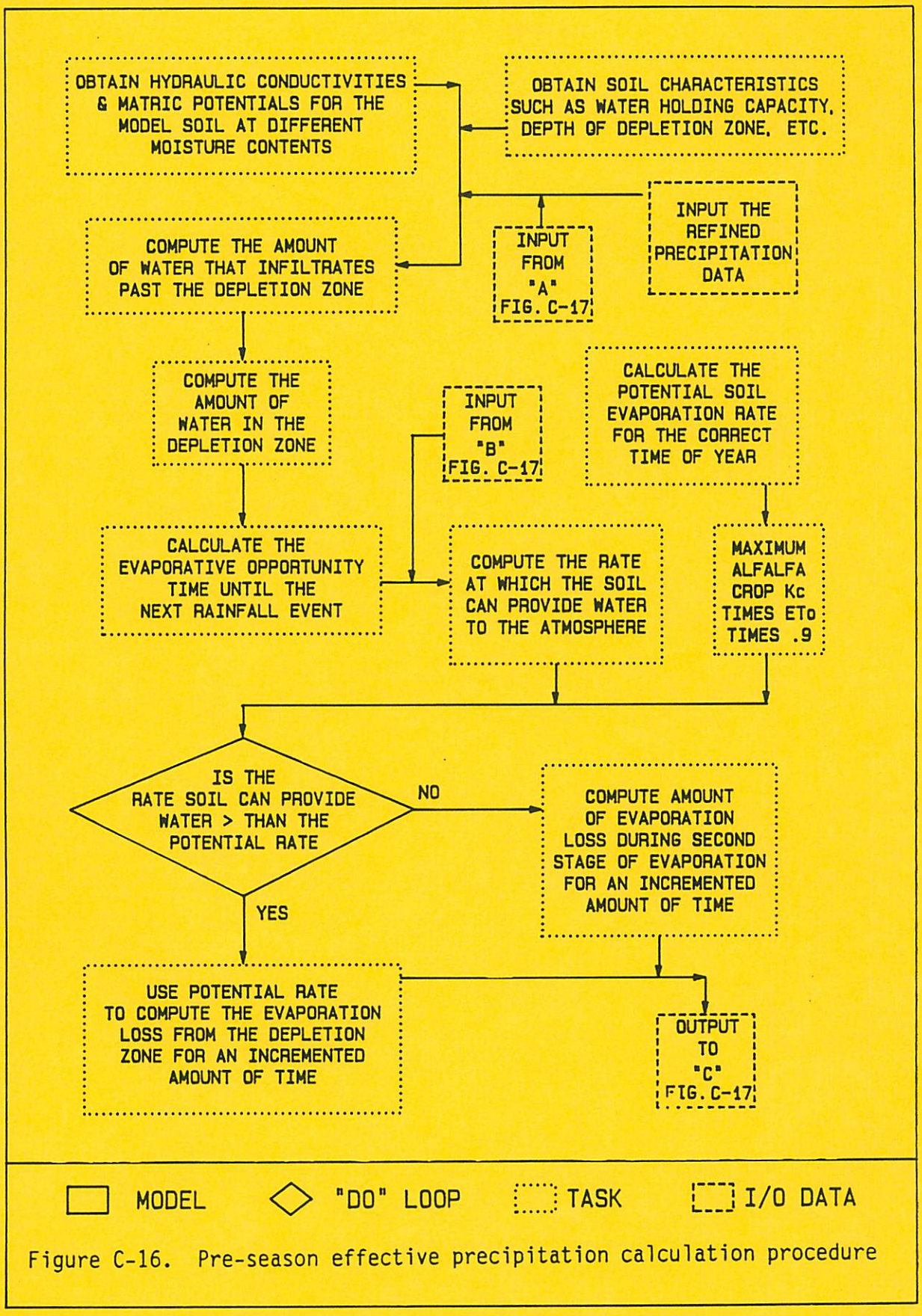


Figure C-16. Pre-season effective precipitation calculation procedure

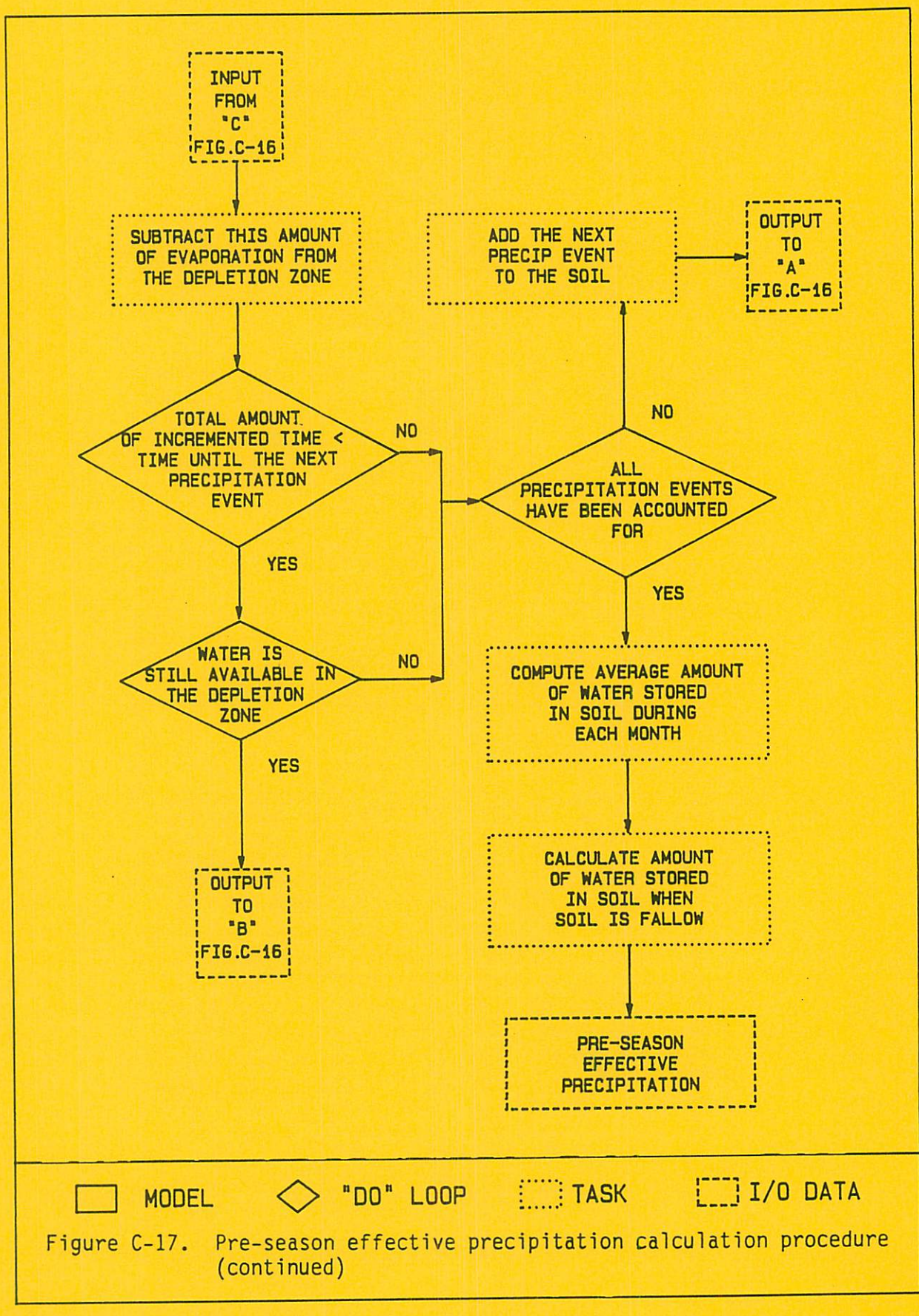


Figure C-17. Pre-season effective precipitation calculation procedure (continued)

than computing PEP directly. Table C-8 provides a list of the values obtained for the Redington subwatershed.

TABLE C-8

PRE-SEASON EFFECTIVE PRECIPITATION
AS A PERCENTAGE OF TOTAL PRECIPITATION
REDINGTON SUBWATERSHED

MONTH	PRECIPITATION	PRE-SEASON EFFECTIVE PRECIPITATION	PERCENTAGE OF PRE-SEASON PRECIPITATION
January	0.98	0.35	0.36
February	0.92	0.50	0.54
March	0.91	0.26	0.29
April	0.33	0.02	0.05
May	0.55	0.09	0.16
June	0.49	0.15	0.31
July	2.28	0.82	0.36
August	2.52	1.16	0.46
September	1.52	0.76	0.50
October	1.56	0.53	0.34
November	0.70	0.16	0.23
December	1.05	0.36	0.34

Since the leaching requirement, other water needs, and subbed water components are negligible within the San Pedro River watershed, Equation C-2 can be reduced to:

EQUATION C-12

NIR = Consumptive Use Requirement - Effective Precipitation

Equation C-12 is used to determine the NIR for each crop identified within each subwatershed and represents the values that DWR utilized in the maximum observed, regional, and maximum potential quantifications that will be described later. The results of the procedures mentioned above for normal irrigated crops are shown in Table C-9.

In some instances, Table C-9 lists a crop more than one time. This is due to the crop being observed during the spring crop survey, the fall crop

survey, or during both surveys. A different weight may have been associated with each depending on prevalence in each subwatershed when weighted consumptive use values were calculated.

TABLE C-9

WEIGHTED AVERAGE CROP CONSUMPTIVE USE,
EFFECTIVE PRECIPITATION, AND NET IRRIGATION REQUIREMENTS
SAN PEDRO RIVER WATERSHED

CROP	ET	EP	PEP	NIR
Alfalfa	4.11	0.69	0.09	3.33
Alfalfa (rotating out)	2.11	0.12	0.41	1.58
Alfalfa (rotating in)	2.00	0.60	0.12	1.28
Corn (A)	2.10	0.66	0.18	1.26
Corn (B)	2.09	0.66	0.19	1.24
Corn (C)	1.78	0.56	0.15	1.07
Cotton	2.87	0.50	0.08	2.29
Melons	1.98	0.51	0.15	1.32
Summer pasture (A)	2.84	0.66	0.18	2.00
Summer pasture (B)	2.57	0.58	0.13	1.86
Summer pasture (C)	2.70	0.61	0.14	1.95
Small grains (A)	1.23	0.27	0.43	0.53
Small grains (B)	0.86	0.10	0.34	0.42
Small grains (C)	0.25	0.08	0.17	0.00
Pinto beans	1.41	0.37	0.20	0.84
Mixed vegetables (A)	1.76	0.53	0.21	1.02
Mixed vegetables (B)	1.88	0.57	0.23	1.08
Sorghum	1.58	0.38	0.16	1.04
Orchard without ground cover	3.69	0.61	0.13	2.95
Grapes	1.99	0.58	0.12	1.29
Hay	3.00	0.51	0.16	2.33
Landscaping	1.98	0.32	0.10	1.56
Orchard with ground cover	4.24	0.59	0.13	3.52
Pasture	3.95	0.78	0.01	3.16
Pecans	3.07	0.57	0.12	2.38
Pecans with ground cover	4.17	0.56	0.11	3.50
Pine trees	5.90	0.92	0.00	4.98
Turf	3.23	0.58	0.14	2.51
Unknown crop	4.01	0.75	0.12	3.14
Winter pasture	1.00	0.21	0.33	0.46
Alfalfa DC with sorghum	3.79	0.75	0.12	2.92
Alfalfa DC with small grain	2.39	0.21	0.16	2.02
Alfalfa DC with summer pasture	3.38	0.63	0.14	2.61
Fruit trees DC with vegetables	2.10	0.50	0.12	1.48
Small grain DC with sorghum	2.66	0.65	0.08	1.93
Small grain DC with okra	2.83	0.57	0.09	2.17
Small grain DC with corn	2.74	0.57	0.10	2.07
Small grain DC with summer pasture	3.80	0.85	0.13	2.82
Small grain DC with cotton	3.68	0.66	0.06	2.96
Small grain DC with pinto beans	2.30	0.55	0.10	1.65
Small grain DC with alfalfa	2.92	0.70	0.08	2.14

TABLE C-9 (cont'd)

CROP	ET	EP	PEP	NIR
Summer pasture DC with winter pasture	3.37	0.59	0.04	2.74
Summer pasture DC with small grain	2.95	0.70	0.15	2.10
Winter pasture DC with alfalfa	2.93	0.72	0.08	2.13
Winter pasture DC with corn	2.81	0.69	0.08	2.04
Winter pasture DC with sorghum	2.69	0.65	0.08	1.96
Winter pasture DC with vegetables	2.60	0.61	0.06	1.93
Winter pasture DC with summer pasture	3.58	0.71	0.14	2.73

NOTE: DC means double cropped.

Irrigation Efficiency

Irrigation efficiency is defined in general terms as the effectiveness of water management and application in meeting the net irrigation requirement of a crop throughout the growing season. The efficiency of all irrigation can change from one irrigation to the next. DWR prefers to describe efficiency as an average of all irrigations. The efficiency value most mentioned in this discussion is farm irrigation efficiency, otherwise referred to as efficiency. This is defined as the volume of irrigation water consumptively used by the crop plus any management water, divided by the volume delivered to the farm. This efficiency value includes losses due to on farm conveyance systems as well as losses due to farm irrigation application systems. The other efficiency value often used by DWR in this discussion is Field Application Efficiency or Application Efficiency. This is defined as the volume of water placed in the root zone divided by the water delivered to the field. This value would describe the efficiency of a single irrigation event.

In the San Pedro River watershed, DWR has found inadequate or unavailable data for direct calculation of efficiency values for the watershed. The procedure employed by DWR to estimate efficiencies involves several processes. DWR has developed a set of criteria to describe and categorize irrigation systems and field conditions. Efficiency values from within or near the watershed as well as those published in literature were categorized according to the developed criteria. The data from within the watershed was determined to be the most representative of the watershed, data from nearby locations was determined to be nearly as dependable while published data was

considered the least representative of the watershed. Based on these factors, an efficiency value for each irrigation system and category was derived that would represent all irrigation systems falling within that category and system type (Figure C-18).

The analysis above determines the farm irrigation efficiency of a field that is irrigated in a normal fashion. When the manager or irrigator under irrigates the crop, the irrigation efficiency increases due to fewer losses of water to percolation past the crop root zone. DWR has calculated irrigation efficiencies for deficit irrigated fields based in part upon the efficiency values of a normally irrigated field. The methodology used to compute these values are presented in the deficit irrigation discussion of this report.

The following outline lists the condition of the acreage and the irrigation system types. Table C-10 shows the efficiency categories developed by DWR for these acreage conditions and irrigation system types.

A. Condition of Irrigated Acreage

1. Excellently Maintained

- lined ditches, weed free or pipelines
- measuring devices present
- nonleaking drip systems, sprinklers, or laser levelled flood systems
- uniform and healthy crop growth

2. Maintained

- unlined ditches in good condition (no major leaks or spillage), weed free
- sprinkler system intact (small leaks noted)
- field not laser levelled but properly sloped, borders in good condition
- weeds with crop, small amount of nonuniformity in crop growth

3. Poorly Maintained

- ditches containing weeds and poorly maintained
- field borders in poor condition
- field uneven
- sprinkler pipelines broken
- nonuniform crop growth

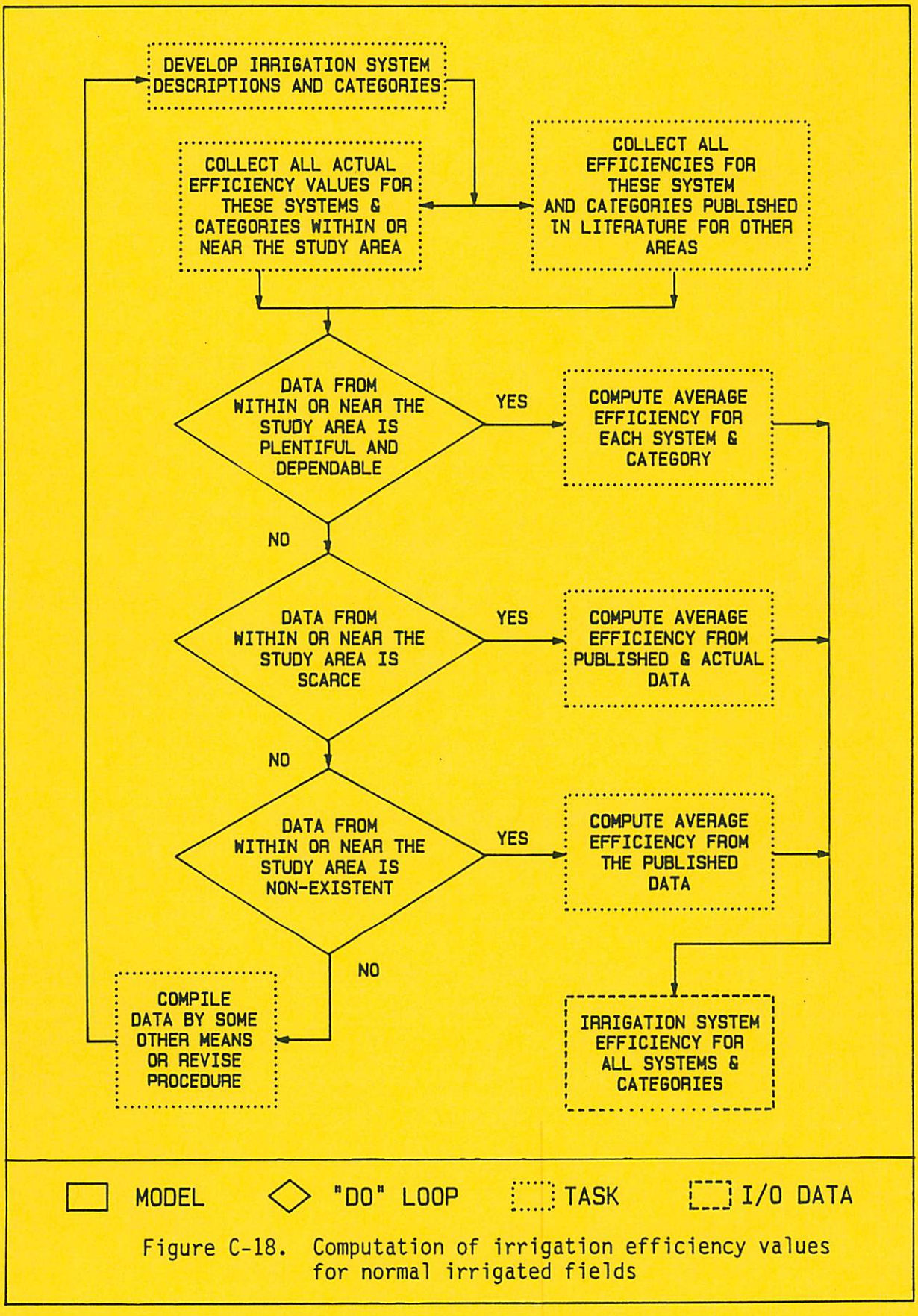


Figure C-18. Computation of irrigation efficiency values for normal irrigated fields

4. Plowed or Fallow

- unknown field condition, crop, or no irrigation system present

B. Type of Irrigation System

A - flood system without pumpback - tailwater recovery system
B - flood system with pumpback - tailwater recovery system
D - drip or trickle system
L - level basin system (laser levelled)
S - sprinkler system

The efficiency values for the San Pedro River watershed are given in Table C-10.

TABLE C-10

FIELD CATEGORIES, SYSTEM TYPES, AND IRRIGATION EFFICIENCIES FOR NORMAL IRRIGATED CROPS

CATEGORY	EFFICIENCY	CATEGORY	EFFICIENCY	CATEGORY	EFFICIENCY
1A	0.50	2A	0.45	3A	0.32
1B	0.70	2B	0.59	3B	0.40
1D	0.80	2D	0.67	3D	0.48
1L	0.80	2L	0.60	3L	0.40
1S	0.72	2S	0.58	3S	0.38

No efficiency value is assigned to plowed or fallow fields (category 4).

Deficit Irrigation

Deficit irrigation is considered by DWR to be an irrigation management practice in which the irrigator applies less water than is necessary to produce a crop of maximum yield. In the San Pedro River watershed, irrigators may either intentionally or unintentionally apply less water than is demanded by the crop. Two procedures can be used to identify a deficit irrigation practice. One method would identify deficit irrigation based upon a comparison of actual water applied to the field, the field application efficiency, and the crop consumptive use requirements. If the net irrigation application were less than the crop consumptive use requirements, the field would be classified as deficit irrigated. Another procedure involves comparing the state of one field to other fields in the area growing the same

Figure C-19. This field, located in the Benson subwatershed, was classified as "2A" by DWR. The "2" represents a well maintained delivery system to a sloped field. The "A" describes the type of irrigation method: furrow irrigation without a tailwater recovery or pumpback system.

Figure C-20. This acreage, located in the Aravaipa subwatershed, was classified by DWR as "3A". The "3" represents a poorly maintained delivery system and uneven field topography. The "A" represents border flooding without a tailwater recovery system. This acreage is representative of much of the pasture acreage in the San Pedro River watershed.

Figure C-21. This irrigated pasture in the Aravaipa subwatershed was classified by DWR as "4U." The "4U" represents an unknown delivery system and the field in very poor condition. This classification is somewhat common in portions of the San Pedro River watershed.

crop. An estimation of the standing vegetative matter is made. If one field is obviously under irrigated based upon this comparison, DWR classifies that field as being deficit irrigated.

The process involved in computing deficit water duties is similar to that of computing normal irrigation water duties. The difference is that deficit irrigation water use requires normal irrigation water use parameters to first be computed. A broad overview of this process is shown in Figure C-22.

Deficit Consumptive Use

When a field is classified as being deficit irrigated, it is assumed that the decrease in vegetative matter or yield is the direct cause of a deficit supply of water and not a result of limiting soil characteristics, disease, pests, weather changes, time of planting, or effect of watering practices at critical growth stages. Deficit irrigation can then be said to reduce a

crop's evapotranspirational requirement at the expense of crop yield. Although the crop would consume more water were it available, DWR terms the crop's current state of water usage as actual evapotranspiration (ETa). A relationship between ETa and crop yield can be found in the United Nations Food and Agriculture Organization Paper 33 (FAO-33) (Doorenbos and Kassam, 1979). The general form of the relationship is as follows.

EQUATION C-13

$$1 - Ya/Ym = Ky \times (1 - ETa/ETm)$$

Where:

Ya = Actual yield of the crop
Ym = Maximum yield of the crop in the region
Ky = Yield response factor of the crop
ETa = Actual Evapotranspiration of the crop at the actual crop yield
ETm = Maximum Evapotranspiration of the crop at the maximum yield

This function demonstrates a straight line relationship between yield and evapotranspiration. The exact shape of this function is under debate, although Stewart and Hagan (1973) acknowledge a linear relationship between yield and ET. Howell (1991, personal communication) does not agree with a linear relationship since extrapolating the function with Ky values less than 1.0 would show crop production without the use of any water. Martin, Watts, and Gilley (1984) state that the model developed for grain sorghum, wheat, and soybeans was a linear yield-ET model. DWR feels that at the relative yield levels used in this analysis, the actual shape of the function throughout the entire range of yield and evapotranspiration is somewhat immaterial. Even if the function were not a straight line, the small portion of the function used by DWR would be nearly a straight line.

The value of ETa can be solved in the above relationship if the other parameters are known. ETm is calculated from the FAO-24 model presented earlier in this discussion, yield response factors for different crops can be found in FAO-33. The Ya/Ym portion of the equation is termed the "relative crop yield" and makes it unnecessary to determine the values of maximum or actual crop yields, only the relationship between the two yields is needed. This can be expressed as a percentage value of actual verses maximum yield. DWR identifies the relative yield based on field characteristics. If the field and irrigation system are classified as category "1" and deficit, the

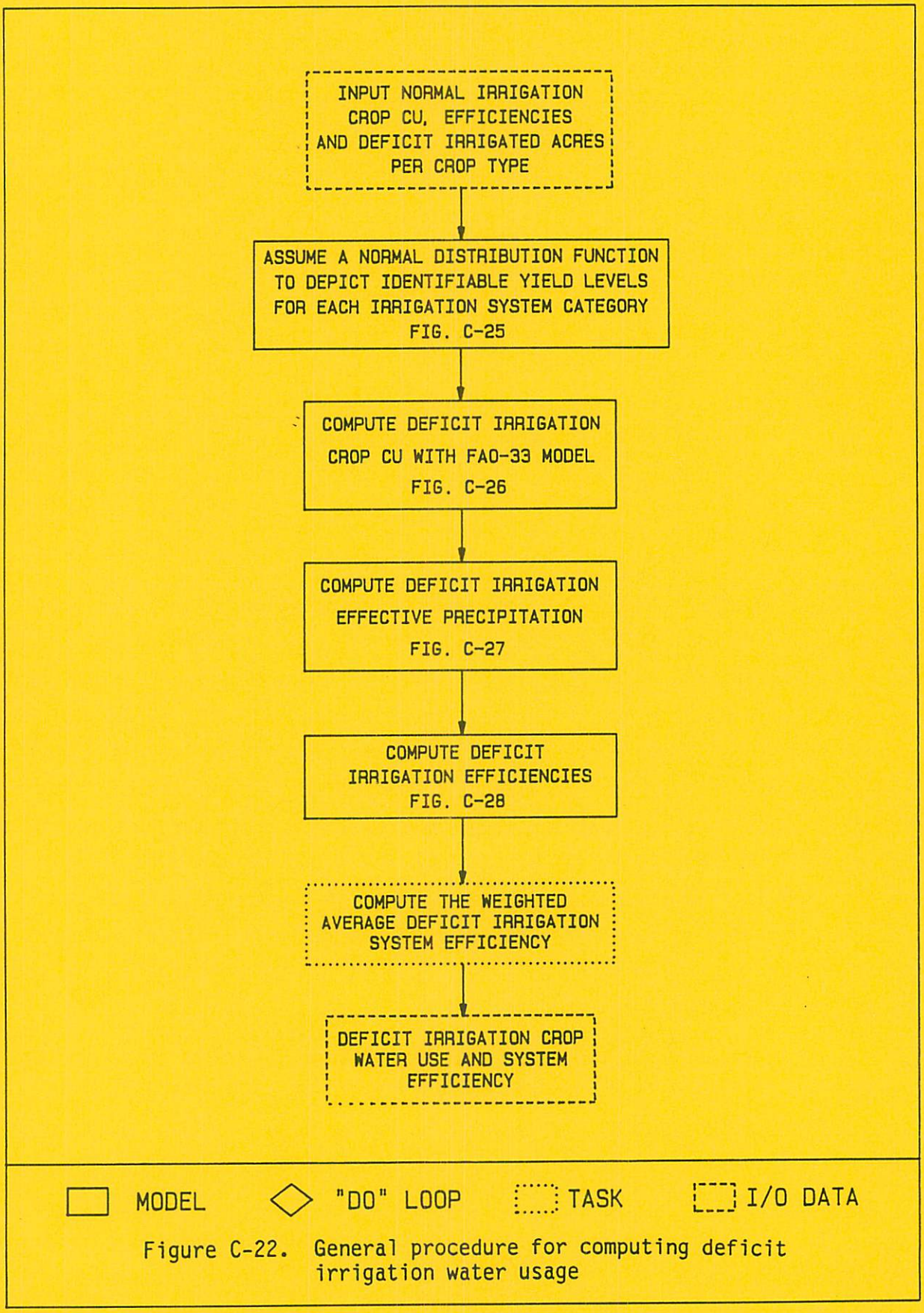


Figure C-22. General procedure for computing deficit irrigation water usage

field is said to be producing 90 percent of maximum yield. A category "2" deficit is said to produce 80 percent of maximum yield and a category "3" deficit field is said to produce 70 percent of maximum yield. The actual evapotranspiration can now be computed.

DWR realizes that a certain amount of error is involved in this type of analysis. For this reason, an assumption was made that the identifiable relative yield levels mentioned above are ultimately influenced by the amount of irrigation water applied, which is itself a function of ETa and the application efficiency. A field identified by DWR to have a low yielding crop may fall anywhere within a large variation in the amount of water applied to meet a low yielding crop's ETa. In other words, DWR does not expect that all category "1" deficit irrigators apply the exact amount of water to produce a yield that is exactly 90 percent of maximum but that all category "1" deficit irrigators have a range of application levels which when plotted on a graph will appear as a normal distribution curve with the median value of irrigation applications producing a yield that is 90 percent of maximum. For example, if a crop with a Ky value of 1.0 were to be grown by a number of deficit irrigators whose application distribution uniformity is 100 percent, the normal distribution of this activity would look somewhat like Figure C-23. The required application to reach a 90 percent relative yield level would be 0.9 x ETm, but as can be seen in Figure C-23, the actual amount of water applied may vary. Finally, adding the areas under the three curves in Figure C-23 together would produce a composite picture of the possible irrigation applications that may occur at all three yield levels. This composite is shown in Figure C-24. A deficit irrigation practice then describes a practice where the irrigator applies from 30 percent to 130 percent of the maximum required volume of water. The majority of deficit irrigators will, however, apply around 80 percent of the maximum volume of water. The process involved is outlined in Figure C-25.

After establishing the identifiable yield levels, DWR was able to compute deficit crop consumptive use values from Equation C-13. This process is outlined in Figure C-26.

Deficit Effective Precipitation

The effectiveness of precipitation on deficit irrigated crops is assumed to be higher than on normally irrigated crops. Deficit irrigated crops would

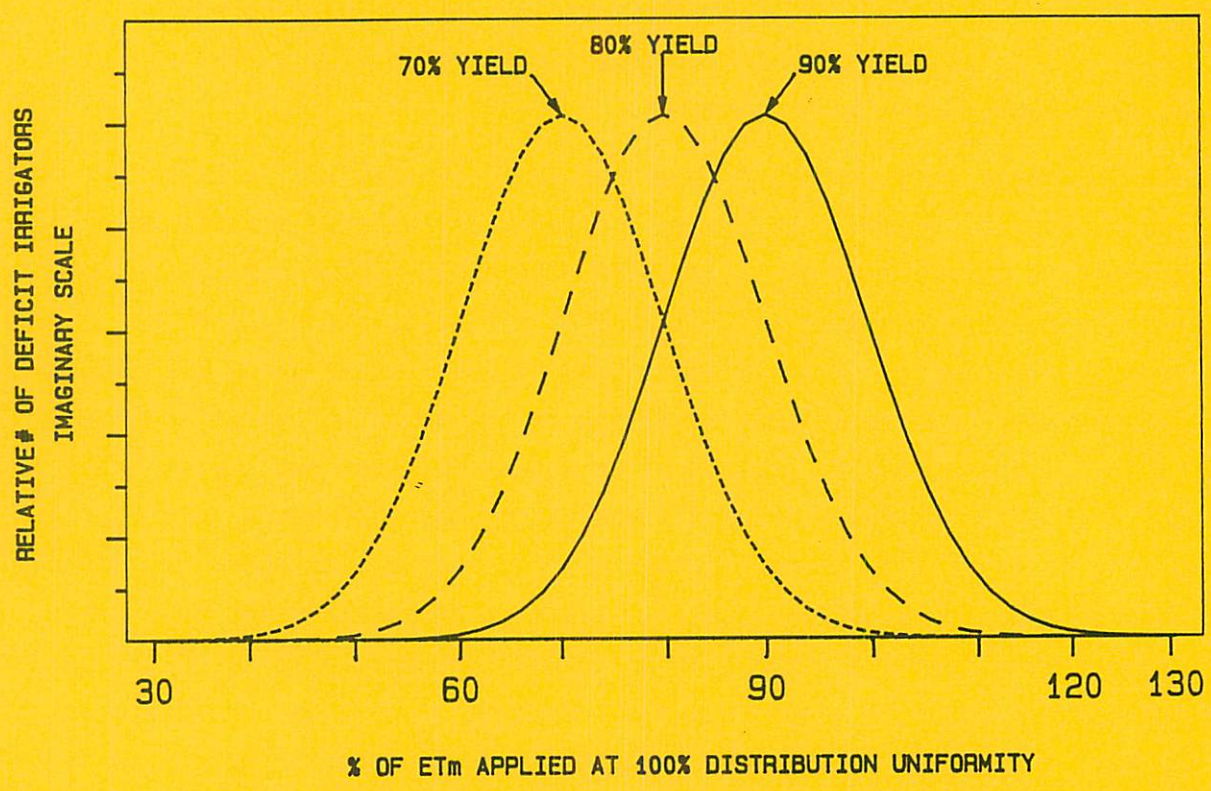


Figure C-23. Estimated distribution uniformity of deficit irrigation practices.

have a larger soil moisture deficit than crops that are normally irrigated, and this in turn would allow for more of the precipitation to infiltrate the soil. The modeling process in this case involves increasing the net depth of application (NDA) value to an assumed amount of water capacity in the soil. DWR increased NDA to 4.0, 4.5, and 5.0 inches for the 90, 80, and 70 percent yield levels, respectively. A new "F" factor was calculated with these new values. Crop consumptive use was left at the normal level. The net result is a deficit irrigated crop effective precipitation that is somewhat higher than if the crop had been fully irrigated. See Figure C-27 for a summary of the methodology. DWR did not consider the slight increase in effective precipitation as having an influence in increasing the deficit crop yield.

In Table C-11, values are presented for deficit crop water usage. These values are derived from a weighted average of deficit crop consumptive use values for all subwatersheds and at all three yield levels.

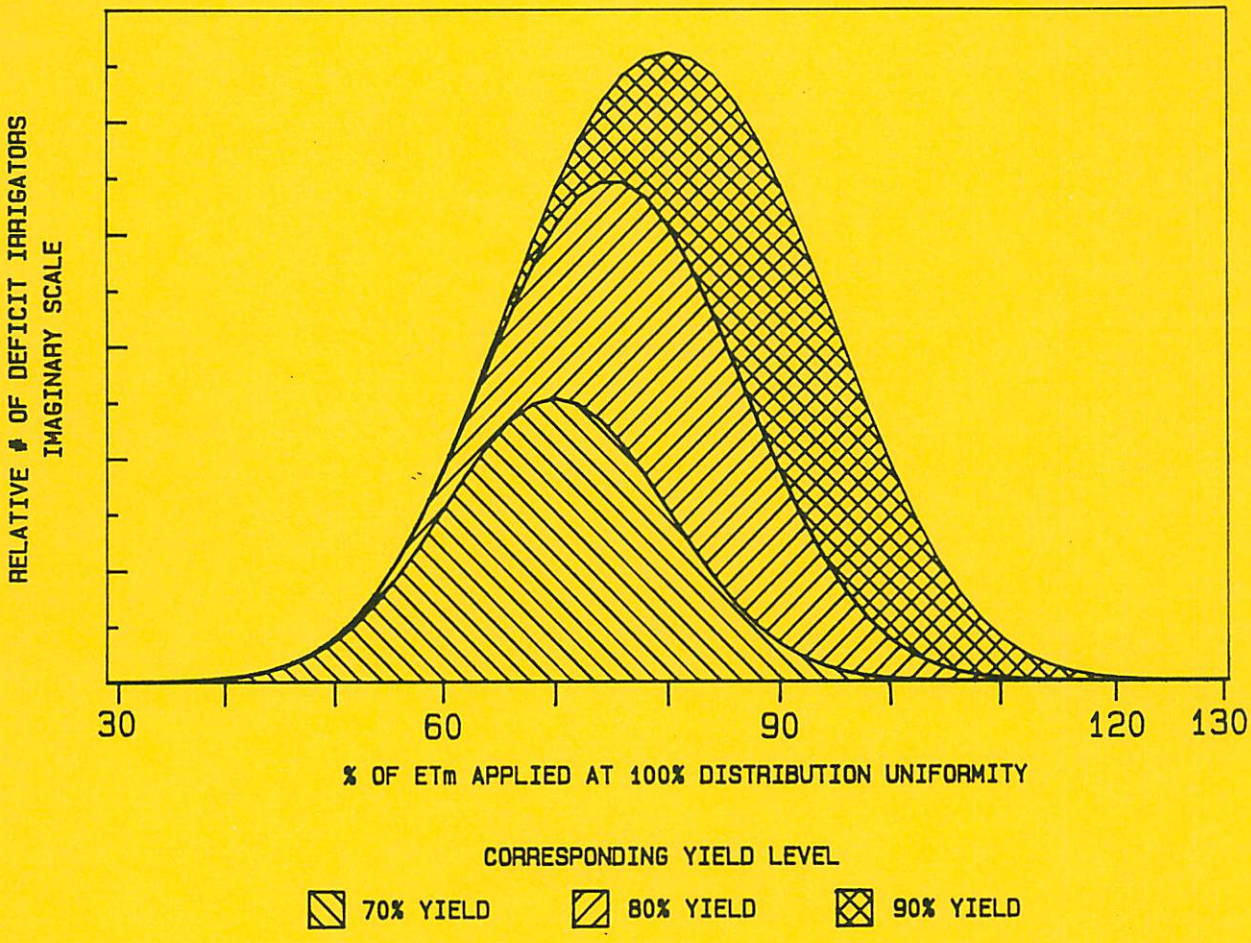


Figure C-24. Composite of estimated distribution uniformity of deficit irrigation practices.

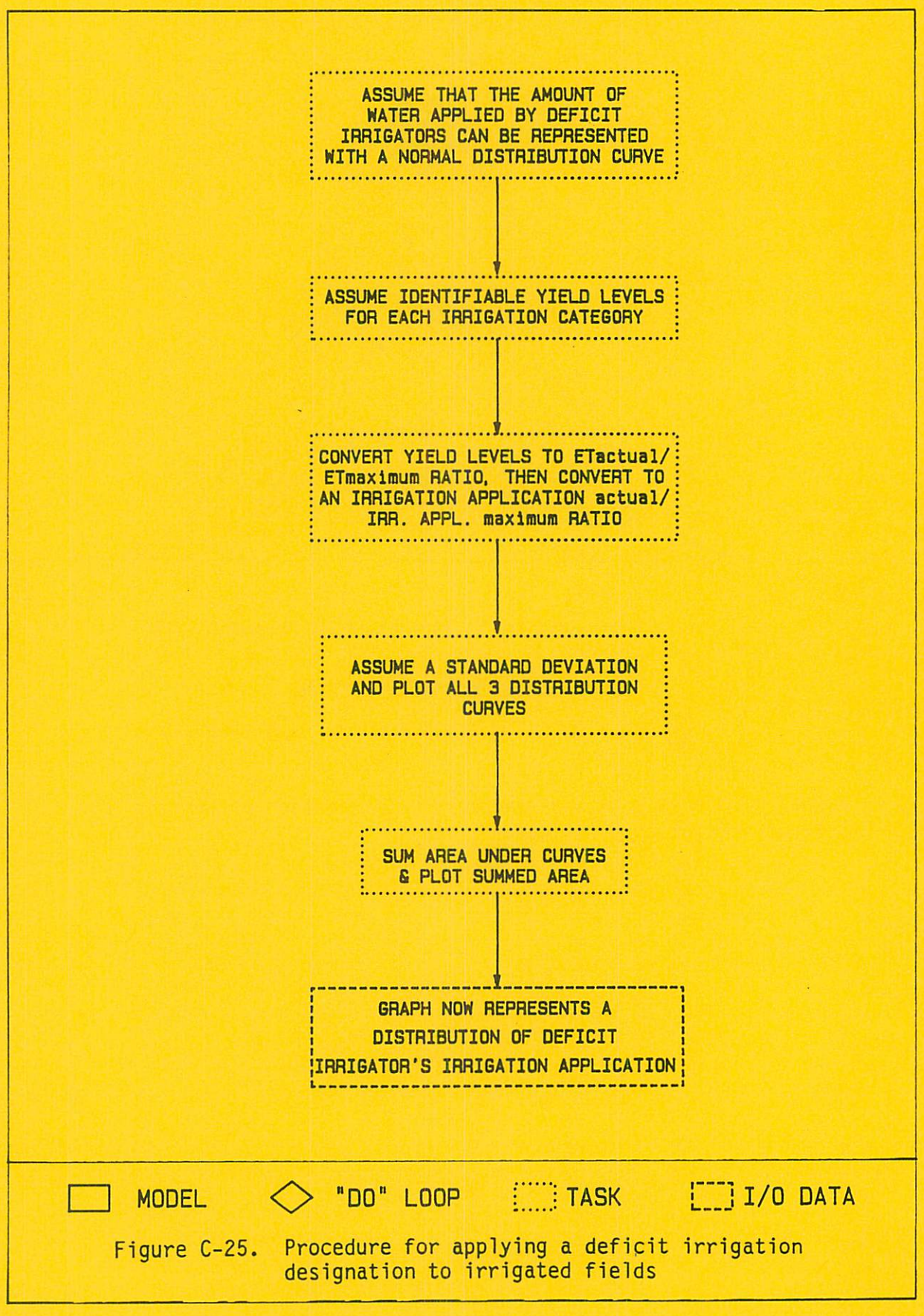
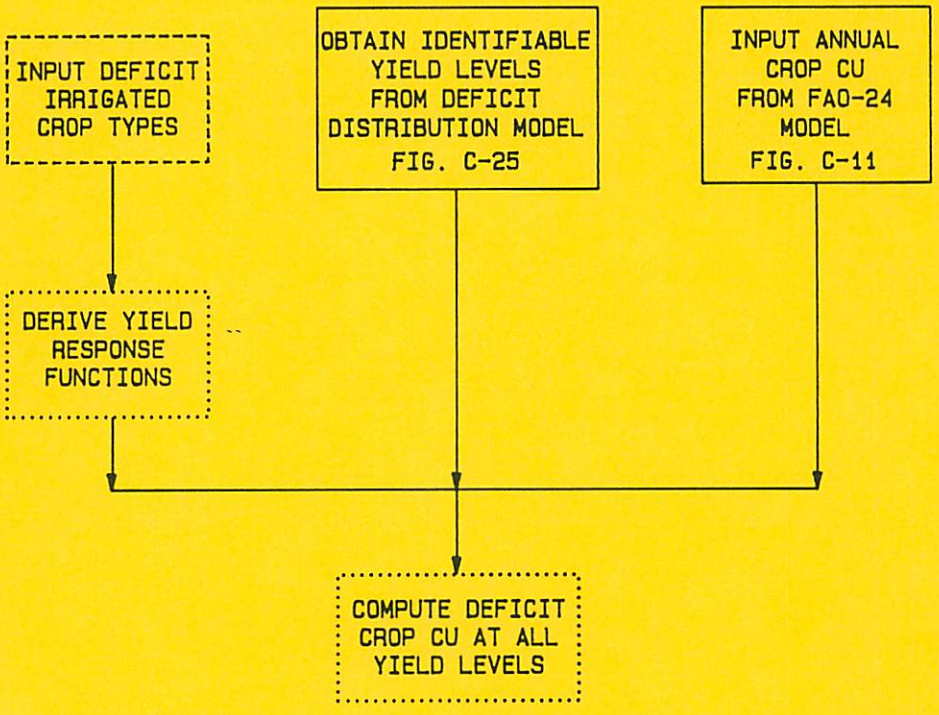


Figure C-25. Procedure for applying a deficit irrigation designation to irrigated fields



MODEL "DO" LOOP TASK I/O DATA

Figure C-26. Process used to compute consumptive use of deficit irrigated crops

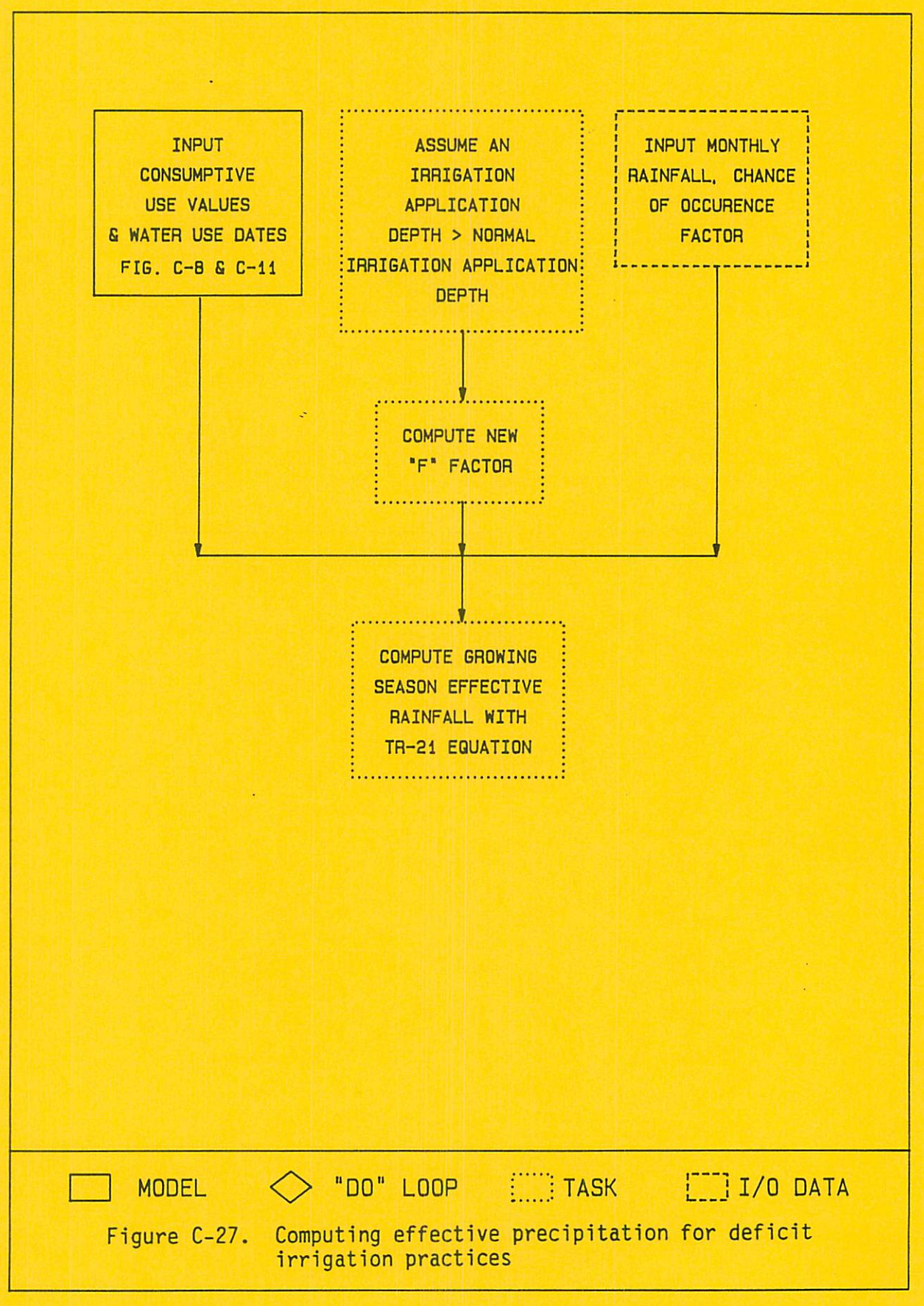


Figure C-27. Computing effective precipitation for deficit irrigation practices

TABLE C-11

WEIGHTED AVERAGE DEFICIT
CROP CONSUMPTIVE USE, EFFECTIVE PRECIPITATION,
AND NET IRRIGATION REQUIREMENTS
SAN PEDRO RIVER WATERSHED

CROP IRRIGATION	ET	EP	PEP	NIR
Deficit alfalfa	2.97	0.73	0.08	2.16
Deficit alfalfa (rotating out)	1.54	0.11	0.42	1.01
Deficit orchard without ground cover	2.32	0.60	0.15	1.57
Deficit orchard without ground cover (retired)	1.30	0.05	0.35	0.90
Deficit small grains	1.03	0.24	0.45	0.34
Deficit grapes	1.29	0.59	0.12	0.58
Deficit landscaping	1.80	0.58	0.10	1.12
Deficit orchard with ground cover	3.12	0.75	0.10	2.27
Deficit pasture	3.06	0.81	0.02	2.23
Deficit pecans	2.28	0.62	0.13	1.53
Deficit pecans with ground cover	3.26	0.71	0.10	2.45
Deficit pine trees	4.73	0.94	0.00	3.79
Deficit summer pasture (A)	1.99	0.58	0.13	1.28
Deficit summer pasture (B)	1.97	0.58	0.15	1.24
Deficit turf	2.43	0.62	0.14	1.67
Deficit winter pasture	1.09	0.20	0.26	0.63
Deficit summer pasture DC with small grains	2.22	0.63	0.18	1.41
Deficit winter pasture DC with okra	2.61	0.56	0.10	1.95

NOTE: DC means double cropped.

Deficit Irrigation Efficiency

Since the moisture level of the entire crop root zone under deficit irrigation is typically less than field capacity, less water is expected to be lost due to deep percolation. According to Stewart (1979) ". . . irrigation efficiency is as dependent on the quantity of water applied as it is on the method of irrigation . . . . A major advantage of a policy of deficit irrigation is that efficiencies of all irrigation methods are improved, with the greatest improvements at the lower levels of technology." For this reason, DWR computed irrigation efficiencies under deficit irrigation conditions as outlined in Figure C-28.

Martin, Watts, and Gilley (1984) proposed several models to predict the increase in irrigation efficiencies due to the decrease in the amount of water applied. DWR chose to use the "Mitscherlich-Spillman" model to predict this relationship. All three models presented predict closely and according to

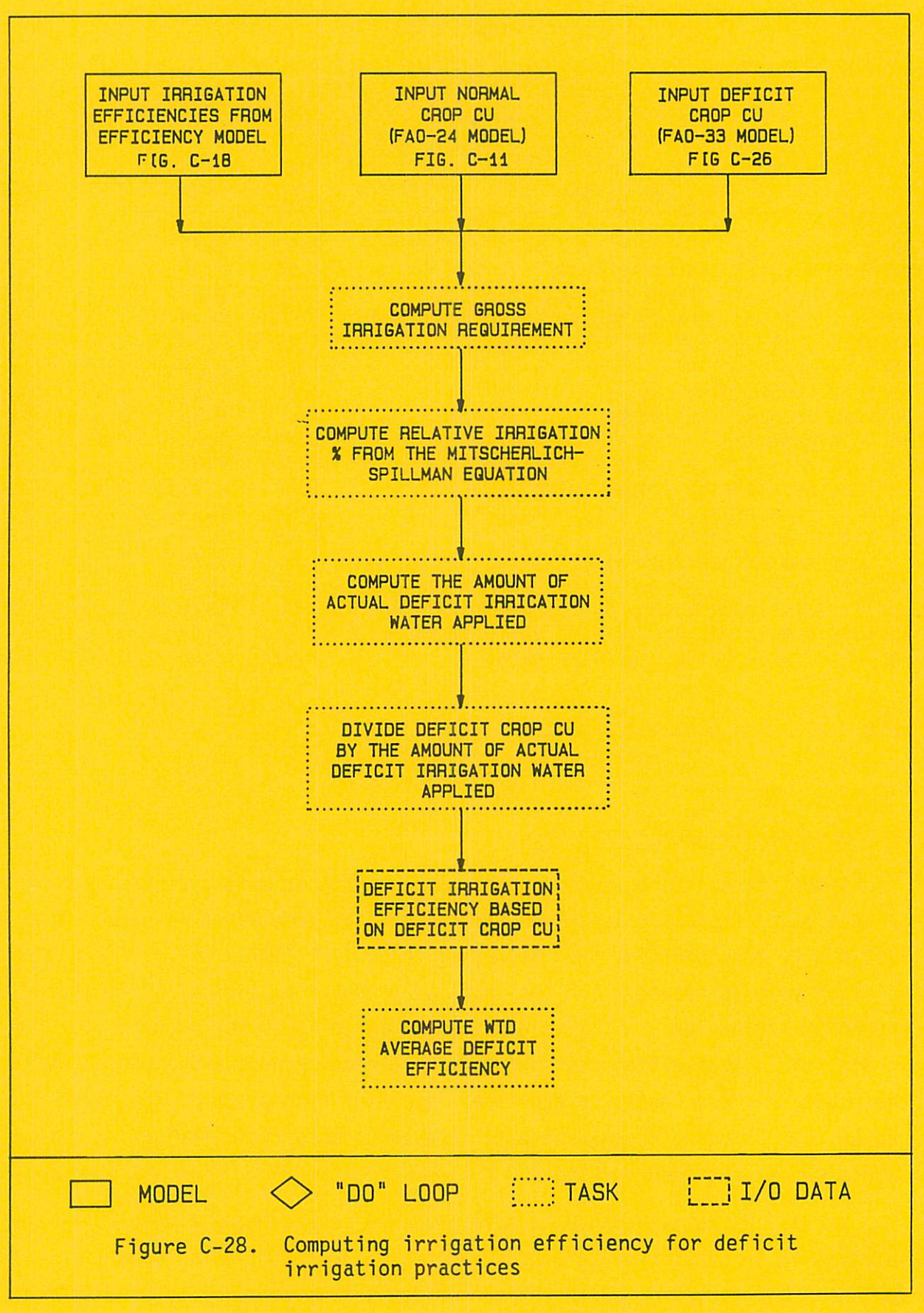


Figure C-28. Computing irrigation efficiency for deficit irrigation practices

Howell (1991 personal communication) the choice of one model over another is immaterial. The relation is represented in Equations C-14 through C-17.

EQUATION C-14

$$Ea = ETa/[Ir(ETm/Em)]$$

Where:

Ea = irrigation efficiency under stressed conditions
ETa = seasonal evapotranspiration for crop under stressed (deficit) conditions (Equation C-13)
Ir = relative seasonal irrigation (Equation C-15)
ETm = seasonal evapotranspiration for crop never suffering water stress (Equation C-3)
Em = irrigation efficiency under nonstressed conditions

This relationship was derived from Equation C-15 (Martin, Watts, and Gilley, 1984).

EQUATION C-15

$$Ir = Ia/Im$$

Where:

Ia = the seasonal amount of irrigation for crop under stressed (deficit) conditions, Ia = K x ETa/Ea
Im = seasonal amount of irrigation for crop never suffering water stress, Im = ETm/Em

By substituting ETa/Ea for Ia and ETm/Em for Im in Equation C-15 and solving for Ea, Equation C-14 can be derived. Another relationship for Ir is required before a solution of Equation C-14 can be derived (Martin, Watts, and Gilley, 1984).

EQUATION C-16

$$Ir = 1n(1-(ETa-ETd)/[(ETm-ETd)am])/-bm$$

Where:

ETd = seasonal evapotranspiration for dryland (rainfall irrigation) conditions
am = $1/[1-\exp(-bm)]$
$-bm/[1-\exp(-bm)] = Im/(ETm-ETd)$

This relationship was derived by considering Equation C-17 (Martin, Watts, and Gilley, 1984).

EQUATION C-17

$$ETa = ETd + [(ETm - ETd)\ f(Ir)]$$

Where:

$$f(Ir) = am[1-exp(-bm\ Ir)]$$

Which, by substitution and solving for Ir yields Equation C-16. Values for ETa, ETm, and Em have been calculated from previous sections. ETd is considered to be equal to zero in this relationship. The f(Ir) parameter is the Mitscherlich-Spillman form of the equation (Martin, Watts, and Gilley, 1984).

Using the analysis presented above, irrigation efficiencies for deficit irrigation conditions were calculated for all system types in the San Pedro River watershed and are presented in Table C-12. The efficiency value changes somewhat for each crop type as a function of crop consumptive use. However, a weighted average deficit irrigation efficiency was calculated for each system based on the number of acres of each deficit irrigated crop type.

TABLE C-12

FIELD CATEGORIES, SYSTEM TYPES, AND IRRIGATION EFFICIENCIES FOR DEFICIT IRRIGATED CROPS

CATEGORY	EFFICIENCY	CATEGORY	EFFICIENCY	CATEGORY	EFFICIENCY
1A	0.60	2A	0.60	3A	0.61
1B	0.74	2B	0.69	3B	0.65
1D	0.82	2D	0.74	3D	0.69
1L	0.82	2L	0.70	3L	0.65
1S	0.76	2S	0.68	3S	0.63

MAXIMUM OBSERVED QUANTIFICATION

The maximum observed estimated volume represents DWR's estimate of actual water use for each irrigation PWR. It is based on the combination of acres irrigated, the specific crop grown, and the type of irrigation system which result in the highest amount of water use in any one year during DWR's investigation period. DWR establishes the total amount of acreage inside of a particular ownership boundary that has been irrigated within the base period from an analysis of historical aerial photography, field investigations, and

claimant interviews. The maximum observed determination is based on review of current aerial photography, field investigations, and claimant interviews to determine cropping patterns. Two situations can result: 1) the maximum observed acreage is the same as the total irrigated acreage and 2) the maximum observed acreage is less than the total irrigated acreage. The following examples explain the two situations.

EXAMPLE C-4

MAXIMUM OBSERVED ACREAGE EQUALS THE TOTAL IRRIGATED ACREAGE

40 acres total irrigated acreage

40 acres maximum irrigated in each year during the five year investigation period

In this example, forty acres would be displayed under the "Acres" column for both the Maximum Observed method and the Regional method in the "Quantities of Use" section in the WFR.

EXAMPLE C-5

MAXIMUM OBSERVED ACREAGE IS LESS THAN THE TOTAL IRRIGATED ACREAGE

40 acres total irrigated acreage

irrigated in year 1

irrigated in year 2

20 acres maximum irrigated acreage in any one year during the five year investigation period

In this second example, twenty acres would be reported under the "Acres" column for the Maximum Observed method and forty acres would be reported for the Regional method in the "Quantities of Use" section of the WFR.

The maximum observed water duty is based on the combination of maximum observed acres, net irrigation requirement, and efficiency value which yields the highest estimated volume of water applied to the PWR (Figure C-29). For instance, 20 acres of alfalfa (NIR = 3.3 acre-feet per acre) on a 2A field (45 percent efficiency) yields a total volume of water applied of 147 acre-feet ([3.3 x 20]/0.45). If the next year, 25 acres of corn were irrigated (NIR = 1.08 acre-feet per acre) the total volume of water applied is 60 acre-feet. The maximum observed acreage and water duty would be reported as 20 acres and 147 acre-feet. The estimated volume is displayed under the "Estimated Volume" column of the "Quantities of Use" section of the WFR. The maximum observed amount will only be reported for irrigation PWRs equal to or greater than two acres, or if it is less than two acres and a contiguous portion of another irrigated PWR. DWR has assumed that the amount of irrigated acreage for parcels less than two acres varies little from year to year, and water use on those acreages is quantified only by the regional method.

REGIONAL QUANTIFICATION

The purpose of reporting a regional amount for irrigation water uses is to provide the Court additional information for making a determination of an appropriate "entitlement" for an irrigation PWR. The regional amount is based on the developement of "regional farming conditions" (RFC). These RFCs are areas which have similar farming practices, cropping patterns, and soil, climate, and topographical conditions. DWR analyzed these factors in the San Pedro River watershed to determine any differences or similarities that would warrant separate RFCs (Figure C-30).

It was assumed that patterns in farming practices or conditions would not be reliable in any area smaller in area than a subwatershed within the San Pedro River watershed. For this reason the San Pedro River watershed was analyzed on a subwatershed basis. Crop irrigation requirements, which include crop evapotranspiration, effective precipitation, and irrigation efficiency, were computed specifically for the conditions found within each subwatershed and a weighted average of these factors was computed. Table C-13 shows the

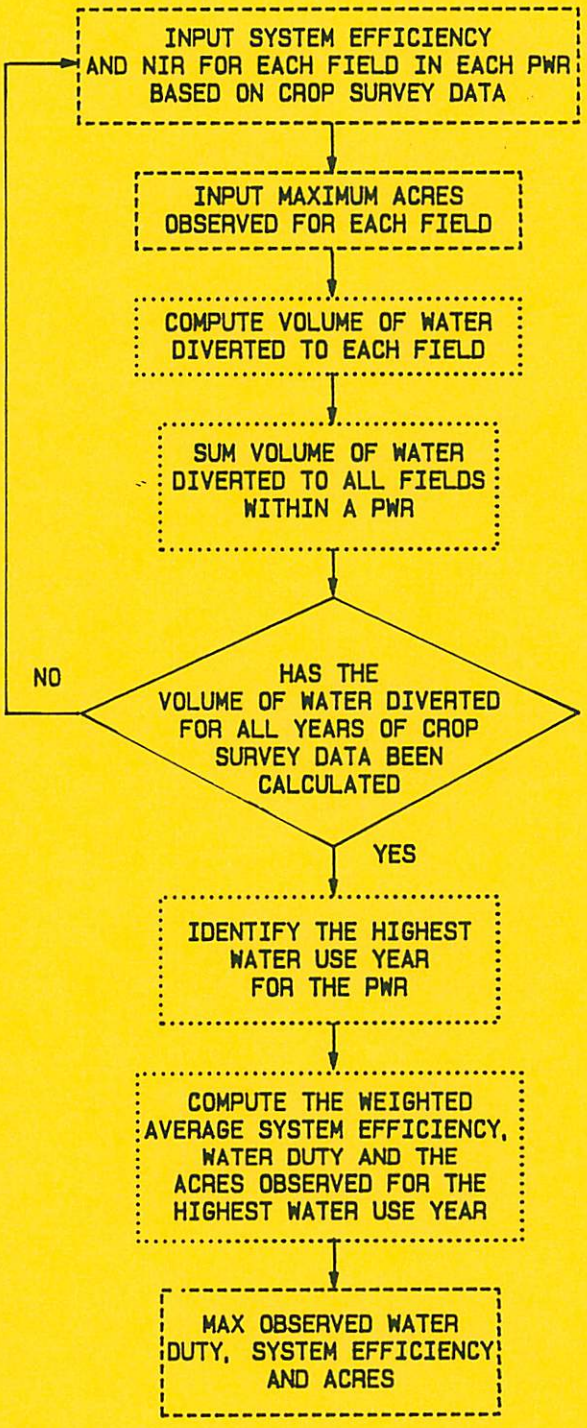


Figure C-29. Procedure for quantifying maximum observed water duty

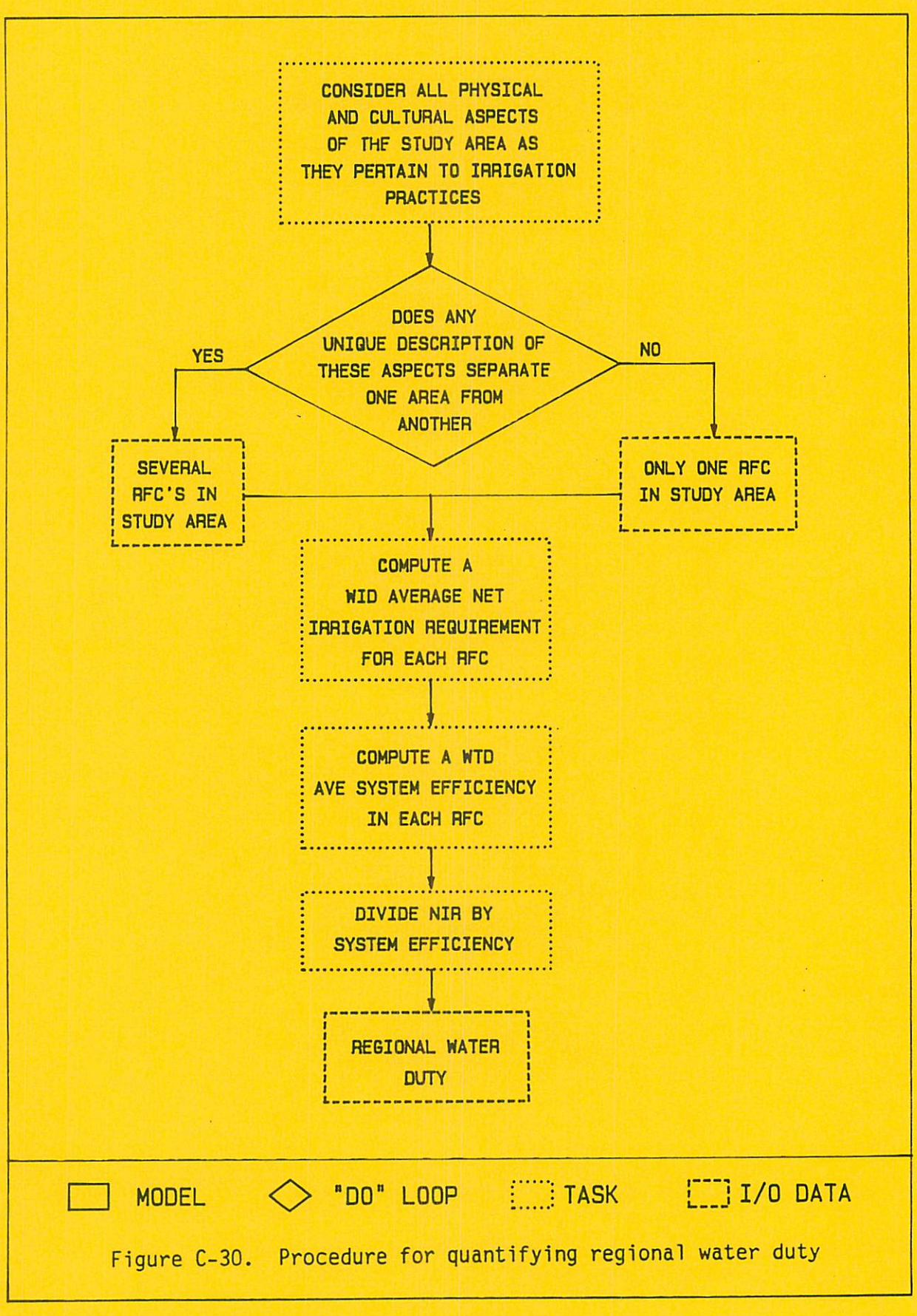


Figure C-30. Procedure for quantifying regional water duty

differences in these factors on a subwatershed basis. This analysis would show any distinctions in irrigation practices based on the climate, cropping patterns, and in part, the topography and farming practices in each subwatershed.

TABLE C-13

REGIONAL WATER DUTY ESTIMATES BY SUBWATERSHED

	WEIGHTED CU (FEET PER ACRE)	WEIGHTED EFFICIENCY	WEIGHTED WATER DUTY (FEET PER ACRE)
Sierra Vista subwatershed	2.59	0.55	4.68
Benson subwatershed	2.78	0.50	5.51
Redington subwatershed	2.74	0.48	5.71
Winkelman subwatershed	2.50	0.49	5.08
Aravaipa subwatershed	2.58	0.49	5.23

Based on the values presented above and the fact that soil types and farming practices are not distinct from one subwatershed to the next, only one RFC was delineated for the entire San Pedro River watershed.

San Pedro River Watershed RFC

Excluding some acreage in the upper portion of the watershed, all of the irrigated lands are concentrated along the San Pedro River or Aravaipa Creek. Approximately 20,840 acres of developed crop land exist in the watershed. However, less than 15,120 acres having been irrigated during the base period, the remainder is considered to be discontinued irrigation use. Of the total developed acres in the watershed, approximately 20,800 acres were investigated at least once during the two crop surveys conducted in 1990. Wells provide water to the majority of the irrigated lands, many of which are located within Zone 1. Only two irrigation districts exist within the watershed: the St. David Irrigation District and the Pomerene Water Users Association. These districts supply users with surface water, however, irrigators in both districts commonly use supplemental water provided by wells located in either Zone 1 or Zone 2.

The elevation of irrigated acreage in the San Pedro River watershed ranges from 4,000 feet at the Mexican border to 1,900 feet near the confluence

of the San Pedro and Gila Rivers. Rainfall in the irrigated portions varies from twelve inches to approximately eighteen inches annually.

Surface irrigation systems without a tailwater recovery system are the primary irrigation system in the San Pedro River watershed. Sprinkler irrigation systems are the next most prevalent system type. The two types together irrigate approximately 94 percent of all of the acres seen to be actively irrigated in 1990. Pasture crops are the most dominant crop type in the watershed, with all pasture crops comprising 56 percent of the crops grown in 1990 (including double cropped acres). Small grains and alfalfa are the next major crops encompassing 20 and 17 percent respectively (including double cropped acres). The result of DWR's 1990 crop surveys is shown in Table C-14, Table C-15, and Table C-16.

TABLE C-14

SAN PEDRO RIVER WATERSHED
1990 CROP TYPES AND ACRES

DOUBLE CROPPED

CROP TYPE	SIERRA VISTA	BENSON	REDINGTON	WINKELMAN	ARAVAIPA	TOTAL
Alfalfa and small grains		278.7		32.4	16.3	327.4
Alfalfa and summer pasture		26.2				26.2
Alfalfa and sorghum		198.6				198.6
Alfalfa and winter pasture		11.0				11.0
Winter pasture and summer pasture	44.6	306.0	71.3			421.9
Winter pasture and corn		5.6				5.6
Winter pasture and sorghum		136.9	20.2			157.1
Winter pasture and mixed vegetables	0.9	2.2				3.1
Small grains and okra				15.0		15.0
Small grains and summer pasture	49.3	248.0	174.2	80.4	92.9	644.8
Small grains and sorghum		170.2	16.4			186.6
Small grains and cotton				65.6		65.6
Small grains and pinto beans				105.3		105.3
Small grains and corn		1.7		60.2		61.9
Fruit trees and vegetables	0.9					0.9
TOTAL	95.7	1,385.1	282.1	358.9	109.2	2,231.0

SINGLE CROPPED

Alfalfa	257.4	998.6	309.5	113.5		1,679.0
Winter pasture	35.1	16.0	54.9	4.9	58.5	169.4
Summer pasture	162.2	434.1	64.4	53.0	88.6	802.3
Permanent pasture	380.3	1,417.9	1,411.2	35.4	259.8	3,504.6

TABLE C-14 (cont'd)

SINGLE CROPPED

CROP TYPE	SIERRA VISTA	BENSON	REDINGTON	WINKELMAN	ARAVAIPA	TOTAL
Corn		22.4	5.9	18.8	1.0	48.1
Small grains	57.0	154.7	644.1	342.3	99.5	1,297.6
Cotton				449.9		449.9
Sorghum		29.6				29.6
Hay			62.7			62.7
Pecans without ground cover	16.4	89.0	19.5	54.0	7.0	185.9
Pecans with ground cover		33.5	13.5	1.8		48.8
Orchard without ground cover	21.4	8.0	6.7	1.4	14.8	52.3
Orchard with ground cover	1.2	28.3	4.0	19.4	16.3	69.2
Pinto beans				42.0		42.0
Mixed vegetables	20.8		1.0	18.2		40.0
Grapes	235.5	0.8				236.3
Turf	226.1	42.6	69.9	3.2	3.1	344.9
Pine trees	0.5	44.0				44.5
Unknown crop					64.9	64.9
Landscaping	16.0	11.6	1.7		1.5	30.8
Melons	53.8	5.6				59.4
Total single cropped acres	1,483.7	3,336.7	2,669.0	1,157.8	615.0	9,262.2

DEFICIT IRRIGATED

Alfalfa		16.9				16.9
Orchard without ground cover	41.5			5.8		47.3
Small grains		7.2		2.8		10.0
Grapes	6.8					6.8
Landscaping	1.0					1.0
Orchard with ground cover		1.9				1.9
Permanent pasture	541.1	509.3	311.9	152.5	39.3	1,554.1
Pecan without ground cover	4.4	0.9			1.9	7.2
Pecan with ground cover		0.6				0.6
Pine trees	0.9	4.0				4.9
Summer pasture		62.1				62.1
Turf	1.4	1.9				3.3
Winter pasture	4.7	3.0	154.7	4.3		166.7
Total	601.8	607.8	466.6	165.4	41.2	1,882.8

DOUBLE CROPPED AND DEFICIT IRRIGATED

Deficit summer pasture and small grains				16.5		16.5
Deficit winter pasture and okra				16.6		16.6
Total				33.1		33.1

TABLE C-15

SUMMARY OF 1990 CROP TYPES AND ACRES

NORMAL IRRIGATION

CROP TYPE	SIERRA VISTA	BENSON	REDINGTON	WINKELMAN	ARAVAIPA	TOTAL
Single cropped	1,483.7	3,336.7	2,669.0	1,157.8	615.0	9,262.2
Double cropped	95.7	1,385.1	282.1	358.9	109.2	2,231.0
Deficit irrigated (1)	601.8	607.8	466.6	198.5	41.2	1,915.9
Total irrigated acres	2,181.2	5,329.6	3,417.7	1,715.2	765.4	13,409.1
Not irrigated (2)	416.5	465.0	321.8	273.6	115.5	2,069.2
Total active PWR acres	2,597.7	5,792.6	3,739.5	1,988.8	880.9	15,478.3
Discontinued	4,070.7	759.4	719.7	135.4	113.1	5,798.3
Total acres crop surveyed	6,668.4	6,552.0	4,459.2	2,124.2	994.0	20,797.8

(1) Includes double cropped and deficit irrigated acres.

(2) Not irrigated acres are acres on which no irrigation was observed in 1990, but are not discontinued.

TABLE C-16

IRRIGATION SYSTEM TYPE BY SUBWATERSHED

NORMAL IRRIGATION

CROP TYPE	SIERRA VISTA	BENSON	REDINGTON	WINKELMAN	ARAVAIPA	TOTAL
Surface/Flood without pumpback	1,177.6	2,983.4	1,421.1	1,215.7	245.9	7,043.7
Surface/Flood with pumpback		177.8		129.9		307.7
Drip	276.2	81.2	21.2	45.8	8.8	433.2
Level basin	8.3	8.1	6.0	15.0	16.8	54.2
Sprinkler	498.6	1,972.7	1,699.5	261.9	487.7	4,920.4
Unknown system	275.4	193.5	131.8	122.0	80.5	803.2
Total	2,236.1	5,416.7	3,279.6	1,790.3	839.7	13,562.4

DEFICIT IRRIGATION

Surface/Flood without pumpback	209.4	238.1	329.3	50.7	15.5	843.0
Surface/Flood with pumpback		0.3				0.3
Drip	48.2	2.5				50.7
Level basin	5.0			5.8		10.8
Sprinkler	339.2	366.9	137.3	142.0	25.7	1,011.1
Total	601.8	607.8	466.6	198.5	41.2	1,915.9

Regional Water Duty for the San Pedro River Watershed RFC

In calculating a regional water duty value, DWR considered the complete mix of crops and irrigation systems excluding deficit irrigated acreage and acreage that was not irrigated during a crop survey or PWRs that were less than two acres in area. Weighted average net irrigation requirement values were computed from the consumptive use values and effective precipitation values previously calculated for each subwatershed. The weighted NIR and efficiency were then calculated for each subwatershed based on these new values and the particular crop mix and irrigation system found in each field. Table C-17 presents these findings.

TABLE C-17

SAN PEDRO RIVER WATERSHED
WEIGHTED AVERAGE WATER DUTY DETERMINATION

A. WEIGHTED TOTAL CROP IRRIGATION REQUIREMENT

SUBWATERSHED	NIR	AVERAGE ACRES IRRIGATED 1990 CROP SURVEYS	WEIGHTED PERCENT OF TOTAL	NIR
Sierra Vista	2.40	1,007.4	10.45	0.25
Benson	2.85	4,161.4	43.17	1.23
Redington	2.67	2,685.4	27.86	0.74
Winkelman	2.41	1,200.7	12.46	0.30
Aravaipa	2.57	583.7	6.06	0.16
TOTAL		9,638.6	100.00	2.68

B. WEIGHTED EFFICIENCY

SUBWATERSHED	EFFICIENCY	AVERAGE ACRES IRRIGATED 1990 CROP SURVEYS	WEIGHTED PERCENT OF TOTAL	EFFICIENCY
Sierra Vista	0.55	1,007.4	10.45	0.06
Benson	0.50	4,161.4	43.17	0.22
Redington	0.48	2,685.4	27.86	0.13
Winkelman	0.50	1,200.7	12.46	0.06
Aravaipa	0.50	583.7	6.06	0.03
TOTAL		9,638.6	100.00	0.50

TABLE C-17 (cont'd)

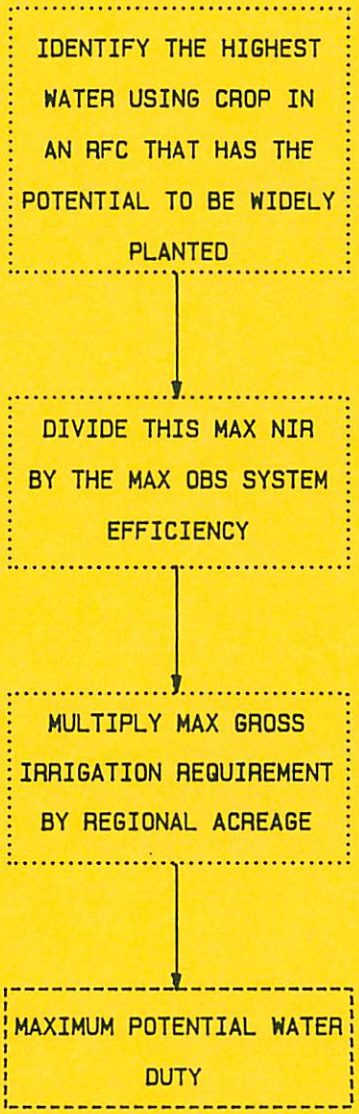
C. WEIGHTED WATER DUTY

$$\text{Weighted Regional Water Duty} = \frac{\text{Weighted NR}}{\text{Weighted Efficiency}}$$

$$\frac{2.68 \text{ FT}}{.5} = 5.36 \text{ ft} = 5.4 \text{ ft (5.4 acre-feet per acre)}$$

MAXIMUM POTENTIAL QUANTIFICATION

The maximum potential quantification is defined by DWR to be a water duty composed of the highest water use crop divided by the actual PWR irrigation efficiency and multiplied by the regional acreage (Figure C-31). The highest water use crop is considered to be the highest water using crop that could reasonably be grown throughout the RFC on a wide scale. In the San Pedro RFC, this crop is represented by alfalfa. This crop has a high water usage and could practically be grown on a wide scale basis. The weighted average consumptive use of this crop is 3.3 acre-feet per acre.



MODEL "DO" LOOP TASK I/O DATA

Figure C-31. Procedure for quantifying maximum potential water duty

C.2 SURFACE WATER DIVERSIONS

This section describes DWR's procedures for estimating quantities of surface water diverted (DVs). DWR is reporting four types of diversion quantities for surface water diversions: diversion capacity, maximum demand rate, decree rate, and certificate rate. These quantities are generally in cubic feet per second (cfs). Only those diversions serving a large number of irrigated acres or diverting a significant portion of the streamflow, which may impact downstream users, will have diversion quantities specified. Instream pumps, and small surface water and spring diversions to single irrigated parcels will not have diversion PWRs created or quantities specified. The following is a discussion of the four types of diversion quantities reported in the HSR.

DIVERSION CAPACITY

The diversion capacities for a surface water diversion is determined from measurements made by DWR of the canal or pipeline capacity system. Measurements were made of canal cross sections and slope, or of pipeline diameters and slopes. Any flow restrictions or obstructions were also noted. Standard hydraulic principles and equations were applied to determine maximum theoretical discharge rates. DWR estimated the maximum theoretical discharge rates for the irrigation district/company diversion systems. These values are listed in Table C-18. These values are reported under the "Diversion Capacity" column of the Quantity of Use section of the WFR. Maximum theoretical discharge rates provide an upper limit to the physical capacity of existing diversions and canal systems to divert surface water flows.

DECREED RATE

Some surface water diversions have diversion rates that are specified in court decrees. These decreed rates are normally expressed in cfs, acre-feet per acre, or acres per cfs. In the San Pedro River watershed, there are no water right decrees that specify a decreed rate or volume in these quantities.

TABLE C-18

SURFACE WATER DIVERSION CAPACITIES

DIVERSION NAME	THEORETICAL MAXIMUM DIVERSION CAPACITY (CFS)
St. David Irrigation District Diversion	24.3
Pomerene Water Users Association Diversion	20.0
Bayless and Berkalew Diversion	13.8
Eureka Ranch - D1	19.6
Eureka Ranch - D2	20.8
Salazar-Tapia Diversion	1.0
Claridge Diversion	22.7
Westerfield Diversion	5.7
Geldmacher Diversion	7.9
Tombstone	1.4

MAXIMUM DEMAND RATE

The maximum demand rate was determined by DWR to show the amount of water that needs to be diverted to optimally supply the crop irrigation requirement during the month of maximum crop demand, after accounting for canal system losses. Table 3-11 shows the maximum demand rates for the irrigation diversion systems discussed in Chapters 3 and 5 of this volume. Example C-6 illustrates the maximum demand rate calculations. Data for the Bayless and Berkalew diversion on the San Pedro River are used in the example.

EXAMPLE C-6

MAXIMUM DEMAND DETERMINATION

STEP 1. Determine crops and acreage.

TYPE OF CROP	ACRES	PERCENT OF TOTAL
Pasture	149.4	100

STEP 2. Determine monthly crop irrigation requirement.

(IN INCHES)	PASTURE CROP IRRIGATION REQUIREMENT											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Evapotranspiration (+)	1.29	2.00	3.32	4.60	6.25	6.87	6.10	5.26	4.41	3.34	2.05	1.39
Effective Precipitation (-)	0.46	0.35	0.32	0.20	0.16	0.45	2.47	2.20	1.21	0.89	0.31	0.59
Monthly Crop Irrigation Requirement	0.73	1.68	3.06	4.49	6.21	6.55	3.70	3.12	3.26	2.50	1.77	0.82

STEP 3. Determine weighted maximum month crop demand from Step 2.
June is the maximum demand month.

CROP TYPE	PERCENT OF TOTAL	JUNE CIR	WEIGHTED CIR
Pasture	100	6.55	6.55 inches

STEP 4. Determine maximum month crop demand in acre-feet.
Field application efficiency is 41 percent.

$$\frac{6.55 \text{ inches} \times 149.4 \text{ acres}}{.41} = 2{,}386.8 \text{ acre-inches}$$

$$\frac{2{,}386.8 \text{ acre-inches}}{12 \text{ inches/foot}} = 199.9 \text{ acre-feet}$$

STEP 5. Determine maximum crop demand per day.
June has 30 days.

$$\frac{199.9 \text{ acre-feet/month}}{30 \text{ days/month}} = 6.66 \text{ acre-feet/day}$$

STEP 6. Determine daily conveyance losses.
Conveyance losses for the Bayless Berkalew ditch is 0.42 acre-feet/day.

STEP 7. Determine maximum daily rate.

6.66 acre-feet/day + .42 acre-feet/day = 7.08 acre-feet/day

STEP 8. Determine maximum daily diversion rate in cfs.

One cfs per day equals 1.98 acre-feet/day.

$$\frac{7.08 \text{ acre-feet/day}}{1.98 \text{ acre-feet/day/cfs}} = 3.57 \text{ cfs}$$

STEP 9. Determine maximum acres per cfs.

$$\frac{149.4 \text{ acres}}{3.6 \text{ cfs}} = 41.5 \text{ acres/cfs}$$ or
1 cfs for every 41.5 acres served by the Bayless and Berkalew diversion

C.3 IMPOUNDMENTS

DWR reports area and capacity information for the following impoundment types: stockponds (SP), small reservoirs (SR), and primary storage reservoirs (PS). Their purposes have been previously described in Chapter 8. Impoundments for which no area and capacity information are reported include: tailwater reservoirs, irrigation regulatory reservoirs, and small stock tanks supplied by stockwells. The maximum controlled surface area in acres and maximum controlled capacity in acre-feet are reported. "Maximum controlled" refers to the capacity of an impoundment below the point where water begins to spill from the impoundment through naturally occurring low points, over the top of the impoundment or through man-made spillways. The criteria for reporting impoundment data is dependent on the surface area of the reservoir. If the surface area of the reservoir is less than two surface acres and has not been surveyed by DWR, the only quantification displayed is that the impoundment is less than two surface acres in area and less than fifteen acre-feet in capacity. When an impoundment is greater than or equal to two surface acres, DWR will survey the impoundment, and the measured maximum controlled surface area and capacity are reported.

The determination of the surface area of an impoundment consists of the following steps:

STEP 1. Recent aerial photography at a nominal scale of 1:24000 (1"=2000') is used to screen impoundments to determine those which appear to be at least two surface acres. Area scales are utilized to estimate impoundment surface areas with a reasonable accuracy of within 10 percent. Surface areas are also estimated using United States Geological Survey (USGS) topographic maps, if the impoundments appear on the map. If the surface area is determined to be two surface acres or greater, it is field checked. Impoundments significantly less than two surface acres are so noted on the aerial photograph (and USGS map).

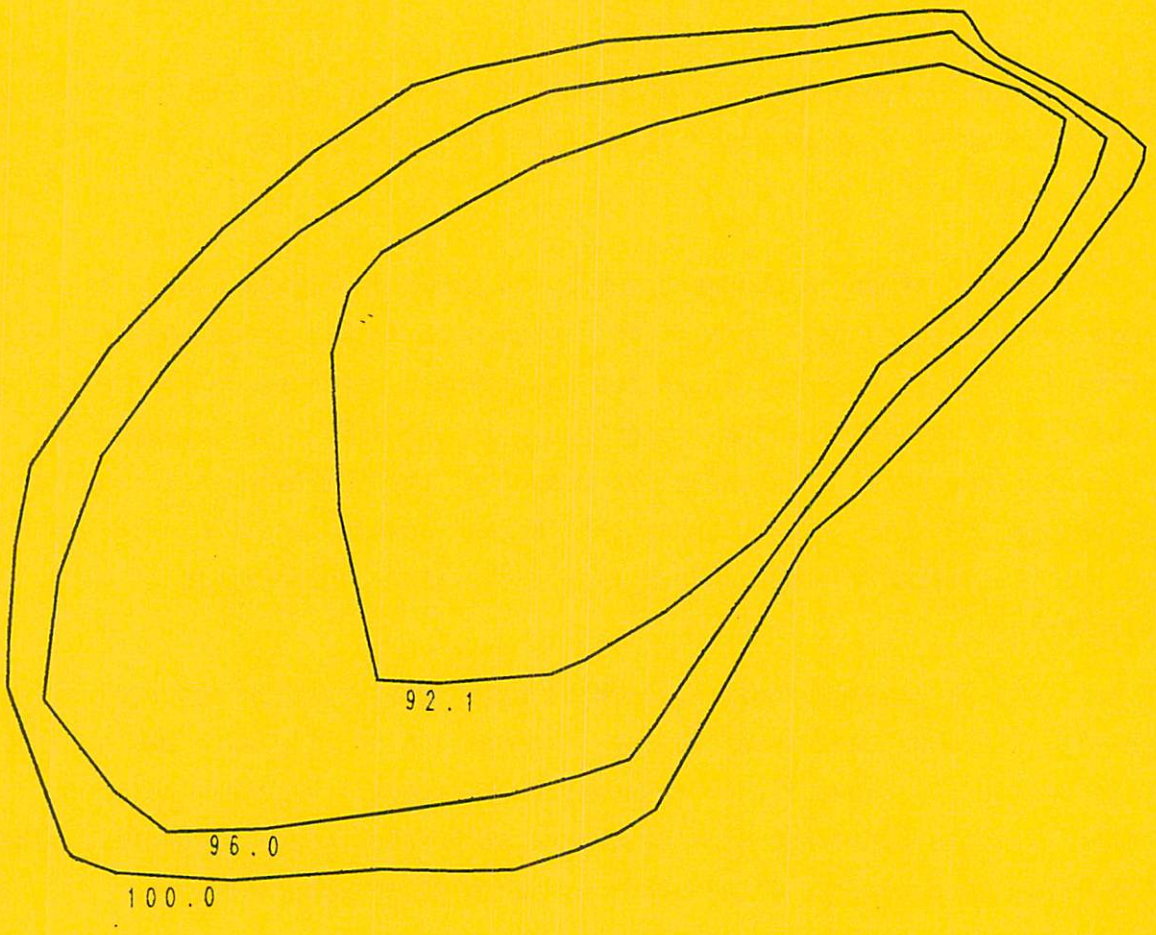
STEP 2. The field check of an impoundment consists of a preliminary estimate of the surface area using a range finder. The impoundment is surveyed if it is within 10 percent of two surface acres.

STEP 3. The field survey entails determining the spillway location and elevation. This elevation sets the maximum controlled water surface. Elevation contours below the maximum elevation are measured using standard surveying techniques. The low point(s) of the impoundment is determined.

STEP 4. A contour map of the impoundment is sketched and digitized into a computer program which calculates the area and capacity of the reservoir.

The results of an impoundment survey is shown in Figure C-32. The maximum controlled surface area of this stockpond is 2.5 acres and the maximum capacity is 15.0 acre-feet. These two amounts are reported under the "Acres" and "Estimated Volume" columns respectively in the WFR. For impoundments less than two surface acres which were not measured, the following notations are displayed in the WFR: LT 2.0 under the "Acres" column, and LTE = 15.0 AF under the "Estimated Volume" column (see the example "Quantities of Use" section below).

For very large impoundments, such as water conservation reservoirs (e.g., Roosevelt Lake) DWR uses area-capacity information on file with DWR's Safety of Dams Section, or as-built or resurveyed area-capacity determinations obtained from the owner/operator or from appropriate federal agencies. There are no large impoundments within the San Pedro River watershed.



Interval	Difference	Surface Area	Capacity
100.0	4.0	25.1	124.1
96.0	3.9	14.2	45.5
92.1	3.1	5.1	7.9

Figure C-32. Typical impoundment survey map

C.4 MUNICIPAL, INDUSTRIAL, AND MINING WATER USES

The procedures for reporting quantities of use for municipal (MU), industrial (ID), and mining (MI) water uses are described below.

1. On site inspections and interviews are performed to gather information on the operation and characteristics of water use. If possible, historical water usage data is obtained.

2. Data on water usage is obtained from the Arizona Corporation Commission. This data is primarily for private water companies under the municipal water use category.

3. Major user reports are prepared describing the operation, water use characteristics, and past water use activity. The quantity of use is normally reported in acre-feet per year, but may also be in cfs, gallons per minute (gpm), or gallons per capita per day (gpcd). The amount reported in the WFR will generally be the highest water usage during DWR's five year investigation period unless other factors warrant otherwise, such as current or projected economic or market conditions which have or may affect water use. Example C-7 illustrates estimation procedures for hypothetical industrial water use.

EXAMPLE C-7

INDUSTRIAL USE

An industrial user has reported the following water use during DWR's five year investigation period:

YEAR	WATER USE (ACRE-FEET PER YEAR)
1986	1,200
1987	1,250
1988	1,450
1989	1,270
1990	1,350

The quantity of use that DWR would report is 1,450 acre-feet per year in absence of any additional pertinent factors.

C.5 DOMESTIC WATER USES

For domestic water uses (DMs), DWR is not reporting quantities of use in the WFRs. The majority of domestic uses in the San Pedro River watershed located outside of municipal or private water company service areas are supplied by groundwater and have irrigation of less than two acres. The Court has not required that quantities be determined for these domestic uses. The Court has directed DWR to report quantities of use for irrigation associated with domestic uses supplied by surface water greater than one-tenth of an acre. This irrigation is reported as "other irrigation" (OT) and applies to irrigation by surface water of land greater than or equal to one-tenth of an acre but less than two acres. The following describes some of the general water use patterns and characteristics associated with a domestic use.

Domestic water uses have two primary components: interior and exterior use. Interior water uses includes water for drinking, cooking, cleaning, washing and waste disposal. In studies of interior water use in the Groundwater Active Management Areas (AMA), DWR has estimated average interior uses to be eighty gallons per capita per day (gpcd) in the Phoenix AMA, seventy-two gpcd in the Tucson AMA, seventy-one gpcd in the Pinal AMA, and fifty gpcd in the Prescott AMA. The average of these four AMAs is sixty-eight gpcd. The Department of Housing and Urban Development (HUD, June 1984) estimated the average interior water use rate to be sixty-six gpcd. They utilized a survey of over 200 households across the United States. Their estimate compares reasonably with the average AMA rate.

Exterior water use is used for landscape/garden irrigation, swimming pools, evaporative cooling, and minor stockwatering. Exterior water use can make up more than 50 percent of the total domestic water use. Some residences may use very little water outside the house. However, residences with up to two acres of irrigation for orchards, gardens, or pasture could potentially use up to ten acre-feet per year (assuming a five acre-feet per acre water duty). Average exterior rates estimated for the AMAs are: Phoenix - seventy-four gpcd, Tucson - thirty-four gpcd, Pinal - sixty-two gpcd, and Prescott - twenty gpcd.

Utilizing the Phoenix and Prescott AMAs' average interior and exterior rates of use as an indication of high and low water usage, the yearly water use in acre-feet per year per person would be 0.17 and 0.08 acre-feet

respectively. In the instructions provided for the domestic statement of claimant, it was suggested by DWR that the claimants use 0.17 acre-feet per person in estimating their domestic water usage.

C.6 STOCKWATERING AND WILDLIFE WATER USES (OTHER THAN STOCKPONDS)

DWR is not reporting a quantity of use for stockwatering and wildlife uses because of the difficulty in quantifying these types of uses and of their relative insignificance. Table C-19 presents some typical stock and wildlife water requirements.

TABLE C-19

STOCK AND WILDLIFE REQUIREMENTS

ANIMAL TYPE	WATER REQUIREMENT (GALLONS PER HEAD PER DAY)
Livestock	
Horses	10 - 12
Cows	10 - 15
Sheep	1.0 - 1.5
Goats	1.0 - 1.5
Wildlife	
Deer	0.5 - 1.0
Elk	2 - 3
Antelope	0.5 - 1.0

(From: Soil Conservation Range Handbook, 1972.)

C.7 LIST OF FREQUENTLY USED SYMBOLS AND ABBREVIATIONS

a	Coefficient for wind speed adjustment
a1	"a" factor for FAO-24 Blaney-Criddle equation
AMA	Active Management Area
b	"b" factor for FAO-24 Blaney-Criddle equation
B-C	Blaney-Criddle ET method
Ce	Empirical soil constant
cfs	Cubic feet per second
cof	Chance of occurrence factor
CU	Consumptive use
Cv	Volume water content
D	Net depth of irrigation application, TR 21 EP calculations
De	Depth of water in a soil
Dvs	Surface water diverted
Dw	Water diffusivity
E	Soil evaporation rate
Ea	Irrigation efficiency under stressed conditions
Em	Irrigation efficiency under nonstressed conditions
EP	Effective precipitation
ET	Evapotranspiration of crop considered
ETa	Actual ET of crop at actual yield under deficit condition
ETd	Seasonal ET for dryland conditions
ETm	Seasonal ET for crop water stress free
ETo	Reference crop evapotranspiration
Etp	Potential Evapotranspiration rate
F	"F" factor for predicting effective precipitation
f	"f" factor for the FAO-24 Blaney-Criddle ET model
FAO-24	ET calculations publication, Doorenbos & Pruitt, 1977
GIR	Gross irrigation requirement
I	Irrigation application under deficit conditions
Ia	Actual irrigation application under deficit conditions
ID	Industrial use
Im	Irrigation application under nonstressed conditions
IR	Agricultural irrigation use
Ir	Relative seasonal irrigation
Kc	Crop coefficient as used by FAO-24 Blaney-Criddle

Kc1	First stage of crop growth crop coefficient
Kc2	Second stage of crop growth crop coefficient
Kc3	Third stage of crop growth crop coefficient
Kc4	Fourth stage of crop growth crop coefficient
Kt	Original Blaney-Criddle equation climatic coefficient
Kw	Hydraulic conductivity
Ky	Crop yield response factor
MAD	Management allowed deficiency
MI	Mining use
Mp	Matric potential
MU	Municipal use
NDA	Net depth of application
NIR	Net irrigation requirement
NWS	National weather service
n/N	Percent sunshine as used by the FAO-24 Blaney-Criddle
OT	Other irrigation use
P	Percent of mean daily total annual daytime hours
PEP	Pre-season effective precipitation
PS	Primary storage reservoir
PWR	Potential water right
RC	Recreational irrigation use
RFC	Regional farming condition
RH	Mean monthly relative humidity
Rt	Monthly precipitation
SCS	USDA soil conservation service
SP	Stockpond
SR	Small reservoir
Sv	Saturation vapor pressure of air at specific height
t	Time from precipitation to beginning of second stage
t1	Duration of first stage of drying
TEMP	Temperature
Tm	Mean monthly temperature
TR-21	Soil Conservation Service ET and EP publication, revised 1970
U	Consumptive use of crop for time period considered
W1	Measured wind speed at height Z1
W2	Estimated wind speed at height Z2
Wd	Mean monthly daytime wind speed

We1 Cumulative loss of water to evaporation in first stage of drying

We2 Cumulative loss of water to evaporation in second stage of drying

WFR Watershed file report

WTD Weighted average value

WUD Water use dates

X1 RH as used by FAO-24 Blaney-Criddle

X2 n/N as used by FAO-24 Blaney-Criddle

X3 U as used by FAO-24 Blaney-Criddle

Ya Actual yield of the crop

Ym Maximum yield of the crop

Z1 Elevation of measured wind speed

Z2 Elevation of estimated wind speed

Zw Depth of wetting front

Mitscherlich-Spillman Equations (Martin, Watts, and Gilley, 1984)

$$am = 1/[1-\exp(-bm)]$$

$$bm/[1-\exp(-bm)] = Im/(ETm-ETd)$$

C.8 DEFINITIONS OF TERMS RELATING TO IRRIGATION

Agricultural Irrigation (IR): Water used to produce plants for sale, or for human or animal consumption.

Appropriable Subflow: "Those waters which slowly find their way through the sand and gravel constituting the bed of the stream, or the lands under or immediately adjacent to the stream, and are themselves a part of the surface stream." 39 Ariz. at 96.

Available Soil Moisture: See Plant Available Water.

Average Water Duty: This is the Weighted Average Net Irrigation Requirement of all crops grown within an area of Regional Farming Conditions divided by the Weighted Average Total Farm Irrigation Efficiency of all irrigation systems within an area of Regional Farming Conditions.

Carry Over Soil Moisture: See Pre-season Effective Precipitation.

Consumptive Use (CU): Also known as Evapotranspiration, (Although Evapotranspiration does not include the water stored in plant tissue), this is the amount of water used by plants in transpiration, retained in plant tissue, and the evaporation of water from adjacent plant and soil surfaces during a specified time period.

Consumptive Use Requirement: The Consumptive Use by a crop for a selected yield level. Unless otherwise specified, Consumptive Use Requirement implies the consumptive use for Maximum Crop Yield.

Conveyance Efficiency: The volume of water delivered to the field, divided by the volume delivered to the farm.

Crop Yield: Often stated as the weight of dry matter of a harvested crop. It is also expressed in terms of the marketable product.

Daytime Wind Speed (U): The average of daytime wind speeds in a given month, expressed in miles per hour.

Deficit Irrigation: The application of less water than is required by a particular crop for full yield. From a field investigation level, this must be obvious and verifiable.

Delivery System Conveyance Efficiency: The volume of water delivered to the farm divided by the volume diverted from a source.

Delivery System Conveyance Losses: The amount of water lost to seepage, evaporation, or transpiration while water is being conveyed through a channel from the diversion to the farm.

Discontinued Irrigation: Acreage that has not been irrigated within the most recent five year period but has been irrigated at least once in the most recent ten year period. This type of irrigated acreage may not receive a water duty.

Diversion Requirement: The Gross Irrigation Requirement plus Delivery System Conveyance Losses.

Double Cropped: When a portion of two or more crops are grown on the same acreage during the calendar year.

Dry Farming: Producing crops with only Effective Precipitation and Pre-season Effective Precipitation.

Effective Precipitation (EP) (Agricultural): This is the portion of rainfall received on a field that is intercepted by vegetation or infiltrated into the soil and utilized for reducing the Net Irrigation Requirement. Precipitation may be considered effective when it reduces the evapotranspirational demand by cooling the crop, by recharging the soil moisture profile or, in cases where leaching is required, by reducing the leaching requirement.

Evapotranspiration (ET): Often synonymous with Consumptive Use, it is the amount of water used by vegetative growth in transpiration and evaporation from adjacent plant and soil surfaces.

Fallow: Acreage or a portion of acreage that does not have an actively irrigated crop for rotational reasons but is intended for future agricultural use. This should not be confused with Dry Farming.

FAO-24: A model developed by the Food and Agriculture Organization of the United Nations for predicting the consumptive use of water by crops (Doorenbos et al., 1977). Also known as FAO-24 Blaney-Criddle it differs from either the original Blaney-Criddle or the SCS Blaney-Criddle method in that it utilizes reference crop coefficients. It also requires additional weather data inputs in the form of Relative Humidity, Daytime Wind Speed, and Percent Sunshine.

Farm Irrigation Efficiency: The volume of irrigation water consumptively used by the crop plus Management Water, divided by the volume delivered to the farm.

Field Application Efficiency: Also known as Irrigation System Efficiency, this is the volume of water placed in the root zone during irrigation, divided by the volume delivered to the field.

Field Capacity: The moisture content of a soil following a large application of water, and after the downward movement of excess water has substantially decreased. Field Capacity is often expressed in inches of water per foot of soil or as inches of water in the root zone.

Five Year Investigation Period: A five year period of time in which The Department of Water Resources investigates claims to water uses.

Gross Irrigation Requirement (GIR): The Net Irrigation Requirement plus On Farm Losses, or the Net Irrigation Requirement divided by the Farm Irrigation Efficiency.

Growing Season: See Water Use Dates.

Irrigation System Efficiency: See Field Application Efficiency.

Landscaping: This is clearly a case where a Potential Water Right has been irrigated for the purposes of beautification but is not as intensively irrigated or densely planted as a production agricultural crop. For example, 100 apple trees per acre and a full cover crop would be considered production agriculture and would be described as Fruit Trees with ground cover. If there are only 20 trees and a small lawn on a one acre parcel it would be designated as Landscaping.

Leaching Requirement: An additional increment of water used to prevent reductions in crop yield due to high soil salinity related to high total dissolved solids in the irrigation water.

Management Allowed Deficiency (MAD): The amount of water deficiency in the soil allowed by farm managers before irrigation water is applied. This would be some amount of soil moisture between the Field Capacity and the Wilting Point and is usually expressed as a percentage of the Plant Available Water.

Management Water: The volume of irrigation water which serves a useful purpose as it evaporates from the soil surface or seeps below the root zone. Water used for leaching of salts, water for frost protection or crop cooling, activation of fertilizers and herbicides, crop seed germination, insect control, soil conditioning, and maintenance of crop quality during harvest.

Maximum Crop Yield: The maximum yield attainable by a given crop provided that water or nutrients are not limited.

Maximum Observed Acreage: Formerly known as the Maximum Annual acreage, this is the maximum amount of land per Potential Water Right that has been irrigated in any given one year out of the Five Year Investigation Period.

Maximum Observed Water Duty: Formerly known as the Maximum Annual Water Duty, this is the Net Irrigation Requirement of the highest water use crop grown on the Maximum Observed Acreage times the Maximum Observed Acres, divided by the Total Farm Irrigation Efficiency. This quantity will be applied to IR and RC Irrigation Types.

Maximum Potential Acreage: This acreage is the same as the Regional Acreage.

Maximum Potential Water Duty: The Maximum Potential Acreage (or Regional Acreage) times the Consumptive Use of the highest water using crop (or combination of double crops) grown in the region divided by the existing Total Farm Irrigation Efficiency. This quantity will be applied to IR Irrigation Types only.

Maximum Theoretical Flow: The highest flow rate allowed by the limiting physical characteristics in a diversion and/or related conveyance system.

Monthly Percentage of Annual Daylight Hours (P): The percentage of daylight hours in a year that occur in a given month.

Multiple Crops: When a portion of two or more crops are grown on the same PWR but not within the same acreage during the calendar year.

Multiple-Double Crop: When a portion of two or more crops are grown on the same acreage within the calendar year as well as having two or more crops grown within the same Potential Water Right but not within the same acreage during the calendar year. Example: IR001 totals 40 acres. Small Grains and Sorghum are grown on the same 20 acre parcel during the winter and summer, respectively. The other 20 acres has cotton growing on it from April to October and is fallow the remainder of the year.

Net Irrigation Requirement (NIR): Also known as Crop Irrigation Requirement and Total Irrigation Requirement. This is the Consumptive Use Requirement plus Management Water minus Effective Precipitation, Pre-season Effective Precipitation and Subbed Water from the Water Table.

No Crop: Acreage on which DWR investigators have not observed agricultural water usage for at least one year.

On Farm Losses: The amount of water lost to seepage, evaporation, or transpiration from the time that water has been supplied to the farm to the time the water is consumed by the crop.

Original Blaney-Criddle: The original model developed by H.F. Blaney and W.D. Criddle (1950) for predicting consumptive use of crops. This model utilizes crop coefficients not based upon a reference crop but upon an Empirical Crop Coefficient. It also utilizes an empirical relationship between temperature, length of Growing Season and the Monthly Percent of Annual Daytime Hours.

Other Irrigation (OT): Water used to produce plants used primarily for landscaping, aesthetic value, erosion control, and similar purposes. Common examples of Other Irrigation include cemeteries, and landscaping around businesses and along highways. Also included in this category is irrigation of land associated with a domestic use by surface water sources less than two acres and greater than or equal to 0.1 acres, or greater than or equal to 0.5 acres and less than two acres when supplied by Appropriable Subflow.

Percent Sunshine (n/N): The percentage of possible sunshine in a given month that actually strikes the ground surface.

Plant Available Water: Water in the root zone that can be extracted by plants. The Plant Available Water is the difference between Field Capacity and Wilting Point. Also known as Available Soil Moisture.

Planting and Harvest Dates: See Water Use Dates.

Potential Evapotranspiration (EP): The rate at which water, if available, would be removed from wet soil and plant surfaces. It is expressed as the rate of latent heat transfer per unit area or an equivalent depth of water.

Potential Water Right (PWR): A water use which eventually may need to be recognized as a separate and distinct right.

Pre-season Effective Precipitation (PEP): Also known as Carry Over Soil Moisture, this is the portion of rainfall received on a field when the field is Fallow and is stored in the soil for later use by a crop.

Recreational Irrigation (RC): Water used to produce plants which are and integral part of a recreation facility. Common examples of Recreational Irrigation include golf courses, parks, and ball fields.

Regional Acreage: Formerly known as the Average Efficient Acreage, this is the total of the irrigated acreage per Potential Water Right irrigated during the Five Year Investigation Period.

Regional Farming Conditions (RFC): Formerly known as Areas of Similar Farming Conditions, this is an area where farming conditions are, for the most part, similar in some major aspect(s) such as climate, irrigation system types, or crop types.

Regional Water Duty: Formerly known as the Average Efficient Water Duty, this is the Regional Acreage times the Average Water Duty of all crops within an area of Regional Farming Conditions. This quantity will be applied to IR, RC, and OT Irrigation Types.

Relative Humidity (RH): A ratio of the amount of moisture in a given volume of air to the amount of moisture that volume of air could contain if saturated.

Return Flow: That part of a diverted flow which is not consumptively used and returns to its source or another body of water.

Root Zone: The depth to which plant roots penetrate the soil.

SCS TR-21 (TR-21): A modified Blaney-Criddle method for predicting the consumptive use of crops. Also known as SCS Blaney-Criddle or the Modified Blaney-Criddle method. The modification to the Original Blaney-Criddle is the use of a climatic coefficient which is related to mean air temperature and a coefficient reflecting the growth stage of the crop.

Soil Storage Efficiency: The volume of water stored in the soil root zone, divided by the volume placed in the root zone during irrigation.

Subbed Water: The amount of water from a high groundwater table that reaches the root zone through capillary action and becomes available for crop water needs.

Total Farm Irrigation Efficiency: The volume of irrigation water consumptively used by the crop plus Management Water, divided by the volume diverted from the source. This differs from Farm Irrigation Efficiency by including Delivery System Conveyance losses.

Unavailable Soil Moisture: Water in the root zone that is held so firmly by various forces that it usually cannot be absorbed by plants.

Unidentified Crop: A crop that was too immature to be properly identified or acreage that was definitely being irrigated but no crop was yet visible on the surface.

Water Duty: The total amount of water needed to successfully produce a crop based on crop type and the effectiveness of water management and application utilized to meet the needs of a crop. In general terms, the water requirement of a crop is known as the Net Irrigation Requirement while the effectiveness of water management and application is called the Total Farm Irrigation Efficiency. Dividing the Net Irrigation Requirement by the Total Farm Irrigation Efficiency produces a Water Duty.

Water Table: The level of water held within the ground, usually expressed in feet below ground level or the elevation above sea level.

Water Use Dates: Formerly known as the Planting and Harvest dates or the Growing Season Dates. This is defined as the time period when a given crop is utilizing water for plant growth and cooling.

Water Use Efficiency: The Crop Yield divided by the consumptive use. The concept of Water Use Efficiency is not a direct consideration in the process of water movement from source to the point of consumptive use but is relevant to discussions of consumptive use requirements for specific yields.

Weighted Average Net Irrigation Requirement: The average of all Net Irrigation Requirements calculated by multiplying the acreage associated with each individual Net Irrigation Requirement by the Net Irrigation Requirement and dividing by the total acreage within the area of Regional Farming Conditions.

Wilting Point: The moisture content of a soil at which a plant can no longer obtain sufficient moisture to satisfy its consumptive use requirements and will wilt permanently.

APPENDIX D: DETERMINATION OF RIPARIAN SALVAGE

Riparian salvage is a term used here to connote water not consumed because of cultivation of lands that would otherwise support natural phreatophytic vegetation. Estimates of riparian salvage are based on consumptive use determinations employing the Blaney-Criddle approximation as described under Natural Uses (APPENDIX B). The estimation of potential riparian displacement through clearing is based on the assumption that current cultivated land can support riparian communities proportional to the percent of riparian cover on adjacent, noncultivated lands, in approximately the same species composition.

To determine this cover potential, quadrat analysis was employed that aggregated all land by subwatershed into six-by-six mile cells. Figure D-1 shows an example of this process. Within each of these thirty-six square mile cells, land cover was aggregated by total irrigated area and total riparian vegetated area by species association. Cell size was selected as representing a homogenous climatic-edaphic regime within which riparian vegetation would occur in the same distribution and proportional composition. Land area within the cell occurring outside of the floodplain aquifer (younger alluvial surface) was excluded from tabulation.

For each cell, the percentage of riparian cover to nonvegetated cover was calculated by vegetative association along with the percentage of land under irrigation. These values then were aggregated for each subwatershed. APPENDIX B describes the techniques of vegetative classification utilizing Landsat image data and the quantification of consumptive use estimates for riparian associations.

Because riparian salvage occurs only through clearing of land and its removal of phreatophytic species, the proportion of riparian vegetation that could exist was determined by applying the percentage of phreatophytic cover to the sum of the areas of cultivated land within each six-by-six mile cell (Figure D-1). For example, if 17 percent of the uncultivated land area within a cell is under riparian cover, then 17 percent of the cultivated land within the cell is assumed to displace riparian vegetation in the same species class proportions as that occurring naturally outside the cultivated area.

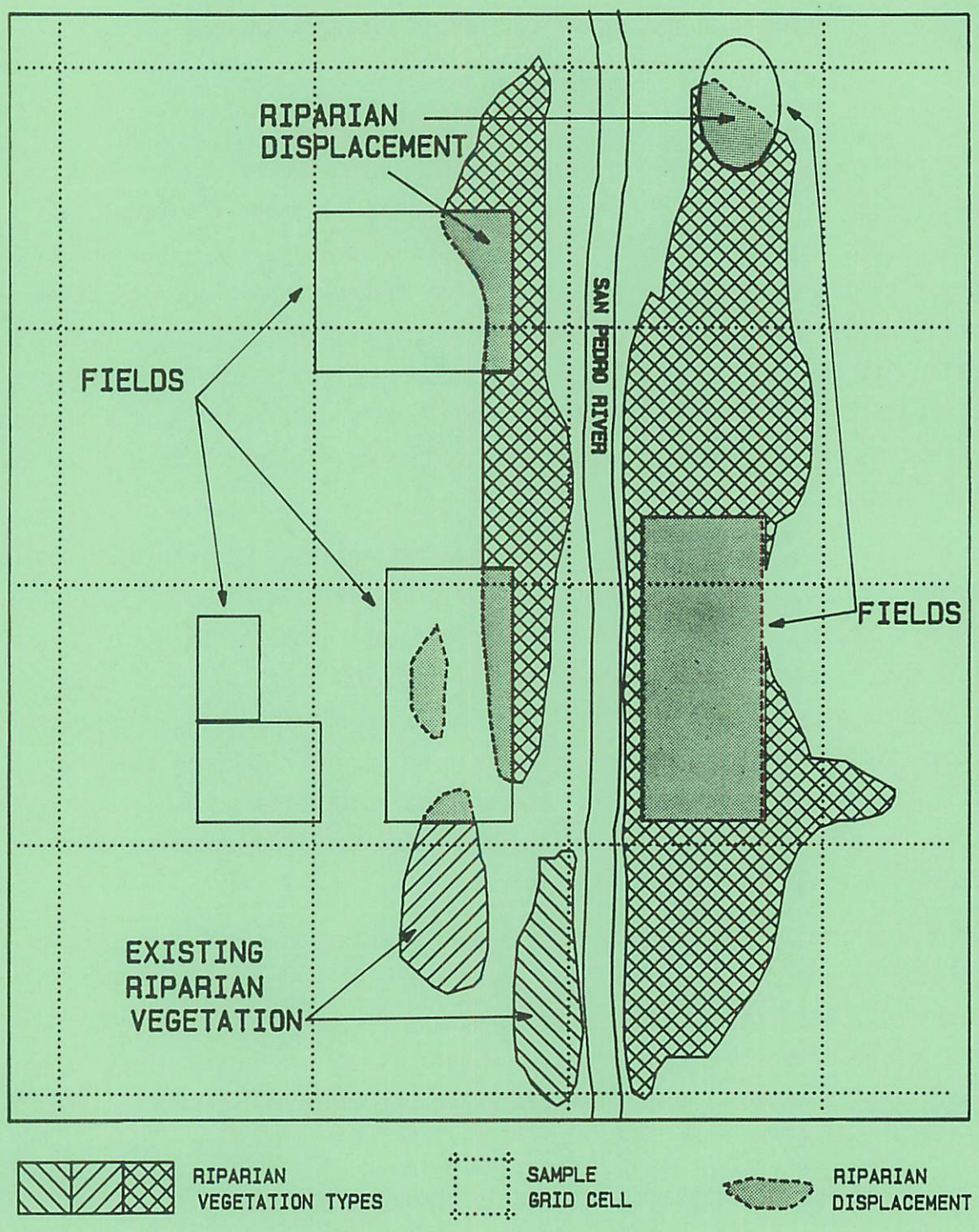


Figure D-1. Schematic showing an example of potential vegetative cover determination for riparian salvage

Consumptive use for this displaced vegetation was determined using the Blaney-Criddle methods described in APPENDIX B. Table D-1 gives the estimated percentages of irrigated area that may have been covered by phreatophytes.

TABLE D-1

PERCENTAGES OF RIPARIAN VEGETATION DISPLACEMENT

SUBWATERSHED	IRRIGATED AREA (1986)	DISPLACEMENT AREA	PERCENT OF IRRIGATED AREA
Sierra Vista	3,358.0	759.8	22.63
Benson	6,325.8	924.3	14.61
Redington	3,816.0	644.2	16.88
Winkelman	2,201.8	549.5	24.96
Aravaipa	820.4	23.4	2.85
TOTAL	16,522.0	2,901.2	17.56

Table D-2 gives the predicted areas of riparian vegetation displacement by subwatershed and by primary vegetation class. By applying these acreages to the consumptive use of each primary vegetation class as given in Appendix B (Table B-6) and adjusting for five inches of annual effective precipitation, results in the predicted consumptive use of riparian vegetation displacement as given in Table D-3. Approximately 7,630 acre-feet per year of water was consumed within the San Pedro River watershed by riparian vegetation on lands cleared of this vegetation prior to the clearing process.

TABLE D-2

PREDICTED AREA OF RIPARIAN VEGETATION DISPLACEMENT
(ACRES)

	COTTONWOOD/ SYCAMORE	TAMARISK/ MESQUITE	DENSE MESQUITE	MEDIUM DENSE MESQUITE	WILLOW	CIENEGA/ DENSE GRASS	TOTAL
Sierra Vista	135.3	0.0	289.2	313.2	0.0	22.1	760
Benson	47.1	280.4	345.2	173.8	0.0	77.8	924
Redington	58.6	36.5	461.4	4.0	0.0	83.7	644
Winkelman	15.7	27.1	195.1	311.6	0.0	0.0	550
Aravaipa	14.7	0.0	1.3	7.4	0.0	0.0	23
TOTAL	271.4	344.0	1,292.2	810.0	0.0	183.6	2,901

TABLE D-3

PREDICTED CONSUMPTIVE USE OF RIPARIAN VEGETATION DISPLACEMENT (ACRE-FEET PER YEAR)

	COTTONWOOD/ SYCAMORE	TAMARISK/ MESQUITE	DENSE MESQUITE	MEDIUM DENSE MESQUITE	WILLOW	CIENEGA/ DENSE GRASS	TOTAL*
Sierra Vista	564.2	0.0	717.2	498.0	0.0	69.2	1,850
Benson	192.2	1,186.1	835.4	269.4	0.0	237.3	2,720
Redington	243.8	157.7	1,139.7	6.4	0.0	261.1	1,810
Winkelman	65.9	118.2	487.8	501.7	0.0	0.0	1,170
Aravaipa	61.3	0.0	3.2	11.8	0.0	0.0	80
TOTAL	1,127.4	1,462.0	3,183.3	1,287.3	0.0	567.6	7,630

Annual consumptive use = [(value from Table B-6)-0.42] x value from Table D-2

where 0.42 is annual effective precipitation.

* Values are rounded to nearest tens.

APPENDIX E: ZONE 1 DETERMINATIONS

Provided in Chapter 4, Section 4.6 is the "Delineation of Zone 1." The Zone 1 area defines the location of wells that have the potential of withdrawing appropriable subflow. That presentation is fairly complete in describing the methodology used in developing the Zone 1 area. The purpose of this appendix is to provide additional information on the methodology and to give further detail on the location of each estimated "a" value (distance of "brightline" from channel bank) along Zone 1.

ADDITIONAL INFORMATION ON METHODOLOGY

The purpose of the methodology is to develop a zone for the San Pedro River and its major tributaries that would define the areas where the surface water system has the potential to be affected by the pumpage of groundwater from the alluvial aquifer system according to the criteria set forth by the Court's order of September 9, 1988 (50 percent/90 day test).

Scope

The floodplain areas of the San Pedro River, Babocomari River, and Aravaipa Creek were examined as potential areas of "brightline" development. All available "35" and "55" drillers logs were obtained from DWR records and analyzed. Water well information including water levels were obtained from DWR's Groundwater Site Inventory (GWSI) (ADWR, 1990a) and from the United States Geological Survey (USGS). All available aquifer parameters were gathered from various sources. Surface water gaging records from the USGS along with historical precipitation records were analyzed. A review of the surface water/groundwater interaction models, along with the model assumptions, was conducted to determine which model would best fit both the data available and time constraints.

Basic Data Collection

Before any attempt to set up a surface water/groundwater interaction model, all available basic data was collected. Data used in this evaluation is

available from DWR upon request. Location and estimations of aquifer parameters and water well locations and water level data was evaluated. Aquifer parameters came from four sources: 1) aquifer tests, 2) USGS Open File Report 82-752, 3) DWR drillers log program, and 4) water well completion reports. The reliability of these parameters decreases in the same order with the aquifer tests being the most reliable source and completion reports giving the least reliable estimates. An average transmissivity for the younger alluvium was estimated at approximately 60,000 gallons per day per foot (8,020 square feet per day) with a specific yield averaging about 17.5 percent.

Surface water gage records were collected from nine stations on the San Pedro River: Palominas, Charleston, Tombstone, St. David, Pomerene, Benson, Redington, Mammoth, and Winkelman, and from one station on Aravaipa Creek, Aravaipa Creek near Mammoth. Daily flow records, monthly flow records, flow time percentage, and duration curves were constructed and analyzed for each gage. Only one gage record, Charleston, showed a 100 percent flow time. All other gages showed flow for greater than 90 consecutive days but less than a full year.

Surface Water/Groundwater Interaction Model Availability

After the basic data collection was achieved, the next step was to look at how the data would fit into a surface water/groundwater interaction modeling effort. The two mathematical categories of methods examined for analysis of surface water/groundwater interactions were the analytical and numerical models. Solutions of analytical models were found to be constrained by numerous assumptions. Results from the analytical models may show excellent agreement with real world conditions when all these assumptions are met.

However, when some assumptions of the model are not met, as sometimes occurs under natural field conditions, solutions of the model are less realistic. Following is a list of the main assumptions of analytical methods for analysis of surface water/groundwater interactions:

1. The aquifer has identical hydraulic properties throughout (homogeneous) and its properties are the same in all directions (isotropic).
2. The aquifer is of semi-infinite areal extent.
3. Saturated thickness of the aquifer is constant.

4. Prior to pumping the water table is horizontal.
5. The course of the river is idealized as a straight line.
6. Groundwater is in free hydraulic connection with the stream.
7. The rate of well pumping is constant.
8. Flow is predominately horizontal.
9. Water is released instantaneously from storage.
10. Full penetration of the aquifer by the well is required.
11. Residual effects of previous pumping are negligible.
12. Drawdown in the well is insignificant when compared to the saturated thickness.

Numerical models are generally constrained by fewer and less significant assumptions then analytical models. Data requirements for numerical models, however, are large in both number and coverage if the model is to show good agreement with real world conditions.

Model Chosen

In review of both data availability and time restraints, an analytical modeling approach was chosen for determination of the "brightline". Review of the basic data showed that in a large number of areas data was sparse and had poor reliability, making a numerical model impractical at this time.

An analytical method by C.T. Jenkins (1968), titled: "Techniques for Computing Rate and Volume of Stream Depletion by Wells," was used to determine the "brightline." This analytical method utilizes Jenkins' equation which incorporates transmissivity (T), specific yield (S), and a derived constant. This equation is used to determine the distance from the principal channel boundary within which a 50 percent/90 day surface water/groundwater interaction would occur. The principal channel boundaries or banks as defined for this analysis mark the area of the floodplain that exhibits a potential for dynamic change. It includes the present low flow channel and potential high flow areas as depicted from 1984 through 1986 aerial photography and represents the area where streamflow would be expected to meander back and forth in natural high flow adjustments. It does not account for extremely high flows that may shift the active channel out of this principal channel boundary.

Development of the Brightline

Using the above analytical formula a "brightline" was developed for: 1) all perennial stream reaches on the San Pedro River, Babocomari River, and Aravaipa Creek, and 2) all intermittent stream reaches that meet the criteria of having greater than ninety days of consecutive flow and maintaining depths to water of generally less than twenty feet. Intermittent reaches as compared to perennial reaches do not generally qualify to be analytically modeled by the Jenkins method. This is due to the fact that: 1) the model assumes continuity which states that the saturated thickness of the aquifer must remain constant, and 2) the model assumes that there must be a continuous hydraulic connection between the surface water and groundwater systems. For this analysis, if the river does have at least 90 days of continuous flow and has relatively shallow water levels below the land surface, then the intermittent reaches can be treated as perennial reaches in this model. During the above 90 days of continuous flow, it was considered that the saturated thickness would remain constant and therefore conform with the first assumption. It was also considered that in areas of shallow groundwater levels, quick hydraulic reconnection of the surface water/groundwater systems would occur during flow events in the ninety day review period conforming to the second assumption. Using the above approach, the San Pedro River was "brightlined" in its entirety and select reaches of the Babocomari River and Aravaipa Creek were "brightlined."

Within the Sierra Vista subwatershed area, the "brightline" was determined using aquifer parameters taken from the USGS Upper San Pedro Model area (Freethey, 1982 and Putman et al., 1988). In all other areas aquifer parameters used in the Jenkins model came from the following: 1) for each of the two areas (St. David - Benson and Redington - Mammoth) that have a confining clay unit, T and S values from basic data were averaged and used in the formula to develop a "blanket coverage brightline" for each confining area, and 2) in the remaining areas of nonconfining conditions, T and S values from basic data were averaged by Township and Range or by special areas and used in the formula to develop a "blanket coverage brightline" for each area. Only T and S values that were derived from the stream alluvium and had an associated S value equal to or greater than 10 percent were used. This was to better represent true stream alluvium aquifer conditions.

Zone 1 Boundary Generation

Definition of Zone 1 boundary was accomplished by generating a boundary at "a" distance from the edge of the principal channel throughout the defined area. The specific procedure utilized a geographic information system (GIS) algorithm that creates a buffer zone around a defined floodplain feature. Figure E-1 depicts the operation of this function.

In Part (a) of Figure E-1, the floodplain or principal river channel (shaded area) is defined on either side of the river. A radius of length "a" is then established for each point along the floodplain boundary (Part (b) Figure E-1), and replicated for all points (Part (c)), creating an envelope of "a" distance from the opposite side of the floodplain, resulting in the creation of a bounded zone (Part (d), Figure E-1). Because the "a" values change along specific reaches of the river system, the envelope expands and contracts through reach transitions according to the associated "a" values. Plates 6 through 14 provide the "a" values for all reaches used in this determination as well as the areas in which each "a" value was applied.

LOCATION OF ESTIMATED BRIGHTLINE VALUES

The purpose of this section is to further define the assigned "brightline" values along the boundaries of Zone 1. Plates 6 through 14 show the segments of the channels that have been assigned a "brightline" or "a" value. The "a" values shown on these plates are preceded by a key that represents or identifies the controlling feature used in defining the area each "a" value was calculated for. For example, TR represents Township and Range value while CR is Confined Aquifer value. Table E-1 furnishes each "a" value that is outside of the Freethey Model area and the average T and S values used in its determination. An attempt has been made to associate "a" values with corresponding township and range. However, this is not possible within the Model area where the "a" values correspond with Model cells rather than township and range. Table E-2 furnishes the average T and S values used within the specific cell or cell groupings of the Freethey Model area. Figure E-2 gives the location and number of each of the Freethey Model cells and identifies those which were used to develop the Zone 1 boundary. Further identification of the relationship between individual wells and Zone 1 can be

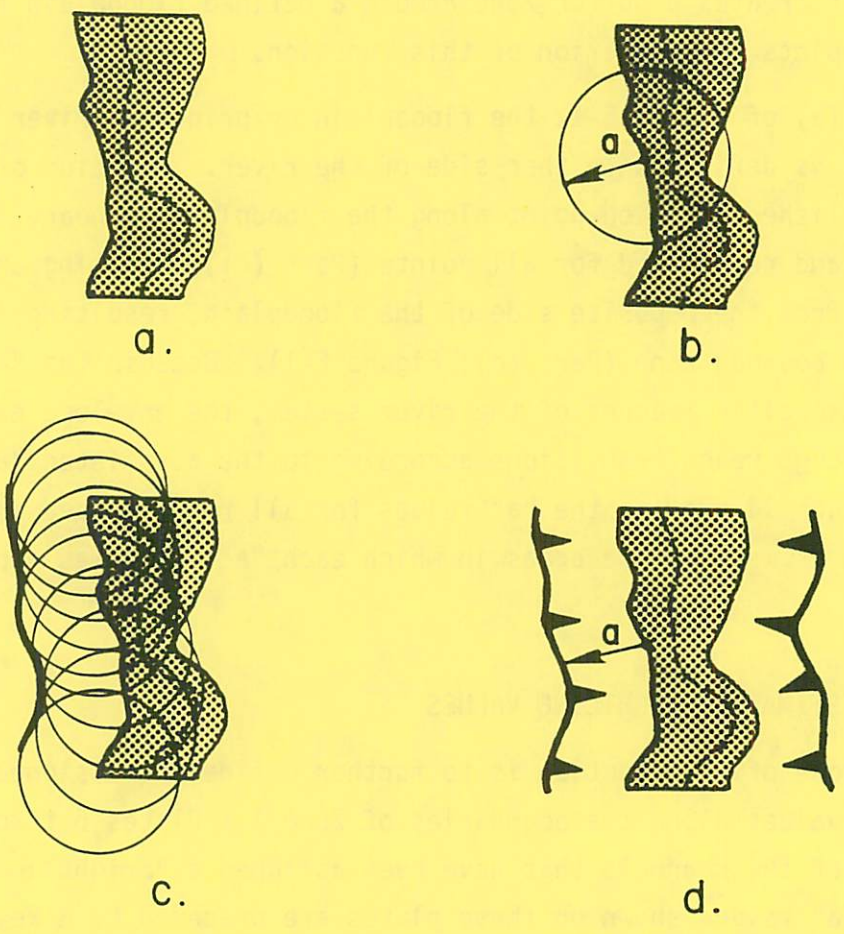


Figure E-1. Schematic showing the development of Zone 1 boundary using GIS

found on water use maps in Volume 9. The "brightline" boundaries are drawn on the water use maps to show the relationship between cultural uses and Zone 1.

TABLE E-1

LOCATION AND PARAMETERS FOR EACH BRIGHTLINE VALUE WITHIN THE SAN PEDRO RIVER WATERSHED - EXCLUDING THE FREETHEY MODEL AREA

LOCATION	MAP CODE (1)	TRANS. VALUE (ft2/day)	STORAGE COEFF. (%)	ZONE 1 "a" VALUE (ft)	SOURCE OF T/S DATA
TOWNSHIP & RANGE					
San Pedro River					
T 5 S, R 15 E T 5 S, R 16 E T 6 S, R 16 E	TR	7716	0.182	1120	Driller's log program
T 7 S, R 16 E	TR	9254	0.167	1280	Driller's log program
T 8 S, R 16 E T 8 S, R 17 E (2)	TR	10752	0.164	1393	Driller's log program
T 11 S, R 18 E (2)	TR	11554	0.226	1230	Driller's log program
T 12 S, R 18 E T 12 S, R 19 E	TR	9449	0.203	1173	Avg. of T11S, R18E and T13S, R19E; T13S, R20E
T 13 S, R 19 E T 13 S, R 20 E	TR	7343	0.180	1098	Driller's log program
T 14 S, R 20 E	TR	9632	0.169	1298	Driller's log program
T 15 S, R 20 E T 16 S, R 20 E (2)	TR	8410	0.169	1213	Driller's log program All data was in T16S, R20E
T 19 S, R 21 E (2)	TR	2088	0.080	879	Used Freethey Cell 35/17
Confined Areas					
St. David - Benson T 16 S, R 20 E (3) T 17 S, R 20 E T 16 S, R 21 E T 18 S, R 20 E T 18 S, R 21 E T 19 S, R 21 E (3)	CR	4676	0.189	855	Aquifer tests/driller's log program

TABLE E-1 (cont'd)

LOCATION	MAP CODE (1)	TRANS. VALUE (ft2/day)	STORAGE COEFF. (%)	ZONE 1 "a" VALUE (ft)	SOURCE OF T/S DATA
Confined Areas					
North of Redington - South of Mammoth T 8 S, R 17 E (3) T 9 S, R 17 E T 9 S, R 18 E T 10 S, R 18 E T 11 S, R 18 E (3)	CR	4234	0.201	789	Aquifer tests/driller's log program
Palominas - Hereford (4)					
Special Areas					
Babocomari River (5) T 21 S, R 18 E T 21 S, R 19 E	BR	3754	0.120	962	Driller's log program
Aravaipa Creek (West of Hard rock) T 7 S, R 16 E T 7 S, R 17 E	AV	3661	0.167	805	Driller's log program
Aravaipa Creek (East of Hard rock) T 6 S, R 18 E T 6 S, R 19 E	AV	3497	0.125	910	Driller's log program

NOTES:

(1) Map codes correspond to controlling feature:
AV Aravaipa Creek value
BR Babocomari River value
CR confined aquifer area value
TR township/range value.

(2) Only a portion of this T/R is covered by this value. See confined areas for remaining coverage.

(3) Only a portion of this confined area is covered by this value. See T/R for remaining coverage.

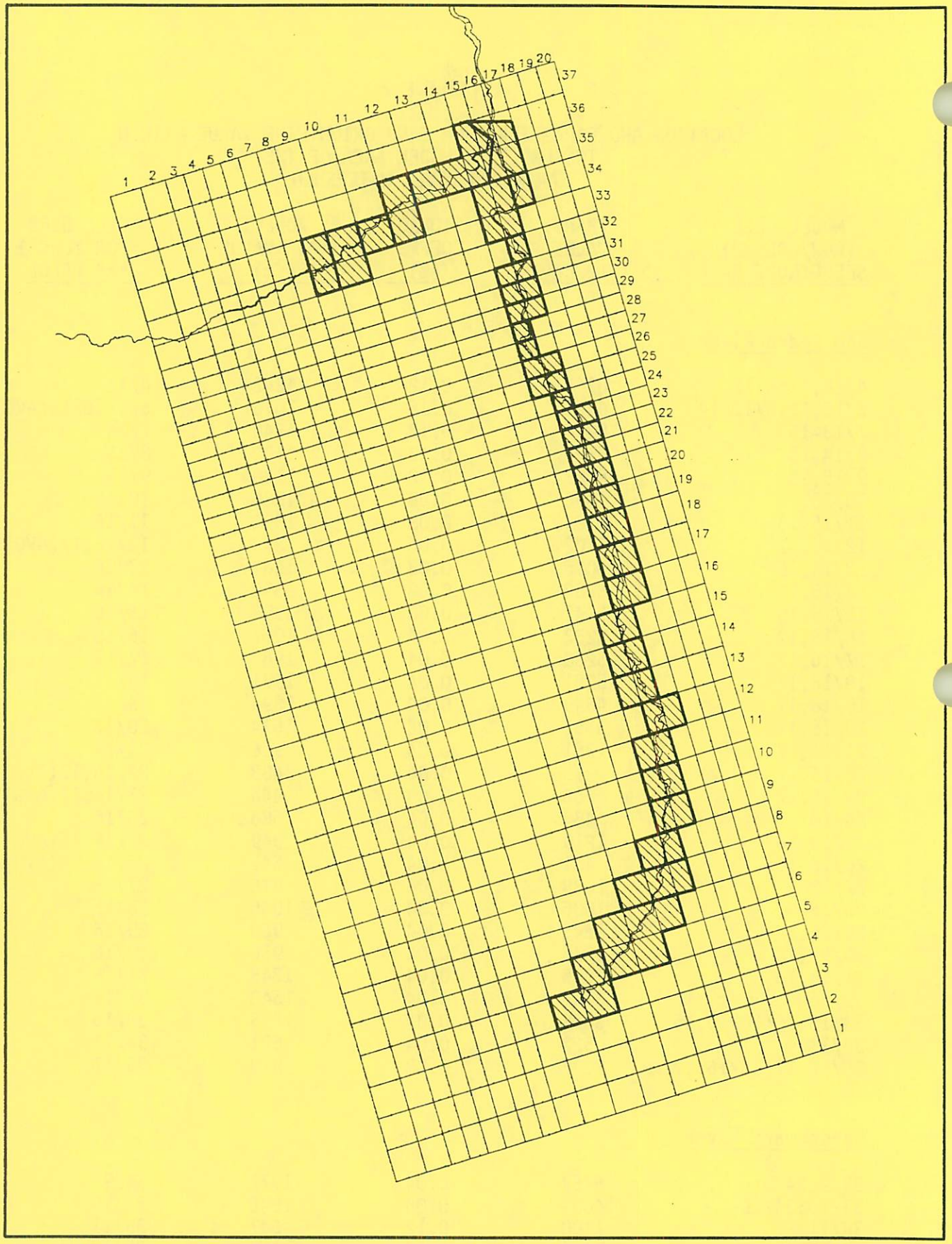
(4) Palominas - Hereford confined area is covered under the Freethey model area.

(5) This value is for the area upstream of the Freethey model area.

TABLE E-2

LOCATION AND PARAMETERS FOR EACH BRIGHTLINE VALUE WITHIN
THE FREETHEY MODEL AREA OF THE
SAN PEDRO RIVER WATERSHED

MODEL CELL (ROW/COLUMN) SEE FIGURE E-2	TRANS. VALUE (ft2/day)	STORAGE COEFF. (%)	ZONE 1 "a" VALUE (ft)	CELL USED FOR ZONE 1 "a" VALUE
San Pedro River				
4/10,11;5/11	6262	0.12	1242	4/11
5/12,13;6/12-14	6266	0.16	1076	5/12;6/13(AVG)
7/13-15	6234	0.12	1240	7/14
8/14,15	5194	0.12	1132	8/15
9/15,16	5088	0.12	1120	9/15
10/15,16	5196	0.08	1386	10/16
11/15,16	5234	0.08	1391	11/16
12/16,17	5102	0.08	1373	12/16,17(AVG)
13/15,16	5006	0.08	1361	13/16
14/15,16	5282	0.08	1398	14/16
15/15,16	5241	0.08	1392	15/16
16/16,17	5232	0.04	1967	16/16
17/16,17	5230	0.04	1967	17/17
18/16,17	5251	0.04	1971	18/17
19/16,17	4849	0.04	1894	19/17
20/16,17	3351	0.04	1574	20/17
21/16,17	1261	0.04	966	21/17
22/16,17	315	0.04	483	22/16,17(AVG)
23/16,17	266	0.04	444	23/16,17(AVG)
24/16	464	0.04	586	24/16
25/15,16	1219	0.04	949	25/15,16(AVG)
26/15,16	401	0.04	545	26/15,16(AVG)
27/15	1038	0.04	876	27/15
28/15	1506	0.04	1055	28/15
29/15,16	1246	0.04	960	29/16
30/15,16	1235	0.04	956	30/16
31/15,16	2095	0.04	1245	31/16
32/16	3208	0.04	1540	32/16
33/15,16;34/15,16	3658	0.04	1645	33/16
34/17	522	0.04	621	34/17
35/16,17;36/16,17	2088	0.08	879	35/17
Babocomari River				
33/9;34/9	5257	0.04	1972	34/9
33/10;34/10	4609	0.04	1846	34/10
34/11	1700	0.12	647	35/11
34/12;35/12	1096	0.16	450	35/12
35/13-16;36/15,16	293	0.04	465	35/15



Area of Freethey Model where brightline methodlolgy is applied

Freethey Model cellgrid

Extent of individual A-value application

Figure E-2. Freethey model cell location index map

APPENDIX F: PROCEDURES FOR QUANTIFYING WATER BUDGET TERMS

This appendix describes the procedures and assumptions utilized in quantifying the water budget terms that appear in Section 4.7 of Chapter 4. This information is provided in order to assist the reader in his or her interpretation of the hydrologic system of the San Pedro River watershed. In addition to the discussion of each water budget component, the water budget table from Chapter 4 (Table 4-14) is provided here as Table F-1. Each water budget value in Table F-1 is followed by a number that refers to a reference at the bottom of Table F-1. For example, the tributary surface water value of 35,900 for the Mexico portion of the watershed is followed by the number (9) which refers to reference (9). This allows the reader to easily verify and reference the water budget value in Table F-1. More detailed information about the references can be found in the bibliography.

The groundwater inflow, tributary surface water, and groundwater recharge components represent estimated water supply inputs to the budget. Cultural depletions, whether from surface water or groundwater, are assumed to have an immediate effect upon water supply outflows. In actuality, some of the cultural depletions are comprised of groundwater pumpage which is occurring some distance from the principal streams and therefore have only an indirect interference effect on streamflow. Consequently, the effect of these withdrawals are delayed. The budget analysis, therefore, represents the effect that 1990 development conditions would have on outflows after a long period of time when aquifer gradients (and resultant groundwater discharge to the stream) have come into balance with the amount of pumpage. Actual outflows under current conditions are thus higher than those reported in the budget, but would gradually recede to the budget values as groundwater levels come into equilibrium with pumpage.

The analysis also assumes that the groundwater overdraft has no effect on streamflow and is available independent from the surface water supply. Over the period of time required for groundwater levels to come into balance with withdrawals as discussed above, the cones of depression associated with some areas of groundwater overdraft may have intercepted the streams, causing an increase in streamflow loss and reducing the supply derived from groundwater overdraft.

TABLE F-1

WATER BUDGET ANALYSIS OF THE SAN PEDRO RIVER WATERSHED
1990 DEVELOPMENT CONDITIONS
VALUE REFERENCE KEY
(ACRE-FEET PER YEAR) (1)

	MEXICO	SIERRA VISTA	BENSON	REDINGTON	WINKELMAN	ARAVAIPA	TOTAL
SUPPLY (+)							
SW Inflow	-	23,420 (4)	39,200 (4)	25,500 (4)	32,100 (3)	-	23,420 (4)
GW Inflow	-	3,000 (2)	0 (5)	120 (5)	150 (5)	-	3,000 (2)
Tributary SW	35,900 (9)	17,300 (7)	11,800 (7)	15,710 (7)	34,070 (7)	1,500 (7)	78,880 (8)
GW Recharge	-	13,860 (6)	11,760 (6)	20,350 (7)	9,650 (7)	-	55,620 (8)
Imports	-	200 (1)	0 (1)	310 (1)	0 (1)	-	510 (1)
Exports	-	-960 (1)	0 (1)	0 (1)	-1,860 (1)	-	-2,820 (1)
TOTAL	35,900 (8)	56,820 (8)	62,760 (8)	61,990 (8)	74,110 (8)	1,500 (8)	158,610 (8)
WATER USE (-)							
Cultural							
Irrigation	5,000 (1)	4,590 (1)	14,230 (1)	8,480 (1)	3,360 (1)	1,810 (1)	30,660 (1)
Domestic	300 (1)	460 (1)	260 (1)	130 (1)	170 (1)	30 (1)	1,020 (1)
Municipal	2,300 (1)	4,530 (1)	750 (1)	1,220 (1)	10 (1)	0 (1)	6,510 (1)
Stockpond	1,000 (1)	1,460 (1)	870 (1)	780 (1)	160 (1)	600 (1)	3,270 (1)
Reservoirs	- (1)	160 (1)	270 (1)	80 (1)	110 (1)	100 (1)	620 (1)
Mining	3,000 (1)	- (1)	0 (1)	19,560 (1)	0 (1)	0 (1)	19,560 (1)
Industrial	100 (1)	50 (1)	380 (1)	30 (1)	0 (1)	0 (1)	460 (1)
TOTAL	11,700 (8)	11,250 (8)	16,760 (8)	30,280 (8)	3,810 (8)	2,540 (8)	62,100 (8)
Natural							
Channel Evap	- (1)	950 (1)	770 (1)	2,220 (1)	1,680 (1)	970 (1)	5,620 (1)
Phreatophytes	- (1)	14,450 (1)	17,690 (1)	13,400 (1)	7,060 (1)	1,500 (1)	52,600 (1)
TOTAL	- (8)	15,400 (8)	18,460 (8)	15,620 (8)	8,740 (8)	2,470 (8)	69,920 (8)
TOTAL USE	11,700 (8)	26,650 (8)	35,220 (8)	45,910 (8)	12,550 (8)	5,010 (8)	132,030 (8)
SURPLUS (=)							
GW Outflow	900 (5)	0 (5)	120 (5)	150 (5)	1,570 (5)	800 (5)	1,570 (5)
SW Outflow	23,420 (4)	39,200 (4)	25,500 (4)	32,100 (3)	56,540 (4)	27,559 (10)	56,540 (4)
Change in storage	-120 (8)	-9,030 (8)	1,920 (8)	-16,160 (8)	3,450 (8)	-	-19,820 (8)

See continuation table for explanation of footnotes.

TABLE F-1 (cont'd)

(1) Portions of this Appendix (APPENDIX F), along with APPENDIX B and APPENDIX C of this report.
(2) DWR, 1990f, (Flow Net Analysis).
(3) U.S. Geological Survey, 1991, (Stream gage records of the San Pedro River near Redington).
(4) DWR, 1990c, (Linear Regression Analysis).
(5) Heindl, 1952.
(6) DWR, 1984a, (Channel Loss Study).
(7) U.S. Geological Survey, 1973.
(8) Internal calculation of this analysis (Water Budget Analysis).
(9) Putman, Mitchell, and Bushner, 1988.
(10) U.S. Geological Survey, 1991b, (Stream gage records of Aravaipa Creek near Mammoth).

Table F-2 lists the categories that make up the water budget as they appear in Table 4-14 and Table F-1. The specific portions of this appendix which contain the quantification procedures for each identified water budget category are denoted by parenthesis (#) in Table F-2.

TABLE F-2

WATER BUDGET FOR THE SAN PEDRO RIVER WATERSHED
1990 DEVELOPMENT CONDITIONS
(ACRE-FEET PER YEAR)

	CATEGORY
SUPPLY	
Surface Water Inflow	(1)
Groundwater Inflow	(2)
Tributary Surface Water	(3)
Groundwater Recharge	(4)
Import	(5)
Export	(6)
WATER USE	
Cultural	
Irrigation	(7)
Domestic	(8)
Municipal	(9)
Stockpond	(10)
Reservoirs	(11)
Mining	(12)
Industrial	(13)
Natural	
Channel Evaporation	(14)
Phreatophytes	(15)
SURPLUS	
Groundwater Outflow	(16)
Surface Water Outflow	(17)
Change In Storage	(18)

(1) SURFACE WATER INFLOW

Surface water inflow is the average annual discharge entering each subwatershed for the period of record from 1968-1988. Discharge data was derived from United States Geological Survey (USGS) stream gages located on the San Pedro River at or near Palominas, Charleston, Tombstone, Benson, Redington, Mammoth, Winkelman, and Aravaipa Creek near Mammoth. For stream gages with an insufficient period of record (Benson and Winkelman), synthetic

streamflows were calculated by correlation to an adjacent gage through statistical linear regression analysis. For the Palominas and Tombstone gage stations, a regression analysis was performed to determine how well these gages correlate with the Charleston gage data. For the Redington and Aravaipa gages, there was no need to conduct a regression analysis due to the available history of the data. The linear regression analysis was conducted on a seasonal basis. The summer season was taken from June through October and the winter season from November through May. The results of the seasonal analysis were then summed to derive the annual flow at each gage. Table F-3 provides a synopsis of the statistical analysis performed for the gage data on the San Pedro River. This table includes a listing of the station ID and the regressed station ID for each gage, the period of record for each gage used, the period of record used for the water budget, the season of the data, the r^2 coefficient (where applicable), and the resultant seasonal and annual flow values for the gage.

(2) GROUNDWATER INFLOW

Groundwater inflow is the amount of water moving through the floodplain alluvium from an upstream subwatershed to the adjacent downstream subwatershed. With the exception of inflows from Mexico which are comprised of approximately 900 acre-feet of subflow in the floodplain alluvium and approximately 2,100 acre-feet of inflow through the regional aquifer. Inflow from the regional aquifer in Mexico was estimated through a flow net analysis (ADWR, 1990f). Inflow to the Benson subwatershed was assumed to be zero due to the overdraft in the Sierra Vista subwatershed. Inflow to the Redington subwatershed is equivalent to outflow from the Benson subwatershed and is the average of values reported by Heindl (1952). Groundwater inflow to the Winkelman subwatershed is equivalent to the outflow from the Redington subwatershed and was calculated for the floodplain alluvium consistent with the method described by Heindl (1952).

(3) TRIBUTARY SURFACE WATER

Tributary surface water is the amount of runoff contributed to the San Pedro River as a result of precipitation on the watershed. These inflows

TABLE F-3

STATISTICAL ANALYSIS OF GAGE DATA FOR THE SAN PEDRO RIVER

GAGE	STATION ID (Y VARIABLE)	STATION ID (X VARIABLE)	PERIOD OF GAGE RECORD	PERIOD OF DATA FOR WATER BUDGET
Palominas	(9470500) San Pedro River at Palominas	(9471000) San Pedro River at Charleston	1930-32 1935,40 1951-87	1968-87
	(9470400) San Pedro River at Palominas	(9471000) San Pedro River at Charleston	1931-33 1936-42 1951-87	1968-87
Tombstone	(9471550) San Pedro River near Tombstone	(9471000) San Pedro River at Charleston	1967-85	1968-87
	(9471550) San Pedro River near Tombstone	(9471000) San Pedro River at Charleston	1967-86	1968-87
Benson	(9471800) San Pedro River near Benson	(9471550) San Pedro River near Tombstone	1967-75	1968-88
	(9471800) San Pedro River near Benson	(9471550) San Pedro River near Tombstone	1968-76	1968-88
Winkelman	(9473400) San Pedro River near Winkelman	(9472000) San Pedro River near Redington(+) (9473000) Aravaipa Creek near Mammoth	1967-78	1968-88
	(9473400) San Pedro River near Winkelman	(9474000) Gila River at Kelvin (-) (9470000) Gila River at Winkelman	1962-78	1968-88

TABLE F-3 (cont'd)

GAGE	SEASON OF DATA	r^2 COEFFICIENT	AVERAGE VALUE AT GAGE	ANNUAL GAGE VALUE
Palominas	y var: cal yr - summer runoff	.95	15150	23420
	x var: cal yr - summer runoff			
	y var: wtr yr - Nov to May runoff	.99	8270	23420
	x var: wtr yr - Nov to May runoff			
Tombstone	y var: cal yr - summer runoff	.92	25040	39200
	x var: cal yr - summer runoff			
	y var: wtr yr - Nov to May runoff	.97	14160	39200
	x var: wtr yr - Nov to May runoff			
Benson	y var: cal yr - summer runoff	.95	22500	25500
	x var: cal yr - summer runoff			
	y var: wtr yr - Nov to May runoff	.98	3000	25500
	x var: wtr yr - Nov to May runoff			
Winkelman	y var: wtr yr - Nov to May runoff	.99	28320	56540
	x var: (wtr yr - Nov to May runoff) - (s.t.s. wtr yr - Nov to May runoff)			
	y var: cal yr - summer runoff	.90	28220	56540
	x var: (cal yr - summer runoff) - (s.t.s. cal yr - summer runoff)			

occur primarily from the many small ungaged ephemeral tributaries that drain the bordering mountain ranges. The tributary surface water values used in the budget were based on determinations made in a USGS administrative report (U.S. Geological Survey, 1973). These determinations incorporated a method based on a regional regression equation developed by Moosburner (1970). This method relates surface water runoff discharge to drainage area and annual precipitation.

(4) GROUNDWATER RECHARGE

Groundwater recharge results from streamflow infiltration losses to the regional aquifer occurring in tributary streams draining the mountain areas. Rainfall and snowmelt that does not reach the San Pedro River as tributary surface water inflow or is not lost to evaporation is recharged to the aquifer. Values used in the water budget were based on determinations by Putman, Mitchell, and Bushner, (1988) and the USGS (1973).

(5 & 6) WATER EXPORTS AND IMPORTS

Water exports total 2,822 acre-feet per year and are considered to be a 100 percent depletion from the hydrologic system. Water imports only contribute a portion of the total volume transferred to the hydrologic system since most of the water is depleted by cultural uses. Of the 510 acre-feet per year that is imported, only 63 acre-feet is added to the hydrologic system.

(7) IRRIGATION DEPLETIONS

Irrigation depletion within the San Pedro River watershed is the amount of water depleted from the hydrologic system as a result of evaporation and transpiration associated with irrigation related activities. Of the volume of water utilized for irrigation purposes, a certain amount meets crop needs while the remainder is evaporated from irrigation structures, runs off of the field, or percolates past the crop root zone. The volume of water transpired by the crop or evaporated from any portion of the irrigation system or irrigated field is the volume considered to be depleted from the hydrologic

system. The amount of water transpired by the crop and evaporated from the adjacent soil is discussed in APPENDIX C. The evaporational and transpirational depletions consider 1990 conditions only and do not reflect a water duty volume.

The actual volume depleted in 1990 by crops was computed by multiplying the net irrigation requirement of the crop found on an individual field by the areal extent of that crop. It was assumed that no depletions occurred from a field that was not irrigated in 1990. The total volume depleted per subwatershed was then summed.

In addition to the depletions of water by crops, DWR also considered the depletions from irrigation structures. This simply includes the additional evaporation occurring before or after water is applied to the field. This depletion volume is dependent on irrigation system type. Sprinkler systems have an additional amount of evaporation from the spray just prior to infiltration. This is calculated as in Equation F-1 (Martin, Watts and Gilley, 1984) and is represented as a percentage of applied water lost to evaporation.

EQUATION F-1

$$L = 3.32 \exp (0.11 \times u)$$

Where:

L = % of water applied that is lost to wind
u = wind speed, miles per hour

The adjusted annual daytime wind speed for the San Pedro River watershed is 2.59 mph at approximately a 6 foot height, L equals 4.42. This means that 4.42 percent of the irrigation water is evaporated prior to reaching the soil surface.

Flood irrigation systems were considered to have an additional depletion due to open ditch conveyance systems and additional wetted areas caused by runoff. Evaporation from any reservoirs associated with flood systems is computed in the section of this appendix on reservoir depletions. The amount of depletion from the additional wetted areas is assumed to be 2 percent of the amount of water applied.

Drip irrigation systems were not considered to have any additional unrecoverable losses. The total volume in acre-feet of the evaporation losses associated with irrigation in the San Pedro River watershed is presented below.

Evaporation losses from the three large conveyance ditches were also included. These evaporation losses were computed by taking the ditch length and average width to compute the free water surface area, the net evaporation rate from a free water surface, and the estimated percentage of time that the ditch is full.

IRRIGATION ASSOCIATED EVAPORATION LOSSES
(EXCLUDED RESERVOIRS)

SUBWATERSHED	EVAPOTRANSPIRATION DEPLETIONS (AC-FT)	SPRINKLER EVAPORATION (AC-FT)	FLOOD SYSTEM EVAPORATION (AC-FT)	CONVEYANCE DEPLETIONS (AC-FT)	TOTAL UNRECOVERABLE LOSSES (AC-FT)	TOTAL* DEPLETIONS (AC-FT)
Sierra Vista	4,376.9	119.1	91.3	0	210.4	4,590
Benson	13,437.8	385.8	373.4	28.9	788.1	14,230
Redington	7,934.0	384.3	162.2	4.4	550.9	8,480
Winkelman	3,210.0	47.6	105.8	0	153.4	3,360
Aravaipa	1,683.7	97.0	25.7	0	122.7	1,810
TOTAL	30,642.4	1,033.8	758.4	33.3	1,825.5	32,470

* Values are rounded to nearest tens.

(8) DOMESTIC DEPLETIONS

There were 2,599 domestic uses with water sources independent of municipal and water company systems. An average water usage of 0.5 acre-feet per year per household was assigned for each of these domestic uses. This assumes an average household size in the San Pedro River watershed of three persons and an average use of 150 gallons per capita day. It was also assumed that 20 percent of the water diverted for domestic purposes is recharged back to the groundwater system, primarily from on site sewage disposal systems.

SUBWATERSHED	NUMBER OF DOMESTICS	AMOUNT DEPLETED* (AC-FT)
Sierra Vista	1,139	460
Benson	639	260
Redington	328	130
Winkelman	418	170
Aravaipa	75	30
TOTAL	2,599	1,050

* Values are rounded to nearest tens.

(9) MUNICIPAL DEPLETIONS

Water use amounts by municipalities and water companies were obtained from DWR investigations. The values are based on the water company reports to the Arizona Corporation Commission and reported uses to DWR. Where possible, diversion amounts for 1988 were used. Magma Copper Company, which supplied water to the Arizona Water Company - San Manuel System, provided information on water sold in 1989. One water company, Arizona Water Company - Oracle System imported 312.9 acre-feet per year to the watershed and Arizona Water Company - Bisbee System exported 962 acre-feet per year. In some instances, diversion amounts were not available for 1988. DWR assumed that the most current year with available diversion data was equal to 1990 diversions. When this information was not available, the number of service connections were multiplied by 0.43 acre-feet per connection per year. This value was derived by dividing the total reported diversion amounts by the total number of connections served.

Under current development conditions, the water provided by municipal and water company systems totals 8,125 acre-feet per year for use within the watershed. This takes into account the water exported from the watershed and unavailable for use and the amount imported to the watershed and available for use. It was assumed that 20 percent of the water withdrawn for municipal and water company purposes is recharged back to the groundwater system, primarily from various sewage disposal systems. The various sewage disposal systems include effluent irrigation, wastewater treatment facilities, and on site sewage disposal systems.

SUBWATERSHED	AMOUNT DIVERTED FOR USE WITHIN THE WATERSHED (AC-FT)	AMOUNT DEPLETED* (AC-FT)
Sierra Vista	5,662	4,530
Benson	938	750
Redington	1,520	1,220
Winkelman	5	10
Aravaipa	0	0
TOTAL	8,125	6,510

* Values are rounded to nearest tens.

(10) STOCKPOND DEPLETIONS

Within the San Pedro River watershed, DWR surveyed 322 stockponds and identified 1,569 stockponds that were less than two surface acres and which were not surveyed. The survey established surface area and capacity data for each of the 322 surveyed stockponds. Of the 1,569 unsurveyed ponds, 32 are associated with an irrigation PWR and were mapped but not surveyed. The average surface area of these unsurveyed ponds was found to be 0.5 acres. All unsurveyed ponds were multiplied by this value to compute surface area. Depletions from these ponds is assumed equal to the evaporation loss from the surface of the ponds. Seepage from the ponds is a return to the hydrologic system and is not considered a depletion. Stockponds retain surface runoff only for part of the year. A retention factor of 0.6 is assumed for all stockponds. This factor adjusts the surface area available for evaporation downward to account for the level of water in a stockpond being typically less than capacity. It is further assumed that the average net evaporation from open water surface in the watershed is 4.3 feet per year (average gross evaporation of sixty-five inches minus average precipitation of 13.8 inches).

SUBWATERSHED	NUMBER OF MAPPED PONDS	AREA OF PONDS (ACRES)
Sierra Vista	18	6.4
Benson	8	4.4
Redington	5	4.7
Winkelman	0	0
Aravaipa	1	0.5
TOTAL	32	16.0

Average area of unsurveyed stockponds = 16 acres/32 ponds = 0.5 acres/pond

SUBWATERSHED	NUMBER OF MEASURED PONDS	AREA OF MEASURED PONDS	NUMBER OF UNMEASURED PONDS	AREA OF UNMEASURED PONDS	TOTAL AREA (ACRES)	AMOUNT* DEPLETED (AC-FT)
Sierra Vista	71	217.6	709	354.5	572.1	1,460
Benson	99	203.3	271	135.5	338.8	870
Redington	88	163.9	284	142.0	305.9	780
Winkelman	23	38.6	48	24.0	62.6	160
Aravaipa	41	107.5	257	128.5	236.0	600
TOTAL	322	730.9	1,569	784.5	1,515.4	3,870

* Values are rounded to nearest tens.

(11) RESERVOIR DEPLETIONS

To compute the depletion from reservoirs, DWR multiplied the amount of net evaporation from a free water surface by a retention factor and the area of the reservoirs. Gross evaporation from free water surfaces was computed from National Weather Service Publication 33 (Farnsworth, Thompson, and Peck, 1982) and is sixty-five inches per year for the San Pedro River watershed. Annual rainfall in the irrigated areas of the watershed was computed to average 13.8 inches per year. Subtracting rainfall from gross evaporation yields net evaporation or 65.0 - 13.8 = 51.2 inches of net evaporation per year.

A retention factor for each type of reservoir was computed by conducting a photo survey on recent aerial photography. The average percentage of submerged reservoir surface area was computed by estimating whether each

reservoir was 0, 25, 50, 75, or 100 percent full. This percentage was then assumed to equal the retention factor for that type of reservoir. A retention factor of 0.56 was then computed on a weighted average basis for the entire watershed and applied to all reservoirs.

The total surface area of the reservoirs was computed from surveyed ponds and mapped ponds. The surveyed area was utilized when available, otherwise the mapped area was used. DWR surveyed fifty-three small reservoirs and primary storage reservoirs within the San Pedro River watershed. Another 260 small reservoirs, regulatory reservoirs, and tail water ponds were mapped.

SUBWATERSHED	MEASURED RESERVOIRS	UNMEASURED RESERVOIRS	SURFACE AREA SW SUPPLY (ACRES)	SURFACE AREA GW SUPPLY (ACRES)	AMOUNT* DEPLETED (AC-FT)
Sierra Vista	11	30	39.1	25.9	160
Benson	19	169	2.2	108.8	270
Redington	4	40	8.4	26.4	80
Winkelman	18	4	7.4	37.7	110
Aravaipa	1	17	39.7	2.2	100
TOTAL	53	260	96.8	201.1	720

* Values are rounded to nearest tens.

(12) MINING DEPLETIONS

The primary mining activity within the San Pedro River watershed is associated with copper mining. Mining activities divert almost 23,300 acre-feet of water annually. Another 1,860 acre-feet is exported out of the watershed. These values are based on reported figures obtained by DWR. Most of the 23,300 acre-feet is utilized by Magma Copper Company not including the water diverted for municipal and irrigation uses. It is estimated that their operation returns 16 percent of the water diverted. The remaining 84 percent is consumed. This percentage is based on an estimate of the percentages of water used within each category of the mining operation. For example, 100 percent of the water used in the smelter and solvent extraction operation is consumed while the mill operation is estimated to consume only 80 percent of

the water diverted. The 84 percent consumption estimate represents a weighted average of all categories of use. Exports are equal to 100 percent depletion from the watershed.

SUBWATERSHED	AMOUNT DIVERTED (ACRE-FEET)	AMOUNT EXPORTED (ACRE-FEET)	PERCENT CONSUMED	AMOUNT DEPLETED* (ACRE-FEET)
Sierra Vista	2	0	100	0
Benson	0	0	0	0
Redington	23,287	0	84	19,560
Winkelman	1	0	84	0
Aravaipa	0	0	0	0
TOTAL	23,290	0		19,560

* Values are rounded to nearest tens.

(13) INDUSTRIAL DEPLETIONS

The primary industrial uses with independent water sources in the San Pedro River watershed are sand and gravel operations and Apache Nitrogen Products, Inc. The industrial depletions were handled in a similar way as the mining depletions. An estimate of the percent return to the groundwater system was made depending upon the type of operation. For example, sand and gravel operations were assumed to return 80 percent of the water diverted back to the hydrologic system.

SUBWATERSHED	AMOUNT DIVERTED (ACRE-FEET)	PERCENT CONSUMED	AMOUNT DEPLETED* (ACRE-FEET)
Sierra Vista	225	20	50
Benson	542	70	380
Redington	144	20	30
Winkelman	0	0	0
Aravaipa	0	0	0
TOTAL	911		460

* Values are rounded to nearest tens.

(14) CHANNEL EVAPORATION

See APPENDIX B for information on procedures for estimating natural uses of water on the San Pedro River watershed.

(15) PHREATOPHYTES

See APPENDIX B for information on procedures for estimating natural uses of water on the San Pedro River watershed.

(16) GROUNDWATER OUTFLOW

Groundwater outflow at the watershed outlet is the average of the values reported by Heindl (1952). The outflow from the watershed occurs entirely as underflow within the floodplain alluvium since groundwater flow in the regional aquifer adjacent to the northern watershed boundary in toward the San Pedro River. Groundwater outflows for each subwatershed is equivalent to the inflow to the adjacent downstream subwatershed (see groundwater inflow).

(17) SURFACE WATER OUTFLOW

These values were determined using USGS stream gage records in the same manner as surface water inflows.

(18) CHANGE IN STORAGE

Change in storage is the amount of water depleted from or added to the watershed, including both the surface water and groundwater systems. Change in storage is equal to total supply minus total uses minus surface water and groundwater outflows.

CULTURAL DIVERSIONS

DWR computed the total amount of water diverted for cultural uses within the San Pedro River watershed. This is the amount of water that must be diverted to supply the cultural uses plus any additional amount of water lost

in the process of supplying these uses. The cultural diversion is the amount of water depleted from the watershed by cultural uses plus the amount of water that returns to the hydrologic system.

The quantity of irrigation diversion is equal to the consumptive use of the crop plus any unrecoverable losses plus returns to the hydrologic system. It is computed by dividing the crop consumptive use by the farm irrigation efficiency (which includes unrecoverable losses and returns) and adding any conveyance losses. Some irrigation uses are supplied by water imported into the watershed. In these instances, the excess application of irrigation water is a water export, therefore, the diversion quantity reported for these situations is simply the depletion amount.

Domestic diversions are estimated by multiplying the number of domestic diversions by 0.5 acre-feet per year.

Municipal diversion amounts are collected by DWR and are as reported in Section 9 above. The quantity reported for municipal diversions does not consider the water imported or exported from the watershed. The quantity of municipal exports and imports is included in Sections 5 and 6.

Stockpond diversions were calculated by summing the volume lost to depletions and the volume that is returned to the hydrologic system. The volume of water that is consumed by livestock or that remains in storage is considered negligible. The amount of water that is returned to the hydrologic system is computed by multiplying the area by the retention factor (see Section 10 above) and a seepage rate of 0.02 feet per day (Kiyose, 1984).

Reservoir diversions are usually part of an irrigation operation and the diversion amount is computed with the irrigation diversion. The amount of water diverted for reservoirs not associated with an irrigation operation was considered negligible except for the two commercial fish operations. Diversion quantities for these operations was computed the same as were stockpond diversions.

Mining and industrial diversions were calculated from information obtained by DWR and as presented in Sections 12 and 13 above.

One additional exporter, ASARCO, exports water out of the San Pedro River watershed to the Upper Gila watershed. The diversion amount is reported as obtained by DWR.

	SIERRA VISTA (AC-FT)	BENSON (AC-FT)	REDINGTON (AC-FT)	WINKELMAN (AC-FT)	ARAVAIPA (AC-FT)	TOTAL (1) (AC-FT)
Irrigation	7,830	28,030	16,780	6,530	3,520	62,690
Domestic	570	320	160	210	40	1,300
Municipal	5,660	940	1,520	10	0	8,130
Stockponds	3,970	2,350	2,120	430	1,630	10,500
Reservoirs	0	0	10	250	0	260
Mining	0	0	23,290	0	0	23,290
Industrial	230	540	140	0	0	910
Exports	960	0	0	1,860	0	2,820
Imports (2)	200	0	310	0	0	510
Net Diversion	19,020	32,180	43,710	9,290	5,190	109,390

(1) Values are rounded to nearest tens.

(2) Imported water is subtracted from the Net Diversion.

APPENDIX G: METHODOLOGY USED IN THE DETERMINATION OF SIGNIFICANT DIMINISHMENT TO FEDERAL RESERVED RIGHTS

This appendix describes the procedure and methodology used in determining impacts to the groundwater supply on Fort Huachuca. The basis of this determination was the United States Geological Survey (USGS) model that has been reported in the USGS Open-File Report 82-752, by Freethey, 1982.

PROBLEM IDENTIFICATION

Increased groundwater withdrawal rates due to the growing population of the Sierra Vista, Fort Huachuca, and Huachuca City areas has and will continue to result in water being extracted from aquifer storage. Water levels in this region are declining despite the apparently large water supply of the aquifer(s). Further population growth, and subsequent pumpage from the aquifer(s) in this area will accelerate the decline of the water table threatening the operability of the existing wells in the vicinity (U.S. Army Corps of Engineers, 1987). The problem of special interest is, per the instructions of the court's order of September 9, 1988: "determine all stream users or diversions of either surface water or groundwater which significantly affect those sources reasonably available on, at, or near the federal parcel . . ." (emphasis added).

SCOPE OF WORK

An initial review of stream users or diversions of surface water in the area around Fort Huachuca resulted in the conclusion that no surface water users existed that would have a "significant" impact on the military reservation's water supplies. Subsequently, the scope of work concentrated on a four step process. The first step was identifying groundwater users that might significantly impact Fort Huachuca's groundwater supply. The second step was updating and refining the pumpage data in the area of Sierra Vista, Huachuca City, and Fort Huachuca for the time period 1986 through 1988. These data sets were used in conjunction with a groundwater flow model previously developed by Freethey (1982) and revised by Putman et al., (1988). The third

step was estimating future pumpage by using the Department of Economic Security (DES) projected population figures (1989). The fourth step was to evaluate the accumulative impact of eight nearby municipal water companies pumping groundwater by running the updated model through 2038 in lieu of the projected increased pumpage.

PREVIOUS WORK

A numerical groundwater flow model for the Upper San Pedro River basin was developed by Freethey (1982). This model incorporated the area north from the International Boundary to the Babocomari River and east from the Huachuca Mountains to the San Pedro River. The hydrologic system for this area was defined by Freethey from previous work on the basin.

The Arizona Department of Water Resources (DWR) updated and revised the model for the time period 1977 through 1985 as reported in Putman et al., (1988). The U.S. Army Corps of Engineers study (Los Angeles District, 1987) incorporated the USGS Modflow model of the Upper San Pedro Basin to analyze the outcome of increased pumpage resulting from the municipal growth surrounding the military reservation. The analysis demonstrated results similar to this investigation by DWR, namely that water levels in Fort Huachuca's Well Nos. 1 and 2 will drop below the wells drilled depth within the next 30 years unless corrective measures are taken.

VERIFICATION OF THE UPPER SAN PEDRO NUMERICAL GROUNDWATER FLOW MODEL FOR SITE SPECIFIC USE

Several past investigations including Freethey (1982), the U.S. Army Corps of Engineers (1987), and Putman et al., (1988), have evaluated the Upper San Pedro using a numerical model. Freethey stated in the USGS open file report 82-752: "The numerical model developed for the Upper San Pedro basin simulates the hydrologic system to an acceptable degree of accuracy on the basis of current knowledge and definition of the system." However, Freethey goes on to say in the report that "The purpose of the model was not to analyze site specific groundwater conditions or to predict water level changes in wells." Near the summary of the report he also states "Although the model as developed is not designed for use in site specific studies, generalized

planning for the future of the groundwater is possible." Therefore, realizing the model's limitations in analyzing site specific conditions, it was used to assess regional impacts to the aquifer near the military reservation and natural conservation area boundaries.

Table G-1 lists wells, the respective modflow cell that contains the well, and the column that compares actual measured head to calculated modeled head (model minus actual). In most of the cases, the modeled heads are within twenty feet of measured heads for approximately the same time frame. In the few cases that the difference was greater than thirty feet; either the model simulates actual head much better in other stress periods (time frames) for the same cell or that adjacent modeled cells are much more accurately approximating actual measured water levels. Table G-1 demonstrates that the parameters used in the model generally result in calculated water levels that are reasonably close to actual measured water level for the purposes of this study. Therefore, the evaluation of the area's future growth and its impact on the Fort Huachuca concentrated primarily on increased pumpage scenarios with few modifications to other data sets. The ending 1988 Water Level Map including Fort Huachuca, Sierra Vista and Huachucha City municipal well locations is shown in Figure G-1.

IDENTIFICATION OF GROUNDWATER USERS AND QUANTIFICATION OF PUMPAGE OFF THE MILITARY RESERVATION THROUGH 1988

Eight water companies were identified as having a possible impact on Fort Huachuca within the model domain. Each well within the water company's service area boundary was converted to its respective model cell using the adjudication file maps. Pumpage figures from 1986 through 1988 were obtained from records from the Arizona Corporation Commission (ACC) and USGS. Total sales amount (in million gallons) by private water companies are reported to the ACC on an annual basis per service area rather than on a per well basis. The conversion of sales per year to pumpage per cell was prorated according to how many service area wells were located in each pumping cell. It was assumed that all wells pumped equal amounts of water per year for any given water company because of the lack of well specific pumpage data. The number of wells in each water company's service area and the three year average for pumpage from 1986 through 1988 in acre-feet is given below in Table G-2.

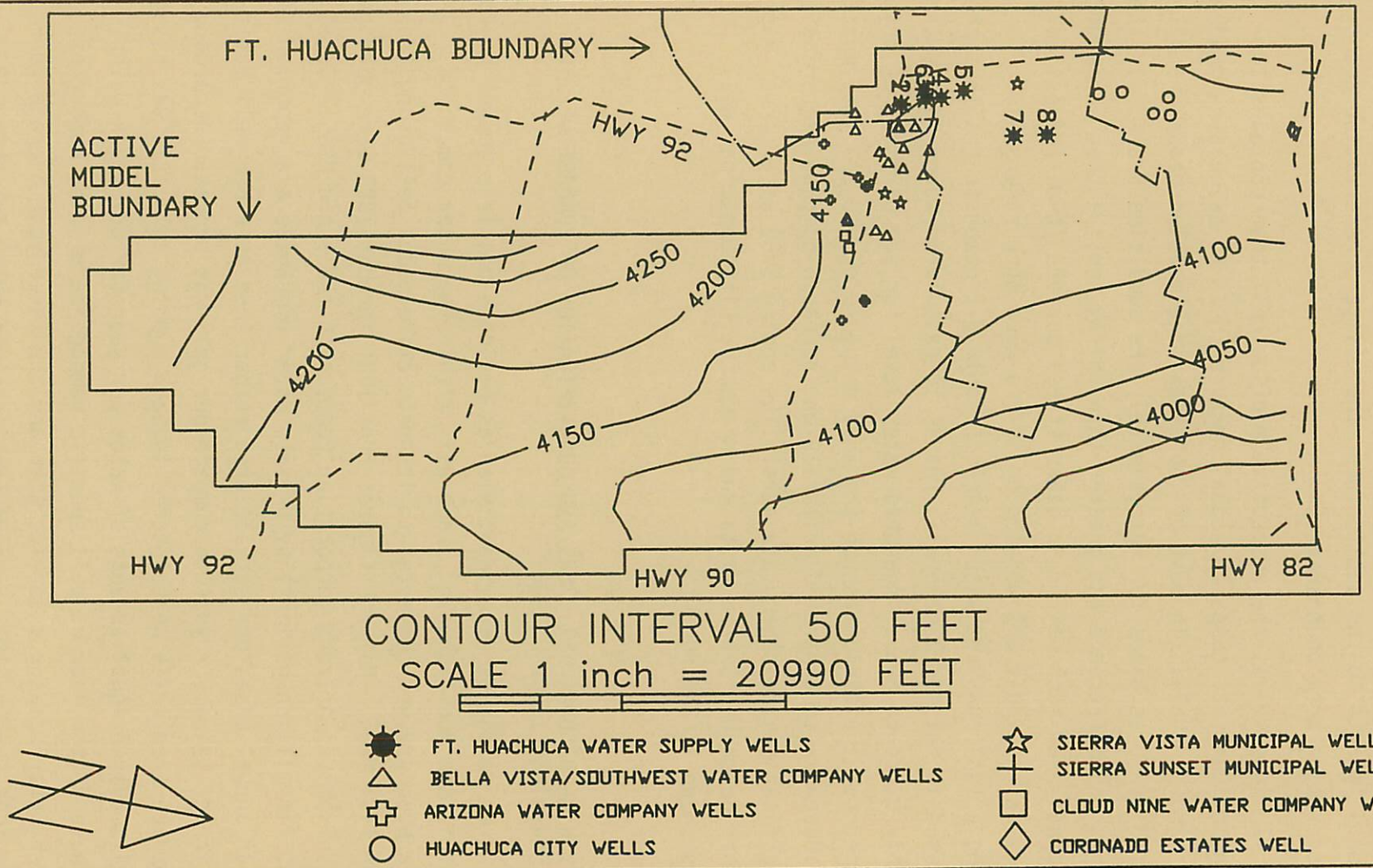


Figure G-1. Water level map ending 1988 - including Fort Huachuca, Sierra Vista, and Huachuca City municipal well locations

TABLE G-1

COMPARISON OF MODELED WATER LEVELS VERSUS MEASURED WATER LEVELS (RUN - INCLUDES FORT HUACHUCA AND SURROUNDING MUNICIPAL PUMPAGE)

WELL NO.	CADASTRAL	CELL	DATE COMPLETE	ALT. (MSL)	DEPTH OF WELL (MSL)	WATER LEVEL	DATE MEAS.	MODEL W.L	DATE	MEAS. W.L.- MODL. W.L.	STRESS PERIOD
Arizona Water Co.											
2	D-21-21 33dcd	11,20		4,330	4,020	4,152.1	12\85	4,137.2	12\85	14.9	11
				4,330		4,158.9	4\78	4,150.4	12\77	8.5	10
3	D-21-21 33cbb2	11,21	1972	4,327	3,827	4,148.4	12\85	4,126.5	12\85	21.9	11
6	D-22-20 1bca1	7,21	1959	4,530	3,820	4,141.8	12\85	4,127	12\85	14.8	11
				4,530		4,151	4\78	4,155.2	12\77	-4.2	10
				4,530		4,139.2	3\69	4,171.6	12\68	-32.4	7
				4,530		4,171	3\68	4,173.5	12\67	-2.5	6
7	D-22-20 1bcc	7,21	1965	4,550	3,945	4,147.9	12\85	4,127	12\85	20.9	11
				4,550		4,149.4	3\68	4,173.5	12\67	-24.1	6
8	D-22-20 1bca2	7,21		4,530	4,026	4,141.8	12\85	4,127	12\85	14.8	11
9	D-22-20 12aab	7,20	1978	4,515	3,465	4,164	12\85	4,143.9	12\85	20.1	11
Bella Vista/Southwest Wells											
1	D-21-20 35cdd	6,22	1956	4,560	3,920	4,131.2	12\85	4,113.9	12\85	17.3	11
2	D-21-20 35cbc	5,23	1958	4,580	3,930	4,128.8	12\85	4,107.2	12\85	21.6	11
				4,580		4,130.8	4\78	4,126.2	12\77	4.6	10
3	D-21-20 35dbb	6,23	1968	4,545	3,920	4,128.7	12\85	4,111.7	12\85	17	11
				4,545		4,134.9	4\78	4,130.7	12\77	4.2	10
				4,545		4,154.1	3\69	4,150.7	12\68	3.4	7
4	D-22-20 2bac	6,22	1956	4,585	3,885	4,134.7	12\85	4,113.9	12\85	20.8	11
5	D-21-21 31bdc	9,22	1972	4,440	3,820	4,152.3	12\89	4,122.7	12\89	29.6	12
				4,440		4,154.9	12\85	4,122.7	12\85	32.2	12
7	D-21-20 34aaa	5,24	1968	4,566	3,866	4,130.5	12\85	4,113	12\85	17.5	11
9	D-21-20 34dcc1	5,22	1956	4,615	3,960	4,120.8	7\77	4,131.7	12\77	*	10
				4,615		4,123.5	7\76	4,134.2	12\76	*	9
10	D-21-20 34dcc2	5,22		4,615	3,915	4,107.4	12\85	4,107.8	12\85	-0.4	11
				4,615		4,041.3	3\68	4,150.4	12\67	-109.1	6
12	D-22-20 10abb	4,21		4,677		4,135.5	12\85	4,125.4	12\85	10.1	11
				4,677		4,101.9	2\89	4,115.7	12\88	-13.8	12

TABLE G-1 (cont'd)

WELL NO.	CADASTRAL	CELL	DATE COMPLETE	ALT. (MSL)	DEPTH OF WELL (MSL)	WATER LEVEL	DATE MEAS.	MODEL W.L	DATE	MEAS. W.L.- MODL. W.L.	STRESS PERIOD
Bella Vista/Southwest Wells (cont'd)											
13	D-22-20 3ddd	5,21	1978	4,640	3,773	4,029	12\85	4,113.4	12\85	-84.4	11
14	D-22-21 6bcc	8,20	1972	4,480	3,880	4,079.1	2\89	4,137.7	12\88	-58.6	12
				4,480		4,145.8	12\85	4,142.3	12\85	3.5	11
15	D-22-21 6bcd	8,20	1972	4,476	3,774	4,163.3	12\85	4,142.3	12\85	21	11
16	D-21-21 31cac	9,21	1960	4,440	3,939	4,143.16	12\85	4,132.8	12\85	10.36	11
				4,440		4,163.7	3\68	4,167.1	12\67	-3.4	6
Cloud 9 Water Co. wells											
2	D-22-21 6acc	9,20	1969	4,425	3,825	4,154.6	7\77	4,153.5	12\77	*	10
				4,425		4,157.4	7\67	4,166.6	12\76	*	9
Coronado Estates wells											
1	D-2-20 18cad	5,36		4,360		4,145.9	4\69	4,138.6	12\68	7.3	7
Fort Huachuca wells											
1	D-22-20 3bbb2	4,23	1939	4,641	4,571	4,124	12\67	4,132.7	12\67	-8.7	6
				4,619.3		4,121.3	12\67	4,149.9	12\67	-28.6	6
				4,619.3		4,128.3	3\67	4,145.8	12\68	-17.5	7
				4,619.3		4,130.3	11\77	4,138.2	12\77	-7.9	10
7	D-21-20 22bbb2	5,27	1976	4,476	3,714	4,144.7	12\85	4,126	12\85	18.7	11
	D-21-20 22bbb1	5,27	1963	4,477	3,727	4,141.9	2\89	4,120.3	12\88	21.6	12
				4,477		4,144.2	12\85	4,126	12\85	18.2	11
				4,477		4,142	12\76	4,137.7	12\76	4.3	9
				4,477		4,152.1	2\73	4,141.1	12\72	11	8
				4,477		4,156.5	3\69	4,145.9	12\68	10.6	7
				4,477		4,155.5	3\68	4,147.6	12\67	7.9	6
8	D-21-20 16ada2	5,28	1971	4,426	3,619	4,137.1	12\85	4,127.5	12\85	9.6	11
	D-21-20 16ada1	5,28	1971	4,400	3,593	4,115	2\89	4,122.4	12\88	-7.4	12
				4,400		4,113.7	11\88	4,122.4	12\88	-8.7	12
				4,400		4,117.5	2\86	4,127.5	12\85	-10	11
				4,400		4,117.1	12\85	4,127.5	12\85	-10.4	11

TABLE G-1 (cont'd)

WELL NO.	CADASTRAL	CELL	DATE COMPLETE	ALT. (MSL)	DEPTH OF WELL (MSL)	WATER LEVEL	DATE MEAS.	MODEL W.L	DATE	MEAS. W.L.- MODL. W.L.	STRESS PERIOD
Huachuca City Municipal wells											
1	D-21-20 5cdc	3,32	1957	4,375	4,075	4,162.6	7\77	4,143.1	12\76	*	9
3	D-20-20 31dda	4,33	1957	4,250	3,950	4,162.8	3\68	4,143.2	12\67	19.6	6
4	D-21-20 5abc	4,32	1971	4,331	3,929	4,131.1	1\86	4,133.2	12\85	-2.1	11
				4,331		4,132	11\72	4,141.5	12\72	-9.5	8
5	D-21-20 8bdd	3,31	1974	4,431	3,929	4,140.5	1\86	4,137.7	12\85	2.8	11
Sierra Vista Water Co. wells											
3	D-21-20 20dcd	3,28	1971	4,600	3,799	4,168.6	7\76	4,149.2	12\76	*	9

* = More than a four month span between simulated water level and measured water level.

TABLE G-2

AVERAGE WATER COMPANY PUMPAGE DATA FOR 1986 THROUGH 1988

WATER COMPANY	NUMBER OF WELLS	PUMPAGE (AF/YR)
Arizona	9	833
Bella Vista/Southwest	16	2,932
Cloud 9	2	43
Coronado Estates	1	22
Sierra Sunset	1	22
Crystal	1	7
Huachucha City	5	253
Sierra Vista Municipal	3	130
TOTAL	38 wells	4,241

Table G-3 lists these water companies along with the cell layer, row and column, followed by the 1986-1988 average pumping rates per cell [depicting well(s)] and the projected pumping rates through 2038.

QUANTIFICATION OF PUMPAGE ON FORT HUACHUCA

Well locations and pumpage on Fort Huachuca were also converted to model cells. Pumpage figures for the period from 1986 through 1988 were supplied by Fort Huachuca on a well by well basis. Currently, Fort Huachuca operates eight water supply wells that withdraw approximately 2,787 acre-feet per year for the 1986 through 1988 base period. Table G-3 also lists the reservation's cell locations, pumpage from 1986 through 1988 and projected pumpage through 2038. The average pumpage for Fort Huachuca from 1951 through 1988 was 2,666 acre-feet per year.

EFFECTS OF OFF-RESERVATION GROUNDWATER PUMPAGE TO RESERVATION GROUNDWATER SUPPLIES THROUGH 1988

To evaluate the impact of the municipal pumpage on Fort Huachuca's water supply wells, a model run was produced where all of the municipal pumpage was excluded. This base run reflects only the impact that Fort Huachuca's pumpage has on the aquifer storage in the vicinity. Such a scenario reflects a no impact condition on local aquifer storage by nearby groundwater users. This run was then compared to the model run that included the municipal pumpage. Referring to Chapter 5, Section 5.4, Figure 5-27 entitled Upper San Pedro River Basin Drawdown Map Due to Municipal Pumpage Through 1988, illustrates the difference in water levels between the projected drawdown due solely to Fort Huachuca pumpage (1940 through 1988) compared to modeled water levels that also include the surrounding municipal pumpage. Table G-4 estimates the additional lift costs and maintenance costs to Fort Huachuca due to the increased projected drawdown from the municipal pumpage surrounding Fort Huachuca for the time period 1940 through 2038. See Table G-4 "Explanation of Columns" for a description of calculations and assumptions. Also see Table G-5 for a listing of quantities of water lifted (acre-feet per year) from 1951 through 1988 and projected quantities from 1989 through 2038.

TABLE G-3

PUMPAGE VALUES USED FOR NUMERICAL MODEL 1986-2038 FOR FORT HUACHUCA AND SURROUNDING MUNICIPAL WATER COMPANIES (UNITS ARE CUBIC FEET PER SECOND)

GROUNDWATER USER	LAYER	ROW	COLUMN	STRESS PERIOD 12 1986-1988	PROJECTED: STRESS PERIOD 13 1989-1993	STRESS PERIOD 14 1994-1998	STRESS PERIOD 15 1999-2003	STRESS PERIOD 16 2004-2008	STRESS PERIOD 17 2009-2013	STRESS PERIOD 18 2014-2018	STRESS PERIOD 19 2019 2023	STRESS PERIOD 20 2024-2028	STRESS PERIOD 21 2029-2033	STRESS PERIOD 22 2034-2038
SIERRA VISTA MUN.	1	7	23	0.06	0.06	0.08	0.10	0.11	0.12	0.14	0.15	0.16	0.17	0.19
" "	1	8	23	0.06	0.06	0.08	0.10	0.11	0.12	0.14	0.15	0.16	0.17	0.19
" "	1	3	28	0.06	0.06	0.08	0.10	0.11	0.12	0.14	0.15	0.16	0.17	0.19
ARIZONA WATER COMPANY	1	5	20	0.13	0.13	0.18	0.21	0.23	0.26	0.29	0.32	0.35	0.38	0.40
" "	1	11	20	0.13	0.13	0.18	0.21	0.23	0.26	0.29	0.32	0.35	0.38	0.40
" "	1	7	21	0.5	0.5	0.68	0.80	0.90	1.01	1.13	1.24	1.35	1.45	1.56
" "	1	7	20	0.13	0.13	0.18	0.21	0.23	0.26	0.29	0.32	0.35	0.38	0.40
CLOUD 9 WATER COMPANY	1	9	20	0.06	0.06	0.08	0.10	0.11	0.12	0.14	0.15	0.16	0.17	0.19
ARIZONA WATER COMPANY	1	11	21	0.26	0.26	0.35	0.41	0.47	0.52	0.59	0.64	0.70	0.76	0.81
HUACHUCA CITY	1	4	33	0.07	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16
" "	1	4	32	0.07	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16
" "	1	3	31	0.07	0.07	0.10	0.11	0.13	0.14	0.16	0.17	0.19	0.20	0.22
BELLA VISTA/SOUTHWEST	1	6	22	0.21	0.21	0.29	0.33	0.38	0.42	0.47	0.52	0.57	0.61	0.65
" "	1	9	21	0.25	0.25	0.34	0.40	0.45	0.50	0.56	0.62	0.67	0.73	0.78
" "	1	9	22	0.15	0.15	0.20	0.24	0.27	0.30	0.34	0.37	0.40	0.44	0.47
" "	1	5	23	0.51	0.51	0.70	0.81	0.92	1.03	1.15	1.26	1.37	1.48	1.59
" "	1	4	22	0.25	0.25	0.34	0.40	0.45	0.50	0.56	0.62	0.67	0.73	0.78
" "	1	4	21	0.25	0.25	0.34	0.40	0.45	0.50	0.56	0.62	0.67	0.73	0.78
" "	1	8	20	0.51	0.51	0.70	0.81	0.92	1.03	1.15	1.26	1.37	1.48	1.59
" "	1	5	24	0.25	0.25	0.34	0.40	0.45	0.50	0.56	0.62	0.67	0.73	0.78
" "	1	6	23	0.51	0.51	0.70	0.81	0.92	1.03	1.15	1.26	1.37	1.48	1.59
" "	1	5	22	0.71	0.71	0.97	1.13	1.27	1.43	1.60	1.76	1.91	2.06	2.21
" "	1	5	21	0.45	0.45	0.61	0.72	0.81	0.91	1.01	1.11	1.21	1.31	1.40
HUACHUCA CITY	1	3	33	0.07	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16
" "	1	3	32	0.07	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16
CRYSTAL WATER CO.	1	2	36	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
CORONADO EST./SIERRA SUNST	1	5	36	0.06	0.06	0.07	0.08	0.08	0.09	0.10	0.11	0.12	0.13	0.13
FORT HUACHUCA	1	3	24	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
" "	1	4	23	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
" "	1	3	25	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
" "	1	5	27	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
" "	1	5	28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
			TOTALS	9.71	9.71	11.76	13.08	14.23	15.50	16.84	18.14	19.37	20.60	21.77

TABLE G-4

ESTIMATE OF ADDITIONAL COSTS TO FORT HUACHUCA WELLS DUE TO MUNICIPAL PUMPAGE

(1)	(2)	(3)	(4)		(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
WELL NUMBER	MODFLOW CELL	DATE COMPLETED	WELL ALTITUDE	ALTITUDE OF BOTTOM OF WELL	DEPTH OF WELL (BSL)	EFFECTIVE DEPTH	MODEL W.L. RUN 42 12/1988 (MSL)	MODEL W.L. RUN 41 12/1988 (MSL)	ADDNL AVG LIFT THRU 1988	DATE OF DIVERGENCE	ADDNL ENERGY COSTS	REPAIR COSTS THRU 1988	TOTAL COSTS THRU 1988	MODEL W.L. RUN 42 12/2038 (MSL)	MODEL W.L. RUN 41 12/2038 (MSL)	ADDITIONAL AVG. LIFT 1989-2038	ADDITIONAL ENERGY COSTS	REPAIR COSTS 1989-2038	PROJECTED DEEPENING DATE	PROJECTED DEEPENING COSTS	TOTAL COSTS 1989-2038
1	4,23	1939	4641	3938	703	3998	4093	4134	21	(1951-63)	$27,760	$ 6,762	$ 34,522	3888	4111	111	$ 93,991	$ 22,896	2017	$ 7,505	$124,392
2	4,23	1940	4641	3931	710	3991	4093	4134	21	(1951-63)	$27,760	$ 6,762	$ 34,522	3888	4111	111	$ 93,991	$ 22,896	2019	$ 7,155	$124,042
3	3,24	1942	4619	3817	802	3877	4095	4123	15	(1951-63)	$ 5,223	$ 1,272	$ 6,496	3958	4100	70	$ 89,973	$ 21,917	----	0	$111,890
4	3,24	1942	4619	3812	807	3872	4095	4123	15	(1951-63)	$ 5,223	$ 1,272	$ 6,496	3958	4100	70	$ 89,973	$ 21,917	----	0	$111,890
5	3,25	1942	4610	3810	800	3870	4114	4137	12	(1951-63)	$ 6,141	$ 1,496	$ 7,637	3999	4115	57	$ 19,392	$ 4,724	----	0	$ 24,115
6	3,24	1958	4643	3840	803	3900	4095	4123	15	(1951-63)	$ 5,223	$ 1,272	$ 6,496	3958	4100	70	$ 89,973	$ 21,917	----	0	$111,890
7	5,27	1976	4476	3714	762	3774	4120	4135	8	(1951-63)	$ 2,182	$ 531	$ 2,713	4031	4116	42	$ 20,977	$ 5,110	----	0	$ 26,087
8	5,28	1971	4426	3619	807	3679	4122	4135	8	(1969-73)	$ 914	$ 223	$ 1,137	4044	4116	34	$ 17,031	$ 4,149	----	0	$ 21,180
											$80,427	$19,592	$100,019			TOTALS 1989-2038	$515,302	$125,523		$14,660	$655,485
											TOTAL THRU 1988		$100,019				PROJECTED GRAND TOTAL 1989-2038 (DOES NOT ADJUST FOR FUTURE INFLATION)				$655,485

EXPLANATION OF COLUMNS:

1. WELL NUMBER = FT. HUACHUCA PRODUCTION WELL NUMBER
2. MODFLOW CELL = MODFLOW NUMERICAL MODEL PUMPING CELL THAT REPRESENTS THE PUMPING WELL
3. DATE COMPLETED = DATE WELL WAS ASSUMED COMPLETED PER U.S. ARMY CORPS OF ENGINEERS REPORT (U.S. ARMY CORPS OF ENGINEERS, 1974)
4. WELL ALTITUDE = ALTITUDE OF WELLHEAD (MEAN SEA LEVEL DATUM)
5. DEPTH OF WELL = DEPTH WELL COMPLETED TO PER ADWR RECORDS
6. EFFECTIVE DEPTH = DEPTH OF WELL LESS 60 FEET TO ACCOUNT FOR DRAWDOWN WHEN WELLS ARE PUMPING (U.S. ARMY CORPS OF ENGINEERS, 1987)
7. MODEL W.L. RUN 42(M.S.L.) 12/31/88 = ENDING HEAD (MEAN SEA LEVEL DATUM) FOR MODFLOW CELL REPRESENTING APPROPRIATE WELL(S). RUN 42 REPRESENTED FINAL CALIBRATED RUN THAT INCLUDED PUMPAGE FROM EIGHT IDENTIFIED SURROUNDING MUNICIPAL WATER COMPANIES
8. MODEL W.L. RUN 41(M.S.L.) 12/31/88 = ENDING HEAD (MEAN SEA LEVEL DATUM) FOR MODFLOW CELL REPRESENTING APPROPRIATE WELL(S). RUN 41 REPRESENTED FINAL CALIBRATED RUN THAT EXCLUDED PUMPAGE FROM EIGHT IDENTIFIED SURROUNDING MUNICIPAL WATER COMPANIES
9. ADDITIONAL AVERAGE LIFT THRU 1988 = CALCULATED BY SUBTRACTING THE MODEL RUN 42 WATER LEVEL FROM THE MODEL RUN 41 WATER LEVEL IN THE FIRST STRESS PERIOD THAT REFLECTS A DIFFERENCE IN HEADS, THEN TAKING THE DIFFERENCE IN WATER LEVELS BETWEEN RUNS 42 AND RUNS 41 AT THE END OF STRESS PERIOD 12 (12\31\88), THEN ADDING THOSE TWO DIFFERENCES TOGETHER AND DIVIDING THE SUM BY TWO (DOUBLE END AVERAGING)
10. DATE OF DIVERGENCE = THE TIME PERIOD REFLECTING THE FIRST STRESS PERIOD IN WHICH THE MODFLOW CELL REPRESENTING THE RESPECTIVE WELL(S) SHOWED A DEVIATION IN HEADS BETWEEN THE BASE CASE RUN (NO MUNICIPAL PUMPAGE, RUN 41) AND THE RUN THAT INCLUDED THE EIGHT MUNICIPAL WATER COMPANIES PUMPAGE (RUN 42)
11. ADDITIONAL ENERGY COSTS = THE ADDITIONAL LIFT COSTS ASSOCIATED WITH LIFTING THE WATER THE "ADDITIONAL AVERAGE LIFT THRU 1988" (SEE COMMENT #9) WERE CALCULATED USING THE FOLLOWING EQUATION: (WADE,SCHWENNESEN, 1989)
    ENERGY COST = (1.024 * "ADDITIONAL AVERAGE LIFT THRU 1988") / .540 * .026 * AF. WHERE: 1.024 = KWH (KILOWATT HOURS) TO LIFT 1 AF OF WATER 1 FOOT AT 100% OVERALL EFFICIENCY, "ADDITIONAL AVERAGE LIFT THRU 1988" (DESCRIBED IN COMMENT #9), .540 = OVERALL EFFICIENCY OF WELL STATED AS A DECIMAL, .026 = POWER COST PER KWH (.026 PER KWH IS A WEIGHTED AVERAGE FOR 1972-1988 TAKEN FROM THE #14 RATE SCHEDULES PER TUCSON ELECTRIC POWER COMPANY), AF = TOTAL ACRE FEET OF WATER LIFTED FOR THE TIME PERIOD BEING EVALUATED, A CONVERSION FROM MODFLOW CUBIC FEET/SEC TO AF/YR AND A SUMMATION TO TOTAL AF PUMPED FROM THE "DATE OF DIVERGENCE" THRU THE TIME PERIOD BEING ANALYZED (SEE TABLE G-5 FOR LISTING OF QUANTITIES)
12. REPAIR COSTS THRU 1988 = .012010 * AF (COST OF PLANT REPAIRS, MAINTENANCE, LUBRICATION AND ATTENDANCE PER FOOT OF LIFT * AF = (AS DESCRIBED IN COMMENT #11)
13. TOTAL COSTS THRU 1988 = ADDNL ENERGY COSTS + REPAIR COSTS THRU 1988
14. MODEL W.L. RUN 42(M.S.L.) 12/31/2038 = ENDING HEAD (MEAN SEA LEVEL DATUM) FOR MODFLOW CELL REPRESENTING APPROPRIATE WELL(S). RUN 42 REPRESENTED FINAL CALIBRATED RUN THAT INCLUDED PUMPAGE FROM EIGHT IDENTIFIED SURROUNDING MUNICIPAL WATER COMPANIES
15. MODEL W.L. RUN 41(M.S.L.) 12/31/2038 = ENDING HEAD (MEAN SEA LEVEL DATUM) FOR MODFLOW CELL REPRESENTING APPROPRIATE WELL(S). RUN 41 REPRESENTED FINAL CALIBRATED RUN THAT EXCLUDED PUMPAGE FROM EIGHT IDENTIFIED SURROUNDING MUNICIPAL WATER COMPANIES
16. ADDITIONAL AVERAGE LIFT 1989-2038 = DOUBLE END AVERAGE CALCULATION OF DIFFERENCE IN HEADS BETWEEN RUNS 42 & 41 IN STRESS PERIOD #13 (1988-93) PLUS THE DIFFERENCE IN HEADS BETWEEN RUNS 42 & 41 FOR STRESS PERIOD 22 (2033-2038) DIVIDED BY TWO
17. ADDITIONAL ENERGY COSTS = (SEE COMMENT #11) CALCULATED THE SAME AS #11 EXCEPT LIFTS AND QUANTITIES OF WATER ARE FROM THE PROJECTED 1989-2038 TIME FRAME
18. REPAIR COSTS 1989-2038 = (SEE NOTE #12)
19. PROJECTED DEEPENING DATE = PROJECTED DATE THAT MODELED WATER LEVELS WILL FALL BELOW THE "EFFECTIVE DEPTH" OF WELL
20. PROJECTED DEEPENING COSTS = (DEPTH OF WELL - WATER LEVEL OF RUN 42 @ 2038 - 60 FEET)) * 50.00/FT. + $2,000.00 (MOVE IN/MOVE OUT RIG),(BEEMAN PUMP SERVICE & DRILLING CO., PER. COMM.)
21. TOTAL COSTS 1989-2038 = ADDITIONAL ENERGY COSTS (1989-2038) + REPAIR COSTS (1989-2038) + PROJECTED DEEPENING COSTS (1989-2038)

TABLE G-5

ACRE-FEET OF WATER LIFTED PER STRESS PERIOD OF NUMERICAL MODEL (CONVERTED FROM CFS TO ACRE-FEET PER STRESS PERIOD)

FT. HUACHUCA WELL(S)	MODFLOW CELL	STRESS PERIOD 4 1951-63 AF LIFTED	STRESS PERIOD 5 1964-66 AF LIFTED	STRESS PERIOD 6 1967 AF LIFTED	STRESS PERIOD 7 1968 AF LIFTED	STRESS PERIOD 8 1969-72 AF LIFTED	STRESS PERIOD 9 1973-76 AF LIFTED	STRESS PERIOD 10 1977 AF LIFTED	STRESS PERIOD 11 1978-85 AF LIFTED	STRESS PERIOD 12 1986-88 AF LIFTED
NO. 1 & 2	4,23	17,411	4,604	1,788	1,860	7,413	6,602	1,390	10,365	2,063
NO. 3, 4 & 6	3,24	3,858	1,238	485	507	1,795	897	224	7,875	4,669
NO. 5	3,25	0	1,411	550	571	2,227	1,158	246	3,936	412
NO. 7	5,27	2,070	629	246	253	521	463	94	753	608
NO. 8	5,28	0	0	0	0	521	463	94	753	608
TOTAL ACRE-FEET LIFTED FOR STRESS PERIOD		23,339	7,882	3,069	3,191	12,477	9,583	2,048	23,682	8,360
TOTAL ACRE-FEET LIFTED PER YEAR		1,795	2,627	3,069	3,191	3,119	2,396	2,048	2,960	2,787
AVERAGE ACRE-FEET LIFTED PER YEARS (1951-1988)										2,666

		PROJECTED									
FT. HUACHUCA WELL(S)	MODFLOW CELL	STRESS PERIOD 13 1989-93 AF LISTED	STRESS PERIOD 14 1994-98 AF LIFTED	STRESS PERIOD 15 1999-2003 AF LIFTED	STRESS PERIOD 16 2004-08 AF LIFTED	STRESS PERIOD 17 2009-13 AF LIFTED	STRESS PERIOD 18 2014-18 AF LIFTED	STRESS PERIOD 19 2019-23 AF LIFTED	STRESS PERIOD 20 2024-28 AF LIFTED	STRESS PERIOD 21 2029-33 AF LIFTED	STRESS PERIOD 22 2034-38 AF LIFTED
NO. 1 & 2	4,23	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438	3,438
NO. 3, 4 & 6	3,24	7,782	7,782	7,782	7,782	7,782	7,782	7,782	7,782	7,782	7,782
NO. 5	3,25	687	687	687	687	687	687	687	687	687	687
NO. 7	5,27	1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013
NO. 8	5,28	1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013	1,013
TOTAL ACRE-FEET LIFTED PER STRESS PERIOD		13,933	13,933	13,933	13,933	13,933	13,933	13,933	13,933	13,933	13,933
TOTAL ACRE-FEET LIFTED PER YEAR		2,787	2,787	2,787	2,787	2,787	2,787	2,787	2,787	2,787	2,787

TOTAL ACRE FEET LIFTED PER WELL FROM 1940 THROUGH 1988

WELL	ACRE FEET
NO. 1	26,748
NO. 2	26,748
NO. 3	7,183
NO. 4	7,183
NO. 5	10,511
NO. 6	7,183
NO. 7	5,637
NO. 8	2,439

PROJECTED TOTAL ACRE-FEET LIFTED PER WELL FROM 1989 THROUGH 2038

WELL	ACRE-FEET
NO. 1	17,190
NO. 2	17,190
NO. 3	25,940
NO. 4	25,940
NO. 5	6,870
NO. 6	25,940
NO. 7	10,130
NO. 8	10,130

PROJECTED GROUNDWATER PUMPAGE 1989 THROUGH 2088

The results of the analysis through 1988 demonstrates that the impact to the water levels at Fort Huachuca's water supply wells ranges from approximately thirteen feet at Well No. 8 to forty-one feet at Wells No. 1 and 2. The estimated cost due to the additional lift and repair costs could range from $75,000 to $125,000 from 1940 through 1988 (refer to Table G-4). Table G-4 is only an estimate and does not reflect actual costs.

Future pumpage rates were calculated using population projections supplied by DES (Arizona Department of Economic Security, 1990), the projections were available to 2040. The methodology used in determining future pumpage rates through 2038 compared past population with past pumpage Arizona Department of Economic Security, 1986), Table G-6. Population figures were supplied for Sierra Vista, Huachuca City, and Fort Huachuca from 1960 to 1985 by DES. Pumpage figures for the same time periods were supplied by ACC and USGS and incorporated into the numerical model. Table G-6 compares pumpage with population by establishing a ratio of pumpage/population for several different time periods from 1960 to 1985. For Fort Huachuca, Sierra Vista and Huachuca City several of the more recent ratios were averaged to project future pumpage/population ratios through 2038. These ratios were then multiplied by the DES projected populations for Sierra Vista and Huachuca City to arrive at projected groundwater pumpage through 2038. Fort Huachuca has been incorporated by Sierra Vista since 1971, subsequently when arriving at Sierra Vista's population figures Fort Huachuca's projected population was subtracted out of the value supplied by DES. A no growth scenario for Fort Huachuca was used, or a constant pumping rate of about 2,787 acre-feet per year. The average pumpage for Fort Huachuca from 1951 through 1988 was 2,666 acre-feet per year.

PROJECTED CUMULATIVE IMPACT TO FORT HUACHUCA 1988 THROUGH 2088: FORT HUACHUCA PUMPAGE

A projected water level map to the year 2038 including Fort Huachuca, Sierra Vista and Huachuca City municipal well locations is shown in Figure G-2. Figure 5-28 entitled: Upper San Pedro River Basin Drawdown Map Due to Municipal Pumpage Through 2038, which is located in Section 5.4, shows the calculated drawdown from the projected groundwater withdrawals for the eight

TABLE G-6

RELATION BETWEEN POPULATION AND PUMPAGE (1960-1988) AND FUTURE PUMPAGE PROJECTIONS INFERRED FROM POPULATION PROJECTIONS (1989-2040)

YEAR	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
FT. HUACHUCA POPULATION			6,659	8,067	9,475	9,238	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000	9,000
FT. HUACHUCA PUMPAGE (CFS)			4.24	3.31	4.09	4.09	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85
FT. HUACHUCA PUMPAGE/POPULATION			0.00063	0.00041	0.00043	0.00044	0.00043	0.00043	0.00043	0.00043	0.00043	0.00043	0.00043	0.00043	0.00043	0.00043	0.00043
FT. HUACHUCA GPCD			411.502	265.174	278.971	286.128	276.460	276.460	276.460	276.460	276.460	276.460	276.460	276.460	276.460	276.460	276.460
SIERRA VISTA POPULATION	2854	4635	6689	12054	15462	19550	25000	31345	36730	41370	46460	51865	57070	62032	66995	71695	76395
SIERRA VISTA PUMPAGE (CFS)	0.32	0.96	1.61	2.39	4.55	4.55	5.44	7.41982	8.66828	9.76332	10.9645	12.2401	13.4685	14.6395	15.8108	16.9200	18.0292
SIERRA VISTA PUMPAGE/POPULATION	0.00011	0.00020	0.00024	0.00019	0.00029	0.00023	0.00021	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023
SIERRA VISTA GPCD	72.4621	133.855	155.553	128.139	190.178	150.411	140.628	152.982	152.520	152.520	152.520	152.520	152.520	152.520	152.520	152.520	152.520
HUACHUCA CITY	1131	1186	1241	1691	1661	1978	2295	2585	2930	3225	3550	3900	4230	4547	4865	5168	5470
HUACHUCA CITY PUMPAGE (CFS)	0.1	0.18	0.29	0.37	0.28	0.28	0.40463	0.45496	0.51568	0.5676	0.6248	0.6864	0.74448	0.80027	0.85624	0.90956	0.96272
HUACHUCA CITY PUMPAGE/POPULATION	0.00008	0.00015	0.00023	0.00021	0.00016	0.00014	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017	0.00017
HUACHUCA CITY GPCD	57.1416	98.0851	151.022	141.407	108.944	91.4844	113.945	113.743	113.743	113.743	113.743	113.743	113.743	113.743	113.743	113.743	113.743

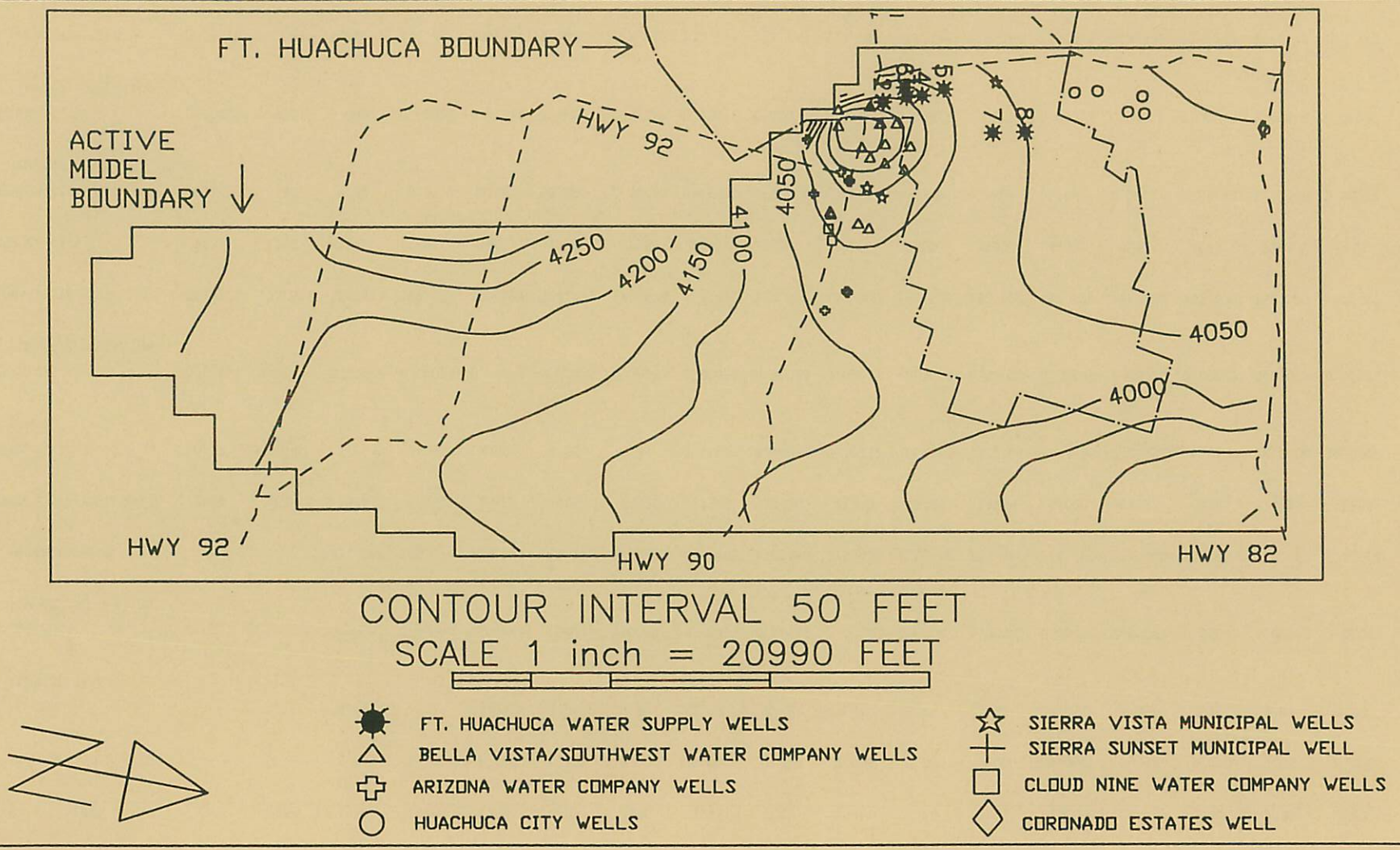


Figure G-2. Water level map ending 2038 - including Fort Huachuca, Sierra Vista, and Huachuca City municipal well locations

identified municipal water companies from 1940 through 2038. Drawdowns in the pumping center exceed 200 feet over the 98 year period. Projected costs to Fort Huachuca could range from $500,000 to $1,000,000 over the 98 year period. DWR believes that projecting fifty years into the future is an extremely difficult task. Many "best guesses" are assumed (i.e. population projections, pumpage projections, population/pumpage ratios, constant per capita usage, using only existing well locations, etc) utilizing existing trends and figures. Therefore, DWR cannot put a great amount of confidence in a fifty year projection.

METHODOLOGY USED IN THE DETERMINATION OF SIGNIFICANT DIMINISHMENT TO THE SAN PEDRO RIPARIAN NATIONAL CONSERVATION AREA

The methodology used to determine the significant diminishment to the San Pedro Riparian National Conservation Area (SPRNCA) was based on the same modeling analysis used to determine the significant diminishment to Fort Huachuca. For determining the significant diminishment to the SPRNCA, the model incorporated both the present day and projected pumpage rates. The model incorporates the affects of groundwater users in the Sierra Vista - Fort Huachuca area in addition to other major users in the basin. Although other minor groundwater users outside the Sierra Vista - Fort Huachuca area could impact or diminish groundwater supplies to the SPRNCA, the Sierra Vista - Fort Huachuca area consists of the most concentrated area of groundwater withdrawals within the Sierra Vista subwatershed. Therefore, this shows the potential effects that the major groundwater users would have on the SPRNCA. Refer to the previous sections for specific information regarding projected pumpage rates, use of the model, verification of the model and results.