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PALO VERDE TEST

LAND FALLOWING PROGRAM

August 1, 1992 - July 31, 1994

FINAL REPORT

VOLUME I: MAIN REPORT

Prepared by
Great Western Research

for

The Metropolitan Water District
of Southern California

August 1995

EXECUTIVE SUMMARY
PALO VERDE TEST LAND FALLOWING PROGRAM
August 1, 1992 - July 31, 1994

On May 29, 1992, a Program Agreement was signed ratifying a two-year Test Land Fallowing Program (Program) between The Metropolitan Water District of Southern California (MWD) and the Palo Verde Irrigation District (PVID). Under the Program, MWD would receive water saved through fallowing agricultural land in PVID in exchange for monetary compensation. The agreement required MWD to pay for administrative costs, enforcement costs, contract monitoring, and to compensate Program participants $1,240 per acre over the two-year period. Payment dates for Program participants were August 1, 1992; February 1, 1993; August 2, 1993; February 1, 1994; and August 15, 1994. Payments were made on schedule. Program participants were responsible for payment of taxes, PVID water tolls, dust control costs and maintenance costs associated with maintaining participating fields fallow.

A five-member Measurement Committee (Committee) was established to provide ongoing review of the Program. The Committee consisted of one representative from each of the following organizations: U.S. Bureau of Reclamation (USBR), PVID, MWD, Imperial Irrigation District (IID), and Coachella Valley Water District (CVWD).

Prior to Program implementation, an environmental analysis was conducted. It was determined that no significant impacts would result from the Program for the following reasons: (1) with implementation of approved mitigation measures, no significant impact to area resources was anticipated; (2) effects would be small and diffuse since only a maximum of 25 percent of base agricultural acreage would be accepted from each participant; (3) effects would be temporary as the Program was intended to last only two years; and (4) no previous significant environmental effects had been observed when PVID agricultural lands were left fallow for other reasons over a period of time.

The Program began on August 1, 1992 and ended on July 31, 1994. Landowners and lessees participating in the Program agreed to fallow a total of 20,215 acres (Fallowed Acreage). Sixty-three (63) contracts were executed with landowners/lessees in PVID. The total acreage participating in the Program (base acreage) was 80,366 acres consisting of 20,215 fallowed and 60,151 non-fallowed acres. Fallowed Acreage was 25 percent of the base acreage, consisted of 261 fields, and was approximately 22 percent of the total cropped acreage in PVID of 93,000 acres.

Over 73 percent of the Fallowed Acreage would have been used for forage production (alfalfa, sudan, and bermuda), absent the Program. Cotton and small grains would have been planted on approximately 16 percent of the Fallowed Acreage, and melons and vegetables on the remaining 11 percent.

The Fallowed Acreage was estimated to generate 4.6 acre-feet per fallowed acre each year (AF/ac/yr) during the two-year Program. Based upon 4.6 AF/ac/yr, the "saved water" was estimated to total 92,989 AF/yr or 185,978 AF during the two-year Program. The saved water was stored in Lower Colorado River Basin reservoirs, managed by the United States, and will be released at the request of MWD subject to provisions of the Program Agreement.

Executive Summary
Palo Verde Test Land Fallowing Program

Maintenance of the Fallowed Acreage for the duration of the two-year Program was accomplished according to specific Land Management Plans (Plans) submitted by each participant and reviewed by MWD at the start of the Program. The purpose of the Plans was to conserve land and water resources, and eliminate or minimize adverse impacts to adjacent farms, the community or PVID through control of weeds and wind erosion. Weed control measures included chemical and mechanical methods. Wind erosion control measures included application of appropriate cultural practices such as providing stubble, sod remnants or cloddy fallow.

The most preferred method to begin the fallowing process was application of chemicals to existing crops. Chemicals were applied to 10,513 acres which is 52 percent of the total Fallowed Acreage. Disking was the most preferred mechanical method, used on 5,414 acres (27 percent), followed by plowing with 2,835 acres (14 percent), knifing with 1,068 acres (5 percent), and subsoiling with 385 acres (2 percent) which account for the initial land fallowing of the 20,215 acres. After initial fallowing, chemicals and disking were the most common methods employed in maintaining Program compliance.

The total weighted average cost during the two-year Program for all fallowing treatments, including initial fallowing and all follow-up treatments, was $53.38 per acre. Total weighted average costs among Program participants ranged from a low of $23.08 per acre to a high of $135.00 per acre.

Program fields were monitored throughout the two-year period to ensure compliance with the terms of the fallowing agreements. Fields were visually checked a minimum of once a month. Soil moisture readings were taken from selected fields (138 fallowed and 21 non-fallowed) up to 11 times during the two-year Program. Groundwater was monitored on a monthly basis through readings from 285 observation wells. Satellite images were taken at the beginning, mid-point, and end of the Program. All monitoring efforts provided cross-checks and verified that no water was applied to fallowed fields during the Program.

One of the components of the Program Agreement was development of a computerized water ordering system for PVID. The new PVID water ordering system is being used on a daily basis and has replaced the previous manual system improving water control and manpower scheduling.

Parties to the Program Agreement agreed that 4.6 AF of water would be considered the amount saved for each fallowed acre. Part of the post-Program efforts involved estimating the amount of water actually saved. Following an in-depth review of available procedures, three methods were employed to estimate the amount of water actually saved which included: 1) Historical Comparison; 2) Rule Curve; and 3) Actual Use. The Historical Comparison method compared net diversions during the two-year Program to the 1981-91 average net diversions with the difference of 207, 334 acre-feet or 5.1 AF/ac/yr considered as an estimate of Program water savings. The Rule Curve method relies upon historic water use patterns to predict future water use. Historic water use for the 11-year period 1981-91 was used to develop a rule curve for predicting water use during the two-year period of the Program. The difference between predicted PVID net diversions and actual net diversions during the Program provided an estimate of water savings of 4.5 AF/ac/yr. The third method used to estimate water savings was based on actual water use during the Program. Inherent to this method is the assumption that the cropping pattern and water use on the fallowed fields,

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Palo Verde Test Land Fallowing Program
August 1, 1992 - July 31, 1994
Final Report

Prepared by
Great Western Research
for
The Metropolitan Water District
of Southern California

1.0 GENERAL ACTIVITIES

The General Activities section presents a summary of the Palo Verde Test Land Fallowing Program (Program) results followed by a background description, Measurement Committee and Technical Subcommittee activities, and brief descriptions of important events.

1.1 Program Summary

- **Program Agreement signed May 29, 1992 implementing two-year Test Land Fallowing Program between MWD and PVID.**
  - ► MWD to compensate participants $1,240 per acre in five payments and pay administration, enforcement, and monitoring costs.
  - ► Program participants to pay taxes, PVID water tolls, dust control, and all other items.
  - ► Five-member Measurement Committee consisting of USBR, PVID, MWD, IID, and CVWD to provide ongoing review of the Program.
  - ► Environmental analysis determined that no significant impacts would result from the Program.
  - ► The Fallowed Acreage to generate 4.6 acre-feet per fallowed acre each year.
  - ► Fallowing methods could include chemical, biological or mechanical applications.

- **The two-year Program began on August 1, 1992.**
  - ► Sixty-three (63) contracts were executed with landowners/lessees in PVID.
  - ► Total acreage participating in the Program (base acreage) was 80,366 acres consisting of 20,215 fallowed and 60,151 non-fallowed acres.
  - ► Fallowed Acreage was 25 percent of the base acreage, consisted of 261 fields and was approximately 22 percent of the total cropped acreage in PVID of 93,000 acres.
  - ► Absent the Program, 73 percent of Fallowed Acreage would have been in forage production, 16 percent in cotton and small grains, and 11 percent in vegetables and melons.
  - ► Land Management Plans reviewed by MWD for each participant.

- ► Initial fallowing consisted of chemicals (52 percent), disking (27 percent), plowing (14 percent), knifing (5 percent), and subsoiling (2 percent).
- ► After initial fallowing, chemicals and disking were the most common methods employed in maintaining Program compliance.
- ► Wind erosion control included provision of stubble, sod remnants or cloddy fallow.
- ► Fields were visually checked a minimum of once a month.
- ► Soil moisture readings were taken from selected fields (138 fallowed and 21 non-fallowed) up to 11 times during the two-year Program.
- ► Groundwater was monitored on a monthly basis through readings from 285 observation wells.
- ► Satellite images were taken at the beginning, mid-point, and end of the Program.
- ► Computerized water ordering system for PVID used on a daily basis and has replaced the previous manual system improving water control and manpower scheduling.
- ► Participants surveyed following each year finding Program beneficial, and willingness to enter into another, similar Program with only minor modifications.

- **Two-year Program ended on July 31, 1994.**
  - ► Three methods employed to estimate amount of water actually saved with results ranging from 4.5 to 5.1 AF/ac/yr. Confirmed agreement amount of 4.6 AF/ac/yr.
  - ► Post-Program survey found, as of February 1995, 17,931 acres had been planted, leaving only 2,284 unplanted acres with spring planting planned for 1,747 of those acres. Alfalfa was planted on 62 percent of the acreage previously in the Program.
  - ► Economic survey of third party businesses found that the Program did not affect overall regional economic performance, property or sales tax bases, or governmental services; however, there was a slight (1 percent) loss of employment in the region.
  - ► Total weighted average fallowing cost was $53.38 per acre, ranging from a low of $23.08 per acre to a high of $135.00 per acre.
  - ► The total cost of the Test Land Fallowing Program to MWD was $26.6 million.
  - ► 185,978 acre-feet of water saved and stored in Lower Colorado River Basin reservoirs.
  - ► Average cost per acre-foot of water saved for MWD was $143.

1.2 Background

The Metropolitan Water District of Southern California (MWD) delivers supplemental water to its 27 member agencies situated within the coastal plain of Southern California. Water sources for MWD deliveries are the Colorado River and the State Water Project. In order to enhance the supply and availability of water for member agencies, MWD has maintained an open dialogue with districts which utilize Colorado River water to explore mutually beneficial water savings programs. These programs have included measures such as lining canals with concrete and reducing irrigation runoff from agricultural fields through tailwater recovery systems.

In the mid-1980s, MWD and the PVID, headquartered in Blythe, California, began discussions related to a possible water savings program in PVID. The Palo Verde Valley is located at the eastern edge of California, separated from Arizona by the Colorado River. The valley is about 40

miles long and 10 miles wide and lies primarily in eastern Riverside County, with a small portion extending into northeastern Imperial County (Figure 1). The dominant land use is agriculture, which occupies approximately 93,000 acres per year. Principal crops grown in the valley include cotton, alfalfa, wheat, melons, and lettuce.

The PVID diverts water from the Colorado River at Palo Verde Diversion Dam into a 250-mile canal network for distribution throughout the valley. Drainage is provided by a 147-mile system of open channels which maintain an average depth-to-groundwater of approximately 10 feet. The system of drainage canals conveys return flows from irrigation to the Colorado River at the southern end of the district.

Since PVID delivers Colorado River water to approximately 93,000 irrigated acres in the Palo Verde Valley, an opportunity existed to develop a program that would decrease water used by irrigated agriculture, through fallowing a portion of the acreage, and increase the quantity of water available to MWD. Such an arrangement would be unique among water organizations with a number of management and implementation factors requiring careful attention. In order to gain experience with these factors, it was decided that a two-year test land fallowing program would be appropriate prior to development of longer-termed agreements.

In 1991, MWD and PVID agreed in principle (See Appendix A.1, Principles of Agreement) on the structure of a test land fallowing program containing the following components:

1. Two-year test program with the objective of saving 100,000 acre-feet per year.

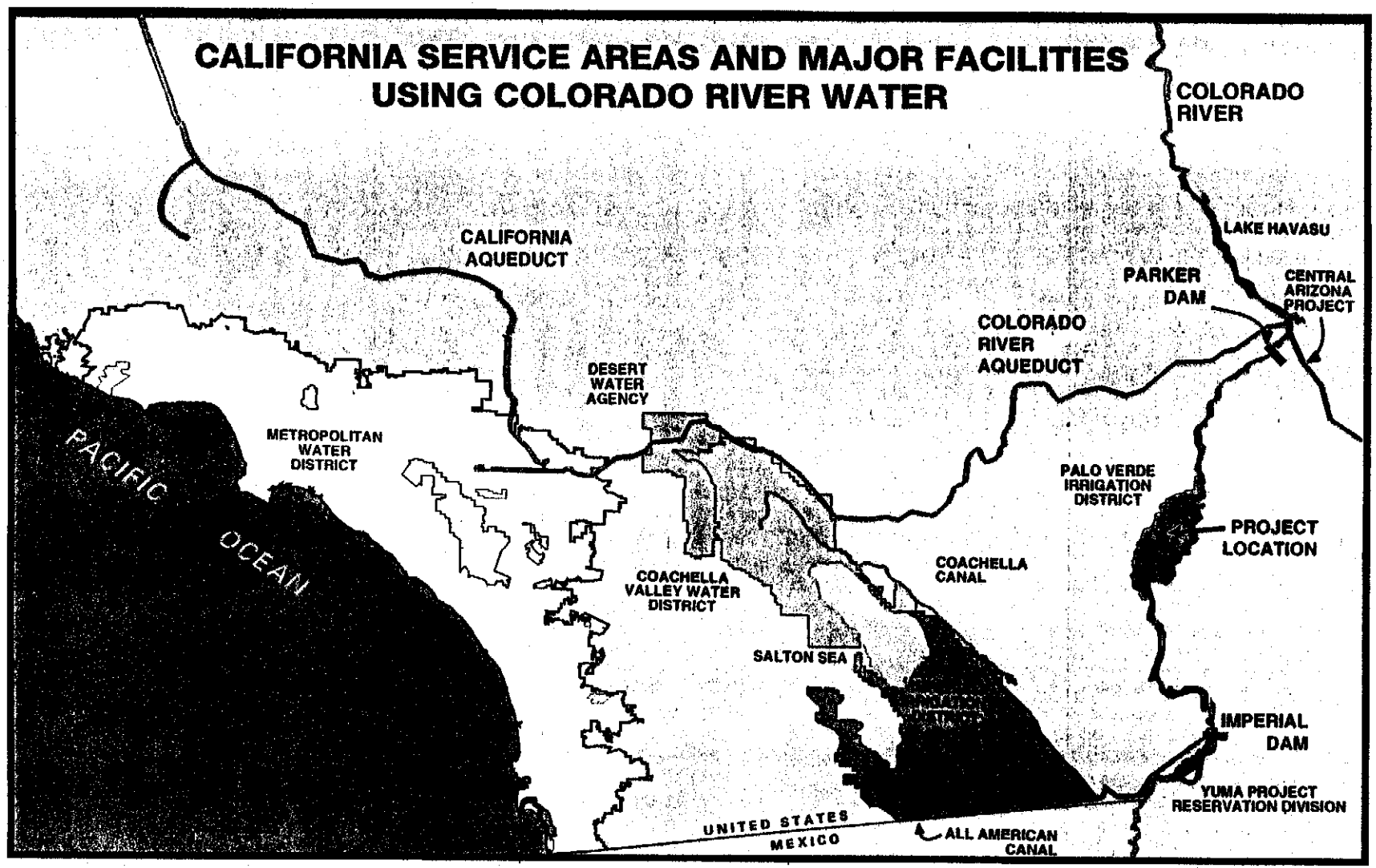
2. Land fallowing to begin July 1, 1992 and run through June 30, 1994, with the same land lying fallow for the entire two-year period.

3. MWD, with concurrence of PVID, to select party to monitor the land fallowing agreement.

4. Water savings to be 4.6 acre-feet per acre.

5. Conserved water (200,000 AF) to be used by MWD before the year 2000. If not needed, or fully needed, during 1992, 1993, or 1994 (i.e., sufficient Colorado River water available to maintain MWD's aqueduct at full capacity absent program), such water would be maintained in a MWD water management account in Lake Mead. To the extent the reservoirs fill and spill, MWD loses its right to the water. To the extent MWD does not use the water prior to January 1, 2000, MWD loses its right to the water and it becomes system water.

FIGURE 1: PROJECT LOCATION



6. Two types of agreements are required: (1) Program Agreement signed by MWD, PVID, IID, CVWD, and the USBR; and (2) a Fallowing Agreement between MWD and each participant that fallows acreage.

7. MWD will reimburse PVID for administrative costs and pay directly for contract implementation and monitoring, and $620 per acre per year to program participants. Program participants are responsible for payment of taxes, PVID water tolls, dust control, and all other items.

8. Qualifying lands must have a history of farming (i.e., would have been farmed absent program); program participants will not farm lands that would not have been farmed absent the program and will provide maintenance of weeds, dust control, etc.; minimum size of fallowed land not to be less than 20 water toll acres; a maximum participation of 25 percent of any single participant's farm unless insufficient interest for 100,000 acre-feet per year, in which case the maximum can be increased (prorated) up to a maximum of 35 percent. The 20 acre field size, 25 percent and 35 percent total farm allotments are intended as guidelines. Further adjustment may be necessary to recognize practicable plot sizes, connections to headgates, etc.

The foregoing "principles of agreement" provided the framework for the Diversion Agreement (which became the Program Agreement) and the Land Agreement (which became the Fallowing Agreement). Drafting of these documents began in late 1991. The Program Agreement (dated May 29, 1992) was completed and executed by MWD, PVID, IID, CVWD, and USBR. The Fallowing Agreement was completed and signed by individual Program participants in PVID during the "sign-up" period during June and July 1992. The complete text of the Program Agreement and Fallowing Agreement are contained in Appendix A.2.

The Principles of Agreement also provided the necessary information to begin the environmental documentation process and preparation of a Negative Declaration in compliance with provisions of the California Environmental Quality Act (CEQA). Environmental documentation was required by both the State of California and the Federal Government in order to implement the Program. A Negative Declaration is required by the State of California to comply with the requirements of California Code of Regulations, Title 14, Section 15070 et seq., which promulgates regulations adopted by the California Secretary for Resources in accordance with the requirements of CEQA (Public Resources Code Section 21000 et seq.). The Negative Declaration is used by the Federal Government as the basis to determine the appropriate action required under the National Environmental Policy Act (NEPA).

A draft Negative Declaration and Initial Study were filed in March 1992 and approved by PVID, the lead agency, on April 21, 1992 (See Appendix B). A mitigated Negative Declaration was adopted and, in accordance with Section 21081.6 of the Public Resources Code of California, the lead agency was required to adopt a monitoring and reporting program to mitigate or avoid significant environmental effects. The monitoring agencies were PVID and MWD. Additional information concerning the findings of the Initial Study is presented in Chapter 13.0

Based upon the Negative Declaration and Initial Study, the USBR, on behalf of the Federal Government, issued a Categorical Exclusion on April 30, 1992 (See Appendix B).

One month later than originally intended in the Principles of Agreement, the Test Land Fallowing Program began on August 1, 1992. Landowners and lessees participating in the Program agreed to fallow a total of 20,215 acres (Fallowed Acreage), from August 1, 1992 through July 31, 1994, in exchange for financial consideration provided by MWD. Sixty-three (63) contracts were executed with landowners/lessees in PVID. The total acreage participating in the Program (base acreage) was 80,366 acres consisting of 20,215 fallowed and 60,151 non-fallowed acres. Fallowed Acreage was 25 percent of the base acreage and about 22 percent of total cropped acreage in PVID. Figure 2 shows the location of the fallowed acreage within PVID.

Absent the Program, the following crops were planned to be planted on the Fallowed Acreage during the two-year period of 1992-93 and 1993-94:

	1992-93		1993-94	
Crop	Acres	Percent	Acres	Percent
Cotton	1,837	9.1	1,774	8.8
Wheat	1,308	6.5	1,203	6.0
Alfalfa	12,787	63.2	13,103	64.8
Sudan	1,554	7.7	1,441	7.1
Melons	1,985	9.8	1,985	9.8
Bermuda	481	2.4	481	2.4
Lettuce	158	0.8	158	0.8
Barley	35	0.2	0	0.0
Squash	70	0.3	70	0.3
Totals	**20,215**	**100.0**	**20,215**	**100.0**

Absent the Programs, over 73 percent of the Fallowed Acreage would have been in forage production (alfalfa, sudan, and bermuda). Cotton and small grains would have been planted on approximately 16 percent of the Fallowed Acreage and melons and vegetables on the remaining 11 percent.

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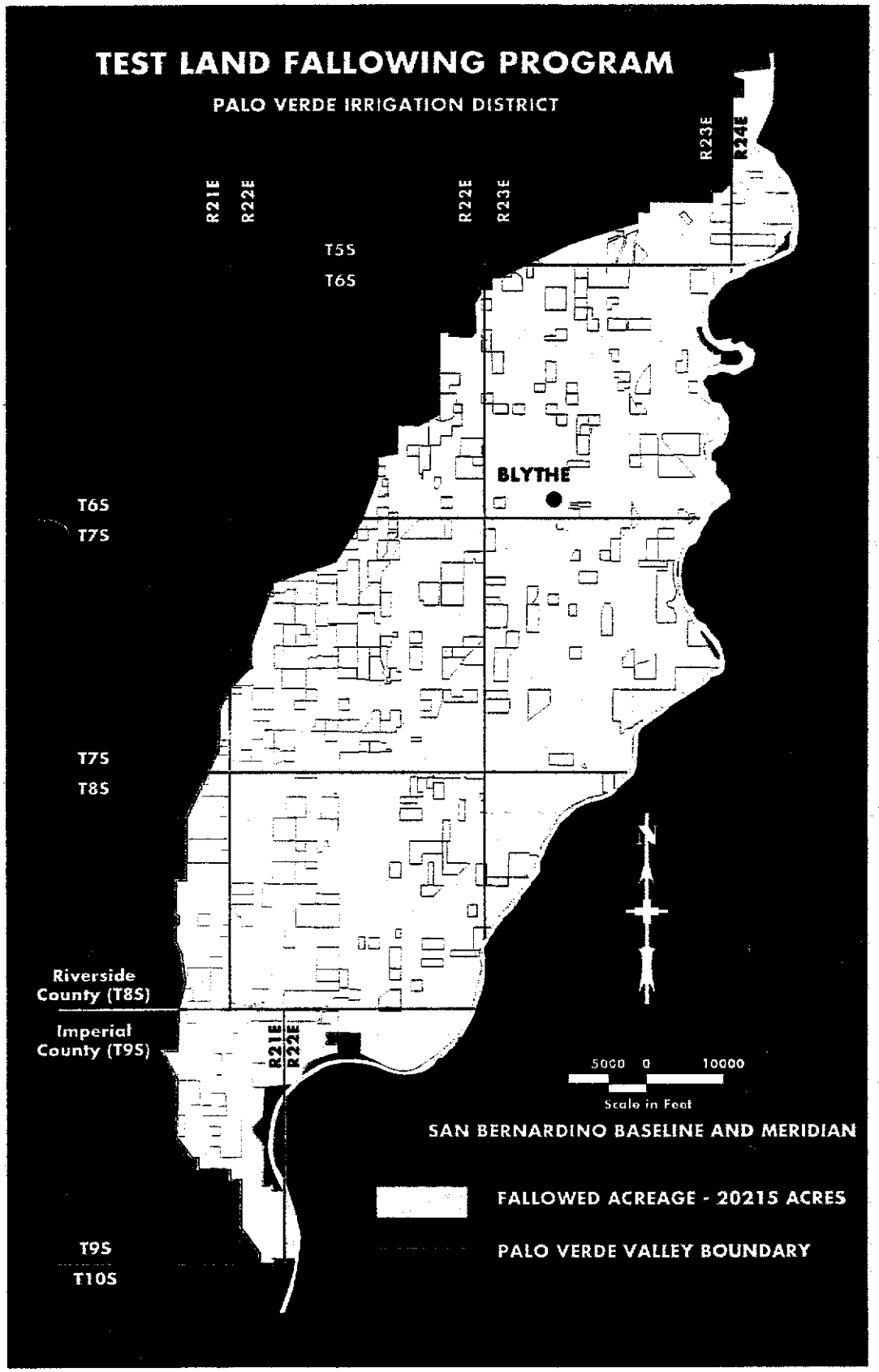
FIGURE 2: LOCATION OF FALLOWED ACREAGE



The Fallowed Acreage was estimated to generate 4.6 acre-feet per fallowed acre each year during the two-year Program. Based upon 4.6 acre-feet per acre, the "saved water" was estimated to be 92,989 acre-feet per year during the two-year Program. The saved water was stored, by the United States, in reservoirs within the Lower Colorado River Basin and will be released at the request of MWD subject to provisions of the Program Agreement.

A five-member Measurement Committee (Committee) was established to provide ongoing review of the Program. The Committee consisted of one representative from each of the following organizations: USBR, PVID, MWD, IID, and CVWD.

Maintenance of the Fallowed Acreage for the duration of the two-year Program was accomplished according to specific Land Management Plans (Plans) submitted by each participant and reviewed by MWD at the start of the Program. The purpose of the Plans was to conserve land and water resources, and eliminate or minimize adverse impacts to adjacent farms, the community or PVID through control of weeds and wind erosion. Weed control measures included chemical and mechanical methods. Wind erosion control measures included application of appropriate cultural practices such as providing stubble, sod remnants or cloddy fallow.

The Program was successfully completed on July 31, 1994 and, following a final review of the Fallowed Acreage, the last payment was made on August 15, 1994.

1.3 Measurement Committee/Technical Subcommittee

In accordance with Section 4.3 of the Program Agreement, a Measurement Committee was created to: (1) review the status of the Fallowed Acres; (2) calculate the amount of saved water available to MWD; and (3) determine an estimate of the actual water saved by the Program. Officially, members of the Measurement Committee consisted of one representative from each of the five parties in the Program Agreement, MWD, PVID, IID, CVWD, and USBR. The representative from USBR was designated as chairperson of the Measurement Committee. Most Committee organizations sent more than one representative to committee meetings.

The Measurement Committee held its first meeting on October 8, 1992 at the offices of PVID in Blythe, California. The initial meeting was followed by a total of five meetings during the two-year period held on the following dates: March 11, 1993; June 30, 1993; October 28, 1993; February 24, 1994; October 6, 1994; and August 14, 1995. All meetings were held at PVID and the complete text of meeting minutes is contained in Appendix I.1. The following paragraphs summarize the proceedings of each meeting.

On October 8, 1992, members of the Committee held their first meeting to discuss and review the Program. Metropolitan staff provided the Committee members with data relating to PVID net diversions from the Colorado River for the past ten years, cropped acreage and type of crops, and rainfall. These data were used to calculate the average water use per acre for the past ten years. It was agreed that the Committee would review the provided information and strategies for monitoring and determining the actual amount of saved water. Committee members were briefed

on the monitoring activities that are underway including ground truthing, soil moisture monitoring and satellite imagery acquisition. Following the meeting, the Committee conducted a field inspection of approximately 50 fallowed fields in the Program.

On March 11, 1993, members of the Committee met to review the first six months of the Program covering the period August 1992 through January 1993. Committee members received updated information related to PVID net diversions, rainfall, and groundwater levels. Briefings were presented which described ongoing compliance monitoring activities including acquisition of satellite imagery, ground truthing, and soil moisture measurement. Copies of the October 5, 1992 satellite image were given to the Committee members and it was agreed that MWD and USBR would continue to coordinate efforts related to acquisition of satellite imagery and the sharing of available information.

The Committee discussed procedures for reporting the Fallowed Acreage in the PVID Annual Crop Report. Also, compliance of fallowed fields containing highly erodible soils with U.S. Soil Conservation Service (SCS) regulations was discussed. The Committee reviewed a copy of MWD's January 21, 1993 letter sent to Program participants requesting lessees with fallowed fields in the SCS "noncompliance" category to amend their Plans.

A suggestion was made that crop and Colorado River diversion data for the Colorado River Indian Tribes (CRIT), Arizona be examined and compared to PVID data. CRIT farms land in Arizona to the northeast of the Palo Verde Valley. Another suggestion was that evapotranspiration data be investigated for PVID using the Department of Water Resources' California Irrigation Management Information System (CIMIS) incorporating data from weather stations in the Palo Verde Valley. Staff from MWD were assigned to prepare an analysis of evapotranspiration data for the Committee by the next meeting. The Committee members inspected the fallowed fields and scheduled the next meeting for June 30, 1993 in Blythe.

On June 30, 1993, a Committee meeting was held in Blythe. Updated charts and information were reviewed by the Committee members relative to diversions, surface returns, crops, soil moisture, satellite imagery, and groundwater. Crop and water diversion data for CRIT and evapotranspiration based on CIMIS were distributed (See Appendix I.1). Committee members inspected the fallowed fields and scheduled the next meeting for October 28, 1993 in Blythe.

On October 28, 1993, a Committee meeting was held in Blythe. A draft of the annual progress report covering the period August 1, 1992 through July 31, 1993 was discussed (See Appendix I.1). A major point of the discussion concerned estimates related to water savings attributed to the Program. It was suggested that several qualifications be used in the annual progress report relative to the further studies that would be undertaken to estimate water savings and to proceed to finalize the report.

Preliminary results of a survey conducted to collect information and data on various economic, labor, and land maintenance issues from Program participants were presented. A draft report of survey results was prepared for discussion at the next meeting. The status of the Program was reviewed and found to be satisfactory. The next meeting was scheduled for February 24, 1994.

On February 24, 1994, a Committee meeting was held in Blythe. Committee members were informed that monitoring of the Program indicated that it was well received by participating farmers and only minor temporary compliance problems had been observed in which solutions were quickly implemented. Updated charts related to diversions, returns, net water use, and groundwater levels were presented to Committee members for discussion (See Appendix I.1). The annual progress report had been finalized and distributed to Committee members prior to the meeting along with final results of the first-year survey. Committee members were provided with a copy of the September 22, 1993 satellite image of Palo Verde Valley.

Discussions continued with regard to estimating water saved by the Program and several methods were suggested for additional investigation. In view of the details requiring analysis, it was decided to form a Technical Subcommittee. The purpose of the subcommittee would be to form a smaller, technical group consisting of six members from the Measurement Committee to investigate specific methodologies for calculating the amount of water saved by the Program, perform detailed calculations, and evaluate corresponding results. Through this process, it would be possible to eliminate the less applicable methodologies and focus on the more relevant data and procedures that would assist the Measurement Committee in calculating water savings from the Program. The next meeting was scheduled for September 2, 1994 (later rescheduled for October 6, 1994).

On October 6, 1994, a Committee meeting was held in Blythe. It was reported to the Committee that all Program fields were in compliance with lower maintenance costs than during the first year due to less precipitation. Since the Program was completed on July 31, 1994, a discussion followed related to the status of fields at the present time. Observations indicated that most of the fields (80 percent) had been irrigated and no difference was noted in water orders compared to other fields in PVID. Diversion, crop, and groundwater data were updated and distributed to Committee members (See Appendix I.1). The Committee was informed that another satellite image acquired in May 1994 in coordination with USBR was in the process of being analyzed.

A survey of Program participants during the second year had been completed and the data were currently being compiled and tabulated. In addition, a survey and analysis of possible regional economic impacts from the Program had been completed with preliminary results showing indications that impacts had been minimal. Final copies of reports for both surveys would be available in the near future and distributed to Committee members.

The first report from the Technical Subcommittee, formed at the last meeting, was presented to the Committee to inform it of progress in the analysis of techniques for estimation of water savings. It was decided that efforts should continue with the methods suggested. The next meeting was scheduled for February 16, 1995 (later rescheduled to August 14, 1995).

The Technical Subcommittee held its first meeting on May 16, 1994 at the offices of MWD in Los Angeles, California. A total of five subsequent subcommittee meetings were held, all at the offices of IID in Imperial, California, on the following dates: August 4, 1994; September 16, 1994; October 24, 1994; January 12, 1995; and March 9, 1995. The Technical Subcommittee

decided to recommend three methods for estimating water savings which are discussed in Section 10 of this report.

1.4 Events

The SCS had indicated to MWD that a small number of the fallowed fields in the Program may not be in compliance with federal SCS guidelines for highly erodible soils. In response to this matter, a letter, dated January 21, 1993, was sent by MWD to all lessees with recommendations on how they may wish to comply with SCS guidelines. The letter also requested lessees with fallowed fields in the SCS "noncompliance" category to amend their Land Management Plans. The Palo Verde Resource Conservation District (PVRCD), which is responsible for wind erosion control in the area, responded with a letter indicating gratitude for MWD's efforts to encourage the lessees to comply with federal guidelines. Affected lessees responded by modifying their plans which included land maintenance practices acceptable to both MWD and PVRCD.

The normal "dry-up" period for PVID, when the delivery system is dewatered for normal maintenance activities, is the first two weeks of January. Because of the abnormally heavy rainfall during December 1992 and January 1993, the "dry-up" period continued to the 25th of January 1993.

2.0 Sign-up and Program Initialization

Following the preparation of contract formats and notification of potential participants, Program "sign-up" began the week of June 15, 1992. At sign-up, potential Program participants were required to complete a preliminary form requesting information concerning the acreage contained in the total farming operation (base acreage) and the area proposed for fallowing. Documentation was requested from landowners and lessees, such as title policies, tax assessor statements and lease agreements, to demonstrate proper ownership and leasing arrangements for any proposed land to be included in the Program. For example, where lessees were not owners, a copy of a legal lease agreement covering the two-year period of the Program was required.

Based on information contained in the preliminary sign-up form, MWD proceeded to work with potential participants to prepare the documentation necessary for execution of individual Fallowing Agreements. Farm location information provided by participants was used to develop a complete legal description of the fallowed and non-fallowed acres contained in the base acreage. Through this process, it was possible to certify that all base acreage was located within PVID valley lands and to cross-check for possible duplication. Maps were generated from the legal descriptions for each participant which showed all base acreage, and identified acreage that would be fallowed under the Program. Legal information and corresponding maps were included as Exhibit B to the Fallowing Agreement.

The next step was to verify the acreage estimates for both fallowed and non-fallowed fields. Since PVID maintains precise records of acreage served by its delivery system, it was agreed that

these figures, called "water toll" acres, would be used in all cases as the official source to calculate Program acreage for fallowed and non-fallowed areas. Water toll acres were used to calculate the percentage of fallowed acreage to total base acreage and ensure that the proportion of fallowed acreage did not exceed 25 percent of the total base acreage.

Program participants were required to affirm that proposed fallowed lands had been in agricultural production in four of the five years from August 1, 1987 to the start of the Program. Water toll records at PVID were cross-checked to verify that all fields in the Program met the criteria for recent agricultural production.

Program participants were also required to complete, to the best of their knowledge, a list of crops that were planned to be grown on the fallowed acres during the two years of the Program. ✓ Since farm crop rotations are planned up to several years in advance for most fields, this information was readily available in most cases. A table was developed to show each type of crop and the corresponding acreage planned for each year of the two-year Program which was included in the Fallowing Agreement as Exhibit C.

Each participant was required to submit a Land Management Plan for the fallowed acres which set forth the procedures to be followed during the Program. The objective of the Land Management Plan was to conserve land and water resources, and to eliminate or minimize any adverse impacts to adjacent farms, the community or PVID which may be caused by the fallowing process. The Land Management Plan was attached to the Fallowing Agreement as Exhibit D.

A summary sheet of procedures to be followed in establishing and maintaining fallowed lands was attached to the sign-up letter and included the following:

1. All partial fields must have a double border, roadway, or very large single border between the Fallowed Acres and non-fallowed acres.

2. On partial fields, all irrigation outlets must be sealed with plastic, concrete or other material to prevent any leakage onto the fallowed part of the field.

3. On partial fields, wherever possible, the fallowed portion should be located on the higher elevations of the field.

4. Wheat stubble is acceptable as an initial condition for fallowing. Before August 1, 1992, alfalfa, sudan, and bermuda must be dead, or have been sprayed with a chemical that will cause it to die. Where tillage is the selection mode of operation for the Land Management Plan, it must be started before August l, 1992.

5. All irrigation turnout gates to the Fallowed Acres must be locked or blocked with dirt to prevent any water from entering any field ditch.

6. Weed control must be maintained for the full two-year program (No weeds permitted to go to seed).

7. Dust control must be maintained for the complete two-year Program.

8. Any water on the Fallowed Acres must be reported.

9. To assist in monitoring the program, at MWD's cost, a soil moisture monitoring site will be located on each of the fallowed fields. Each party will be contacted to locate the site in order to minimize interference with farm operations.

3.0 Maintenance of Fallowed Fields

3.1 Land Management Plan

As explained in the previous section, each participant was required to develop and submit a Land Management Plan as part of the Fallowing Agreement. The Land Management Plan identified land and water management requirements, along with conservation procedures, that were to be observed by the participant throughout the Program. A focus of the plan was to set forth the methods that would be implemented to address weed growth and wind erosion on fallowed fields. Measures to control weed growth were to be undertaken by Program participants, at their expense, to prevent the spread of noxious plants, limit unnecessary water consumption, and minimize this source of diffusion for plant disease, insects and other pests.

The potential for wind erosion was small considering the average prevailing wind conditions and soil types in the Palo Verde Valley. Proper measures to minimize or eliminate the hazards of wind erosion on fallowed acreage with soil types that may be susceptible under certain conditions was required of participants. Wind erosion control measures could include leaving stubble residue, sod remnants, cloddy fallow, spreading residues or other methods approved by the U.S. Soil Conservation Service.

Participants were required to indicate the type of land management that would be used for all fallowed lands. Control measures could include chemical, biological or mechanical methods and the participant could choose the method or combination of methods for their fallowed acreage. In the event that chemicals were applied, only those chemicals approved for use by the State of California were allowed provided that proper local, county, state and federal permits and licenses were obtained.

Part of the Land Management Plan required the participant to indicate which fallowing method would be followed during the Program. If, for example, 200 acres were to be fallowed, the participant may indicate that for 100 acres wheat stubble would be used for wind erosion control and herbicides for weed control. On the other 100 acres, alfalfa stubble would be used for wind control and herbicides for initial killing of alfalfa and further weed control. The stubble would be

left at a minimum height of six inches and, if inadequate control resulted, cloddy fallow would be employed. Each participant was required to develop this type of detailed plan which differed in methods and contingent plans to ensure control of weed growth and wind erosion throughout the two-year Program.

The most preferred method to begin the fallowing process was application of chemicals to existing crops. Chemicals were applied to 10,513 acres which is 52 percent of the total Fallowed Acreage. Disking was the most preferred mechanical method and used on 5,414 acres (27 percent). Plowing followed disking in preference with 2,835 acres (14 percent), succeeded by knifing with 1,068 acres (5 percent) and subsoiling with 385 acres (2 percent) to account for initial land maintenance applied to the total 20,215 acres of fallowed ground.

3.2 Fields Checks

The field checking process began during Program sign-up to verify that proposed fields were eligible for participation. Measurements were also made of partial fields to verify the precision of acreage estimates given during registration. The process consisted of visual inspection of each of the 261 fallowed fields proposed for the Program. Once field locations were verified, information was entered into the PVID water delivery system in which a "flag" or instruction was placed indicating that no water was to be delivered.

Fallowed fields were closely monitored during the initial months of the Program to ensure that fallowing methods were effective and that the Land Management Plans were strictly observed by Program participants. Special attention was concentrated on fields where chemical applications were applied to kill existing crops, primarily alfalfa, as a period of time was required before the full effect of the chemical would be evident. During this period, visual monitoring of fields occurred several times each month.

After the initial fallowing was completed, the frequency of visual monitoring decreased. However, all fields were visually checked a minimum of once a month throughout the two-year Program. Observations made during the visual monitoring process were conveyed to Program participants first by telephone and, if required, by written notification. Most observations were quickly resolved by telephone. In only a few instances was a written notification required to restore proper fallowing maintenance. After exhausting the verbal and written avenues, and as a last resort, MWD was empowered to perform any necessary fallowing operation deemed appropriate to maintain proper fallowing conditions and bill the participant. This option was used only once during the Program.

3.3 Soil Conservation Compliance

Shortly after the Program began, the SCS local staff indicated that some of the Fallowed Acreage had previously been designated as "highly erodible" and required special management in order to limit adverse impacts from wind erosion. It was estimated that 10 to 15 percent of the Fallowed Acreage had highly erodible soils of which approximately 5 percent may require special treatment to control erosion during the fallowing period.

A letter was sent from MWD to Program participants providing instructions for Fallowed Acreage designated as highly erodible by the SCS. It was requested that participants contact MWD and indicate which fallowed fields were highly erodible and include a written amendment to their Land Management Plan describing what methods would be used to comply with SCS regulations. An amended plan was important to verify that Fallowed Acreage was properly maintained in order to support estimates of water savings by the Program.

Fallowed Acreage containing the highly erodible hazard were identified by the SCS and notification was sent to the respective Program participants. Several options are available to comply with SCS regulations, including distribution of crop residue or manure, provision of cover foliage and/or application of light irrigations. Participants could employ any of three options. There were no sanctions in the case of residue, manure or cover foliage; however, the participant was required to pay MWD $135 per acre-foot of water that was applied to the Fallowed Acreage. The light irrigation option was not selected by any Program participant as an erosion control technique.

Given the fact that unseasonably large amounts of rainfall occurred in the early months of the Program (discussed in the next section), participants requested that an allowance be made for control of weeds on highly erodible lands in such a manner to provide both a cover crop and residue. In consideration of this situation, MWD instructed participants to permit weeds to grow into the "windy season" (March, April and May) and allow them to die from lack of moisture or apply a herbicide and leave the plant residue in place to mitigate wind erosion. In no case should roots be allowed to reach the groundwater table or seeds be allowed to mature.

Through modified Land Management Plans, all Program participants were able to fully comply with the conditions of the Fallowing Agreement and SCS regulations for highly erodible soils.

3.4 Rainfall

An abnormally high amount of rainfall occurred during the first year of the Program followed by a lower than normal rainfall during the second year (See Appendix C, Chart 7). During the first year (August 1992 - July 1993), 9.15[1] inches of rainfall were recorded compared to 2.40 inches during the second year (August 1993 - July 1994). The 11-year (1981-92) August through July annual average for Palo Verde Valley is 4.19 inches.

Slightly over 94 percent (8.63 inches) of the Program first-year rainfall occurred in the four months of August 1992 (1.91 inches), December 1992 (2.26 inches), January 1993 (2.46 inches), and February 1993 (2.00 inches). The 11-year average monthly rainfall for August is 0.71 inches, 0.63 inches for December, 0.37 inches for January, and 0.35 inches for February. Monthly rainfall during the second year of the Program was near or below the 11-year monthly averages, and the 12-month total of 2.40 inches was only approximately half of the 11-year average.

[1] All rainfall amounts are the average of the readings taken at Blythe Airport and the Blythe Fire Station.

A consequence of the abnormally high amount of rainfall during the first year was accelerated weed growth on fallowed fields requiring additional control measures unanticipated at the start of the Program. This situation increased land maintenance costs for participants and administration costs for MWD because of additional visual monitoring activity. The below average rainfall in the second year did not off-set the higher costs incurred during the first, however, land maintenance costs were somewhat lower than anticipated.

The annual average for the two Program years was 5.78 inches which is 1.59 inches higher than the 11-year annual average of 4.19 inches.

4.0 Soil Moisture Monitoring

In addition to visual monitoring, Program fields were also monitored by measuring soil moisture. The purpose of this effort was to track moisture in the soil profile during the Program. Soil moisture measurements were taken with a neutron probe through a series of metal access tubes installed in selected fallowed and non-fallowed fields. All installation sites were recorded on maps and marked with brightly colored flags for easy location in the field. Access tubes were galvanized pipes ($2\frac{3}{8}$ inches in diameter) located in sites representative of soils in a selected field and installed by driving the tubes to depths of five feet or deeper as conditions permitted with a portion of each tube extending above the ground surface. Steel caps were placed on both ends of each access tube. Soil moisture readings were taken by removing the top cap and inserting the neutron probe into the tube. The probe could be lowered to any depth in the tube in order to take a soil moisture reading. Neutron probe readings are converted to inches of moisture. It is possible to estimate the amount of moisture in a soil profile through the process of taking readings at several prescribed depths.

A certified technician operated the neutron probe when soil moisture readings were taken. Soil moisture readings were taken at depths of 12 inches, 36 inches and 60 inches. A reading point was indicative of the amount of soil moisture contained in the soil 12 inches above and 12 inches below that point.

Access tubes were installed in a total of 138 (53 percent) of the 261 fallowed fields. Nine monthly readings were taken during the first Program year (November 1992, January and March 1993 excepted), and in December 1993 and July 1994 during the second Program year. Arrangements for monitoring non-fallowed fields were more difficult to complete, however, access tubes were eventually installed in a total of 21 fields. Readings began in December 1992 and continued from this date on the same schedule established for the fallowed fields. Several tube sites were inadvertently destroyed and, in the end, soil moisture data were recorded from 16 non-fallowed fields for the same depths and months as for the fallowed fields.

Data collected from field measurements were entered into a computerized database which tracked soil moisture by depth. A total of 11 readings were taken from fallowed fields during the two-year Program and 8 readings from non-fallowed fields. Neutron probe readings were converted to inches of moisture. Data from the three readings for each field are combined in

Chart 1 to estimate the average moisture, in inches, contained in the 60-inch soil profile for different periods throughout the Program. The fallowed fields clearly display the effects of above normal rainfall during the first six months of the Program where soil moisture in the 60-inch profile actually increased. As the rainfall returned near average conditions, the effect of fallowing is quite evident in that soil moisture began declining in February 1993 and continued this downward trend through the remaining months of the Program. In contrast, data from non-fallowed fields displayed a soil moisture pattern typical of irrigated agricultural crop production.

Although soil moisture data did supplement field monitoring efforts, the results related to a maximum of 11 points in time and not to continuous soil moisture conditions throughout the Program. It was determined that an effort to represent continuous conditions would be cost prohibitive, especially when the results are supplemental to another monitoring procedure and, therefore, soil moisture monitoring would not be necessary in future Programs.

5.0 Groundwater

Groundwater elevation in the Palo Verde Valley is monitored by PVID through a network of observation wells. The network includes 285 wells which are located throughout the valley, dispersed in a manner so that each section contains one well and most sections contain several wells. Each month, PVID takes water-depth readings from the observation wells.

The groundwater level for valley lands ranges from very near the surface (1 to 2 feet) to as deep as 30 feet below the surface. Part of the monitoring effort was to observe the level of groundwater during the Program since fallowing 22 percent of PVID reduced the amount of irrigation water applied to valley lands.

Another part of the effort included compilation of historic data for the period from August 1981 through July 1992. Data for this 11-year period was compiled and the monthly average groundwater level is shown on Chart 2. Overall monthly averages range from 8.9 feet below the ground surface in September to 10.8 feet below the ground surface in December. The annual average depth to groundwater for the 11-year period was 9.8 feet.

Also shown on Chart 2 are the monthly groundwater depths for the 24 months (August 1992 through July 1994) of the Program. It can be observed that the average monthly depth to groundwater was greater during each year of the Program than the eleven-year average for all twelve months. During the first Program year (August 1992 through July 1993), monthly averages ranged from 9.6 feet below the surface in August 1992 to 11.9 feet below the surface in March 1993. The annual average depth to groundwater during the first Program year was 11.1 feet. During the second Program year (August 1993 through July 1994), monthly averages of depth to groundwater ranged between 10.2 feet in July 1994 and 12.0 feet in February 1994. The annual average groundwater depth during the second Program year was 11.3 feet. Data presented in Chart 2 indicate that the average groundwater depth increased approximately 1.5 feet during the two-year Program.

CHART 1

AVERAGE SOIL MOISTURE

Average Inches in 60-Inch Profile

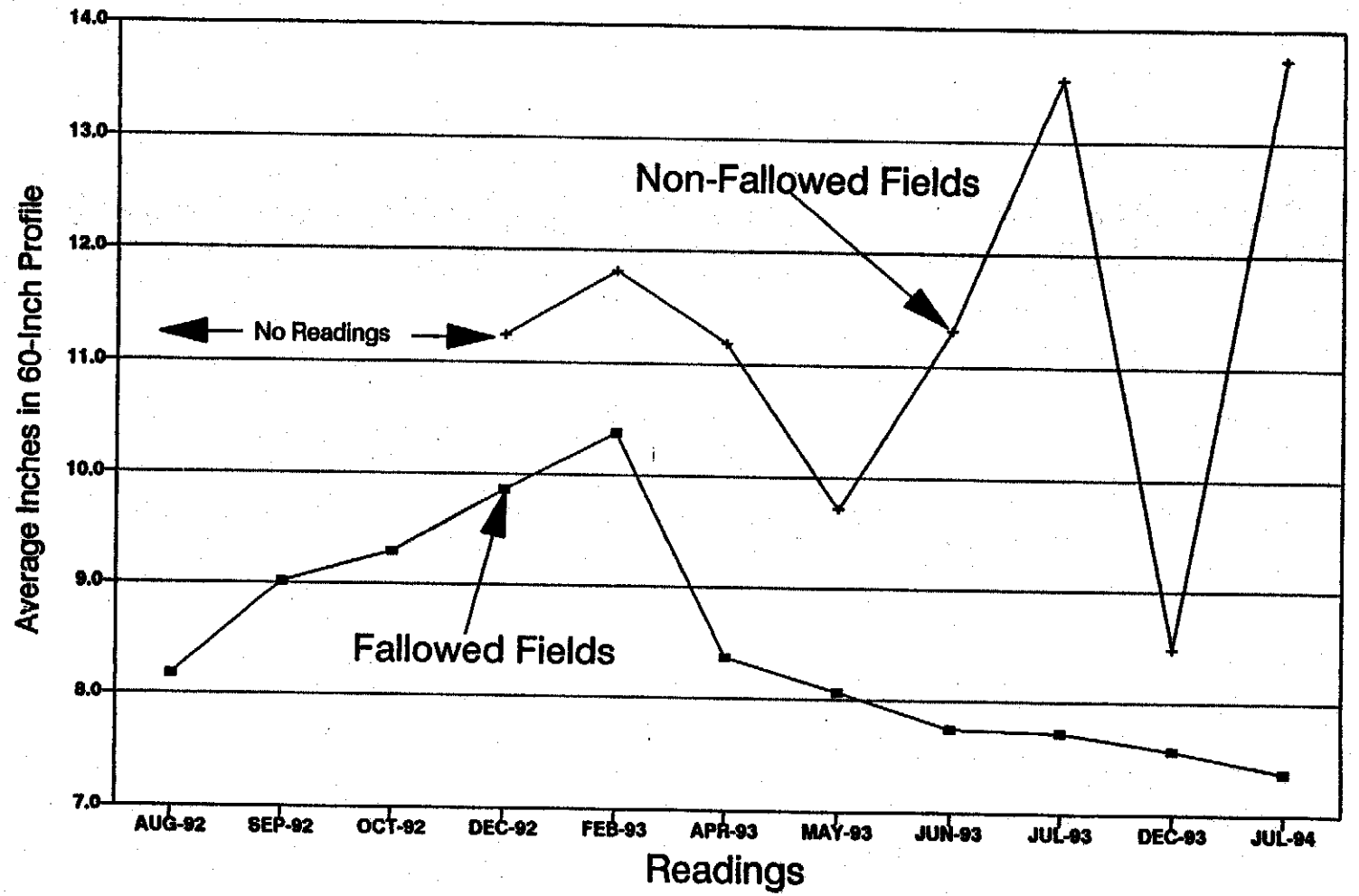
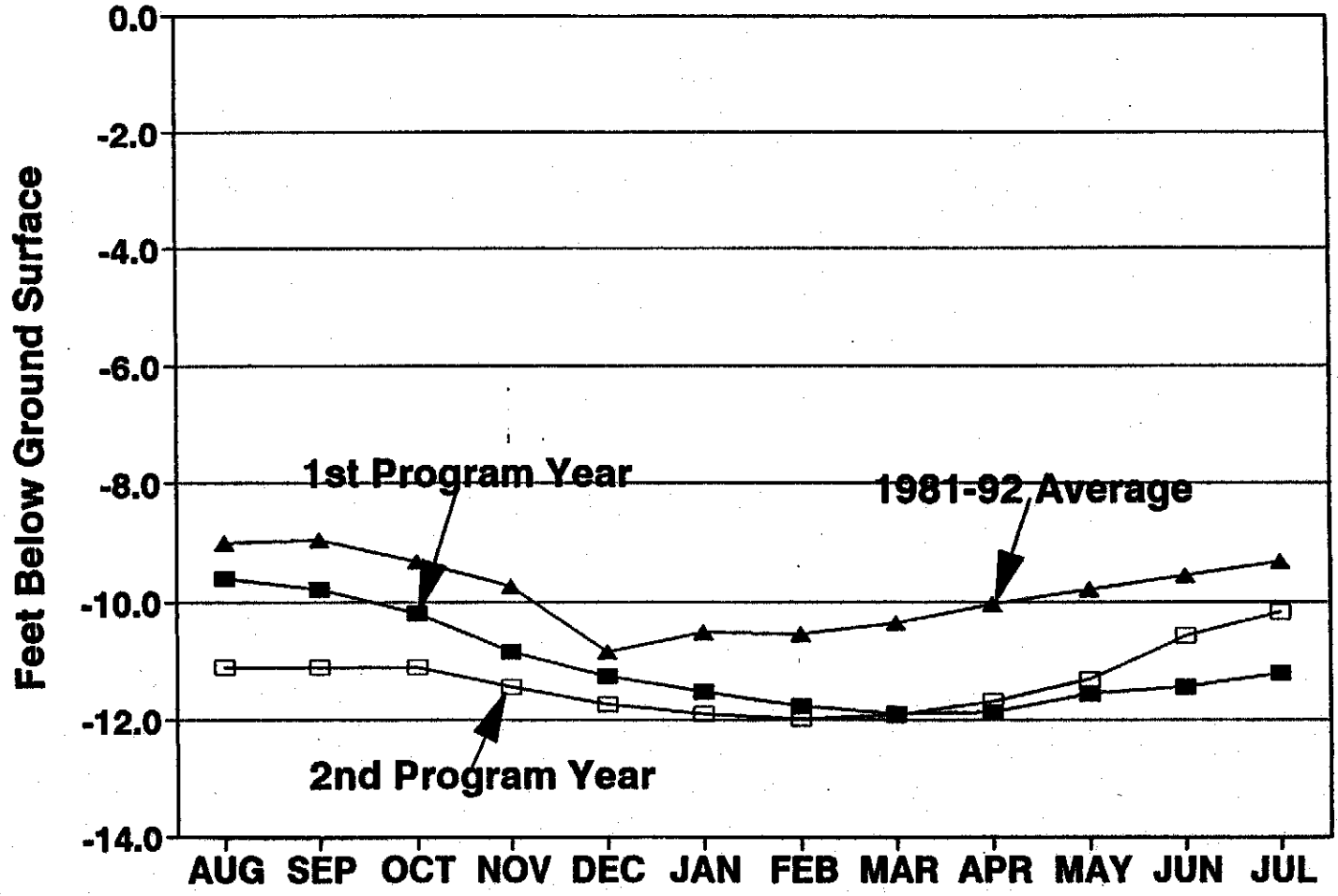


CHART 2
Monthly Average Groundwater Level-PVID



Another view of the groundwater trend was developed by calculating the "running" monthly average for the 14-year period 1981 through 1994. The 12-month running average (Chart 3) shows the trend of increasing depth to groundwater began in late 1992 and continued to February 1994 when the decline ceased at 11.5 feet. These data indicate that the groundwater table declined approximately 1.5 feet during the two-period of the Program.

6.0 Payments

Participants received $620 per year for each fallowed acre or a total of $1,240 per acre during the two-year Program. The total amount due participants was paid in five payments of $248 for each acre fallowed and in compliance with Program regulations. Visual field checks, described earlier, were used to verify Program compliance. Payment dates were August 1, 1992; February 1, 1993; August 2, 1993; February 1, 1994; and August 15, 1994. All payments were made on schedule.

7.0 Canal Breaks

Two canal breaks occurred in PVID that affected fallowed fields during the first year of the Program. The first canal break occurred on August 17, 1992 and the second occurred on September 5, 1992. Only one fallowed field was affected by each canal break. Immediately following each mishap, spilled water was pumped back into PVID canals or let flow into nearby drains. As stated in the Program Agreement, PVID was responsible for repairing the mishap and eliminating spilled water from fallowed fields as quickly as possible. In addition, PVID was responsible for controlling any subsequent weed growth resulting from a canal break. Both responsibilities were completely fulfilled as PVID provided quick responses to mitigate the breaks and follow-up to control any resulting vegetation growth. No other canal breaks occurred during the remainder of the Program.

8.0 Remote Sensing

A total of four satellite images were acquired of the Palo Verde Valley to support ground compliance monitoring activities during the Program and provide a visual record of the fallowed acreage over the entire Palo Verde Valley. The amount of spectral reflectance from each field as detected by a spaceborne sensor was used to evaluate the fallowed status of participating fields and to provide Program managers with another tool for the monitoring process. The first image was acquired on October 5, 1992, shortly after the Program started, the second image was acquired on September 22, 1993, shortly after completion of the first Program year, the third image was acquired in the final months of the Program on May 20, 1994, and the final image was acquired on November 28, 1994, approximately four months following Program completion (See Appendix F).

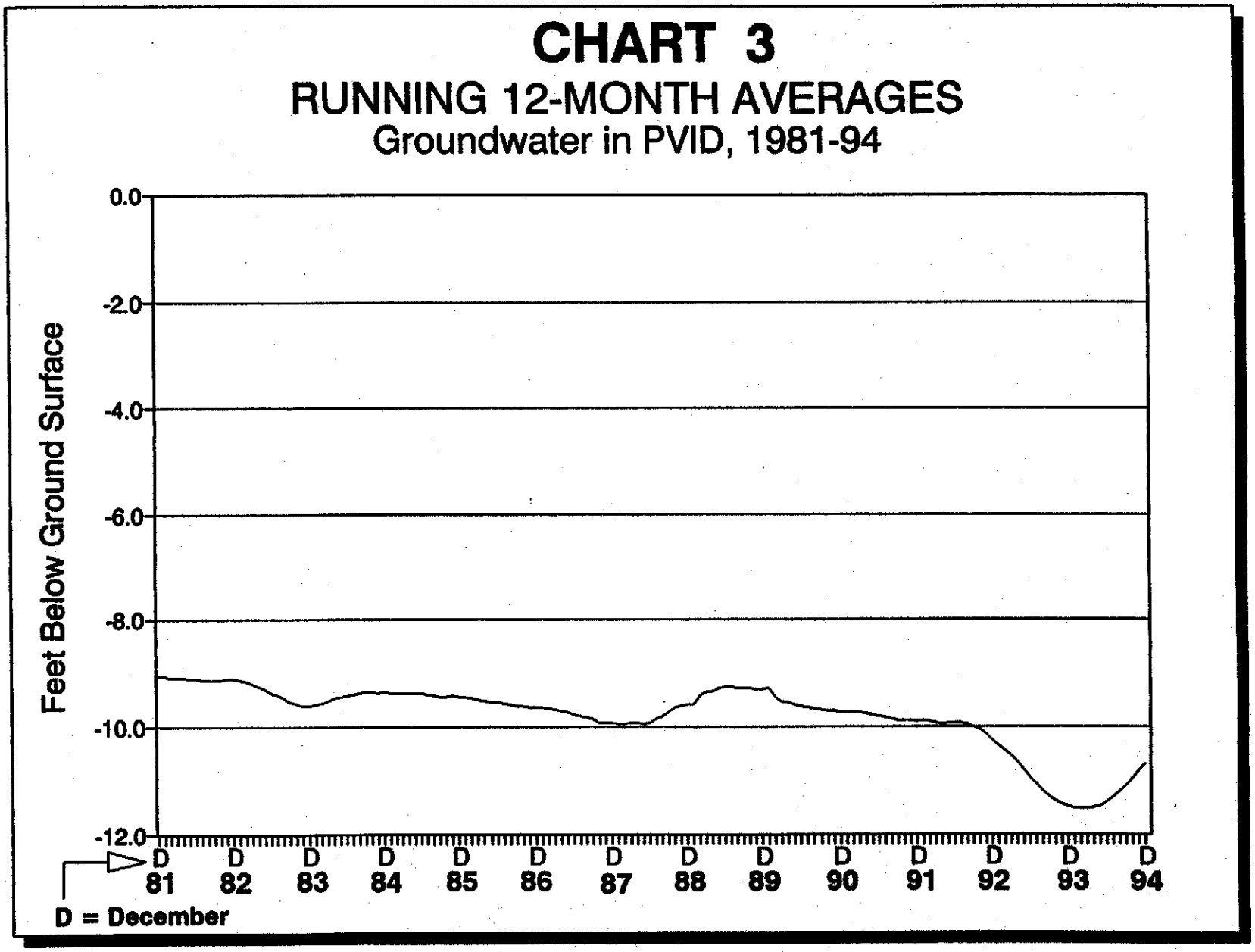


CHART 3
RUNNING 12-MONTH AVERAGES
Groundwater in PVID, 1981-94
Feet Below Ground Surface
0.0
-2.0
-4.0
-6.0
-8.0
-10.0
-12.0
D 81
D 82
D 83
D 84
D 85
D 86
D 87
D 88
D 89
D 90
D 91
D 92
D 93
D 94
D = December

The remote sensing process utilized Landsat Thematic Mapper (Landsat) imagery which incorporates spectral reflectivity of healthy vegetation in infrared wavelengths. The Landsat views the Earth's surface in an instantaneous field of view called a "pixel" which measures 28.5 meters by 28.5 meters (about 93.5 feet by 93.5 feet). Seven different sensors for each pixel record a digital value for the intensity of reflectance in each of three visible (blue, green, and red) and three infrared spectral "bands", as well as in the thermal (emitted heat energy) range.

During processing, a single band vegetation intensity image is created with pixel values increasing directly with intensity between zero and 255. Higher intensities indicate the presence of increased healthy vegetation. For example, the variation between the amount of energy reflected by green-vegetated versus brown- or non-vegetated surfaces was used as a tool for the detection of the presence and quantity of vegetation (biomass--leaves, stems, stalks, bark and branches) present in the Program fields. Since Program fields were to remain either non-vegetated, with dead crop residue or unvegetated (bare ground), it is only necessary to detect the presence of living vegetation, dead vegetation, or bare ground and not distinguish between different types of living vegetation. Through a series of processing steps, starting with single band images, vegetation content categories were developed, ranging from "no biomass" to "high biomass" as shown in Table 1.

TABLE 1
LANDSAT Classification Categories

Category Name	Description Of Typical Findings	Program Status/ Required Action
Water	Deep water cover, e.g., Colorado River, main intake canal, Palo Verde Lagoons	Did not occur in Program fields.
Absent/Minimal Biomass	Bare ground or sparse senescent cover	Consistent with Program requirements (Compliance).
Low/Moderate Biomass	Moderate stubble or light senescent weed cover; small amounts of emergent green vegetation.	Consistent with Program requirements (Compliance).
Moderate Biomass	Heavy stubble or moderate to high senescent weed cover; light volunteer weed cover and naturally occurring grasses; phreatophytes; early prebloom or senescing agricultural cover.	Verbal inquiry of compliance to Metropolitan for visual review (Potential Compliance).
Moderate/High Biomass	High senescent cover mixed with volunteer weeds; moderate to high volunteer weed cover; late prebloom to early bloom crop cover; heavy phreatophytes.	Report to Metropolitan for compliance check.
High Biomass	Fully mature crops; trees with full leaf canopy; high amounts of cleared agricultural residue.	Report to Metropolitan for compliance check.

Boundaries of Program fields were overlaid on each of the three images and an analysis of compliance was conducted in which each Program field was assessed relative to the content of each category detected. Program fields exhibiting values within the lowest two classes

(Absent/Minimal or Low/Moderate) were considered in compliance without further review. Fields exhibiting biomass levels within the upper three classes (Moderate, Moderate/High, or High) were flagged for further inquiry. These inquiries involved interactively reviewing the satellite image appearance and reviewing field notes to determine if a ground condition had existed previously which may explain the amount of healthy vegetation detected. Physical inspection of the fields in question was also made by Metropolitan.

Landsat Image 1, acquired on October 5, 1992, is a composite of bands 2 (green), 3 (red), and 4 (near infrared) in photographic colors blue, green, and red, respectively. In this band combination, which is similar to color infrared aerial photography, mature, dense, healthy vegetation appears bright red. Overlaying this background are the 261 Program fields outlined in yellow.

It was found that 193 Program fields were in the lowest two biomass categories (Absent/Minimal or Low/Moderate) and required no further consideration. The remaining 76 fields exhibited circumstances of the higher biomass categories and were individually examined and visually checked by Metropolitan. All fields were found to be in compliance.

Image 2 was acquired on September 22, 1993. As with Image 1, this image was processed and printed in a band 2,3,4 false color composite with red representing infrared reflectance and, therefore, healthy vegetation. Results of a systematic analysis of field compliance for Image 2 indicated that all but nine fields were in compliance. Vegetation detected in all nine fields was caused by green weeds in the fields at the time of imaging. These weeds were subsequently treated or removed.

Image 3 was acquired by Landsat on May 20, 1994. Each field was examined for its vegetative content and all but four fields were found to be in compliance with the Program. The four fields found to have high vegetative growth were visually examined by Metropolitan and found to be in compliance.

Image 4 was acquired by Landsat on November 28, 1994, almost four months following completion of the Program. The fourth image was acquired to assess agricultural use trends in Program fields following the two-year fallowing period.

The remote sensing process provided a visual "snap-shot" of the Palo Verde Valley at four different time periods during and immediately following the Program. Image processing assisted Metropolitan in verifying the compliance of Program fields. None of the three compliance assessments during the Program revealed any evidence of water usage on Program fields. As with soil moisture monitoring, due to the limited benefit of remote sensing in relation to the substantial costs, it was determined that this activity would not be necessary in future programs.

9.0 PVID Water Ordering System

One of the components of the Program Agreement was development of a computerized water ordering system for PVID. Prior to development of this system, water orders and crop information were recorded by hand. Development of a computerized water order system began in the fall of 1992 when bids were solicited from several vendors. Through this process, PVID hired Custom Automation of Phoenix, Arizona which developed the water ordering software and recommended appropriate hardware to run the system.

The water ordering system was installed in January 1993 and consists of a four-station network with supporting equipment. The system has simplified the water ordering process for both PVID and water users. When placing orders, water users supply the turnout number to PVID staff, as under the old system, which is entered into the computer and the recent water use history for the corresponding field(s) is displayed. This information allows the water user to review previous orders and indicate if a different quantity is needed for the present order. Daily water orders are automatically sorted by zanjero route, compared to delivery capabilities, and balanced for the entire district.

The water ordering system provides a history of deliveries and water use for each field in PVID. This information is retrieved and used to establish the quantities of water to be diverted from the Colorado River. The precision of estimated PVID diversions from the river has greatly improved with the aid of this information. In addition, the computer system also assists PVID personnel in controlling water in the canal network more efficiently to reduce unnecessary spills and breaks.

Another feature of the water ordering system allows crop information to be recorded for each field and updated as crops are changed throughout the year. This feature allows PVID to generate a crop report at any point in time, although, its primary utility is applied in preparation of the Annual Crop Report.

The PVID water ordering system is used on a daily basis and has replaced the previous manual system. Improved water control and manpower scheduling have been achieved through the new computerized system.

10.0 Indicators of Water Saved

In order to estimate the amount of water saved by the Program, it is necessary to estimate the amount of water that would have been consumed on the fallowed lands had crops been in production during the two-year period. Preparatory to Program implementation, historical PVID water use data were reviewed and it was estimated that 5.1 acre-feet per acre, or more, of water could be saved through land fallowing. It was decided to make an allowance for certain unknown evaporation and system losses in order to conservatively estimate potential water savings from the

Program. Consequently, the amount of water saved was "...deemed to be 4.6 AF per Fallowed Acre per year..."[2] as stated in the Program Agreement.

Part of the documentation process was to estimate how the amount of water actually saved by the Program compared to 4.6 acre-feet per acre. It was evident that calculating an absolute amount of water saved would be extremely difficult in view of the overwhelming data requirements and measurement precision. Efforts to calculate an absolute value would involve critical assumptions and subjective parameters open to interpretation. In view of this situation, it was decided to define a range for the amount of estimated actual water savings from the Program. Such a range would encompass most, if not all, of the subjectivity present in critical parameters such as weather, changes in cropping patterns and irrigation practices, changes in groundwater depth, changes in water losses; and additional water required to bring land back into production.

A review was made of possible indicators that may be relevant in estimating the amount of water saved by the Program. Through this process, the following six types of indicators were recommended.

1. Reduction in PVID net diversions.

2. Evapotranspiration-based (ET) estimates for fallowed lands, including a comparison of "with" and "without" Program effects.

3. Rule Curve using historical net diversions for 10- and 30-year periods compared to net diversions during the Program.

4. Historical water use and 1-2 months water use immediately preceding and following the Program (Acre-feet/acre).

5. ET based estimates for fallowed lands based upon analyses of ET estimates for the whole PVID.

6. Land out of production.

These six indicators were divided into two general groups. The first group included indicators based on direct measurements, which included 1, 3, 4 and 6; and the second group included indicators based on estimated measurements, which included 2 and 5. A consensus was reached that the above indicators should be used in quantifying water savings for the Program.

Next, a list of factors to be considered in estimating the water savings indicators was developed and is shown in Table 2. Each factor was classified as quantitative or qualitative depending upon the precision of data available. Two factors, rainfall and water applied prior and after the program, were classified as both quantitative and qualitative as data are available to describe the events, however, there is still a degree of uncertainty regarding the extent to which these factors affected water savings from the Program.

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[2] Program Agreement, Article II, Section 2.2, p.7.

TABLE 2
Factors and Data Sources Considered in Water Savings Indicators

Factor	Quantitative	Qualitative	Data Source
1. Diversions	X		Decree Accounting.
2. Measured Surface Returns	X		Decree Accounting.
3. Unmeasured Returns		X	USGS Reports
4. Rainfall	X	X	National Weather Service or PVID. SCS TR 21 for effective rainfall.
5. Cropping Pattern During Program	X		PVID crop data.
6. Changes in Cropping Pattern	X		PVID crop data.
7. White Fly		X	Agricultural Commissioner.
8. Farm Product Prices	X		Agricultural Commissioner.
9. Double Cropping	X		PVID crop data.
10. Under- and Over-Irrigation		X	PVID.
11. Changes in Groundwater Depth	X		PVID data.
12. Changes in Water Delivery Losses		X	PVID data.
13. Federal Set-aside Land	X		ASCS.
14. ET-Based Estimate	X		Blaney-Criddle formula, National Weather Data, crop groups, consumptive use from SCS TR 21, planting dates from PVID and Extension Service, acreage and crops from PVID.
15. Applied Water Prior/After Program	X	X	Decree Accounting and PVID records.
16. Rule Curve (IID, CVWD, CRIT, PVID)	X		Decree Accounting.

The factors listed in Table 1 were taken into account, to the extent that data permitted, in preliminary efforts to quantify water savings for the six indicators. Initial water savings estimates ranged between 4.30 and 5.28 acre-feet/acre per year.

Information developed during preliminary efforts to estimate water savings indicated that the indicators involving evapotranspiration and historical water use (Indicators 2, 4 and 5) could be combined into one estimate without compromising precision. Preliminary efforts also suggested that it was prudent to refine water savings estimates for Indicators 1 (reduction in PVID net diversions) and 3 (Rule Curve), and additional development of indicator 6 (Land out of

production) was not required. Through this initial effort, it was possible to reduce or combine the number of indicators that would be developed in more detail to three:

1. Comparison With Historical Water Use;

2. Rule Curve; and

3. Actual Water Use During the Program.

10.1 Comparison With Historical Water Use

The general methodology for estimating the difference in PVID net diversions involves a comparison of net diversions during the Program to net diversions prior to the Program. The 11-year period 1981-91 was selected to be representative of recent historical PVID diversions. Net diversions during the two-year Program were compared to the 1981-91 average net diversions with the difference considered as an estimate of Program water savings. During the two-year Program, PVID's net diversions totaled 634,252 AF and averaged 317,126 AF/yr. The 1981-91 net diversions averaged 420,793 AF/yr. The difference between the 11-year average of 420,793 AF and the annual Program average of 317,126 AF is 103,667 AF or 207,334 AF over the two years which equates to a Program water savings of 10.3 AF/ac (207,334 AF/20,215 ac) or 5.1 AF/ac/yr.

The estimate of 5.1 AF/ac/yr is considered to be near the upper limit of the water savings range considered to apply to the Program. This consideration is based on the above normal rainfall in the fall of 1992 and spring of 1993, and the apparent decline in the groundwater table. Adjustments for rainfall or groundwater, if possible, would decrease the 5.1 AF/ac/yr estimate of water saved by the Program.

10.2 Rule Curve

Another method selected to estimate water savings from the Program was the "rule curve". The rule curve method relies upon historic water use patterns to predict future water use. Historic water use for the 11-year period 1981-91[3] was used to develop a rule curve for predicting water use during the two-year period of the Program. The difference between the rule curve and PVID net diversions during the Program provided an estimate of water savings.

PVID's water use for the period January 1 through July 31, 1992 was 88.5 percent of the 1981-91 average of the January 1 through July 31 period. Based on this trend, PVID's 1992 year-end water use was projected to total 372,401 AF. The Program caused a significant reduction in water use from August through December of 1992 resulting in a yearly total of 334,689 AF, which was 37,712 AF below the predicted value of 372,401 AF. The difference of 37,712 AF between the predicted water use and the actual water use was estimated to be the amount of

[3] A rule curve was also developed using data for the 28-year period 1964-91. The shape of this rule curve was almost indistinguishable from the 1981-91 rule curve.

water saved by the Program for 1992. Taking into account that 20,215 acres were fallowed, the water savings was estimated to be 1.9 AF per acre (37,712 acre-feet/20,215 acres).

Net diversions for PVID during 1993 were 334,467 AF compared to the 11-year average of 420,793 AF which resulted in an estimated 86,326 AF saved by the Program. The estimated water savings per acre were 4.3 AF for 1993.

Since the Program concluded on July 31, 1994, it was necessary to estimate water savings for the first seven months of the year. At the end of July 1994, PVID cumulative net diversions of 233,257 AF were 77 percent of the 11-year average of 302,982 AF which resulted in an estimated water savings of 69,726 AF or 3.4 AF per acre. Since water savings in the first seven months do not take into account extra water required to return fallowed fields to production, water use during the last five months of 1994 must also be considered. Total 1994 water use was 382,476 AF, or 91 percent of the 11-year average of 420,793 acre-feet. Subtracting actual water use from the 11-year average results in an estimated water savings of 38,317 AF or 1.9 AF per acre. It appeared that 3.4 AF per acre during the first seven months would overestimate water savings and that the twelve-month result of 1.9 AF per acre would underestimate water savings. In order to make an allowance for extra water used to return fallowed fields to production, the mid-point between 3.4 AF per acre and 1.9 AF per acre of 2.7 AF per acre was taken as the estimate of water savings in 1994.

Summation of the estimated water savings from the rule curve method for 1992 (1.9 AF per acre), 1993 (4.3 AF per acre) and 1994 (2.7 AF per acre) results in a total estimate of 8.9 AF per acre for the two-year Program or an annual water savings of 4.5 AF per acre.

10.3 Actual Water Use

The third method used to estimate water savings was based on actual water use during the Program. The actual water use method is based upon the water use of crops on the non-fallowed fields (approximately 73,000 ac) during the two-year period of the Program which is used to provide an estimate of water use on the fallowed fields, absent the Program. Inherent to this method is the assumption that the cropping pattern and water use on fallowed fields absent the Program would have been similar to the non-fallowed fields during the Program. Therefore, water use on non-fallowed fields is used to provide an estimate of water savings for the fallowed fields.

Actual water use during the Program was computed based on monthly Decree Accounting records. Net diversions during the period August through December 1992 totaled 66,528 AF, 334,467 AF during 1993, and 233,257 AF during the period January through July 1994. It was necessary to reduce net diversions by the amount of water delivered to mesa lands, which were ineligible to participate in the Program, and identify water use for only lands in the valley portion of the Palo Verde Irrigation District (PVID). These adjustments resulted in the following net Program diversion amounts: 64,071 AF during 1992, 325,855 AF during 1993, and 227,683 AF during 1994.

Valley acreage that was not in the Program was tabulated and divided into net diversions to establish water use per acre. In the period August through December 1992, water use was 0.97 AF per acre (64,071 AF/66,173 acres), 4.83 AF per acre in 1993 (325,855 AF/67,490 acres), and 3.35 AF per acre from January through July 1994 (227,683 AF/67,961 acres). Absent the Program and assuming that the fallowed fields would have been planted with a crop mix similar to that of the non-fallowed fields, this method estimates that 9.2 AF per acre for the two-year Program, or 4.6 AF/acre/year, would have been consumptively used on the fallowed fields.

However, under this method, an estimate of 4.6 AF/acre/year is considered conservative since no corrections to PVID's net water diversions were made to adjust for the drop in the groundwater table during the two-year Program nor for the above average rainfall during the first Program year. Since the average groundwater elevation is higher than the elevation of the surface drains, the drop in the groundwater table during the two-year Program resulted in certain groundwater draining into the surface drains. Consequently, the additional drainage water resulted in an increase in the measured surface return flow credits. This, in turn, caused a reduction in PVID's net diversions which are calculated by subtracting measured surface returns from measured diversions. Similarly, the above-average rainfall during the first Program year resulted in an increase in the measured surface return flow credits and, likewise, a reduction in PVID's calculated net diversions. Net diversions adjusted for groundwater and rainfall would result in a higher water use figure than 4.6 AF/acre/year which is considered a minimum value under this method.

11.0 Survey of Participants

An important component of the Test Land Fallowing Program was to obtain "feedback" from participants with regard to its operation, structure and impacts. Feedback information was obtained through the administration of three surveys to Program participants. The first survey applied to conditions during the first year of the Program (August 1992 through July 1993) and was taken in the last week of June 1993. The second survey applied to conditions during the second year of the Program (August 1993 through July 1994) and was administered during the first two weeks of July 1994. The third survey was designed to solicit information for the period immediately following the Program and was conducted during January and February of 1995.

The first two surveys were more comprehensive than the third, focused on obtaining detailed information related to fallowing procedures, equipment use, labor and application of compensation received by participants from the Program. These two surveys were very similar and will be summarized together. The third survey was much less rigorous and sought general information pertaining to use of the fallowed fields following completion of the Program. Separate reports for each survey are contained in Appendices J-1, J-2 and J-3.

11.1 First and Second Surveys

The structure of the first- and second-year surveys was very similar and targeted three main areas. The first area was concerned with fallowing methods used by participants both at the start of the

Program and to maintain compliance throughout the two years; the **second area** involved labor, equipment, purchase of goods and services, crop marketing, and use of Program funds; and the **third area** covered miscellaneous topics such as issues associated with non-fallowed fields due to the Program, acreage enrolled in federal programs, preferable Program implementation dates, irrigations saved in anticipation of the Program, and general comments.

11.1.1 Land Fallowing Methods

Five different methods were used to fallow fields at the start of the Program: applying chemicals, disking, plowing, knifing and subsoiling. Approximately half of the Program acres (10,513 acres) were fallowed through the use of chemicals, applied primarily to alfalfa stands. Program participants, with few exceptions, used "Roundup" at a rate of one quart per acre applied with ground spray equipment. About 25 percent (5,414 acres) of the Fallowed Acreage, consisting mainly of alfalfa, wheat and melons, were disked. The remainder of the Fallowed Acreage, primarily alfalfa stands, were plowed (2,835 acres), knifed (1,068 acres) or subsoiled (385 acres).

Due to above normal rainfall in the first year, follow-up operations occurred on almost 38,000 acres compared to 18,000 acres in the second year. The total number of follow-up fallowing operations varied among participants from a low of one to a high of seven. Most of the Fallowed Acreage received at least two or three follow-up treatments during the two-year Program.

The most frequent method used in follow-up operations was disking which was used on approximately 59 percent of the acreage. Chemical control was the next most frequent method and was applied to 33 percent of the acreage. Together, disking and chemical control were used on 92 percent of the area that received follow-up treatments. The remaining 8 percent of the area was treated through plowing, swathing, subsoiling, ripping or knifing.

11.1.2 Fallowing Costs

Disking was by far the least costly of all initial fallowing methods having a weighted average cost of $10.55 per acre. Disking is followed by subsoiling having a weighted average cost of $14.00 per acre; chemicals, $17.82 per acre; knifing, $21.34 per acre; and plowing, $23.25 per acre. The weighted average cost of initial fallowing of all Fallowed Acreage was $16.75 per acre. The cost ranged from a low of $8.00 per acre to a high of $27.00 per acre.

During the first year of the Program, the weighted average cost for all follow-up treatments applied by Program participants was $25.89 per acre, ranging from a low of $8.00 per acre to a high of $75.00 per acre. The weighted average cost during the second year was $10.74 per acre, ranging from a low of $6.00 per acre to a high of $75.00 per acre.

The total weighted average cost during the two-year Program for all fallowing treatments, including initial fallowing and all follow-up treatments, was $53.38 per acre. Total weighted average costs among Program participants ranged from a low of $23.08 per acre to a high of $135.00 per acre.

11.1.3 Compliance With Soil Conservation Service Regulations for Wind Erosion Control.

Special operations were performed on 1,251 acres of highly erodible soils (6 percent of the Fallowed Acreage) to comply with SCS regulations during the first year of the Program. Cover foliage was the most widely used technique which consisted of broadcasting grain seed over the fallowed fields and relying upon rainfall for germination. Plants were permitted to develop mature root systems, without applying any irrigation water, and chopped, mowed or swathed. before "going to seed". The remaining root systems and plant residue left in the fields provided excellent protection for soils against wind erosion.

Plant residue was applied to 1,204 acres at an average weighted cost of $23.07 per acre. One Program participant used cloddy fallow on 20 acres at a cost of $9.75 per acre, and another participant plowed 27 acres at a cost of $25.00 per acre. During the second year of the Program, special fallowing operations to comply with SCS regulations were performed on only 414 acres (41 percent) of the 1,251 acres designated by the SCS as highly erodible soils (3 percent of the Fallowed Acreage) as operations initiated during the first year were still effective on the remaining 837 acres. Weed chopping was used on 324 acres of highly erodible land at an average cost of $20.41 per acre. Plowing of cloddy fallow was used on the remaining 90 acres at an average cost of $18.89 per acre.

The total weighted average cost for Program participants to control highly erodible soils during the first year was $22.90 per acre. Weighted costs for fallowing operations during the second year on the total 1,251 acres of highly erodible land were $6.65 per acre. The total weighted average cost to control highly erodible soils over the two-year Program was $29.55 per acre. Costs to treat highly erodible soils were part of the follow-up treatments applied by Program participants and are included in the $53.38 per acre total fallowing costs.

11.1.4 Changes in Full-Time and Seasonal Labor

During the first year, 57 of the 63 respondents representing 89 percent of the Fallowed Acreage reported no change in **full-time equipment operators**. Five Program participants, accounting for 10 percent of the Fallowed Acreage, reported a total reduction of 4.5 full-time equivalent equipment operators ranging from 0.5 to 2.0 full-time equivalent positions each. The remaining Program participant, who is a custom operator with 1 percent of the Fallowed Acreage, reported a reduction of 10 workers for a total first-year reduction of 14.5 full-time equivalent equipment operators. In the second year, 62 of the 63 respondents, representing 96 percent of the Fallowed Acreage, reported no change in full-time equipment operators. One Program participant, accounting for the remaining 4 percent of the Fallowed Acreage, reported a reduction of 1.0 full-time equivalent equipment operator. The total reduction in full-time equivalent equipment operators was 15.5 over the two-year Program. All respondents reported no change in **seasonal equipment operators** throughout the Program.

In the first year, 56 respondents representing 79 percent of the Fallowed Acreage reported no change in **full-time irrigators**. Seven respondents, representing the remaining 21 percent of the Fallowed Acreage, reported a total reduction of 11.5 full-time equivalent irrigators ranging from

0.5 to 3.0 each. During the second year, all 63 participants in the Program reported no changes in full-time irrigators. Therefore, the total reduction in full-time irrigators was 11.5 during the two-year Program. All of the survey respondents (63) indicated no change in **seasonal irrigators** during either year of the Program.

All 63 Program participants indicated that no changes occurred in **full-time or seasonal laborers** during the two years of the Program.

11.1.5 Changes in Equipment Use.

In the first year, 59 Program participants indicated that **tractor use** had not changed as a result of the Fallowed Acreage. A reduction of 10 percent was indicated by three participants and one operator estimated a 15 percent reduction. No Program participant indicated an increase in tractor use. This compares to the second year results in which 61 participants indicated no change in tractor use, 1 participant indicated a 50 percent decrease and 1 participant indicated a 100 percent increase.

As with tractor use in the first year, 59 participants indicated that no change had occurred in **disk usage**. Two participants indicated that their disk usage had increased 10 percent. One participant indicated a 15 percent reduction in disk usage and another had observed a 20 percent reduction. Second-year results included 61 participants with no change in disk usage, 1 participant indicated a 50 percent decrease and 1 participant indicated a 100 percent increase.

With regard to **plow usage** in the first year, 60 participants indicated no change, 2 participants observed a 10 percent increase, and one participant indicated a 15 percent increase. No Program participant indicated a decrease in plow usage during the first year. This compares to the second year results in which 62 participants indicated no change in plow usage and 1 participant did not respond.

In the first year of the Program, 62 participants indicated no change in **spray equipment usage** and one participant indicated a 25 percent increase. No participant indicated a decrease in usage of spray equipment. In the second year of the Program 62 participants reported no change in spray equipment usage and 1 participant indicated a 70 percent decrease.

All 63 participants indicated that no change had been observed in the usage of **knifing equipment** during the first year of the Program. In the second year, 62 Program participants responded that no change had been observed in the usage of knifing equipment and one participant indicated a 100 percent increase.

11.1.6 Impacts to Purchases of Goods and Services

Participants were asked how Program revenues had influenced their purchases of goods and services both within and outside of the Palo Verde Valley[4]. In the first year, 60 participants, representing 97 percent of the Fallowed Acreage, indicated no change in **local purchases** and

[4] All revenues were classified local or outside valley expenditures according to point-of-purchase.

three participants, representing the remaining 3 percent, indicated a decrease in local purchases. No respondent indicated an increase in local purchases. In the second year, 49 Program participants, representing 81 percent of the Fallowed Acreage, indicated no change in local purchases, 7 participants, representing 10 percent of the Fallowed Acreage, indicated that local purchases had increased, ranging from 10 to 100 percent depending upon the specific circumstance. A reduction in local purchases from 12.5 to 70 percent was reported by 7 participants representing 9 percent of the Fallowed Acreage.

All 63 respondents indicated that they had observed no change in their purchases of goods and services outside of the Palo Verde Valley during the two-year Program.

11.1.7 Impacts to Marketing Contracts

During both years of the Program, 62 participants, representing 98 percent of the Fallowed Acreage, indicated an insignificant change (less than 10 percent) in marketing contracts for farm products as a result of the Program. One participant, representing 2 percent of the Fallowed Acreage, indicated a moderate change (10 percent to 25 percent) in marketing contracts. There were no responses indicating a significant change (greater than 25 percent) in marketing contracts.

11.1.8 Use of MWD Funds

During the first year of the Program, 38 participants (51 percent of fallowed acres) used Program funds on local purchases, 16 participants (36 percent of fallowed acres) used the funds for purchases outside of Palo Verde Valley, and 9 participants (13 percent of fallowed acres) had both local and outside expenditures. In the second year, 44 Program participants, representing 59 percent of the Fallowed Acreage, indicated that they had used all revenues for local purchases. Eleven participants, representing 28 percent of the Fallowed Acreage, indicated all revenues were used for purchases outside of the valley. The remaining 8 participants, representing 13 percent of the Fallowed Acreage, used Program revenues for both local and outside purchases.

Local purchases during the first year accounted for approximately 57 percent of total funds received and 43 percent was spent outside of the valley. Local purchases were distributed among farm improvements (11 percent), repayment of loans (14 percent) and farm operations (32 percent). Expenditures outside of the valley were spent on loans (29 percent), land rent (5 percent) and farm operations (4 percent). In the second year, local purchases accounted for 66 percent of total revenues during the second year, while 34 percent of the revenues were spent on purchases outside of the valley. Local purchases were distributed as follows: 63 percent for operations, 18 percent for farm improvements, 10 percent for loans, 7 percent for miscellaneous items, and 2 percent for rent. Purchases outside of the valley primarily were used to repay loans (81 percent), 9 percent was spent on operations, 7 percent on miscellaneous items, and 3 percent on rent.

11.1.9 Miscellaneous

Miscellaneous topics included issues associated with non-fallowed fields, acreage enrolled in federal programs, preferable Program implementation dates, irrigations saved prior to the Program, and general comments.

During both years of the Program, all 63 respondents indicated they had experienced no difficulties in irrigating the non-fallowed fields because of the Program.

Cotton and wheat are the only crops in the Palo Verde Valley that are participating in the Federal Crop Program. Farmers, participating in the Federal Crop Program, establish a base acreage for each crop. Each year, the Federal Government requires participating farmers to not farm, or "set-aside", a percentage of the base acreage. However, the set-aside acreage can be planted in cotton, wheat, or some other crop, cultivated and irrigated during the set-aside period (usually 12 months), but not harvested.

A total of 1,791 acres of set-aside were included in the Program during the second year as compared to 1,465.5 acres during the first year. Cotton set-aside acreage accounted for 1,428 acres compared to 1,413.5 acres during the first year, and wheat accounted for 363 acres compared to 51 acres during the first year. Future programs will not permit set-aside acreage to be included as part of the fallowed area.

With regard to the preferred time of year to initiate a fallowing program, approximately two-thirds of the participants, representing 49 percent of the Fallowed Acreage, believed that August was the best month, 13 respondents (representing 36 percent of Fallowed Acreage) favored September, 10 (representing 14 percent of Fallowed Acreage) opted for January and one (representing 1 percent of Fallowed Acreage) preferred May. There are 64 responses because one respondent preferred either May or August.

In anticipation of beginning the Program on August 1, 1992, twenty-two participants chose to skip, on average, from 1 to 2 irrigations in the months immediately preceding the start date. Assuming an average of three inches of consumptive use per acre for each irrigation, approximately 3,400 acre-feet of water were saved in anticipation of the Program.

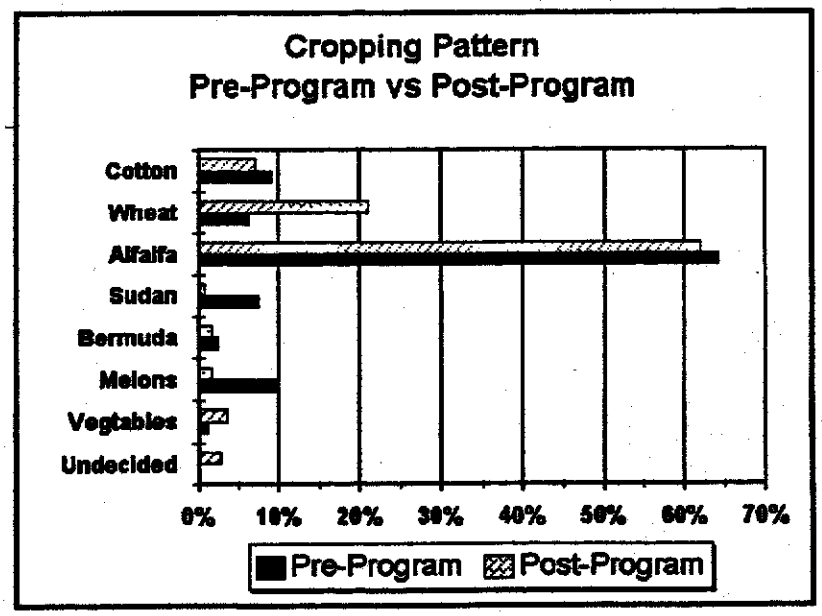
Three themes were observed to recur in the general comments received. First, a majority of participants indicated that the Program was beneficial and would be willing to enter into another, similar Program. Second, some participants would prefer to stagger the starting dates to fit into farming operations and better accommodate water delivery requests upon completion of the Program. Third, some participants would like to rotate fields each year of the Program. Fourteen participants preferred to withhold comments until after the emergence of crops planted on previously fallowed fields.

11.2 Third Survey

A third survey of Program participants was completed in February 1995. Information requested was less detailed than in the two earlier surveys and related to (1) the process of bringing fallowed fields back into production, (2) crops planted or planned for the fallowed fields, and (3) perceptions of the Program by participants.

The first area, concerning the process of bringing fallowed fields back into production, requested information related to tillage and irrigation. Participants were asked to comment whether different tillage operations were required to prepare the fallowed fields for crop production in addition to normal operations. All 63 participants provided information in this area. A total of 57 participants, representing 18,910 acres of the 20,215 acres of fallowed lands (94 percent), indicated that no additional operations were required. Five participants, representing 1,105 acres (5 percent), indicated that an extra tillage operation was needed (2 disking, 3 unspecified) and 1 participant, with 200 acres (1 percent), indicated that extra laser leveling work was required to return the fallowed fields to appropriate crop production conditions In addition to tillage, participants were asked to comment on irrigation requirements of the fallowed fields. There were 61 participants, representing 19,095 acres (94 percent), indicating that no additional irrigations were required, however, three participants (611 acres) within this group did notice that it took longer to irrigate the fallowed fields. Only 2 participants, representing 1,120 acres (6 percent), indicated that one additional irrigation was needed on the fallowed fields.

The second area of the third Survey solicited information about the resumption of cropping on the Fallowed Acreage. Participants were asked what crops they had planted on the Fallowed Acreage or, in the case where all or part of the fields had not been planted, what crops were planned. It was reported that as of February 1995, 17,931 acres (89 percent) had been planted, leaving only 2,284 acres unplanted. Crops that would be planted in the spring on 1,747 acres had been decided, leaving only 537 acres in which a decision was still pending. The cropping pattern of post-Program use of Fallowed Acreage was developed using crops that had already been planted, planned crops and the area for which no decision had been made. It was observed that most of the Fallowed Acreage was planted into alfalfa (62 percent) followed by wheat (21 percent) and cotton (7 percent). As shown in the figure, the post-Program cropping pattern closely resembles the pre-Program cropping pattern



where alfalfa occupied 64 percent of the land that was to be fallowed, wheat was grown on 6 percent and cotton on 9 percent. The largest difference is in wheat with only minor differences in the other crops.

Program participants were asked if there were differences in crops growing on fallowed fields in comparison to crops growing on non-fallowed fields. There were 57 respondents to this question, representing 19,428 acres, and 6 participants, representing 787 acres, chose not to provide a response. Of the 57 respondents, 46 participants, with 13,075 acres (67 percent), responded that they could not observe any difference between crops on fallowed and non-fallowed fields. There were 7 participants, with 3,126 acres (16 percent), which indicated that crops growing on the fallowed fields looked better than crops on non-fallowed fields. A total of 4 participants, representing 3,227 acres (17 percent), stated that crops on fallowed fields did not appear as good as crops on non-fallowed fields. According to these responses, fallowing did not affect growing conditions on the majority of the fields, 16 percent of the Fallowed Acreage was improved and 17 percent of the acreage did encounter adverse impacts that required additional cultural operations to restore proper growing conditions.

The third area of the third Survey asked participants questions concerning their perception of the Program and related comments. First, participants were asked to make an overall comment about the Program. A total of 48 responses (16,550 acres) were received with 15 respondents (3,665 acres) not replying to this question. There were 43 responses, representing 12,840 acres, indicating that the Program was well received while 5 participants, with 3,710 acres, stated that minor changes should be made although they felt the Program was beneficial.

When asked about interest concerning participation in another similar program, all 58 participants, representing 19,795 acres, responding to this question indicated "yes"; 5 participants with 420 acres did not respond. This is an indication that the Program was, overall, well received by the participants.

Participants were asked what length of time they would prefer for a fallowing Program. A total of 60 participants, representing 19,646 acres (97 percent), responded to this question; 3 participants representing 569 acres (3 percent) did not respond. The majority of participants, 40 (12,100 acres), preferred a two-year program. The remaining 20 respondents were divided among several options; 6 (1,165 acres) preferred a 1-year program, 8 (5,194 acres) preferred a program of 6 years or longer, and 6 (1,187 acres) preferred a 1- to 3-year program.

Finally, participants were asked which method they preferred to use for fallowing their fields at the start of a program. There were 61 total respondents, representing 19,918 acres while 2 participants (297 acres) did not provide an answer to this question. Most of the participants, 36 representing 14,526 acres, indicated that the method used depended upon the crop in the field at the time of fallowing including mechanical or chemical or a combination of these two methods. There were 16 participants (3,406 acres) that preferred the use of chemicals; 6 participants (707 acres) preferred plowing; 2 participants (1,159 acres) would disk; and 1 participant (120 acres) would knife.

Overall, the surveys indicated the Program was well accepted by the participants and only minor issues arose during its two-year period of implementation.

12.0 Regional Economic Impacts

The Program fallowed approximately 22 percent of the cultivated acres in the Palo Verde Valley. Since agriculture is the largest component of the economy in the Palo Verde Valley, a survey and study were undertaken to examine possible economic impacts at the regional and local levels. Copies of the survey and study are contained in Appendix K.

In recent years, prior to the Program, several other events have affected regional economic activity, either positively or negatively. To assess the effect that the Program had on the regional and local economy, it is necessary to note these events:

- the construction and staffing of the Chuckawalla Valley and Ironwood State Prisons;
- a substantial increase in housing and commercial construction;
- the statewide economic recession; and
- the depressed agricultural economy in the Palo Verde Valley.

Prior to the start of the Program, the economic performance of the regional economy was mixed. The construction and subsequent staffing of the prisons brought an important new source of jobs and income to the region. By the end of 1994, it was estimated that the prisons created approximately 1,800 jobs for the region. The prisons also are largely responsible for the mini-construction boom the valley has experienced since 1988, and probably helped lessen the regional effects of the statewide recession.

At the same time, the region's agricultural economy had been under significant financial stress. Gross farm revenue in 1991 was 58 percent below its 1988 level and the estimated total demand for farm labor was 68 percent lower. It is important to emphasize that this decline occurred prior to the start of the Program and is largely due to the region's long-term decline in vegetable production and the more recent loss of much of the region's melon production (due to whitefly). In particular, it should be noted that the farm job losses associated with these adjustments are far larger than those that have been associated with the Program.

12.1 Program Impacts

A survey was conducted in the Blythe Market Area to gather additional information on impacts of the Program to local businesses. The purposes of the survey were to provide an indication of: (1) how revenues of local businesses were affected by the Program versus other economic events; (2) how employment of local businesses was affected by the Program versus other economic events; and (3) perceptions held by local businesses of the Program and how it affected the local economy.

The scope of the project did not allow for random sampling of local businesses on a scale large enough to develop a sample from which statistically valid inferences could be drawn. Therefore, efforts were focused on identifying business most likely to have been affected by the Program and administering the survey to them. A total of 20 contacts were made and 13 surveys were completed for the following types of businesses: firms providing farm services (5 contacted, 4 completed), firms providing farm supplies (6 contacted, 4 completed), firms handling farm products (4 contacted, 3 completed), and firms not directly related to agriculture (5 contacted, 2 completed).

It was found that negative economic impacts of the Program were concentrated within farm-related businesses providing services or supplies to the region's farmers. Three of the four businesses surveyed providing farm services characterized the Program as causing a significant decrease in revenues in 1993, while three of four respondents providing farm supplies characterized it as causing a minor decrease. It should be noted, however, nine of the thirteen firms surveyed characterized the Program as causing only a minor decrease or having no impact on their revenues during the first year, while ten of thirteen firms characterized it as causing a minor decrease, no impact, or a minor increase in their revenues during the second year.

Employment losses caused by the Program also were found to have been concentrated within farm-related businesses. Employment losses related to the Program were not found to have extended to nonfarm related businesses. Similarly, respondents whose farm-related revenue was a low proportion of their total revenue did not report any Program related employment losses. Overall, four of five surveyed firms providing farm services or supplies characterized the Program as a primary, though not necessarily the only, reason for reducing employment between 1992 and 1994. Over the two-year period, the Program was estimated to have contributed to the loss of 26 full-time farm jobs, 25 full-time jobs in farm-related businesses, and seven part-time/seasonal jobs in farm-related businesses. Based on Employment Development Department employment counts for the region, tallied employment losses associated with the Program are equal to approximately 1.3 percent of average regional employment for 1991-92. It should be noted, however, that it was beyond the scope of this analysis to estimate the employment stimulus associated with regional spending of Program payments. As a result, employment losses due to the Program may be less than stated here.

The Program was not found to have caused reductions in employment or revenues for non-farm-related businesses in the region. Surveyed and interviewed non-farm-related businesses indicated that the Program had no perceptible effect on their revenues, and did not cause them to adjust their employment. Businesses surveyed, whose farm-related sales in the region comprised less than 20 percent of their total revenue, also indicated that the Program did not affect their businesses in any significant way.

The Program was found to be only one of several causes for a reduced regional demand for farm-related labor, services, and manufactured inputs. It is important to emphasize that there were many factors simultaneously affecting the local demand for farm services and supplies. For example, since 1988, the region's lettuce acreage has decreased by approximately 15,000 acres

due to whitefly infestation and other factors unrelated to the Program. It is estimated that this reduction has caused the annual demand for seed, fertilizer, chemicals, and custom services to fall by approximately $8.3 million, and the annual demand for custom harvest services by approximately $19.0 million. By comparison, it is estimated that the Program reduced the annual demand for seed, fertilizer, chemicals, and custom services by approximately $4.0 million during the two-year period. While the Program did produce a measurable decrease in farm-related activity, it should be noted that the significant decrease in vegetable and melon production in the region due to whitefly and other factors not related to the Program has had a more pronounced and lasting effect on the demand for farm labor, services, and supplies.

In addition, a high proportion of Program payments were injected into the local economy. Program participants reportedly spent 93 percent of Program payments in excess of fallowing and maintenance costs on farm-related improvements, operation, rent, and debt repayment. Estimates indicate that approximately 61 percent of Program payments in excess of costs was spent within the local economy. The Program was found to have provided timely financial relief to the region's agricultural producers who had been under significant hardship due to low prices for key commodities, especially alfalfa, and pest infestation.

In summary, the Program was not found to have affected overall regional economic performance to any significant degree. City officials and local bank representatives characterized the current state of the regional economy as improved relative to pre-Program conditions. The Program was not found to have affected the region's property or sales tax bases, or the provision of governmental services. It was, however, found to have contributed to a slight loss of employment in the region.

13.0 Regional Environmental Impacts

A Negative Declaration and Initial Study were completed to determine if potentially significant environmental impacts would occur as a result of the Program. Three areas, earth (soils), air and plant life, were identified in which potential adverse impacts could occur through implementation of the Program. The basis for potential impacts to earth resources is possible wind erosion of specific soils left exposed under certain conditions over an extended period of time. A soil survey (Soil Survey of Palo Verde Area, California) of the PVID area has grouped soils into classes to show the suitability of soils for agricultural production. Soils are grouped according to their limitations when used for crop production. Limitations found in PVID include erosion, poor drainage, and saline conditions. Drainage and saline limitations have been corrected on cultivated lands to the point that continued agricultural operations are possible. Soils subject to erosion, unless close-growing plant cover is maintained, total almost 4,000 acres. The majority of these soils are located on the Palo Verde Mesa, are not under cultivation, and were not eligible to participate in the Program. However, approximately 1,300 acres of highly erodible soils were included as fallowed lands in the Program. Without appropriate land management, some limited wind erosion of these soils could occur which would possibly damage crops grown on neighboring fields.

Appropriate conservation practices in PVID to control wind erosion include leaving crop residues and sod, and plowing the soil into large clods. When the last crop before fallowing a field is wheat (or other small grain), stubble and straw residue are left as a protective cover from erosive winds. In some instances, sod from alfalfa or other grass crops is left in place on fallowed fields which serves the same purpose as stubble and straw residues. Where soils are primarily clay or clay loam, plowing will leave large clods which become hard and are not easily eroded by the wind. This is called "cloddy fallow" and is an effective measure against wind erosion of such soils in PVID.

All of the conservation practices mentioned in the previous paragraph are common methods used by PVID farmers as effective measures against wind erosion. Although it was expected that good conservation practices would continue on the fallowed lands under the Program, each participant was required to develop and follow an approved land management plan. The program participant was required to apply appropriate mitigation measures to soil types that may be subject to wind erosion. This plan was merely an extension of good management practices currently used on fallowed lands in PVID and the monitoring and reporting procedures required by the Program helped to ensure that no adverse impact occurred.

The next area of potential impacts from the Program was air quality. Air quality monitoring activities at the start of the Program were quite recent in PVID with insufficient data to determine annual air quality values for the area. Partial data for ozone showed no violations of either State or federal standards, although the State standard had been approached. Data related to PM_{10} (particulate matter less than 10 microns) contained values exceeding the 24-hour State standard but no values exceeded federal standards.

The sources of PM_{10} in the Blythe area have not been identified and data are insufficient to determine if agriculture is a major contributor or how much PM_{10} is actually contributed from this source. Most of the dust from agricultural operations, being of visible size, is probably larger than PM_{10} and settles out of the air quickly. In addition, Blythe and the PVID are surrounded by a large expense of desert land which may also be an important contributor.

Concern for air quality was centered on the increased chance for the occurrence of small dust particles (PM_{10}) from the Fallowed Acreage since this area was larger than normal. Under the assumption that some dust problems may occur which could degrade the air quality, appropriate land management practices to control dust were mandatory under the Program. Acceptable practices, as described above, included techniques such as leaving stubble residue, sod remnants, or cloddy fallow.

The third area of potential adverse impacts was plant life. Normal agricultural activities involve application of various chemicals to enhance crop production and control weeds. Under fallow conditions, there would be no need to enhance plant growth or apply water, however, weed growth would occur on the fallowed fields if left unchecked. Control of weeds is necessary during the fallowing periods because, if allowed to proliferate and produce seeds, weeds could affect neighboring fields and crop production on the fallowed acres for a number of years afterward.

Therefore, control of undesirable plants (weeds) within and on the periphery of fallowed fields was mandatory under the Program. Participants were to use various weed control measures of their choice including chemical, biological or mechanical methods. Only chemicals approved for use by the California Department of Food and Agriculture were used for controlling weeds. Proper local, county, State or federal permits were to be obtained for the use of herbicides, pesticides or insecticides as is the normal practice within PVID.

Through the environmental analysis, it was determined that no significant impacts would result from the Program for the following reasons: (1) with implementation of described mitigation measures, no significant impact to area resources was anticipated; (2) effects would be small and diffuse since only a maximum 25 percent of base acreage would be accepted from each participant; (3) effects would be temporary as the program was intended to last only two years; and (4) no previous significant environmental effects had been observed when large amounts of PVID agricultural land were left fallow for other reasons over a period of time.

Under Section 21081.6 of the Public Resources Code (California), when a mitigated Negative Declaration is adopted, it is also necessary to adopt a monitoring and reporting program for those areas that will be impacted through implementation of the Program. Those areas requiring mitigation were: earth (soil erosion); air quality; and plant life and were covered under the mandatory Land Management Plan adopted by each Program participant. Through implementation of mandatory mitigation measures adopted for the Program, the environmental impacts of land fallowing were insignificant and within the range of past farming practices used in the PVID.

14.0 Total Program Costs

The total cost of the Test Land Fallowing Program was $26.6 million. Almost 96 percent ($25.1 million) of the total Program costs was in the form of compensation to Program participants for fallowing their lands. The remaining 4 percent ($1.5 million) was for professional and technical services ($1.3 million), and Program administration ($0.2 million).

Expense Category	Program Costs ($millions)
Payments to Participants (20,215 acres x $1,240/acre)	$25.1
Professional and Technical Services	1.3
Administration	0.2
Total Program Costs	**$26.6**

Based on 4.6 acre-feet of water saved per acre of fallowed land, the Program saved an average of 92,989 acre-feet per year and a two-year total of 185,978 acre-feet. Considering both the amount of water saved and the total Program costs, the average cost per acre-foot of water saved was $143.00.