

ARROYO COLORADO WATERSHED

NONPOINT SOURCE POLLUTION PROJECT

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**FINAL REPORT
FEBRUARY 1998**

TIAER

PR 98-02

Participating Agencies:

Texas State Soil and Water Conservation Board

Southmost Soil and Water Conservation District

Texas Institute for Applied Environmental Research

Texas Agricultural Extension Service

Natural Resources Conservation Service

**ARROYO COLORADO WATERSHED
NONPOINT SOURCE POLLUTION PROJECT
FINAL REPORT**

TEXAS STATE SOIL AND WATER CONSERVATION BOARD

CONTRACT #994-592-713-4200000051

FY92 CWA SECTION 319(h)

FEBRUARY 1998

Final Report prepared by Nancy Easterling, TIAER

TAEX Report prepared by Guy Fipps

TIAER Report prepared by Joan Flowers, Nancy Easterling, and Larry Hauck

ACKNOWLEDGMENTS

The Texas State Soil and Water Conservation Board (TSSWCB) is especially indebted to the two landowners that participated in this project, George Labar and Wayne Halbert. They persevered in spite of government bureaucracy, drought and various other problems encountered during the course of this project. Without the patience of these two individuals, this project would not have been successfully completed.

The TSSWCB also sincerely appreciates the patience and cooperation of the agencies involved in this project. Specifically, the TSSWCB would like to thank the Southmost Soil and Water Conservation District (SWCD) for locating the demonstration sites, for coordinating the water quality sampling activities of the demonstration sites and for their involvement in the project-related educational activities. The TSSWCB is also very thankful for the work that Natural Resource Conservation Service (NRCS) completed in this project. Specifically, Tony Gonzales and Allan Moore have worked closely with the Southmost SWCD and assisted them in completing project tasks and also provided technical assistance to the cooperators during the best management practice (BMP) planning and implementation phases of the project. Guy Fipps at Texas Agricultural Extension Service (TAEX) and other TAEX staff did an excellent job on the technology transfer and educational activities. Their efforts are commendable. Lastly, and certainly not least, the TSSWCB would like to thank the staff at Texas Institute for Applied Environmental Research (TIAER), especially Larry Hauck, Joan Flowers, Nancy Easterling and Mark Murphy, for their diligence in analyzing water samples, modeling the effects of the implemented BMPs and completing this final report. The TSSWCB is always pleased with the high quality performance of TIAER.

SUMMARY

This section 319(h) project was designed to promote the adoption of best management practices (BMPs) to abate nonpoint source pollution from agricultural sources in the Arroyo Colorado study area. The project was funded by the U.S. Environmental Protection Agency through Texas Natural Resource Conservation Commission (TNRCC) and Texas State Soil and Water Conservation Board (TSSWCB), with some matching funding for mathematical modeling efforts provided by Texas Water Development Board. Project participants included the Texas Agricultural Extension Service (TAEX), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), Southmost Soil and Water Conservation District (SWCD), and Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University. Primary tasks of the project included the establishment of coordinating committees, the installation of BMPs and monitoring of demonstration sites, mathematical modeling of the study area, and education and technology transfer.

The project's advisory committees selected BMPs appropriate for crops grown in the study area. Demonstration sites for the project were implemented with BMPs and were monitored over a fifteen-month period for water quality parameters. A multi-layer GIS database for the study area was assembled as part of the mathematical modeling efforts, which also used data collected from demonstration sites. Average annual loads of nutrients and pesticides were estimated for the study area based on the modeling results for the six BMPs listed below:

1. improved nutrient management,
2. improved residue management,
3. improved irrigation water management,
4. improved irrigation technology,
5. irrigation land leveling/precision land forming, and
6. integrated pest management.

The project accomplished several important objectives:

- Improved nutrient and residue management, irrigation land leveling/precision land forming, crop rotation and integrated pest management were demonstrated through implementation on two demonstration sites. Effectiveness of BMP implementation was evaluated through edge-of-field monitoring at the demonstration sites.
- Mathematical modeling efforts, calibrated with monitoring data from the demonstration sites, indicated that substantial reductions in nutrient and pesticide loadings would be achieved from BMP implementation within the study area.
- Exchange of information with agricultural interest groups was promoted through numerous education and technology transfer activities that had a cumulative attendance exceeding one thousand.
- An Internet site was established which contains environmental information and research data, plus agricultural management guides pertinent to the study area.
- Five publications and a videotape which supply information useful to agricultural producers in reducing nutrient and pesticide loadings to the watershed were produced and made available to area agricultural producers.

ADMINISTRATIVE HISTORY OF THE PROJECT

<i>Date</i>	<i>Action</i>
May 25, 1994	TNRCC contract with the TSSWCB for the FY92 Arroyo Colorado Project was executed, project period April 15, 1994 through August 31, 1996.
August 2, 1994	TSSWCB executed subcontract with TAEX.
August 24, 1994	TSSWCB executed subcontract with TIAER.
September 9, 1994	TSSWCB executed subcontract with NRCS.
October 12, 1994	TSSWCB executed subcontract with the Southmost SWCD.
April 7, 1995	TSSWCB submitted contract amendment revising the project workplan and budget and extending the project throughout August 31, 1997.
July 13, 1995	TSSWCB submits draft QAPP to TNRCC.
August 28, 1995	TNRCC submits formal letter request for contract amendment.
September 8, 1995	TNRCC sent comments on the QAPP to be addressed by the TSSWCB.
October 4, 1995	EPA approves workplan and budget changes in letter to TNRCC.
November 22, 1995	TSSWCB made revisions to the QAPP and resubmitted it to TNRCC.
November 30, 1995	QAPP approved by TNRCC and submitted to EPA.
February 5, 1996	QAPP approved by EPA.
November 27, 1996	TNRCC submits to TSSWCB the revised contract amendment for signatures.
December 10, 1996	TSSWCB executed subcontract with TAEX to extend project to August 31, 1997.
December 16, 1996	TSSWCB executed subcontract with TIAER to extend project to August 31, 1997.
January 16, 1997	TSSWCB executed subcontract with NRCS to extend project to August 31, 1997.
January 24, 1997	TSSWCB executed subcontract with Southmost SWCD to extend project to August 31, 1997.
June 24, 1997	QAPP annual revision sent to TNRCC.

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INTRODUCTION

The Arroyo Colorado watershed, located in the coastal border region of southern Texas, has experienced numerous water quality problems in recent years. Evidence points to agriculture, a primary industry of the area, as one possible source of the pollution. This Clean Water Act section 319(h) project serves to demonstrate best management practices (BMPs) to abate nonpoint source pollution from agricultural sources in the study area, to promote their adoption among area producers, and to estimate the effects of BMP implementation on local water quality.

The project was developed by the Texas Natural Resource Conservation Commission (TNRCC), Texas State Soil and Water Conservation Board (TSSWCB) and the Southmost Soil and Water Conservation District (SWCD). Cooperating agencies include the Texas Agricultural Extension Service (TAEX), Natural Resources Conservation Service (NRCS), and Texas Institute for Applied Environmental Research (TIAER). This project addresses the impact of nonpoint source pollution resulting from agricultural sources, while the TNRCC has developed a companion project addressing nonpoint source pollution resulting from urban runoff to the Arroyo Colorado. In addition to the cooperating agencies, local citizens and technical experts were involved with the project through coordinating committees established early in the project to provide guidance for research and educational activities.

The overall objective of the project was to promote the adoption of BMPs to abate nonpoint source pollution from agricultural sources in the study area. Specific objectives of this project include the following:

- demonstrate improved nutrient and pesticide management practices;
- evaluate the effectiveness of selected BMPs through monitoring of edge-of-field losses, both surface and subsurface, at the demonstration sites;
- estimate the environmental benefits of widespread BMP implementation through the use of mathematical models to predict pollutant load reductions from agricultural enterprises in the study area; and
- promote increased cooperation and exchange of information between agricultural interest groups through the technical advisory committee and the local advisory committee.

Two fields were selected for implementation and demonstration of BMPs suitable to the study area; one employed dryland cropping practices while the other was irrigated. To evaluate the effectiveness of selected BMPs in abating nonpoint source pollution associated with agricultural drainage, each field was divided into a control section managed according to conventional practices and a treatment section utilizing improved management practices. Samples of surface runoff and subsurface drainage were collected from the control and treatment sections of the fields for chemical analyses. Subsequent modeling analysis of best management practices within the Arroyo Colorado study area applied the Environmental Policy Integrated Climate (EPIC) model to estimate the effects of BMP implementation throughout the study area. Water quality data obtained from the monitoring activities at the demonstration sites were used for calibration and testing of the EPIC model prior to its application.

PROJECT ACCOMPLISHMENTS BY TASK

TASK 1. Establish and Sustain Technical Advisory and Local Advisory Committees

Subtask 1.1

TSSWCB and the Southmost SWCD with assistance from NRCS, TAEX, and TIAER will work in concert with TNRCC to sustain a Local Advisory Committee and a Technical Advisory Committee.

The Local Advisory Committee (LAC) and the Technical Advisory Committee (TAC) for the Arroyo Colorado project were formed in 1994, with meetings of the TAC continuing through 1997. Thirty people formed the LAC, including local citizens, local officials, irrigation district representatives, local agricultural producers, members of local environmental conservation organizations, plus representatives of national agencies and organizations. Twenty-two people formed the TAC, including representatives of the Environmental Protection Agency, Texas State Soil and Water Conservation Board, Texas Natural Resource Conservation Commission, and project participants.

Subtask 1.2

TSSWCB and TNRCC will assure that the LAC and TAC are informed of and have an opportunity for input into all aspects of the project through regularly scheduled meetings.

The LAC and TAC took part in project activities, participating in location of project demonstration sites, determination of boundaries for the study area for modeling efforts, selection of potential BMPs for implementation, recommendations for equipment purchase/maintenance and establishing the need for additional data.

Milestones

Establish Technical and Local Advisory Committees.

Both of these committees were formed in 1994.

Deliverables

Minutes of TAC and LAC committee meetings to be attached to quarterly reports.

Minutes were attached to quarterly reports as requested.

List of TAC and LAC members.

Lists of committee members are included in Appendix A.

Attendance list of TAC and LAC meetings.

Attendance lists are also included in Appendix A.

Measure of Success

Interagency cooperation and coordination at the district level through regularly scheduled TAC and LAC meetings.

Project participants cooperated appropriately with TAC and LAC during the project. All meetings were held in the area, with the exception of one TAC meeting in Austin. The cooperation among committee members and project participants supported modeling and sampling efforts.

TASK 2. Identify, Design and Install Two Demonstration Sites

Subtask 2.1

Identification of two demonstration sites.

One demonstration site was located on 60 acres of dryland cropland in Cameron County. This demonstration site had a control field with conventional practices and an adjacent treated field on which BMPs were implemented. The second demonstration site occupied 40 acres of irrigated cropland in Cameron County. This site was selected to take advantage of existing water quality data collected from the site by the Southmost SWCD and NRCS in 1992-93 which could be used as the control data. Although an adequate amount of water quality data had been collected on the site, no accompanying flow data were obtained. Therefore, counter to the original plan, the 40 acre site was divided to provide a control field along with a treated field.

Subtask 2.2

Design and installation of BMPs for treated fields.

NRCS coordinated the design and installation of BMPs with assistance from the Southmost SWCD and TSSWCB. TAEX and NRCS provided technical assistance in BMP application. NRCS utilized data from the automated weather station to assist with scheduling of irrigation and nutrient management. TAEX provided additional technical assistance in nutrient and pesticide management. Nutrient management, pesticide management, residue management, and precision land forming were the BMPs implemented on the dryland treatment field. Nutrient and pesticide management were implemented on the irrigated treatment field. In addition, a subterranean drain tile system and land leveling had previously been implemented on the irrigated site.

Milestones

Preparation of a detailed plan for the two demonstration sites.

Members of the TAC and project participants surveyed BMPs to determine those appropriate for the demonstration sites. NRCS and Southmost SWCD met with site owners several times prior to their September 28, 1995 meeting which finalized the BMPs to be installed on the two demonstration sites. Additional plans for the sites included the following factors:

- Hydrologic isolation of sites by construction of perimeter berms,
- Installation of automatic water samplers in subterranean drain tile system,

- Installation of weather station at demonstration site,
- Precision land forming,
- Soil sample collection and analysis,
- Nutrient management recommendations for plants based on soil analysis,
- Pesticide management based on prevailing field conditions, as determined by scouting professionals,
- Surface irrigation data recommendations based on location, crop, soil type, curve number, irrigation system type and design efficiency,
- Residue management/conservation tillage recommendations based on percent surface cover and timing within the annual crop cycle.

Presentation of the plan to LAC for input.

Project participants updated members at all LAC meetings regarding BMP characteristics and the status of BMP implementation at the demonstration sites.

Install BMPs on treated fields.

The BMPs were successfully implemented on the demonstration sites in 1996.

Deliverables

Quarterly and annual reports.

Project reports have been submitted throughout the term of the project.

Measure of Success

Establishment of two treated fields exhibiting reductions in pesticide and nutrient loading after BMP implementation.

The two fields implemented with BMPs have been established as described above.

TASK 3. Evaluate BMP Effectiveness

Subtask 3.1

Literature review of existing water quality data in the Arroyo Colorado watershed and of current technology for applicable BMPs. The water quality data for stream segment 2202 will be compiled into a Paradox database. At the conclusion of this project, this data will be stored at the TSSWCB and will be available to the public and other governmental agencies upon request.

The literature review completed by TAEX, included in Appendix B, contains a comprehensive survey of water quality problems within stream segment 2202 of the Arroyo Colorado Watershed. Current technology for applicable BMPs is presented within the educational materials prepared by TAEX, which are also found in Appendix B. Existing water quality data has been compiled into a Paradox database and is available on the Internet at <http://arroyo.tamu.edu/arroyo/database.html>.

Subtask 3.2

Quality Assurance Project Plan (QAPP) for the demonstration sites.

TSSWCB coordinated the design of the QAPP with the Southmost SWCD, NRCS and TIAER. Appendix C contains a copy of the final copy of the project QAPP, with a letter indicating its approval by EPA. A copy of the TSSWCB audit of the TIAER laboratory is included as Appendix D.

Subtask 3.3

Purchase and installation of monitoring equipment, collection of samples, and laboratory analysis of samples will be completed.

Water quality monitoring equipment was procured by the Southmost SWCD. TAEX and NRCS worked with the Southmost SWCD in installing the monitoring equipment. Sample collection from the demonstration sites was provided by Southmost SWCD. Laboratory analyses of the samples were completed by TIAER. Laboratory data from analyses of samples are included as Appendix E. Weather data collected from the dryland demonstration site is available upon request from Dr. Guy Fipps at Texas Agricultural Extension Service and will soon be available on the Arroyo Colorado Water Quality Web Site. Weather data collected from the city of Harlingen are found on the Texas ET (evapotranspiration) Network and Web Site at <http://www.gen.tamu.edu/pet>. Other sections on this web site provide information on how to use the data for determining proper irrigation scheduling.

Subtask 3.4

Evaluation and interpretation of the monitoring data collected from the demonstration sites. The interpretation of the monitoring data will include simple statistical tests and trend analysis.

Evaluation and interpretation of the monitoring data are included in the final report prepared by TAEX which is provided in the first section of Appendix B. This report also describes additional project activities completed by TAEX.

Subtask 3.5

Application of mathematical models to demonstration sites and agricultural regions of the study area. The agricultural portion of the study area will be separated into categories based on soil type, crop, and farming practices (dryland or irrigation). Individual simulations will be performed for each grouping, which will then be aggregated into a representative picture of the agricultural portion of the study area. Simulations will be performed to estimate changes in edge-of-field loading for scenarios with and without BMPs.

TIAER has applied the Environmental Policy Integrated Climate (EPIC) mathematical model to the demonstration sites and to agricultural regions of the study area. Data describing the study area have been incorporated into TIAER's GRASS geographic information system. Data layers include soil type, land use/vegetative cover, topographical information, monitoring wells, and geographic/cartographic features. Baseline conditions in the study area were characterized. Simulations were run, using various combinations of BMP implementation, to estimate loading reductions from BMP usage.

Subtask 3.6

Determine the impact of BMPs on agricultural contributions to nonpoint source pollution by evaluating the viability of various BMPs. The improvements to water quality in the Arroyo Colorado through appropriate BMP implementation will be estimated.

TIAER prepared a report (Appendix F) detailing the water quality issues in the study area, informational requirements for the model, the geographic information system and climate database. The report also describes the demonstration sites, the water quality monitoring, baseline conditions, the evaluated BMPs, model selection, calibration and sensitivity analysis, and the results from the model evaluation of BMP implementation in the study area. Section 3.4 of the report details the baseline conditions of the study area; section 3.5 describes the BMPs evaluated by the model; and section 5.0 presents the results of the modeling analyses. Table 14, on page 40 of the report, enumerates the percent change estimates associated with BMP implementation in the Arroyo Colorado study area. In addition, TAEX has evaluated the water quality data associated with BMP implementation on the project sites. These evaluations are found in Section 1 of Appendix B.

Milestones

Draft Quality Assurance Project Plan to TNRCC and EPA.

The draft QAPP was completed by TSSWCB, in coordination with TIAER, TAEX, NRCS, and SWCD. It was sent to the TNRCC in July 1995.

Final Quality Assurance Project Plan approved by TNRCC and EPA.

EPA granted final approval of the QAPP in February 1996. The approved QAPP was updated and submitted to TNRCC in June 1997 and then submitted to EPA.

Conduct literature review and compile existing water quality data.

The literature review is included in Appendix B. This review is available on the Internet for agency personnel and the general public at the following address: <http://arroyo.tamu.edu/arroyo/progrept.html>. TAEX has produced the Arroyo Colorado Water Quality Data Base Web Site at <http://arroyo.tamu.edu>. This web site provides details on the substances analyzed and maps showing the locations of all monitoring stations.

Complete project design/ Install monitoring equipment.

The project design was completed and monitoring equipment was installed by NRCS representatives on both demonstration sites in 1996. The criteria used by the LAC and TAC to identify and select BMPs for implementation included the ability to reduce/prevent NPS pollution, low operating costs and favorable regard from the local agricultural community.

Initiate and complete routine sampling.

Southmost SWCD representatives have completed water quality sampling at the demonstration sites. In addition, laboratory analyses of the samples have been completed by TIAER. TIAER's laboratory data are included as Appendix E.

Review monitoring data with LAC.

The historical water quality monitoring data were presented to the LAC during the January 26, 1995 meeting.

Deliverables

Paradox Database.

TAEX's water quality database, formatted with Paradox software, is available on the Internet at the following address: <http://arroyo.tamu.edu/arroyo/database.html>.

Draft and Final Quality Assurance Project Plan approved by TNRCC and EPA.

The final QAPP for this project is attached as Appendix C.

Report on evaluation of existing water quality data.

TAEX's evaluation of existing water quality data is included in Appendix B.

Quarterly and annual reports.

TSSWCB has submitted project reports through TNRCC to EPA throughout the duration of the project.

Draft and Final reports on modeling results and BMP effectiveness.

BMP effectiveness in reducing agricultural contribution to nonpoint source pollution was estimated through application of mathematical modeling and is provided in a report by TIAER (Appendix F).

Measures of Success

Quantify load reduction in pesticide and nutrient contributions from agricultural runoff and sub-surface drainage from the demonstration sites.

Load quantification from the demonstration sites was not possible due to lack of sufficient flow data. Both flow meters at the dryland site and the flow meter at the irrigated treatment site were not functioning properly, resulting in collection of flow data only from the control area of the irrigated demonstration site. The flow meter at the irrigated control site collected data during the first two irrigation events, then malfunctioned. Southmost SWCD purchased and NRCS installed new flow meters near the end of the project, but no samples were collected after their installation. Although loads cannot be calculated without flow data, TIAER was able to use the existing flow data to calibrate the model and predict load reductions for the study area through mathematical modeling.

TASK 4. Education and Technology Transfer

This task will emphasize an increased awareness of the problems and solutions associated with nonpoint source pollution from agricultural communities. The transfer of technology to agricultural communities as well as other interest groups and state and federal agencies will be a multi-faceted approach and will be ongoing throughout the project period. TAEX will be the lead agency for accomplishing this task. The Southmost SWCD and NRCS will assist in this task by participating in the educational seminars and workshops.

This exchange will include educational seminars and workshops, demonstration tours, dissemination of printed material, development of documentary videotape and research papers and available use of mass media. Efforts will also include individual technical assistance provided by the cooperating agencies as well as assistance from the LAC.

Milestones

Provide fact sheets to local community on pesticide/fertilizer usage.

The fact sheets listed below were produced by TAEX and made available to the local community during seminars. The documents, listed below and included in Appendix B, continue to be available at local NRCS and SWCD offices.

1. *Pest and Beneficial Arthropods of Cotton in the Lower Rio Grande Valley*
2. *Soil Fertility and Fertilizer Management*
3. *Irrigated Grain Sorghum Production*
4. *Calibrating Pesticide Application Ground Equipment-Calibration Guide and Software*
5. *Help Yourself, Help the Environment*

Produce documentary video of demonstrations.

The documentary video was produced by TAEX.

Conduct educational seminars (lectures) for agricultural community.

The educational seminars and hands-on workshops listed below were conducted by TAEX for the study area's agricultural community. Additional information about them is included in Appendix B.

1995	Cotton Pre-Plant Clinic
1995	Conservation Tillage in South Texas (1995)
1995	Cotton Production and Physiology Workshop
1995	Lower Rio Grande Irrigation Conference
1996	Sprayer Calibration Clinic
1996	Lower Rio Grande Irrigation Conference
1996	Irrigation Field Day Tour
1997	Cotton Pre-Plant Clinic
1997	No-Till Field Day
1997	Seminar on the Arroyo Colorado

The seminars listed below were conducted by NRCS and others for the study area's agricultural community.

1996	No Till Field Demonstration
1996	Conservation Tillage Field Day

Deliverables

Fact sheets on pesticide/fertilizer usage.

The following fact sheets were produced for this project and were made available to local agricultural users during the field days. Copies of the fact sheets are included in Appendix B. These materials are also available to the community at local NRCS offices and SWCD.

Pest and Beneficial Arthropods of Cotton in the Lower Rio Grande Valley. Provides information on the appearance, basic biology and management of major pests of cotton and on occasional pests and beneficial organisms in the Lower Rio Grande Valley.

Soil Fertility and Fertilizer Management. Provides a complete guide to fertilizer management, soil fertility, soil testing and interpretation, and nutrient requirements of major crops.

Irrigated Grain Sorghum Production. Provides a complete guide to grain sorghum production including proper nutrient, chemical and irrigation water management.

Calibrating Pesticide Application Ground Equipment - Calibration Guide and Software. This publication and software provides a checklist and a complete guide to proper calibration of ground equipment used for applying pesticides and fertilizers.

Help Yourself, Help the Environment. Links conservation tillage to water quality and
Registration list for seminars and workshops.

Copies of materials distributed at seminars and workshops.

Copies of agendas for seminars and workshops.

Copies of press release for seminars and workshops.

Copies of the deliverables listed above are provided in Appendix G.

Copies of video for presentation to various interest groups.

A copy of the TAEX video is provided with this report.

Measure of Success

Percent of agricultural community exhibiting an increased awareness of the consequences of their actions with regard to pesticide and fertilizer applications as measured through the list of attendees for each seminar and workshop performed.

The combined attendance at the seminars and workshops exceeded one thousand, representing a substantial percentage of the agricultural community. NRCS has provided a video monitor in its local office to encourage agricultural users to view videos which present information on environmental/agricultural topics. In addition, fact sheets produced by TAEX and information on the TAEX website remain available to local agricultural producers. These sources should continue to increase the awareness of the agricultural community in the study area.

TASK 5. Contract Administration

The TSSWCB will manage the interagency contract from TNRCC as well as prepare and administer subcontracts with the cooperating agencies.

TSSWCB managed the interagency contract with TNRCC and completed and administered subcontracts with TIAER, TAEX, Southmost SWCD, and NRCS.

The TSSWCB staff will provide technical assistance to subcontractors as needed throughout the grant period relative to all aspects of work plans.

All necessary technical assistance to subcontractors was provided throughout the grant period.

Milestones

Contracts with cooperating agencies in place.

All contracts with cooperating agencies were completed.

Quarterly reports and draft annual reports to EPA through TNRCC.

Reports have been submitted to EPA through TNRCC.

Final reports to EPA through TNRCC.

This report represents the project's final report.

Technical assistance as needed.

Technical assistance has been provided to subcontractors as needed.

Deliverables

Quarterly, annual and final reports.

This report represents the only report remaining to be submitted to EPA through TNRCC.

Measure of Success

Provide technical and contractual guidance to the cooperating agencies to assure a successful project.

Technical and contractual guidance have been provided as evidenced by the successful completion of this project.

APPENDIX A

List of Technical and Local Advisory Committee Members; Meeting Attendance Lists

LOCAL ADVISORY COMMITTEE

Pete Wright
USDA-NRCS

Jim Chapman
Sierra Club

Larry Ditto
U.S. Fish & Wildlife Service

Rose Farmer
National Audobon Society

Jim Gamble
Independent producer

Noe Garza
D.C. – NRCS

Tony Gonzales
D.C. – NRCS

Alan Moore
Engineer – NRCS

Rick Guerrero
local citizen

Wayne Halbert
Harlingen Irrigation District

Ken Jones
Lower Rio Grande Development Council

Terry Lockamy
County Extension Agent

James Matz
Cameron Co. Comm.

Natalie Prim
Harlingen City Manager

Jose Sanchez
TDA

Billy Mack Simpson
local citizen

Bill Thompson
Irrigation District Director

Steve Thompson
Laguna Atascosa Wildlife Refuge

Gary Wagerman
TPWD

Gail Rothe
TNRCC

Andy Garza
TSSWCB

Charlie Webster
TNRCC

Cloice Coykendall
Laguna Atascosa WF Refuge

Linda Koch
Coalition to Save the Arroyo Co.

Cloice Whitley
Harlingen Waterworks

Lisa Williams
The Nature Conservancy

David Meinhart
Harlingen Proud

Selena Carroll
The Nature Conservancy

Elaine Lockhart
Harlingen Proud

Doyle Warren
TAES

TECHNICAL ADVISORY COMMITTEE

Carl Hutcherson
EPA

Dick Respass
TNRCC

Kerry McCollough
TNRCC

Wayne Halbert
Harlingen Irrigation District

Bo Spoonts
TSSWCB

Ron Jones
TIAER

Allan Colwick
NRCS

Justin Hester
TSSWCB

Guy Fipps
TAEX

Larry Hauck
TIAER

Tony Gonzales
D.C. – NRCS

Terry Lockamy
TAEX

Doyle Warren
TAEX

Arthur Talley
TNRCC

Len Pardee
EPA

Petra Sanchez
EPA

Bill Harris
TAES

Alan Moore
Engineer – NRCS

Lennie Winkelman
TSSWCB

Stormy Sparks
TAEX

James Ratteree
EPA

Kelvin Moore
TNRCC

Agenda
FY92 319(h) Projects on Assessing Nonpoint Source Pollution
in the Arroyo Colorado River Watershed
Local Coordinating Committee Meeting
Harlingen Chamber of Commerce
September 22, 1994
7:00 PM

Mission Statement: The Local Coordinating Committee (LCC) will provide liaison services between the Technical Advisory Committee and the citizens of Cameron County and other surrounding counties in addressing nonpoint source pollution in the Arroyo Colorado River watershed. Specifically, the LCC will provide guidance concerning the historical effects of tested agricultural and urban practices to the managers and scientists involved in this program and assist in developing best management practices to be used by the local community.

- I. Introductions
- II. Overview of CWA, Section 319 (h) - Gary Fisher, Texas Nonpoint Source Project Officer, U.S. Environmental Protection Agency, Region 6
- III. Overview of the FY92 319(h) Grant - Kerry McCullough, Grant Manager, Texas Natural Resource Conservation Commission (TNRCC)
- IV. TNRCC role in project management and discussion of the urban project - Dick Respass, Project Manager, TNRCC
- V. Texas State Soil and Water Conservation Board (TSSWCB) role in project management and introduction of subcontractors - Bo Spoons, Director of Programs, TSSWCB
 - a. Larry Hauck, Research Scientist, Texas Institute for Applied Environmental Research
 - b. Guy Fipps, Associate Professor and Extension Specialist, Texas Agricultural Extension Service
 - c. Alan Moore, Civil Engineer, Soil Conservation Service
 - d. Wayne Halbert, District Director, Southmost Soil and Water Conservation District
- VI. Discussion with the Local Coordinating Committee (LCC) on a proposed site and election of a Chair and Co-chair for the LCC .
- VII. Future actions

September 27, 1994

MEETING MINUTES
of the
Local Coordinating Committee Meeting
FY92 319 (h) Projects on Assessing Nonpoint Source Pollution
in the Arroyo Colorado River Watershed
Harlingen Chamber of Commerce
September 22, 1994
7:00 PM

7:05 PM - Meeting convened by Bo Spoons, Director of Programs, TSSWCB.

7:05-7:10 PM - Personal introductions were made and a sign-up sheet was passed around.

7:10-7:15 PM - Gary Fisher, Texas Nonpoint Source Project Officer from EPA, gave an overview of Section 319 funding. Gary gave EPA's definition of nonpoint source pollution and explained the mechanism of the 319 funding. He said that on the Arroyo Colorado project funds came from EPA to TNRCC to TSSWCB to Subcontractors. He also said that TNRCC was handling the urban side while TSSWCB was handling the agricultural aspect of the project. Gary stressed how we need a Local Coordinating Committee (LCC) to meet the success of the project.

Gary introduced Carl Hutcherson who is the new liaison between SCS and EPA.

Gary then introduced Kerry McCollough of TNRCC who was next on the agenda.

7:15-7:16 PM - Kerry McCollough, TNRCC Grant Manager, explained how the Arroyo Colorado project bridges agricultural and urban problems in the Arroyo Colorado River watershed. The knowledge and BMP's learned from this project can be transferred to other local counties.

Kerry introduced Dick Respess, TNRCC Project Manager on the urban side of the project.

7:16-7:34 PM - Dick Respess said that urban landscaping is a significant contributor to nonpoint source pollution. Dick showed and explained many overheads as listed below:

Overhead #1 - Integrated Landscape Management (ILM)

Explained soil moisture, soil nutrient concentration, and vegetation health

Overhead #2 - Arroyo Colorado Nonpoint Source Project

Explained the benefits of ILM of reducing landscape maintenance costs and nutrient/pesticide loadings

Overhead #3 - Goals and Objectives

Reduce nutrient loadings, provide training to landscape managers, and increase public awareness

Overhead #4 - Project Tasks

Planning, implementation, and technology transfer

Dick said that the urban project was to be done on the Tony Butler Golf Course and passed out a copy of the urban project workplan.

Dick then gave the floor back to Bo Spoons.

7:34-7:44 PM - Bo explained the difference between TNRCC and TSSWCB's role in the project and gave several examples of nonpoint source pollution - cigarette butts on ground, gasoline fumes, oil on a driveway, etc. He said that there was no way to completely stop nonpoint source pollution but it could be slowed down.

Bo then explained that in the workplan there are two (2) sites to be studied: A dryland cropland, and an irrigated cropland site.

Bo introduced Larry Hauck, Research Scientist, Texas Institute for Applied Environmental Research.

7:44-7:46 PM - Larry said that TIAER brings two (2) areas of expertise to the project. The first area of expertise is the chemistry laboratory analyses to study nutrient and bacterial concentrations of Arroyo Colorado River water samples. The second is numerical modeling to predict agricultural run-off of the fields chosen.

Bo then introduced Guy Fipps, Associate Professor, Texas Agricultural Extension Service.

7:46-8:01 PM - Guy Fipps gave an gave a presentation on several overheads which are attached.

Bo introduced Alan Moore, Soil Conservationist, Soil Conservation Service, San Benito.

8:01-8:06 PM - Alan explained the mechanism of the SCS within the USDA. SCS's responsibility is to provide technical assistance to the landowners in installing best management practices. SCS takes a voluntary, non-regulatory approach to assisting landowners. On this particular project, SCS will install and monitor the equipment on the two (2) sites chosen.

Bo introduced Wayne Halbert, Harlingen Irrigation District Director, and Director of the Southmost Soil and Water Conservation District.

8:06-8:12 PM - Wayne said the purpose of the Southmost SWCD is to deal with local soil and water conservation issues. This project originated in 1989 and is finally starting to try to implement BMP's to show nonpoint source pollution improvement. Wayne told the

LCC not to waste the opportunity to work on this important project to make a difference in the community. He stressed how the LCC can influence the success of the project by selling it to the local community.

8:12-9:00 PM - Bo had the LCC look at establishing and sustaining an active coordinating committee as an important aspect of the workplan. Bo also explained the difference between the LCC and Technical Advisory Committee (TAC).

Wayne Halbert intervened to say that there are not two (2) distinct projects - urban and agricultural. The major impact was to better the water quality in the Arroyo Colorado.

Bo asked the LCC if they would like to elect a Chair and Co-chair on the LCC to be the liaison between the LCC and the Technical Advisory Committee. No response from the LCC.

Dick Respass said that the urban side of the project would be done on the Tony Butler Golf Course.

Bo said that the agricultural irrigated site is located near Harlingen and already instrumented. Asked whether any one had any suggestions for the dry land site.

Steve Thompson of the Laguna Atascosa Wildlife Refuge volunteered 150 acres as a controlled monitoring site.

Wayne Halbert said the idea was to take Farms A and B that are the same and install BMP's on Farm A to see if it is improved over Farm B.

Guy Fipps led the discussion back to site selections. He suggested the LCC as a group look at the selection of the 2 sites and respond to the TAC with questions.

Wayne said that the irrigated site was chosen because of money constraints since the equipment has already been installed.

Jim Chapman wanted to know the name of the irrigated site selected or specifics.

Wayne answered him by saying that on the irrigated cropland cotton and grain would be planted on a rotational basis. The dryland site would also be the same.

Steve Thompson asked that if they weren't given the names of the sites selected then are the farmers respected within the community. Bo answered that they were.

Dick Respass reiterated to the LCC that if anyone had any questions on the urban side of the project do not hesitate to call him at TNRCC. He was working on getting the QAPP approved before sampling takes place. Dick also said he would send quarterly reports to the LCC.

Gary Fisher explained the water assessment process. He also stated that EPA's viewpoint is that nonpoint source pollution can and will be abated.

Alan Moore suggested that monitoring on the dryland cropland and the irrigated cropland start in February. This means the QAPP must be submitted by December, 1994.

Terry Lockamy suggested November 17, 1994 as the next meeting date. The LCC agreed that this was a good day and 7:00 PM was a good time.

9:00 PM - Bo adjourned the meeting.

sc

Arroyo Colorado
 Local Coordinating Committee Meeting
 Harlingen, TX

September 22, 1994
 7:00 PM

<u>NAME</u>	<u>Address</u>	<u>Phone No.</u>
Suzanne Cardwell	TSSWCB	(817) 773-2250
Bo Spoons	TSSWCB	(817) 773-2250
Richard O. Respass	TNRCC	(512) 239-4550
Gary Fisher	EPA	(214) 665-6685
CARL Hutcherson	SCS/EPA	(214) 665-6685
Kenny McCollough	TNRCC	512-239-4548
PETE WRIGHT	SCS	512-664-0903
Alan Moore	SCS - San Benito	210-399-2522
STEVE THOMPSON	LAGUNA ATASCOSA NWR	210-748-3607
WAYNE HALBERT	SOUTHMOST SWCD	210-423-7015
Kim Saueck	TAMU	409-847-9797
GUY FIPPS	Texas A&M, College Station	409-845-3977
LARRY HAUCK	TIAER	817-968-9561
Belli Meek Simpson	Rio Hondo, TX	210-748-2752
Natalee F. Prim	City of Harlingen 118 E. Tyler	210 427-8700
LARRY DITTO	FWS	210 630 4636
Rick Guerrero	Harlingen, TX Ag Nursery	210-412-2271
Jim Gamble	P.O. Box 173, La Feria, TX 78559	210-797-2858
Terry Lockamy	650 E Hwy 77 San Benito	210-399-0125
LISA WILLIAMS	THE NATURE CONSERVANCY 410 N. 13TH AVE. - EDINBURG, TX 78539	210/380-3134
Selena Carroll	The Nature Conservancy address above	210/380-3134
JIM Chapman	200 E. 11TH ST Weslaco	210 968-1719

Arroyo Colorado
 Local Coordinating Committee mtg.
 Harlingen, TX

September 22, 1999
 7:00pm.

<u>NAME</u>	<u>ADDRESS</u>	<u>PHONE NO.</u>
Linda Koch (Coalition To SAVE A.C. (C-SAC))	Rt 2, Box 550- San Benito, TX 78586	210-748-2766
DAVE MEINHART HARLINGEN BOARD & VOLUNTEER WATER QUALITY	1325 DIXIELAND HARLINGEN 78552	210-428-5881
DOYLE G. WARREN	2401 E Hy 83 Weslaco TX 78596	210-968-5581
Andy Garza	TSSWEB Falfurrias, Tx.	78355
JOSE SAUCHEZ	TDA P.O. Box 1157	Pharr, TX 7857
Bill Thompson	P.O. Box 867 2514 S. I ST RD STE 2	Mission, TX 785
NOE G GARZA	USDA-SCS EDINBURG TX	78539 (210) 383-3000



TEXAS STATE SOIL AND WATER CONSERVATION BOARD

311 North 5th
P.O. Box 658
Temple, Texas 76503-0658
(817) 773-2250
Fax (817) 773-3311

To: Local Advisory Committee

From: Lennie Winkelman

Date: February 23, 1995

Subject: Meeting Minutes of Local Advisory Committee Meeting

Enclosed you will find a copy of the attendance list and the minutes from the Local Advisory Committee Meeting held in Harlingen on January 26th.

If you have any question please do not hesitate to contact me.

Sincerely,

A handwritten signature in cursive script that reads "Lennie Winkelman".

Lennie Winkelman
Planner

January 26, 1995

MEETING MINUTES

of the

Local Coordinating Committee Meeting
FY92 319 (h) Projects on Assessing Nonpoint Source Pollution
in the Arroyo Colorado River Watershed
January 26, 1995
7:00 PM

7:05 PM - Meeting Convened by Bo Spoonts, Director of Programs, TSSWCB.

7:05 - 7:10 PM - Personal introductions were made and a attendance sign up sheet was passed around. The attendance sheet is attached.

7:10 - 7:13 PM - Bo Spoonts explained that the role of the Local Coordinating Committee (LCC) is of an advisory nature. The LCC would express concerns and provide feedback about the activities on the project. The LCC's name would be changed to the Local Advisory Committee to more accurately reflect its role.

7:13 - 7:40 PM Dick Respess, TNRCC Project Manager, explained that the urban component of the project would take place at Tony Butler Golf Course. A local engineering firm has been contracted to survey several sites at the golf course. The survey will aid in the placement of the sampling sites. TNRCC has been working with Dr. Fipps at TAEX on stormwater monitoring and integrated landscape management. The staff at the golf course will be trained to help in the sampling. The Quality Assurance Project Plan has been submitted to the TNRCC and is awaiting approval before sampling can begin. In March, the stormwater monitoring equipment and BMP's should be installed so that sampling can begin. Samples will be taken at a demonstration site with BMP's and at natural site without BMP's. The urban component will mainly look at nutrients.

Someone questioned why the TNRCC removed pesticides from the study. Dick responded that previous assessments indicated that nutrients were the main problem.

Wayne Halbert stated that the original idea of the project was not to determine what urban and agriculture pollution contributed to the Arroyo Colorado. These projects are demonstrations that are used as land management practices to control pollution runoff.

7:40 - 8:12 PM Dr. Fipps from TAEX reported on the water quality database that was compiled on the Arroyo. He contacted various state and federal agencies to collect this data and has received most of the information he requested.

He showed an overhead of the different routine water quality parameters that have been sampled for by different state and federal agencies. Some of these parameters on this overhead were nitrate nitrogen, dissolved oxygen, and several organic and inorganic constituents.

He showed an overhead map of the Arroyo and described where the segments of 2201 and 2202 were located and where previous water samples had been taken.

Finally, he showed an overhead of the water quality data for 1984. He examined the data for this year and stated that none of the samples exceeded the safe water drinking standards. However, he also noted that there was a high fecal coliform count for several of the samples taken in the Arroyo. This could be attributed to the wastewater treatment plants that discharge treated effluent into the Arroyo.

He concluded his presentation by stating that he has examined only a portion of the water quality data that has been compiled. He hopes to go through all of the water quality data and determine if there are trends.

8:12 - 8:20 PM Tony Gonzales from NRCS discussed the two demonstration sites. The irrigated site is 40 acres and has been field leveled.

The dryland demonstration area is on FM 1420 and is 60 acres in size. The site will be divided into two 30 acre tracts with one being a control site and the other implemented with BMPs. The sites will be planted with a crop rotation of cotton and sorghum. Cotton will be planted this spring. there will be no water sampling on the dryland site this spring. The installation of the BMPs will occur this summer and sampling will occur in the fall.

8:20 - 8:23 PM Lennie Winkelman from the TSSWCB discussed the Quality Assurance Project Plan. He has collected information from TIAER on laboratory procedures to include in the QAPP. He is also working with the SWCD and NRCS in compiling the sampling procedures needed to include in the QAPP. He hopes to have a draft QAPP submitted to TNRCC by March 1995.

8:23 - 8:30 PM Bo Spoons from the TSSWCB asked for suggestion on when the next Local Advisory Meeting should be held. It was decided that the next meeting will be held on May 25, 1995 at 7:00 P.M. at the Harlingen Chamber of Commerce.

8:30 PM The meeting was adjourned.

LW

1/26/95 Arroyo, 3 Colorado Sign-In sheet

<u>Name</u>	<u>Address</u>	<u>Phone</u>
Lennie Winkelman	TSSVCB P.O. Box 658 Temple, TX 76503	(817) 773-225
Guy Fapps	Texas A&M, College Station	409 845-3977
Stormy Sparks	Texas A&M Extension Service, Weslaco	(210) 968-558
Bill Thompson	Hidalgo Soil & Water Dist.	(210) 585-48
WAYNE HALBERT	SMSWCD PO 148 NARRINGEN	210 423-70
CARL HUTCHERSON	EPA Region 6, 1445 Ross, Dallas	(214) 665-80
Petra Sanchez	EPA Region 6 " " Suite 1200 " "	(214) 665-668
	Dallas TX 75202	6W-05
Joan Flowers	TIAER - Tarleton State University	(817) 968-90
	Box 10410	
	Stephenville, TX 76402	
Doyle G WARREN	2401 E Hwy 83	210 928
	Weslaco Tx 78596	<u>o.p.</u>
Terry Lockamy	650 E Hwy 77 San Benito Tx 78586	210-399 4412
Jim Gamble	Rt. 1 Box 173 LA Feria Tx. 78559	210-797-2858
Tony Gonzalez	Rt. 2 Box 372 San Benito Tx 78586	(210) 399-2522
Andy Garza	104 Magnolia, Falfurries, Tx. 78355	512-325-355
Adrian Perez	P.O. Box 345, FREER, Tx 78357	512-394-6
NOE G GARZA	USDA-NRCS. 2514 S. I st RD, STE 2, EDINBURG TX 78539	(210) 383-3002
Richard O. Respess	TNRCC P.O. Box 13087 Austin, TX 78711	(512) 239-455
Linda Keck - C-SAC	Rt 2, Box 550 - SAN BENITO, TX 78586	(210)-748-3.
David V. Smith	TAEX 313 AGEN Aapt., College Station, TX. 77843	(409) 845614

1/26/95

ARROYO COLORADO TECHNICAL ADVISORY

BO SPOUNTS	TSSWCB	(817) 773 2252
Lennie Winkelman	TSSWCB	(817) 773-2252
Guy Fipps	TAEX	405 845-3955
Terry A. Lockamy	TAEX	210-399-4412
Nelda Barrera	TAEX	"
Joyce G Warren	TAEX	210 968 5581
LARRY HAUCK	TAEX	817 968-9526
Joan Flowers	TIER	817-968-9526
WAYNE HALBERT	SM SWCD	210-423-70
CARL HUTCHERSON	EPA/NRCS	(214) 665-808
PETE SANCHEZ	EPA	" " -6656
Tony Gonzales	NRCS	(210) 399-2522
Andy Garza	TSSWCB	512-325-3557
Adrian Perez	TSSWCB	512-394-6786
Dick Regress	TNRCC	(512) 239-4550

1/26/95

ARROYO COLORADO TECHNICAL ADVISORY

Bo Spoons	TSSWCB	(817) 773 2250
Lennie Winkelman	TSSWCB	(817) 773-2250
Guy Fapps	TAEX	409 845-3978
Terry A. Lockamy	TAEX	210-399-4412
Nelda Barrera	TAEX	"
Joy G Warren	TAEX	210 969 5581
LARRY HAUCK	TAEX	817 968-9561
Joan Flowers	TIAER	817-968-955-
WAYNE HALBERT	SMSWCD	210-423-7015
CARL HUTCHERSON	EPA/NRCS	(214) 665-8081
PETE SANCHEZ	EPA	" " 6686
Tony Gonzales	NRCS	(210) 399-2522
Andy Garza	TSSWCB	512-325-3552
Adrian Perez	TSSWCS	512-394-6786
Dick Respass	TNRCC	(512) 239-4550



TEXAS STATE SOIL AND WATER CONSERVATION BOARD

311 North 5th
P O. Box 658
Temple, Texas 76503-0658
(817) 773-2250
Fax (817) 773-3311

To: Local Advisory Committee

Thru: Dick Respass

From: Lennie Winkelman

Date: May 9, 1995

Subject: Local Advisory Committee Meeting on Arroyo Colorado Project

There will be another meeting of the Local Advisory Committee in Harlingen to discuss the Arroyo Colorado Watershed Project. The meeting will be on May 25th at 7:00 p.m. at the Harlingen Public Library. To get to the Library go West on Tyler and turn left on 6th street. The library is at the end of 6th street on 410 76 Drive.

There are three items on the agenda for discussion.

- 1) Overview and update of the Urban component of the project
- 2) Overview and update of the Agricultural component of the project
- 3) Open Discussion of Arroyo Colorado Watershed Project

Dick and I hope to see you at the meeting. If you have any questions please contact me at (817) 773-2250 or Dick Respass at (512) 239-4550.

Sincerely,

A handwritten signature in cursive script that reads "Lennie Winkelman".

Lennie Winkelman
Planner, Texas State Soil and Water Conservation Board

A handwritten signature in cursive script that reads "Richard O. Respass".

Dick Respass
Project Manager, Texas Natural Resource Conservation Commission

cc: Technical Advisory Committee

Arroyo Colorado Local

Advisory Committee meeting

5/25/95*

<u>Name</u>	<u>Address</u>	<u>phone #</u>
Lennie Winkelman	Texas state soil & water Dept P.O. Box 568 Tempe, TX 76503	(817) 773-225
Gail Rothe	Texas Natural Resource Conservation Commission Austin SOUTH TX. LAND STEWARD P.O. Box 13087 PO Box 6281 THE NATURE CONSERVANCY MEALIER TX 78502 MC150	512-239-4617
ISA WILLIAMS	U.S Fish and Wildlife Service P.O. Box 450	210/580-4241
Tim Cooper	laguna Atascosa NWR Rio Hondo	210/748-3607
Alberk Ramirez	TSSWC B	210/381-6614
Wayne Halbert	Southwest SWCD	210/423-7015
LARRY DITTO	320 W. MAIN, McAllen TX 78501 (FWS)	210/670-4636
Guy F. Foss	Texas Agr Extension, Texas A&M	409 845-7454
Larry Hauck	TIAER, TARRANT STATE UNIV, Stephenville	817-968-9561
Richard O. Respass	TNRCC, NPS Program, Austin	(512) 239-4550
JOHN LIGHTNER	AGREX SYNERGETICS INC. HARlingen	(210) 412-2152
Boyle C. WARREN	Texas Agr Ext Dept 2401 East Hwy 83, Weslaco, TX 78596	210 968 5581
Merritt J. Taylor		(210) -968-5581

REPORT ON ASSIGNED DUTIES

Local Advisory Committee and a Technical Advisory Committee

Three Local Advisory Committee Meetings were held as listed in Table 1. At these meeting, Guy Fipps, Merritt Taylor, Alton Sparks and Kim Soucek gave presentations on TAEX's role on the project, the potential benefits of recommended BMPs, and what is known about the water quality of the Arroyo Colorado. TAEX also participated in 6 Technical Advisory Committee Meetings. The date, location and TAEX personnel participating are listed in Table 2.

Table 1. Meetings of the Local Advisory Committee and TAEX Project Team Personnel Participating.

Date	Location	TAEX Team Members Attending
9/22/94	Harlingen	Guy Fipps, Terry Lockamy, Anton Sparks, Kim Soucek
1/26/95	Harlingen	Guy Fipps, Doyle Warren, Merritt Taylor
5/25/95	Harlingen	Guy Fipps, Terry Lockamy, Alton Sparks, Merritt Taylor

Table 2. Meetings of the Technical Advisory Committee and TAEX Project Team Personnel Participating.

Date	Location	TAEX Team Members Attending
7/26/94	Harlingen	Guy Fipps, Ken Lege, Terry Lockamy, Doyle Warren
9/14/94	Austin	Guy Fipps
1/26/95	Harlingen	Guy Fipps, Terry Lockamy, Doyle Warren
9/28/95	Harlingen	Guy Fipps
9/23/96	Harlingen	Guy Fipps, Rod Santa Ana, David Smith
4/1/97	Harlingen	Guy Fipps

TECHNICAL ADVISORY MEETING AGENDA ITEMS 9/23/96

- I. Update on previous and upcoming educational activities and workshops (TAEX)
- II. Update on activities for the irrigated and dryland demonstration sites (John Lightner, NRCS)
- III. Update on modeling efforts for the Arroyo Colorado (TIAER)
- IV. General discussion of coordination efforts and future activities needed to successfully complete the last year of the project.

NOTE: After the meeting, Guy Fipps from TAEX and a video crew will conduct personal interviews with the various project participants involved with the project.

Attending: Guy Fipps, TAEX, College Station + David Smith, asst.
 Bo Sponts, TSSWCB
 Lennie Winkelman, TSSWCB
 Larry Hark, TIAER + Asst.
 Andy Saiza
 John Lightner
 TNRC Rep. -

1. Order 2 sets of bottles.
2. Buy 4 new Campbell data logger. Model CR-10
3. Place rain gauge at irig. site
4. Check irrigation flows. in-line flow meter - gated pipe - or polypipe.
5. Check landowner for computer modeling. (Merriden to Port Harbison)
6. Gather agronomic data.
7. Set up for moisture tracking - Andy's office will read the gypsum blocks.
8. A local committee meeting will be scheduled for Nov. 19, 1996.

For: Justin HESTER

From: Lennie
Winkelman

ARROYO COLORADO TECHNICAL MEETING NOTES 9/23/96

1 sampling event was conducted on the dryland site and several samples have been collected on the irrigated site.

There has also been a problem of vandalism and theft of ISCO batteries on the demo sites.

John Lightner has had problems with access to the irrigated sites because the fields are wet.

Note: Need to remind John that samples must be collected no matter how wet the fields are. If need assistance please ask for help. Andy's office has offered to help with monitoring as needed and time permits.

Little information has been collected on the irrigation and rainfall amounts for the sites. Dataloggers on the demo sites have not worked effectively for a good portion of the last year. Larry Hauck stated that the dataloggers need to be upgraded. Guy Fipps will provide Info Campbell dataloggers. The State Board should plan on purchasing 4 of the dataloggers.

Cotton will be planted on both sites about February.

MODELING

TIAER has collected background data and is evaluating several models including: DRAINMOD, EPIC-WT, and EPIC-4160.

Have info on several of the GIS layers including: landuse, soils, monitoring wells, etc. Need to coordinate with NRCS and others on site specific items including: soil types, nutrient and pesticide application dates, amounts, etc.

TIAER will provide Tony a copy of the Land use map for field verification.

Also the project needs to obtain a flowmeter and gated pipes for the irrigated site.

Educational activities

Guy Fipps and others are working several fact sheets and guides for irrigation, fertilization, and pesticides.

A conservation tillage workshop will be held in January and a regional seminar will be held in June or July 1997.

The 10 minute informational video is behind schedule and the WQ database was sent to TSSWCB, TNRC, and EPA.

NEXT MEETING: NOVEMBER 19TH 3:30 for technical advisory committee and 7:00 local advisory meeting. Can set the meeting at the Chamber of Commerce or Harlingen Library.

Also should have quarterly meetings until the end of the project.

ARRIVO COLONADO

ATTENDANCE

Bo Spoons	TSSWCB	Temple, TX
Tony Gonzalez	NRC5	San Benito
John Lightner	AgroSynergetics	Harlingen, TX
Alan Moore	NRC5	San Benito
Andy Garza	TSSWCB	Harlingen
Larry Hanek	TIAER	Stephenville TX
Joan Flowers	TIAER	Stephenville, TX
Lennie Winkelman	TSSWCB	Temple, TX
Kevin Moore	TNRCC	Stephenville, TX
David W. Smith	TAEX	College Station, TX
George		

APPENDIX B

Nonpoint Source Prevention in the Arroyo Colorado: Accomplishments of the Texas Agricultural Extension Service

APPENDIX B

Nonpoint Source Prevention in the Arroyo Colorado: Accomplishments of the Texas Agricultural Extension Service

**NON POINT SOURCE PREVENTION
IN THE ARROYO COLORADO WATERSHED**

**ACCOMPLISHMENTS OF THE
TEXAS AGRICULTURAL EXTENSION SERVICE**

FINAL REPORT

Submitted to the
Texas State Soil and Water Conservation Board

by

Guy Fipps
Texas Agricultural Extension Service
Texas A&M University System
College Station, TX 77843-2117

November 26, 1997

PREPARED IN COOPERATION WITH THE
U.S. ENVIRONMENTAL PROTECTION AGENCY

The preparation of this report was 60% financed through \$443, 630 in grant funds from the U.S. Environmental Protection Agency through the Texas Natural Resource Conservation Commission

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Appendix D: Fact Sheets and Educational Materials _____ *Section 5*

Report

SUMMARY

This report summarizes the accomplishments of the Texas Agricultural Extension Service (TAEX) on the project *NPS Prevention in the Arroyo Colorado Project*. Funding for this project was provided by the U.S. Environmental Protection Agency (USEPA). TAEX services were performed under Contract No. 994-592-713-420000051 to the Texas State Soil and Water Conservation Board (TSSWCB).

Only a summary of our activities are provided here. Detailed accounting has been provided in the form of Quarterly Reports submitted to the TSSWCB during the course of the project. Copies of the educational materials produced by TAEX in this project are provided in the Appendix of this report. The following agencies cooperated on the project:

U.S. Environmental Protection Agency (USEPA)
Texas Natural Resource Conservation Commission (TNRCC)
Texas State Soil and Water Conservation Board (TSSWCB)
Southmost Soil and Water Conservation District (SSWCD)
Natural Resources Conservation Service (NRCS)
Texas Institute for Applied Environmental Research (TIAER)
Texas Agricultural Extension Service (TAEX).

PROJECT RESPONSIBILITIES

Our major responsibilities on this project were to:

1. Provide assistance to establish a Local Advisory Committee and a Technical Advisory Committee;
2. Provide technical assistance in planning, locating, designing, installing, and evaluating the results of the BMPs (best management practices) implemented for two demonstration sites;
3. Assemble a *PARADOX* data base of existing water quality data on the Arroyo Colorado;
4. Conduct an education and technology transfer program consisting of:
 - a) fact sheets,
 - b) documentary video, and
 - c) educational workshops and seminars; and
5. Provide technical assistance to TIAER in BMP modeling.

PROJECT TEAM

TAEX assembled a multi-disciplinary team for this project as follows. Dr. Guy Fipps served as the TAEX project director.

Core Team Members

<u>Name</u>	<u>Title</u>
Dr. John Bremer	Professor and Extension Weed Scientist
Dr. Guy Fipps	Associate Professor and Extension Agricultural Engineer
Dr. Steve Livingston	Professor and Extension Agronomist
Terry Lockamy	Cameron County Extension Agent
John Norman	Extension Entomologist
Rod Santa Ana	Extension Communications Specialist
Dr. Bryan Shaw	Assistant Professor and Extension Agricultural Engineering Specialist
David Smith	Extension Assistant
Dr. Alton Sparks	Associate Professor and Extension Entomologist
Dr. Charles Stichler	Associate Professor and Extension Agronomist
Doyle Warren	District 12 Extension Director
Ed Wilson	Extension Graduate Assistant (former)

Supporting Team Members

<u>Name</u>	<u>Title</u>
Brent Batchelor	Atascosa County Extension Agent (former)
Carrie Bausch	Student Technician
Brad Cowan	County Extension Agent
Monty Dozier	Extension Graduate Assistant
Ken Lege	Extension Associate (former)
Dr. Bruce Lesikar	Assistant Professor and Extension Agricultural Engineering Specialist
Dr. Mark McFarland	Assistant Professor and Extension
Luis Saldana	Willacy County Extension Agent
Dr. Julian Sauls	Professor and Extension Horticulturist
Kim Soucek	Student Technician (former)
Dr. Merritt Taylor	Professor and Extension Economist (former)

REPORT ON ASSIGNED DUTIES

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Three Local Advisory Committee Meetings were held as listed in Table 1. At these meeting, Guy Fipps, Merritt Taylor, Alton Sparks and Kim Soucek gave presentations on TAEX's role on the project, the potential benefits of recommended BMPs, and what is known about the water quality of the Arroyo Colorado. TAEX also participated in 6 Technical Advisory Committee Meetings. The date, location and TAEX personnel participating are listed in Table 2.

Table 1. Meetings of the Local Advisory Committee and TAEX Project Team Personnel Participating.

Date	Location	TAEX Team Members Attending
9/22/94	Harlingen	Guy Fipps, Terry Lockamy, Anton Sparks, Kim Soucek
1/26/95	Harlingen	Guy Fipps, Doyle Warren, Merritt Taylor
5/25/95	Harlingen	Guy Fipps, Terry Lockamy, Alton Sparks, Merritt Taylor

Table 2. Meetings of the Technical Advisory Committee and TAEX Project Team Personnel Participating.

Date	Location	TAEX Team Members Attending
7/26/94	Harlingen	Guy Fipps, Ken Lege, Terry Lockamy, Doyle Warren
9/14/94	Austin	Guy Fipps
1/26/95	Harlingen	Guy Fipps, Terry Lockamy, Doyle Warren
9/28/95	Harlingen	Guy Fipps
9/23/96	Harlingen	Guy Fipps, Rod Santa Ana, David Smith
4/1/97	Harlingen	Guy Fipps

BMPs and Demonstration Program Support

Demonstration Sites and BMPs

The TAEX Project Team met on August 29-30, 1995 to tour the demonstration sites and to formulate detailed recommendations on BMP design, implementation and evaluation. These recommendations were based on the limited amount of information made available to us on the sites and demonstration program planned. Our conclusions were summarized in a report submitted to TSSWCB on 9/14/97. A copy of this report is provided in Appendix A.

Direct technical assistance was provided to NRCS by Guy Fipps and Ed Wilson on instrumentation, data logging programming, and equipment installation, and through informal discussions on BMPs. No other assistance was requested of TAEX during the remainder of the project.

We also provided technical assistance to NRCS on programming, maintenance and management of the weather station located at the dryland demonstration site. This weather station was included on the *Texas ET (evapotranspiration) Network and Web Site* (<http://www.agen.tamu.edu/pet>). We downloaded the weather data daily, calculated PET, and posted this information on the Web Site. Other sections on the Web Site provided information on how to use this data for determining proper irrigation scheduling. This assistance and project support was provided by Guy Fipps and his WQIT project team (see web site for complete listing of team members).

Evaluation of Demonstration Results

TIAER provided us with diskette and printed copies of the water sample analysis results taken from the demonstration sites on 7/23/97 (all data except for June 1997) and on 8/1/97 (all data). A paper copy of this data is given in Appendix B. We received very little information on the BMPs implemented over the course of the project, and TSSWCB provided us a summary of these (Table 3) in September 1997.

We were not able to do statistical tests and trend analysis of the monitoring data due to the limited amount and inconsistency of the data, and experimental errors in the establishments of the sites. Instead, we completed a qualitative analysis of BMP benefits which are summarized in Tables 4 and 5. For these tables, we made a judgement whether there was evidence of benefits from the BMP's for each parameter analyzed.

For the irrigated site, the BMPs resulted in reductions in the following substances in one or more sampling events: ammonia nitrogen, nitrite nitrogen, total phosphorous, atrazine, malathion, and trifluraline. The reductions in total suspended solids is probably due to either experimental or sampling errors, as we would expect no differences in drain water suspended solids between the two treatments.

For the dryland site, the BMPs resulted in reductions in the following substances in one or more sampling events: nitrite nitrogen, total kjeldahl nitrogen, total suspended solids, COD, atrazine, and malathion.

Table 3. BMPs Implemented on the Irrigated and Dryland Demonstration Sites.

Irrigated Site:
<ul style="list-style-type: none"> • Crop rotation
<ul style="list-style-type: none"> • Conventional tillage system - the producer left 25% of the stubble during fallow period (crop residue management)
<ul style="list-style-type: none"> • Nutrient management — split application of fertilizer and application based on soil analysis
<ul style="list-style-type: none"> • Pesticide management — the producer had a scout from the chemical company advise him on whether or not to apply pesticides for insects. For both insect and weed control, the producer follows the label directions. Pesticides are applied at optimum wind conditions.
Dryland Site:
<ul style="list-style-type: none"> • Crop rotation
<ul style="list-style-type: none"> • Conservation tillage
<ul style="list-style-type: none"> • Precision-land farming (land leveling)
<ul style="list-style-type: none"> • Nutrient and Pest Management

Table 4. Irrigated Demonstration Site: BMP Effectiveness in Reducing Concentrations in Drainage Water

Substance	Event					
	#1	#2	#4	#5	#6	#7
Ammonia Nitrogen	yes	no	yes	no	no	no
Nitrate Nitrogen	no	no	no	no	--	yes
Nitrite Nitrogen	yes	yes	no	no	--	--
Total Kjeldahl Nitrogen	no	no	no	no	--	--
Orthophosphate Phosphorus	no	no	no	yes	--	--
Total Suspended Solids	yes	--	yes	yes	yes	yes
Total Phosphorus	yes	no	no	no	--	--
Chemical Oxygen Demand	no	no	no	no	--	--
Atrazine	yes	no	no	no	--	--
Azinphos	--	--	no	--	--	X
Malathion	--	--	no	yes	--	--
Parathion	--	--	--	--	--	--
Permethrin	--	no	no	no	no	--
Prometryn	--	--	--	--	--	--
Trifluralin	yes	--	--	no	no	no

Footnotes:

Irrigation Sampling Events

Event	Description
#1	4/12-14/96, grain sorghum, post-irrigation, 30-60 hours, control 4/13-15/96, 60-80 hours
#2	5/14/96, grain sorghum, post-irrigation, 6-12 hours, control 5/15/96, 6-12 hours
#3	6/24/96, one sample from rainfall, 6/24/96, irrigated plot only
#4	8/13/96, pre plant seed corn
#5	8/21-26/96, post-irrigation (5 days)

#6	1/97, pre plant irrigation, BMP plot 36-60 hours, post irrigation. control, 60-80 hour post irrigation
#7	6/14-15/97, post irrigation samples, cotton

Key:

- yes - BMP treated site shows clear reduction in concentration
- no - BMP treated site shows no reduction in concentration
- - Data is inconclusive
- X - No data

Table 5. Dryland Demonstration Site: BMP Effectiveness in Reducing Concentrations in surface water runoff.

Substance	Event			
	#1	#2	#3	#4
Ammonia Nitrogen	--	no	no	--
Nitrate Nitrogen	yes	X	no	--
Nitrite Nitrogen	--	X	no	--
Total Kjeldahl Nitrogen	yes	no	no	--
Orthophosphate Phosphorus	no	X	no	--
Total Suspended Solids	yes	no	no	--
Total Phosphorus	--	no	no	--
Chemical Oxygen Demand	yes	no	no	--
Atrazine	--	yes	--	--
Azinphos	--	--	--	--
Malathion	yes	no	--	--
Parathion	--	--	--	--
Permethrin	--	--	--	--
Prometryn	--	--	--	--
Trifluralin	--	--	--	--

Footnotes:

Dryland Sampling Events

<u>Event</u>	<u>Description</u>
#1	8/31/96, sorghum residue, rain event
#2	9/27-28/96, sorghum residue, rain event
#3	10/4-5/96, sorghum residue, large rain event
#4	3/11/97, sorghum residue, rain event

Key:

- yes - BMP treated site shows clear reduction in concentration
- no - BMP treated site shows no reduction in concentration
- - Data is inconclusive
- X - No data

Arroyo Colorado Water Quality Data Base

The Arroyo Colorado Water Quality Data Base was completed in December 1995 and submitted to the TSSWCB on diskette. We also analyzed the data base in order to determine its usefulness in assessing the water quality status and trends of the Arroyo Colorado. A progress report on this analysis was provided to the TSSWCB in August 1996, along with an updated diskette copy of the data base.

During 1996-1997, we continued our assessment of the data base and created the *Arroyo Colorado Water Quality Data Base Web Site* (<http://arroyo.tamu.edu>). The Web Site contains all the water quality data assembled and a search engine, so that any user can perform his own search and analysis of the data base. The Web Site also provides details on the substances analyzed for and maps showing the locations of all monitoring stations.

The Report on the Web Site summarizes our evaluation of both the routine substances and the toxic substances data bases. A copy of the main screens and the text of the Report is provided in Appendix C of this report. The colored maps and charts, however, are not provided here, but are on the Web Site under Charts and Maps at <http://arroyo.tamu.edu>.

Education and Technology Transfer Program

Seminars and Workshops

We conducted a total of ten educational events as part of the educational program for the project. One workshop and seminar conducted each year was used for reporting purposes and to meet the contractual obligations. The other events were co-sponsored by the project in order to provide additional education opportunities for growers to learn about water quality problems and solutions. The TAEX project team planned, conducted, and spoke at these events. Table 6 lists the name of the event, date and estimated attendance.

Fact Sheets

Four new fact sheets and one 2-page handout were written and published for the project. A short description of each follows with copies included in Appendix D of the report. On the back cover of each publication is a description of the Arroyo Colorado, documented water quality concerns, and the project.

Table 6. Educational Programs conducted as part of the Arroyo Colorado Project.

Event	Date	Attendance
Cotton Pre-Plant Clinic	1/13/95	129
Conservation Tillage in South Texas	10/11/95	65
Cotton Production and Physiology Workshop	10/25/95	95
Lower Rio Grande Irrigation Conference	12/12/95	180
Sprayer Calibration Clinic	1/17/96	80
Lower Rio Grande Irrigation Conference	10/29/96	238
Irrigation Field Day Tour	10/30/96	120
Cotton Pre-Plant Clinic	1/15/97	85
No-Till Filed Day	4/30/97	250
Seminar on the Arroyo Colorado	8/28/97	45

Pest and Beneficial Arthropods of Cotton in the Lower Rio Grande Valley by Alton Sparks and John Norman (500 copies, 8/97, 16 pages, 35 color photographs). Provides information on the appearance, basic biology and management of major pests of cotton and on occasional pests and beneficial organisms in the Lower Rio Grande Valley.

Soil Fertility and Fertilizer Management by Mark McFarlland and Guy Fipps (1000 copies, 8/97, 10 pages, 3 photographs, 2 tables). Provides a complete guide to fertilizer management, soil fertility, soil testing and interpretation, and nutrient requirements of major crops.

Irrigated Grain Sorghum Production by Charles Stickler and Guy Fipps (1000 copies, 8/97, 18 pages, 13 tables, 1 photograph). Provides a complete guide to grain sorghum production including proper nutrient, chemical and irrigation water management.

Calibrating Pesticide Application Ground Equipment - Calibration Guide and Software by Bryan Show and Guy Fipps (500 copies, 10/96, 10 pages, 9 tables, 4 figures, software on CD). This publication and software provides a checklist and a complete guide to proper calibration of ground equipment used for applying pesticides and fertilizers.

Help Yourself, Help the Environment (400 copies, 4/97, 2 pages, 1 photograph, 1 map). Two-page handout that links conservation tillage to water quality and summarizes this project.

A professional paper on the project, water quality issues, and the data base was presented at the ***Texas Water '95 Conference***, San Antonio, August 16-17, 1995 (American Society of Civil Engineers): *Is the Arroyo Colorado Polluted* by Guy Fipps and David Smith.

Video

The documentary video on the Arroyo Colorado Project is approximately 17 minutes long and provides an overview of the water quality status of the Arroyo, description of the project and BMPs implemented, and a discussion of additional BMPs appropriated for the area. TAEX contracted with Rick Steward Productions of Harlingen for filming, editing and production services. Rod Santa Ana oversaw filming and production. The script was written by Rod Santa Ana, David Smith and Guy Fipps. A copy of the video accompanies this report.

Technical Assistance to TIAER in BMP Modeling

Our assistance to TIAER consisted of the following:

1. instruction on the use of DRAINMOD;
2. design of the overall modeling strategy;
3. chemical, nutrient, and water usage under the normal year, dry year and wet year scenarios;
4. instruction on some of the limitations and interpretations of simulation results using EPIC, and
5. response to specific information requests, providing referrals as appropriate, and participation in brainstorming sessions.

The following TAEX personnel provided data to TIAER for the modeling effort: Terry Lockamy, Guy Fipps, Charles Stichler, John Norman, Julian Sauls, David Smith, Alton Sparks, and Ed Wilson.

***Appendix A:
Arroyo Colorado Project
Meeting Report***

ARROYO COLORADO PROJECT MEETING
Holiday Inn Sunspree,
South Padre Island, Texas
August 29-30, 1995

The meeting was called to order at 1:00 pm by Dr. Guy Fipps. Arrangements were made for the tour of the Arroyo Colorado to be held on August 30, 1995. Brad Cowan and Terry Lockamy will be responsible for the tour.

Introduction of the participants followed. The participants were as follows:

Dr. Guy Fipps, Extension Agricultural Engineer
Tony Gonzales, NRCS
Dr. John Bremer, Extension Weed Specialist
Luis Saldana, Willacy County Extension Agent
Doyle Warren, District 12 Extension Director
Terry Lockamy, Cameron County Extension Agent
Dr. Stormy Sparks, Extension Entomologist
Brad Cowan, Hidalgo County Extension Agent
Enrique Perez, Starr County Extension Agent
Dr. Bruce Lesikar, Extension Agricultural Engineer
Monty Dozier, Extension Associate
Dr. Bryan Shaw, Extension Agricultural Engineer
Dr. Steve Livingston, Extension Agronomist
Dr. Merrit Taylor, Extension Economist
Brent Bachelor, Atascosa County Extension Agent
Rod Santa Ana, Extension Communications Specialist
David Smith, Extension Assistant
Ed Wilson, Extension Graduate Assistant
Alan Moore, NRCS

The meeting continued with an overview of the Arroyo Colorado Project from it's beginning to the current status. The Texas State Soil and Water Conservation Board (TSSWCB) is responsible for overall project management. The Tarleton Institute for Applied Environmental Research (TIAER) will analyze the samples and conduct the computer modeling. The Texas Agricultural Extension Service will assist with Best Management Practice (BMP) selection and educational programs. The Natural Resource Conservation Service (NRCS) will assist with site identification and instrumentation, implementation of the BMP's (best management practices) and education of local farmers also interested in the BMP's.

The responsibilities of the project team are to:

- a) Provide recommendations on BMP's for the demonstration sites;
- b) Conduct an annual workshop;
- c) Conduct an annual seminar;
- d) distribute fact sheet(s);
- e) evaluate monitoring data; and
- f) produce a documentary video on the demonstrations and project;

An overview of water quality data for the Arroyo Colorado was presented by David Smith. Ed Wilson discussed our current assessment of the data base.

BMP Selection

The BMP will be implemented on an irrigated and two dryland sites (one a control). The irrigated field was previously instrumented and some information has been collected. However, the Quality Assurance Project Plan (QAPP) has not received approval from the TNRCC and USEPA at this point, and no monitoring or sampling can begin.

Irrigated Site

The irrigated field is leveled and has subsurface drainage perpendicular to the row direction.

Existing BMP's:

- a) Subsurface drainage to control salinity and waterlogging from canal seepage
- b) Land leveling

No other information has been provided, and these are the only BMP's known by NRCS.

Possible BMP's include but not limited to:

- a) integrated pest management;
- b) residue management;
- c) field scouting for herbicide applications;
- d) fertilizer rates based on pre-plant soil analysis;
- e) split fertilizer applications;
- f) proper irrigation water management:
 - irrigation scheduling by soil moisture status and current ET,
 - use of gated pipe, and
 - use of surge flow irrigation if poor distribution uniformity exists;
- g) proper calibration and operation of sprayer equipment;

- h) reduced tillage.

Dryland Site:

The dryland farm is a sixty acre field which will be divided into two fields. One field will be the control and the other field will have the BMP's implemented. The BMP field will be leveled with no slope across the rows and a slope of one-third of a tenth per one hundred feet with the row.

Planned BMP (known):

land leveling

Possible BMP's include but are not limited to:

- a) integrated pest management;
- b) residue management;
- c) field scouting for herbicide applications;
- d) fertilizer rates based on pre-plant soil analysis;
- e) split fertilizer applications;
- g) proper calibration and operation of sprayer equipment;
- h) reduced tillage.

The effectiveness of the BMP's will be measured with respect to specific parameters. Water Quality Standards should be established to set a target for the water quality to be attained.

Monitoring

Irrigated Site (Current):

- a) subsurface drainage water sampling;
- b) rainfall.

Possible (depending on which BMP's are implemented and evaluated):

- a) irrigation volumes (measured, not estimated) and timing;
- b) irrigation water sampling;
- c) runoff volumes and quality;
- d) drainwater volumes and hydrographs;
- e) soil sampling:
 - nutrients for fertilizer recommendations,
 - deep soil sampling for nutrient movement,
 - hydrologic properties for modeling.

- f) evapotranspiration;
- g) pest scouting and counts;
- h) document weed presence;
- I) yield and quality of crop;
- j) soil moisture;
- j) expense records/costs of production;
- k) a control for the irrigated site;
- h) shallow water table depth and quality.

Dryland Site (known):

Surface water runoff / Quality and Quantity

Needs:

Sediment in Runoff

Possible (depending on which BMP's are implemented and evaluated):

- a) soil sampling:
 - nutrients for fertilizer recommendations,
 - deep soil sampling for nutrient movement,
 - hydrologic properties for modeling;
- b) evapotranspiration;
- c) pest scouting and counts;
- d) document weed presence;
- e) yield and quality of crop;
- f) soil moisture;
- g) expense records/costs of production;

Fact Sheet

The TAEX will develop a fact sheet to be distributed to the local community on pesticide/fertilizer. The group conducted a brainstorming session to determine ideas for possible fact sheets.

Ideas

Series on Nonpoint Source Pollution from the TSSWCB be rewritten
 Crop Production Handbook Information
 Citrus Production Handbook Information
 Sprayer Calibration Fact Sheet
 Potential Sources of Nonpoint Source Pollutants and How to Control Them

Physical Aspect of the Lower Rio Grande Valley which shows the potential source of pollutants and the drainage area which goes into the Arroyo Colorado (Background Information on the Arroyo Colorado to assist producers understand that they are part of the Arroyo Colorado Watershed and how they may be impacting the water quality in the Arroyo). Corp of Engineers may have a GIS map that describes the Arroyo Colorado Watershed.

Current Status of the Arroyo Colorado Water Quality

Existing information Sheet(s)

Sugarcane publication

Video

A video will be developed to describe the installation of the demonstration projects. Rod Santa Ana will serve as the coordinator of the video program. Additional people on the video committee will be Luis Saldana, Doyle Warren, Terry Lockamy, Stormy Sparks, and Brad Cowan. Bruce Lesikar and Guy Fipps will be advisors. The entire project team will review the video script. A list of items to be included in the video was described as follows:

Aerial view of the demonstration sites and the Arroyo Colorado along with:

- potential sources of nonpoint source pollution
- Crop fields
- Urban Landscape

Land leveling of the site

Finished demonstration sites

Workshops

1. A residue management workshop will be held on Oct. 11 in Willacy County.
2. A sprayer calibration workshop can be conducted on December 14, 1995 in Mercedes.

Seminar

Opportunities:

- 1) Cotton Production Meeting, October 25, 1995, also have a component on Nonpoint Source Pollution
- 2) Irrigation Conference, Jan-Feb, 1996 also have a component on Nonpoint Source Pollution

The irrigation conference will have a program committee consisting of chairman Guy Fipps, members include Merrit Taylor, Stormy Sparks, Bruce Lesikar. The conference will focus on agricultural producers but will also have a component for the Urban irrigators.

Budget

The current budget was presented and the project team informed that Extension will receive an additional funds, pending revised work plan acceptance.

Forward Planning

Video due in December, 1996

Another Planning meeting to be held next fall to evaluate the data collected from the demonstration project.

***Appendix B:
Arroyo Colorado
Monitoring Data***

Arroyo Colorado Monitoring Data

Variable - *format*:

Site - *alpha numeric site designation (see abbreviations) 5.*
Sample # - *numeric 10.0*
Date - *mm/dd/yy*
Time - *hh:mm [military, central standard time]*
NH3-N value - *numeric 8.4*
NH3-N remark - *alpha numeric*
NO2-N value - *numeric 6.3*
NO2-N remark - *alpha numeric*
NO3-N value - *numeric 7.3*
NO3-N remark - *alpha numeric*
TKN value - *numeric 6.2*
TKN remark - *alpha numeric*
PO4-P value - *numeric 6.3*
PO4-P remark - *alpha numeric*
TP value - *numeric 7.3*
TP remark - *alpha numeric*
TSS value - *numeric 8.2*
TSS remark - *alpha numeric*
COD value - *numeric 6.1*
COD remark - *alpha numeric*
Atrazine value - *numeric 8.3*
Atrazine remark - *alpha numeric*
Azinphos (methyl) value - *numeric 8.3*
Azinphos (methyl) remark - *alpha numeric*
Malathion value - *numeric 8.3*
Malathion remark - *alpha numeric*
Parathion (methyl) value - *numeric 8.3*
Parathion (methyl) remark - *alpha numeric*
Permethrin (cis/trans) value - *numeric 8.3*
Permethrin (cis/trans) remark - *alpha numeric*
Prometryn value - *numeric 8.3*
Prometryn remark - *alpha numeric*
Trifluralin value - *numeric 8.3*
Trifluralin remark - *alpha numeric*
Comments - *alpha numeric field containing general comments relating to the sample*

NOTE: For each constituent, a value field and a remark field is listed. The value field contains numeric concentration values. Missing data is denoted with a period (.). The remark field contains explanatory notes relating to the data point such as the method detection limit. When the analyte concentration was below the method detection limit (MDL) for the analytical procedure, the MDL is denoted in the remark column. One-half (1/2) the MDL was reported for concentration values for the following constituents: NH3-N, NO2-N, NO3-N, TKN, PO4-P, TP, TSS, COD. When pesticide concentrations were below the MDL, concentration values were reported as zero (0). If no concentration value is reported, the remark field usually contains an explanation for the missing data. If a quality assurance test fails for a group of samples, no value is assigned to the sample for the affected parameters. A period is entered into the value field and "est. < MDL" is entered into the remark field. When a reduced sample volume was used for a test, the associated MDL was doubled.

Abbreviations and Reporting Units:

<u>Constituent</u>	<u>Abbreviation</u>	<u>Units Reported</u>
Ammonia Nitrogen	NH3-N	mg/L
Nitrite Nitrogen	NO2-N	mg/L
Nitrate Nitrogen	NO3-N	mg/L
Total Kjeldahl Nitrogen	TKN	mg/L
Orthophosphate Phosphorus	PO4-P	mg/L
Total Phosphorus	TP	mg/L
Total Suspended Solids	TSS	mg/L
Chemical Oxygen Demand	COD	mg/L
Atrazine	ATRAZ	µg/L
Azinphos (methyl)	AZINP	µg/L
Malathion	MALAT	µg/L
Parathion (methyl)	PARAT	µg/L
Permethrin (cis/trans)	PERME	µg/L
Prometryn	PROME	µg/L
Trifluralin	TRIFL	µg/L

Abbreviations

bmpdr = Dryland Site with BMP
condr = Dryland Site (Control, without BMP)
bmpir = Irrigated Site with BMP
conir = Irrigated Site (Control, without BMP)
HTEF = Holding time exceeded (field)
EST = Estimated value and/or quality control test(s) fail
IM = Instrument Malfunction
mg/L = milligram per liter
µg/L = microgram per liter
STAT = statistically close
ND = no detection, i.e., concentration is below method detection limit

C97-### or car97### - indicates the reference number (###) of the corrective action report submitted for the sample

Inquiries:

If you have any questions regarding the data reported, please direct inquiries to one of the following individuals.

Joan Flowers	(254) 968-9554	flowers@tiaer.tarleton.edu	Project Manager
Nancy Easterling	(254) 968-9548	easterl@tiaer.tarleton.edu	Quality Assurance Officer
Larry Hauck	(254) 968-9561	hauck@tiaer.tarleton.edu	Project Administrator

These data are also available in digital format by directing a written request to:
Texas Institute for Applied Environmental Research
Tarleton State University
Box T0410, Tarleton Station
Stephenville, Texas 76402
Attention: Joan Flowers
email: flowers@tiaer.tarleton.edu

Results of Water Quality Monitoring - Arroyo Colorado Project

Nutrient and Conventional Constituents

Site	Sample #	Date	Time	NH3-N value mg/L	NH3-N remark	NO2-N value mg/L	NO2-N remark	NO3-N value mg/L	NO3-N remark	TKN value mg/L	TKN remark	PO4-P value mg/L	PO4-P remark	TP value mg/L	TP remark	TSS value mg/L	TSS remark	COD value mg/L	COD remark
bmpdr	1000021631	8/31/96	16:00	0.09		0.001	<0.002	0.42		16.5		0.36		8.82		8120		204	
bmpdr	1000021727	8/31/96	18:00	0.1		0.001	<0.002	0.11		0.72		0.39		0.68		162		22	
bmpdr	1000021728	8/31/96	20:00	0.12		0.001	<0.002	0.1		0.91		0.38		0.64		86		18	
bmpdr	1000021729	9/1/96	0:00	0.11		0.001	<0.002	0.1		0.9		0.37		0.64		68		22	
bmpdr	1000021730	9/1/96	2:00	0.14		0.001	<0.002	0.11		0.9		0.38		0.69		66		16	
bmpdr	1000021731	9/1/96	4:00	0.14		0.001	<0.002	0.09		0.93		0.38		0.74		100		8	
bmpdr	1000023114	9/27/96	23:00	0.28	HTEF		HTEF		HTEF	15.8			HTEF	8.12		6260		124	
bmpdr	1000023115	9/28/96	1:00	0.15	HTEF		HTEF		HTEF	3.95			HTEF	2.75		1590		42	
bmpdr	1000023180	10/5/96	0:00	0.14		0.008		0.12		8.71		0.45		4.44		2500		132	
bmpdr	1000023181	10/5/96	2:00	0.15		0.004		0.06		4.71		0.42		3.01		1920		68	
bmpdr	1000023182	10/5/96	4:00	0.16		0.005		0.05		2.26		0.37		1.6		719		26	
bmpdr	1000023183	10/5/96	6:00	0.16		0.006		0.08		4.58		0.36		2.81		1950		66	
bmpdr	1000023184	10/5/96	8:00	0.13		0.004		0.06		1.9		0.3		1.28		781		21	
bmpdr	1000023185	10/5/96	10:00	0.13		0.003		0.03		1.77		0.21		0.96		574		15	
bmpdr	1000023192	10/5/96	20:00	0.09		0.001	<0.002	0.008	<0.15	0.91		0.25		0.57		587		6	
bmpdr	1000029149	3/11/97	9:00	0.53		0.01		0.08		4.53		0.52		2.06		1260		11	
bmpdr	1000029150	3/11/97	11:00	0.08		0.014		0.08		1.96		0.27		1.19		726		9	
bmpdr	1000029151	3/11/97	13:00	0.08		0.011		0.08		1.21		0.35		0.75		210		8	
bmpir	1000018210	4/15/96	4:00	0.03		0.005		16.6		0.7		0.08		0.055	<11	21		36	
bmpir	1000018211	4/15/96	16:00	0.03		0.005		15.7		0.84		0.11		0.055	<11	39		23	
bmpir	1000018212	4/16/96	4:00	0.0075	<0.15	0.02		13.2		0.75		0.08		0.055	<11	18.7		24	
bmpir	1000018439	5/14/96	6:00	0.11		0.04		11.6		0.78		0.06		0.19		17		19	
bmpir	1000018440	5/14/96	9:00	0.31		0.05		12		0.85		0.06		0.15		5	<10	15	
bmpir	1000018441	5/14/96	12:00	0.09		0.02		11.4		1.02		0.06		0.14		25		18	
bmpir	1000018442	5/14/96	18:00	0.0075	<0.15	0.05		12.9		0.81		0.06		1.21		26		19	
bmpir	1000018443	5/15/96	0:00	0.06		0.05		13		1.09		0.07		0.17		32		21	
bmpir	1000018444	5/15/96	6:00	0.0075	<0.15	0.03		12.8		0.84		0.07		0.055	<11	14		18	
bmpir	1000018445	5/15/96	12:00	0.0075	<0.15	0.02		13.8		0.98		0.08		0.11		17		20	
bmpir	1000018451	5/15/96	18:00	0.0075	<0.15	0.018		13.5		0.51		0.07		0.16		12		22	
bmpir	1000018452	5/16/96	0:00	0.0075	<0.15	0.004		13.2		0.46		0.07		0.14		12		20	
bmpir	1000018453	5/16/96	6:00	0.0075	<0.15	0.004		13.2		0.55		0.07		0.055	<11	84		18	
bmpir	1000018454	5/16/96	12:00	0.0075	<0.15	0.009		12.7		0.7		0.06		0.055	<11	11		16	
bmpir	1000018465	5/16/96	18:00	0.0075	<0.15		HTEF		HTEF	0.46			HTEF	0.055	<11	5	<10	19	
bmpir	1000018466	5/17/96	0:00	0.05			HTEF		HTEF	0.53			HTEF	0.055	<11	11		26	
bmpir	1000018467	5/17/96	6:00	0.06			HTEF		HTEF	0.36			HTEF	0.055	<11	20		16	
bmpir	1000018468	5/17/96	12:00	0.0075	<0.15		HTEF		HTEF	0.7			HTEF	0.055	<11	5	<10	16	

Results of Water Quality Monitor, Arroyo Colorado Project
Nutrient and Conventional Constituents

Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
bmpir	1000018459	5/17/96	18:00	0.0075	<.015		HTEF		HTEF	0.47			HTEF	0.055	<.11	10		21	
bmpir	1000018460	5/18/96	0:00	0.0075	<.015	0.003		11.4		0.67		0.07		0.11		12		21	
bmpir	1000018461	5/18/96	12:00	0.0075	<.015	0.006		11.5		0.54		0.07		0.055	<.11	19		21	
bmpir	1000019617	6/24/96	17:00	1.03		0.001	<.002	0.3		2.18		0.07		0.24		43		12	
bmpir	1000020510	8/14/96	8:00	0.12			HTEF		HTEF	0.99			HTEF	0.33		52		32	
bmpir	1000020511	8/14/96	12:00	0.1			HTEF		HTEF	1.08			HTEF	0.22		19		24	
bmpir	1000020512	8/14/96	16:00	0.12		0.014		2.69		1.07		0.05		0.2		53		23	
bmpir	1000020513	8/14/96	20:00	0.12		0.01		2.47		1.15		0.05		0.21		11		17	
bmpir	1000020514	8/15/96	0:00	0.16		0.08		3.21		1.28		0.04		0.2		35		21	
bmpir	1000020515	8/15/96	4:00	0.11		0.04		3.26		1.09		0.05		0.23		18		20	
bmpir	1000020678	8/16/96	9:00	0.11			HTEF		HTEF	0.91			HTEF	0.16		19		15	
bmpir	1000020679	8/16/96	12:00	0.11		0.001	<.002	4.36		0.77		0.09		0.14		10		15	
bmpir	1000020680	8/16/96	15:00	0.12		0.001	<.002	4.58		0.86		0.09		0.13		5	<10	15	
bmpir	1000020750	8/16/96	20:00	0.13			HTEF		HTEF	0.78			HTEF	0.13		26		11	
bmpir	1000020751	8/17/96	2:00	0.07			HTEF		HTEF	0.53			HTEF	0.16		14		17	
bmpir	1000020752	8/17/96	8:00	0.06			HTEF		HTEF	0.79			HTEF	0.13		10		13	
bmpir	1000020753	8/17/96	14:00	0.07		0.08		0.008	<.015	0.89		4.17		0.055	<.11	14		13	
bmpir	1000020804	8/17/96	20:00	0.08		0.04		4.56		0.69		0.08		0.13		16		15	
bmpir	1000020805	8/18/96	2:00	0.05		0.03		4.71		0.69		0.08		0.12		18		19	
bmpir	1000020806	8/18/96	8:00	0.14		0.017		4.72		0.74		0.08		0.11		11		18	
bmpir	1000020807	8/18/96	14:00	0.06		0.001	<.002	4.54		0.67		0.09		0.055	<.11	12		20	
bmpir	1000020863	8/18/96	20:00	0.11		0.001	<.002	4.47		0.86		0.08		0.24		24		9	
bmpir	1000020864	8/19/96	2:00	0.09		0.001	<.002	4.55		0.76		0.09		0.19		14		10	
bmpir	1000020865	8/19/96	14:00	0.1		0.002		4.32		0.73		0.09		0.18		28		9	
bmpir	1000020951	8/19/96	20:00	0.0075	<.015	0.004		4.41		0.94		0.08		0.055	<.11	24		13	
bmpir	1000020952	8/20/96	2:00	0.0075	<.015	0.004		4.48		0.66		0.08		0.055	<.11	21		17	
bmpir	1000020953	8/20/96	8:00	0.05		0.003		4.49		0.68		0.08		0.055	<.11	15		14	
bmpir	1000020954	8/20/96	14:00	0.16		0.012		3.98		1.07		0.08		0.055	<.11	27		13	
bmpir	1000021089	8/26/96	18:00	0.1		0.001	<.002	5.98		1.32		0.07		0.26		29		22	
bmpir	1000021090	8/26/96	22:00		EST .72	0.001	<.002	5.75		0.96		0.08		0.21		16		20	
bmpir	1000021091	8/27/96	2:00		EST .56	0.001	<.002	5.69		0.81		0.09		0.17		11		24	
bmpir	1000021092	8/27/96	6:00		EST .64	0.001	<.002	5.57		0.94		0.08		0.17		16		22	
bmpir	1000021093	8/27/96	10:00	0.47		0.001	<.002	5.82		0.96		0.08		0.12		16		15	
bmpir	1000021094	8/27/96	14:00	0.61		0.001	<.002	5.43		0.9		0.17		0.055	<.11	12		17	
bmpir	1000021135	8/27/96	18:00	0.12		0.001	<.002	6.22		0.63		0.07		0.17		11		20	
bmpir	1000021136	8/27/96	22:00	0.3		0.001	<.002	6.32		0.67		0.08		0.18		15		21	
bmpir	1000021137	8/28/96	2:00	0.17		0.001	<.002	5.86		0.65		0.07		0.13		5	<10	21	

Results of Water Quality Mon. - Arroyo Colorado Project
Nutrient and Conventional Constituents

Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
bmpir	1000021138	8/28/96	6:00	0.16		0.001	<.002	5.97		0.75		0.07		0.12		5	<10	21	
bmpir	1000021139	8/28/96	10:00	0.12		0.001	<.002	5.6		0.88		0.08		0.12		5	<10	21	
bmpir	1000021140	8/28/96	14:00	0.45		0.001	<.002	5.64		0.88		0.08		0.2		5	<10	22	
bmpir	1000021312	8/28/96	18:00	0.07		0.011		4.61		0.57		0.08		0.12		25		25	
bmpir	1000021313	8/28/96	22:00	0.09		0.011		5.05		0.7		0.08		0.13		14		23	
bmpir	1000021314	8/29/96	2:00	0.09		0.008		4.89		0.77		0.08		0.055	<.11	15		22	
bmpir	1000021315	8/29/96	6:00	0.08		0.011		5.08		0.43		0.08		0.055	<.11	16		22	
bmpir	1000021316	8/29/96	10:00	0.08		0.018		5.15		0.43		0.08		0.26		5	<10	19	
bmpir	1000021317	8/29/96	14:00	0.14		0.011		5.29		0.44		0.09		0.28		11		18	
bmpir	1000021632	8/29/96	20:00	0.03			HTEF		HTEF	1			HTEF	0.28		19		17	
bmpir	1000021633	8/30/96	2:00	0.03			HTEF		HTEF	0.99			HTEF	0.18		16		17	
bmpir	1000021634	8/30/96	8:00	0.04			HTEF		HTEF	0.77			HTEF	0.15	<.10	5		16	
bmpir	1000021635	8/30/96	14:00	0.05			HTEF		HTEF	0.73			HTEF	0.13		26		13	
bmpir	1000026440	1/31/97	18:00	0.1		0.04		4.27		0.71		0.07		0.14		32		17	
bmpir	1000026441	1/31/97	22:00	0.08		0.04		4.78		0.87		0.09		0.051	<.101	12		12	
bmpir	1000026442	2/1/97	2:00	0.11		0.04		5.1		0.79		0.08		0.051	<.101	5	<10	11	
bmpir	1000026443	2/1/97	6:00	0.1		0.04		5.52		0.62		0.08		0.051	<.101	5	<10	10	
bmpir	1000026444	2/1/97	10:00	0.15		0.03		5.12		0.53		0.08		0.051	<.101	5	<10	9	
bmpir	1000026445	2/1/97	14:00	0.09		0.03		4.62		0.73		0.09		0.051	<.101	5	<10	7	
bmpir	1000026452	2/1/97	16:00	0.06		0.05		5.89		1.2		0.07		0.19		5	<10	17	
bmpir	1000026453	2/1/97	20:00	0.07		0.06		5.95		1.22		0.09		0.14		10		19	
bmpir	1000026454	2/2/97	0:00	0.06		0.05		6.22		1.31		0.08		0.13		5	<10	20	
bmpir	1000026455	2/2/97	4:00	0.05		0.05		6		1.25		0.08		0.15		5	<10	16	
bmpir	1000026456	2/2/97	8:00	0.0185	<.037	0.05		5.9		0.69		0.08		0.051	<.101	5	<10	12	
bmpir	1000026457	2/2/97	12:00	0.06		0.05		5.93		0.72		0.08		0.051	<.101	5	<10	17	
bmpir	1000026462	2/2/97	18:00	0.0185	<.037		HTEF		HTEF	1.08			HTEF	0.051	<.101	5	<10	15	
bmpir	1000026463	2/2/97	20:00	0.0185	<.037		HTEF		HTEF	1.57			HTEF	0.051	<.101	5	<10	16	
bmpir	1000026464	2/3/97	2:00	0.0185	<.037		HTEF		HTEF	0.89			HTEF	0.051	<.101	5	<10	16	
bmpir	1000026465	2/3/97	6:00	0.04			HTEF		HTEF	0.82			HTEF	0.051	<.101	5	<10	16	
bmpir	1000026466	2/3/97	10:00	0.04			HTEF		HTEF	0.86			HTEF	0.051	<.101	5	<10	19	
bmpir	1000026467	2/3/97	14:00	0.05		0.05		6.03		0.87		0.13		0.051	<.101	5	<10	17	
bmpir	1000026468	2/3/97	18:00	0.04		0.05		6.08		0.81		0.13		0.051	<.101	5	<10	16	
bmpir	1000026469	2/4/97	0:00	0.0185	<.037	0.05		6.05		0.78		0.16		0.051	<.101	5	<10	17	
bmpir	1000026470	2/4/97	6:00	0.04		0.05		5.84		0.84		0.13		0.051	<.101	5	<10	17	
bmpir	1000026471	2/4/97	12:00	0.05		0.05		5.8		0.66		0.14		0.051	<.101	5	<10	17	
bmpir	1000032683	6/13/97	18:00	0.07			car97201		car97201	1.17			car97201	0.039	<.077	22		11	
bmpir	1000032684	6/13/97	22:00	0.05			car97201		car97201	1.08			car97201	0.1	STAT	14		2	<4

Results of Water Quality Monitoring - Arroyo Colorado Project

Nutrient and Conventional Constituents

Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
bmpir	1000032685	6/14/97	2:00	0.07		car97201	car97201		car97201	1.21			car97201	0.08		5	<10	2	<4
bmpir	1000032686	6/14/97	6:00	0.09		car97201	car97201		car97201	0.76			car97201	0.34			C97-203	2	<4
bmpir	1000032687	6/14/97	10:00	0.14		car97201	car97201		car97201	0.77			car97201	0.28			C97-203	2	<4
bmpir	1000032688	6/14/97	14:00	0.05		car97201	car97201		car97201	0.67			car97201	0.26		5	<10	9	
bmpir	1000032693	6/14/97	22:00	0.07		0.011		6.04		0.59		0.11		0.16		5	<10	2	<4
bmpir	1000032694	6/15/97	2:00	0.04		0.006		5.88		0.57		0.13		0.15		16		5	
bmpir	1000032695	6/15/97	6:00	0.05		0.007		6.01		0.69		0.11		0.14		5	<10	4	
bmpir	1000032696	6/15/97	10:00	0.08		0.014		4.9		0.76		0.1		0.29		5	<10	2	<4
bmpir	1000032697	6/15/97	14:00	0.18		0.01		5.31		0.88		0.11		0.45		5	<10	9	
condr	1000021630	8/31/96	16:00	0.11		0.001	<.002	0.77		25.2		0.39		10.5		11700		380	
condr	1000023112	9/27/96	23:00	0.31			HTEF		HTEF	17.2			HTEF	5.48		5760		117	
condr	1000023113	9/28/96	1:00	0.15			HTEF		HTEF	4.9			HTEF	2.48		1660		53	
condr	1000023174	10/5/96	0:00	0.64		0.006		0.11		7.6		0.37		3.83		3050		108	
condr	1000023175	10/5/96	2:00	0.2		0.006		0.1		4.45		0.37		2.5		1760		55	
condr	1000023176	10/5/96	4:00	0.16		0.005		0.06		3.67		0.45		2.22		1600		54	
condr	1000023177	10/5/96	6:00	0.16		0.004		0.06		1.81		0.39		1.25		471		16	
condr	1000023178	10/5/96	8:00	0.15		0.004		0.06		1.89		0.35		1.02		593		8	
condr	1000023179	10/5/96	10:00	0.13		0.001	<.002	0.05		1.46		0.27		0.98		626		20	
condr	1000023189	10/5/96	20:00	0.13		0.001	<.002	0.018		0.47		0.21		0.29		70		2.5	<5
condr	1000023190	10/6/96	0:00	0.09		0.001	<.002	0.02		0.59		0.23		0.35		110		2.5	<5
condr	1000023191	10/6/96	4:00	0.09		0.001	<.002	0.016		0.51		0.23		0.31		35		2.5	<5
condr	1000029148	3/11/97	8:00	0.19		0.02		0.18		3.77		0.38		2.08		1540		13	
conir	1000018214	4/16/96	4:00	0.04		0.015		15.7		0.63		0.07		0.055	<.11	74		36	
conir	1000018213	4/16/96	16:00	0.06		0.04		16.4		0.91		0.07		0.13		197		30	
conir	1000018215	4/17/96	4:00	0.17		0.001	<.002	16		0.74		0.08		0.18		176		27	
conir	1000018455	5/16/96	0:00	0.0075	<.015	0.003		13.6		0.84		0.08		0.2		119		20	
conir	1000018456	5/16/96	3:00	0.0075	<.015	0.004		13.4		0.65		0.07		0.16		60		20	
conir	1000018457	5/16/96	6:00	0.0075	<.015	0.002		13.2		0.98		0.08		0.11		31		20	
conir	1000018458	5/16/96	12:00	0.0075	<.015	0.002		12.6		0.67		0.08		0.055	<.11	40		16	
conir	1000018469	5/16/96	18:00	0.0075	<.015		HTEF		HTEF	0.42			HTEF	0.14		16		16	
conir	1000018470	5/17/96	0:00	0.0075	<.015		HTEF		HTEF	0.34			HTEF	0.055	<.11	5	<10	21	
conir	1000018471	5/17/96	6:00	0.0075	<.015		HTEF		HTEF	0.63			HTEF	0.055	<.11	5	<10	22	
conir	1000018472	5/17/96	12:00	0.0075	<.015		HTEF		HTEF	0.43			HTEF	0.055	<.11	10		21	
conir	1000018462	5/17/96	18:00	0.04			HTEF		HTEF	0.79			HTEF	0.14		27		23	
conir	1000018463	5/18/96	0:00	0.02		0.07		12.5		0.6		0.09		0.12		14		20	
conir	1000018464	5/18/96	12:00	0.0075	<.015	0.003		14.1		0.46		0.07		0.055	<.11	13		20	
conir	1000018473	5/18/96	18:00	0.0075	<.015	0.003		11.7		0.61		0.07		0.055	<.11	14		34	

Results of Water Quality Monitoring - Arroyo Colorado Project
Nutrient and Conventional Constituents

Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
conir	1000020803	8/18/96	16:00	2.81		0.07		1.35		4.4		0.06		0.29		81		19	
conir	1000020858	8/18/96	20:00	1.67		0.09		1.92		3.11		0.09		0.2		56		12	
conir	1000020859	8/18/96	23:00	1.03		0.019		2.8		2.05		0.08		0.17		16		13	
conir	1000020860	8/19/96	2:00	0.74		0.014		3.12		1.68		0.08		0.17		5	<10	14	
conir	1000020861	8/19/96	8:00	0.32		0.008		3.58		1.28		0.07		0.14		5	<10	10	
conir	1000020862	8/19/96	14:00	0.1		0.003		3.52		0.88		0.06		0.22		14		11	
conir	1000020947	8/19/96	20:00	0.07		0.006		3.2		0.85		0.06		0.055	<.11	19		10	
conir	1000020948	8/20/96	2:00	0.06		0.006		3.03		0.93		0.06		0.14		5	<10	11	
conir	1000020949	8/20/96	8:00	0.37		0.019		2.66		1.54		0.06		0.055	<.11	14		11	
conir	1000020950	8/20/96	14:00	0.06		0.009		2.85		0.57		0.06		0.055	<.11	12		11	
conir	1000020966	8/20/96	20:00	0.04		0.001	<.002	2.78		0.6		0.07		0.055	<.11	5	<10	16	
conir	1000020967	8/21/96	2:00	0.11		0.001	<.002	2.75		0.59		0.06		0.055	<.11	5	<10	14	
conir	1000020968	8/21/96	8:00	0.06		0.001	<.002	2.79		0.91		0.06		0.055	<.11	5	<10	18	
conir	1000020969	8/21/96	14:00	0.06		0.001	<.002	2.82		0.92		0.06		0.055	<.11	5	<10	12	
conir	1000021095	8/26/96	18:00	0.54		0.001	<.002	6.41		1.13		0.2		0.18		86		11	
conir	1000021096	8/26/96	22:00	0.51		0.001	<.002	6.31		1.01		0.21		0.19		18		20	
conir	1000021097	8/27/96	2:00	0.34		0.001	<.002	6.11		0.9		0.18		0.27		12		18	
conir	1000021098	8/27/96	6:00	0.25		0.001	<.002	6.16		0.98		0.08		0.24		16		20	
conir	1000021099	8/27/96	10:00	0.13		0.001	<.002	6		0.76		0.09		0.2		5	<10	21	
conir	1000021100	8/27/96	14:00	0.27		0.07		5.5		1		0.09		0.17		11		21	
conir	1000021141	8/27/96	18:00	0.17		0.001	<.002	5.28		0.78		0.08		0.14		11		20	
conir	1000021142	8/27/96	22:00	0.17		0.001	<.002	5.19		0.86		0.08		0.055	<.11	5	<10	22	
conir	1000021143	8/28/96	2:00	0.08		0.001	<.002	5.02		0.63		0.08		0.055	<.11	5	<10	18	
conir	1000021144	8/28/96	6:00	0.14		0.001	<.002	5.33		0.65		0.08		0.055	<.11	36		18	
conir	1000021145	8/28/96	10:00	0.1		0.001	<.002	5.13		0.6		0.08		0.055	<.11	16		18	
conir	1000021146	8/28/96	14:00	0.0075	<.015	0.001	<.002	5.05		0.71		0.08		0.055	<.11	12		23	
conir	1000021306	8/28/96	18:00	0.11		0.014		5.94		0.59		0.07		0.27		5	<10	23	
conir	1000021307	8/28/96	22:00	0.14		0.014		5.79		0.78		0.07		0.22		24		25	
conir	1000021308	8/29/96	2:00	0.12		0.011		5.45		0.34		0.08		0.17		5	<10	22	
conir	1000021309	8/29/96	6:00	0.09		0.008		5.75		0.9		0.08		0.15		5	<10	22	
conir	1000021310	8/29/96	10:00	0.12		0.011		5.89		0.41		0.08		0.13		5	<10	20	
conir	1000021311	8/29/96	14:00	0.11		0.011		5.42		0.47		0.08		0.13		5	<10	21	
conir	1000021637	8/29/96	20:00	0.03	HTEF		HTEF		HTEF	0.85			HTEF	0.12		5	<10	15	
conir	1000021638	8/30/96	2:00	0.02	HTEF		HTEF		HTEF	1.03			HTEF	0.055	<.11	5	<10	17	
conir	1000021639	8/30/96	8:00	0.018	HTEF		HTEF		HTEF	0.85			HTEF	0.15		5	<10	18	
conir	1000021640	8/30/96	14:00	0.0075	<.015		HTEF		HTEF	1.14			HTEF	0.15		16		16	
conir	1000026427	1/29/97	18:00	0.09		0.13		5.43		1.76		0.13		0.73		490		31	

Results of Water Quality Monito...g - Arroyo Colorado Project

Nutrient and Conventional Constituents

Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
conir	1000026428	1/29/97	22:00	0.1		0.11		5.15		1.28		0.1		0.33		198		13	
conir	1000026429	1/30/97	2:00	0.09		0.1		6.38		1.27		0.12		0.27		156		14	
conir	1000026430	1/30/97	6:00	0.07		0.12		5.9		1.5		0.26		0.25	STAT	137		13	
conir	1000026431	1/30/97	10:00	0.06		0.12		6.57		1.57		0.12		0.24		126		29	
conir	1000026432	1/30/97	14:00	0.05		0.11		6.45		1.45		0.12		0.24		119		12	
conir	1000026434	1/30/97	18:00	0.0185	<.037	0.08		5.25		1.42		0.09		0.37		330		16	
conir	1000026435	1/30/97	22:00	0.11		0.07		4.38		1.38		0.1		0.31		207		14	
conir	1000026436	1/31/97	2:00	0.1		0.06		5.67		1.09		0.1		0.6		515		15	
conir	1000026437	1/31/97	6:00	0.16		0.05		5.74		1.38		0.1		0.44		356		12	
conir	1000026438	1/31/97	10:00	0.11		0.04		5.31		0.9		0.1		0.28		205		13	
conir	1000026439	1/31/97	14:00	0.13		0.04		5.3		0.84		0.1		0.46		438		10	
conir	1000026446	1/31/97	18:00	0.09		0.03		4.63		0.77		0.08		0.24		251		19	
conir	1000026447	1/31/97	22:00	0.09		0.03		4.39		1.39		0.09		0.19		114		25	
conir	1000026448	2/1/97	2:00	0.12		0.03		4.41		1.44		0.09		0.34		245		22	
conir	1000026449	2/1/97	6:00	0.1		0.03		5.33		1.52		0.09		0.35		226		19	
conir	1000026450	2/1/97	10:00	0.09		0.05		6.46		1.41		0.08		0.29		107		20	
conir	1000026451	2/1/97	14:00	0.11		0.05		6.84		1.27		0.1		0.19		69		19	
conir	1000026458	2/1/97	18:00	0.0185	<.037	0.05		7.1		0.92		0.08		0.051	<.101	14		16	
conir	1000026459	2/2/97	0:00	0.04		0.04		7.06		1		0.08		0.051	<.101	22		17	
conir	1000026460	2/2/97	6:00	0.08		0.04		7.35		0.95		0.08		0.051	<.101	5	<10	18	
conir	1000026461	2/2/97	12:00	0.0185	<.037	0.04		7.38		0.97		0.08		0.051	<.101	5	<10	18	
conir	1000032689	6/14/97	2:00	0.11			car97201		car97201	0.82			car97201	0.29		13		9	
conir	1000032690	6/14/97	6:00	0.07			car97201		car97201	0.71			car97201	0.25	STAT	45		12	
conir	1000032691	6/14/97	10:00	0.06			car97201		car97201	0.79			car97201	0.16		12		2	<4
conir	1000032698	6/14/97	14:00	0.36		0.03		5.28		1.18		0.1		0.38		5	<10	6	
conir	1000032699	6/14/97	18:00	0.09		0.011		7.45		0.93		0.11		0.39		48		2	<4
conir	1000032700	6/14/97	22:00	0.1		0.017		7.4		0.86		0.11		0.4		90		7	
conir	1000032701	6/15/97	10:00	0.1		0.008		7.18		0.81		0.12		0.32		44		4	

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Atrazine value µg/L	Atrazine remark	Azinphos (methyl) value µg/L	Azinphos (methyl) remark	Malathion value µg/L	Malathion remark	Parathion (methyl) value µg/L	Parathion (methyl) remark	Permethrin (cis/trans) value µg/L	Permethrin (cis/trans) remark
bmpdr	1000021631	8/31/96	16:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021727	8/31/96	18:00	1.087		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021728	8/31/96	20:00	0.638		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021729	9/1/96	0:00	1.18		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021730	9/1/96	2:00	0.522		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021731	9/1/96	4:00	0	<.1.00	0	<.009	0	<.022	0	<.036	0	<.4
bmpdr	1000023114	9/27/96	23:00	0	<.5	0	<.009	0.016		0	<.018	0	<.2
bmpdr	1000023115	9/28/96	1:00	0	<.5	0	<.009	0.016		0	<.018	0	<.2
bmpdr	1000023180	10/5/96	0:00	0	<.5		EST<.009		EST<.011		EST<.018	0	<.2
bmpdr	1000023181	10/5/96	2:00	1.056			EST<.018		EST<.022		EST<.036	0	<.4
bmpdr	1000023182	10/5/96	4:00	0.994		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000023183	10/5/96	6:00	0	<.5	0.055		0.016		0.019		0.506	
bmpdr	1000023184	10/5/96	8:00	2.063		0	<.009	0.014		0	<.018	0.548	
bmpdr	1000023185	10/5/96	10:00	0.912		0	<.009	0.016		0	<.018	0.5	
bmpdr	1000023192	10/5/96	20:00	0	<.5	0	<.009	0	<.011	0	<.018	0.478	
bmpdr	1000029149	3/11/97	9:00	1.45		0	<.009	0	<.011	0	<.018	0	<.20
bmpdr	1000029150	3/11/97	11:00	10.8		0	<.009	0	<.011	0	<.018	0	<.20
bmpdr	1000029151	3/11/97	13:00	6.33		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000018210	4/15/96	4:00	0	<.86	0	<.016	0	<.019	0	<.031	0	<.34
bmpir	1000018211	4/15/96	16:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000018212	4/16/96	4:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000018439	5/14/96	6:00	5.94		0	<.018	0	<.022		IM	1.1	
bmpir	1000018440	5/14/96	9:00	7.76		0	<.009	0	<.011		IM	2.04	
bmpir	1000018441	5/14/96	12:00	4.69		0	<.009	0	<.011		IM	1.05	
bmpir	1000018442	5/14/96	18:00	2.77		0	<.009	0	<.011		IM	1.24	
bmpir	1000018443	5/15/96	0:00	2.77		0	<.009	0	<.011		IM	0	<.2
bmpir	1000018444	5/15/96	6:00	1.18		0	<.009	0	<.011		IM	0	<.2
bmpir	1000018445	5/15/96	12:00	1.06		0	<.009	0	<.011		IM	0.96	
bmpir	1000018451	5/15/96	18:00	4.85		0	<.009	0	<.011		IM	0	<.2
bmpir	1000018452	5/16/96	0:00	0	<.5	0	<.009	0	<.011		IM	0	<.2
bmpir	1000018453	5/16/96	6:00	0	<.1.0	0	<.018	0	<.022		IM	0	<.4
bmpir	1000018454	5/16/96	12:00	9.11		0	<.018	0	<.022		IM	1.12	
bmpir	1000018465	5/16/96	18:00	1.18		0	<.018	0	<.022		IM	1.17	
bmpir	1000018466	5/17/96	0:00	1.4		0	<.009	0	<.011		IM	2.7	
bmpir	1000018467	5/17/96	6:00	1.63		0	<.009	0	<.011		IM	1.16	
bmpir	1000018468	5/17/96	12:00	1.56		0	<.009	0	<.011		IM	1.98	

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
bmpir	1000018459	5/17/96	18:00	0	<.5	0	<.009	0	<.011		IM	0	<.2
bmpir	1000018460	5/18/96	0:00	0	<.5	0	<.009	0	<.011		IM	0.95	
bmpir	1000018461	5/18/96	12:00	0	<.5	0	<.009	0	<.011		IM	0	<.2
bmpir	1000019617	6/24/96	17:00	0	<1.0	0	<.018	0	<.022	0	<.2	0	<.4
bmpir	1000020510	8/14/96	8:00	11.4		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020511	8/14/96	12:00	6.44		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020512	8/14/96	16:00	3.2		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020513	8/14/96	20:00	2.27		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020514	8/15/96	0:00	5.93		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020515	8/15/96	4:00	5.17		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020678	8/16/96	9:00	1		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020679	8/16/96	12:00	0.645		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020680	8/16/96	15:00	0.552		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020750	8/16/96	20:00	0	1	0	<.018	0	<.022	0	<.036	0.222	
bmpir	1000020751	8/17/96	2:00	0	<.50	0.298	<.009	0	<.011	0	<.018	0	0.2
bmpir	1000020752	8/17/96	8:00	0	<.50	0	<.009	0.028	<.011	0	<.018	0	0.2
bmpir	1000020753	8/17/96	14:00	0	<.50	0	<.009	0	<.011	0	<.018	0	0.2
bmpir	1000020804	8/17/96	20:00	3.95		0	<.009	0.028	<.011	0.019		0.212	
bmpir	1000020805	8/18/96	2:00	2.36		0	<.009	0	<.011	0	<.018	0.292	
bmpir	1000020806	8/18/96	8:00		est<.50	0	<.009	0	<.011	0	<.018		est<.20
bmpir	1000020807	8/18/96	14:00	2.46		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020863	8/18/96	20:00	2.32		0	<.009	0	<.011		est<.018		est<.20
bmpir	1000020864	8/19/96	2:00	2.1		0	<.009	0	<.011		est<.018		est<.20
bmpir	1000020865	8/19/96	14:00	5.95		0	<.009	0	<.011		est<.018		est<.20
bmpir	1000020951	8/19/96	20:00	1.85		0	<.009	0	<.011		est<.018		est<.20
bmpir	1000020952	8/20/96	2:00	2.19		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020953	8/20/96	8:00	1.4		0.211	<.009	0	<.011	0	<.018	0.368	
bmpir	1000020954	8/20/96	14:00	3.89		0	<.009	0.022		0	<.018	0	<.20
bmpir	1000021089	8/26/96	18:00	8.03		0	<.009	0.027		0	<.018	0.333	
bmpir	1000021090	8/26/96	22:00	3.4		0	<.0225	0	est<.027	0	<.045	1.77	
bmpir	1000021091	8/27/96	2:00	0	<1.25	0	<.0225		est<.027	0	<.045		est<.5
bmpir	1000021092	8/27/96	6:00	2.51		0	<.018	0	<.022	0	<.045		est<.5
bmpir	1000021093	8/27/96	10:00	0	<.5	0	<.009	0	<.011	0	<.036		est<.2
bmpir	1000021094	8/27/96	14:00	0	<.5	0	<.009		est<.011	0	<.018		est<.2
bmpir	1000021135	8/27/96	18:00	1.92		0	<.009		est<.011	0	<.018		est<.2
bmpir	1000021136	8/27/96	22:00	1.77		0	<.0225		est<.011	0	<.018		est<.20
bmpir	1000021137	8/28/96	2:00	1.463		0	<.0225		est<.027	0	<.045		est<.50
bmpir	1000021138	8/28/96	2:00	1.463		0	<.0225		est<.027	0	<.045		est<.50

Results of Water Quality Mo, ...g - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
bmpir	1000021138	8/28/96	6:00	0.954		0	<.009		est<.011	0	<.018		est<.20
bmpir	1000021139	8/28/96	10:00	0	<.50	0	<.009		est<.011	0	<.018		est<.20
bmpir	1000021140	8/28/96	14:00	0	<.50	0	<.009		est<.011	0	<.018		est<.20
bmpir	1000021312	8/28/96	18:00	0.705		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000021313	8/28/96	22:00	0	<.00	0	<.018	0	<.022	0	<.036	0	<.40
bmpir	1000021314	8/29/96	2:00	0	<.50	0.109		0.033		0	<.018	0	<.20
bmpir	1000021315	8/29/96	6:00	0	<.25	0.603		0	<.027	0	<.045	0.665	
bmpir	1000021316	8/29/96	10:00	0.542		0	<.009	0.025		0	<.018	0	<.20
bmpir	1000021317	8/29/96	14:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000021632	8/29/96	20:00	11.486		0	<.009	0	<.011	0	<.018	0	<.2
bmpir	1000021633	8/30/96	2:00	11.373		0	<.009	0	<.011	0	<.018	0.266	
bmpir	1000021634	8/30/96	8:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.2
bmpir	1000021635	8/30/96	14:00	0	<.00	0	<.018	0	<.022	0	<.036	0	<.4
bmpir	1000026440	1/31/97	18:00	0	ND <.50	0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026441	1/31/97	22:00	1.7		0	ND <.011	0	ND <.014	0	ND <.022	0.22	
bmpir	1000026442	2/1/97	2:00	2.88		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026443	2/1/97	6:00	3.4		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026444	2/1/97	10:00	1.06		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026445	2/1/97	14:00	1.08		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026452	2/1/97	16:00	1.75		0	ND <.009	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026453	2/1/97	20:00	1.12		0	ND <.009	0	ND <.011	0	ND <.018	0.22	
bmpir	1000026454	2/2/97	0:00	0.87		0	ND <.009	0	ND <.011	0	ND <.018	0	ND <.20
bmpir	1000026455	2/2/97	4:00	0.81		0	ND <.009	0	ND <.011	0	ND <.018	0.24	
bmpir	1000026456	2/2/97	8:00	0.82			EST <.009	0	ND <.011	0	ND <.018	0	ND <.20
bmpir	1000026457	2/2/97	12:00	0.89			EST <.011	0	ND <.022	0	ND <.036	0.22	
bmpir	1000026462	2/2/97	18:00	1.07			EST <.009	0	ND <.011	0	ND <.018	0.26	
bmpir	1000026463	2/2/97	20:00	1.06			EST <.009	0	ND <.011	0	ND <.018	0.3	
bmpir	1000026464	2/3/97	2:00	1.12			EST <.009	0	ND <.011	0	ND <.018	0.23	
bmpir	1000026465	2/3/97	6:00	1.14			EST <.009	0	ND <.011	0	ND <.018	0.28	
bmpir	1000026466	2/3/97	10:00	1.28			EST <.009	0	ND <.011	0	ND <.018	0.22	
bmpir	1000026467	2/3/97	14:00	1.09		0	ND <.011		EST <.022	0	ND <.018	0.28	
bmpir	1000026468	2/3/97	18:00	2.14		0	ND <.009	0	ND <.011	0	ND <.018	0	ND <.20
bmpir	1000026469	2/4/97	0:00	2.16			EST <.009		EST <.011		EST <.018	0	ND <.20
bmpir	1000026470	2/4/97	6:00	1.85		0	ND <.009		EST <.011	0	ND <.018	0.24	
bmpir	1000026471	2/4/97	12:00	1.97		0	ND <.009		EST <.011	0	ND <.018	0.22	
bmpir	1000032683	6/13/97	18:00	0	<.28		C97-228	0	<.022		EST1.48	0	<.40
bmpir	1000032684	6/13/97	22:00	0	<.65		C97-228	0	<.011		EST.724	0	<.20

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
bmpir	1000032685	6/14/97	2:00	0	<1.65		C97-228	0	<.011		EST.733	0	<.20
bmpir	1000032686	6/14/97	6:00	0	<1.65		C97-228	0	<.011		EST.684	0	<.20
bmpir	1000032687	6/14/97	10:00	0	<1.65		C97-228	0	<.011		EST.396	0	<.20
bmpir	1000032688	6/14/97	14:00	0	<1.65		C97-228	0	<.011		EST.583	0	<.20
bmpir	1000032693	6/14/97	22:00	0	<3.45		C97-228		EST<.022		EST<.036	0	<.40
bmpir	1000032694	6/15/97	2:00	0	<1.65		C97-228		EST<.011		EST.36	0	<.20
bmpir	1000032695	6/15/97	6:00	8.45			C97-228	0	<.011	0.265		0	<.20
bmpir	1000032696	6/15/97	10:00	12.6			C97-228	0	<.022	0	<.036	0	<.40
bmpir	1000032697	6/15/97	14:00	5.78			C97-228	0	<.011	0	<.018	0	<.20
condr	1000021630	8/31/96	16:00		est <.5	0	<.009	0.027		0	<.018		est<.20
condr	1000023112	9/27/96	23:00	1.005		0.051		0	<.022	0	<.036	0	<.4
condr	1000023113	9/28/96	1:00	2.853		0	<.009	0	<.011	0	<.018	0.318	
condr	1000023174	10/5/96	0:00	1.968		0	<.009	0	<.011	0	<.018	0	<.2
condr	1000023175	10/5/96	2:00	1.274		0.014		0.018		0.02		0	<.2
condr	1000023176	10/5/96	4:00	0.855		0	<.009	0.014		0.018		0	<.2
condr	1000023177	10/5/96	6:00	0	<.5	0	<.009	0	<.011	0	<.018	0	<.2
condr	1000023178	10/5/96	8:00	0	<.5	0	<.009	0.014		0	<.018	0	<.2
condr	1000023179	10/5/96	10:00	0	<.5		EST<.009		EST.016		EST<.018	0	<.2
condr	1000023189	10/5/96	20:00	0	<.5	0	<.009	0	<.011	0	<.018	0.698	
condr	1000023190	10/6/96	0:00	2.089		0	<.009	0	<.011	0	<.018	0.649	
condr	1000023191	10/6/96	4:00	2.427		0	<.009	0	<.011	0	<.018	0.257	
condr	1000029148	3/11/97	8:00	1.15		0	<.011	0	<.022	0	<.036	0	<.40
conir	1000018214	4/16/96	4:00	2.29		0	<.009	0	<.011	0	<.018	0	<.20
conir	1000018213	4/16/96	16:00	4.54		0	<.009	0	<.011	0	<.018	0	<.20
conir	1000018215	4/17/96	4:00	10.9		0	<.009	0	<.011	0	<.018	0	<.20
conir	1000018455	5/16/96	0:00	7.27		0	<.009	0	<.011		IM	0.95	
conir	1000018456	5/16/96	3:00	1.76		0	<.009	0	<.011		IM	0	<.2
conir	1000018457	5/16/96	6:00	1.33		0	<.009	0	<.011		IM	1.01	
conir	1000018458	5/16/96	12:00	0	<.5	0	<.009	0	<.011		IM	0.95	
conir	1000018469	5/16/96	18:00	1.3		0	<.009	0	<.011		IM	1.23	
conir	1000018470	5/17/96	0:00	1.15		0	<.009	0	<.011		IM	0.85	
conir	1000018471	5/17/96	6:00	0.93		0	<.009	0	<.011		IM	0.86	
conir	1000018472	5/17/96	12:00	1.06		0	<.009	0	<.011		IM	0.85	
conir	1000018462	5/17/96	18:00	0	<.5	0	<.009	0	<.011		IM	0	<.2
conir	1000018463	5/18/96	0:00	2.36		0	<.009	0	<.011		IM	1.99	
conir	1000018464	5/18/96	12:00	1.28		0	<.009	0	<.011		IM	1.33	
conir	1000018473	5/18/96	18:00	0.92		0	<.009	0	<.011		IM	1.98	

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Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
conir	1000020803	8/18/96	16:00	1.83		0.217		0.024		0	<0.018	0.212	
conir	1000020858	8/18/96	20:00	1.25		0	<0.009	0	<0.011	0	<0.18	0	<0.20
conir	1000020859	8/18/96	23:00	0	<1.00	0.185		0	<0.022	0	<0.36	0	<0.40
conir	1000020860	8/19/96	2:00	0	<0.50	0.428		0.025			est<.018		est0.739
conir	1000020861	8/19/96	8:00	0.551		0	<0.009	0.025	<0.011		est<.018		est0.202
conir	1000020862	8/19/96	14:00	2.109		0	<0.009	0	<0.011		est<.018		est<0.20
conir	1000020947	8/19/96	20:00	1.9		0	<0.009	0	<0.011		est<.018		est0.369
conir	1000020948	8/20/96	2:00	0	<0.50	0	<0.009	0	<0.011		est<.018		est<0.20
conir	1000020949	8/20/96	8:00	4.74		0	<0.009	0.023			est<.018		est0.434
conir	1000020950	8/20/96	14:00	5.9		0	<0.018	0	<0.022		est<.036		est<0.40
conir	1000020966	8/20/96	20:00	0	<0.50	0	<0.009	0.032		0	<0.018	0.281	
conir	1000020967	8/21/96	2:00	0	<0.50	0	<0.009	0.025		0	<0.018	0	<0.20
conir	1000020968	8/21/96	8:00	0.722		0	<0.009	0.03		0	<0.018	0.212	
conir	1000020969	8/21/96	14:00	0.924		0	<0.009	0.025		0	<0.018	0	<0.20
conir	1000021095	8/26/96	18:00	0.531		0	<0.009		est<.011	0	<0.018		est<.2
conir	1000021096	8/26/96	22:00	3.06		0	<0.009		est<.011	0	<0.018		est<.2
conir	1000021097	8/27/96	2:00	1.299		0	<0.009		est<.011	0	<0.018		est<.2
conir	1000021098	8/27/96	6:00	0	<.5	0	<0.009		est<.011	0	<0.018		est<.2
conir	1000021099	8/27/96	10:00	0	<1.25	0	<0.0225		est<.027	0	<0.045		est<.5
conir	1000021100	8/27/96	14:00	0	<1.00	0	<0.018		est<.022	0	<0.036		est<.4
conir	1000021141	8/27/96	18:00	0	<.50	0	<.009		est<.011	0	<.018		est<.20
conir	1000021142	8/27/96	22:00	0	<.50	0	<.009		est<.011	0	<.018		est<.20
conir	1000021143	8/28/96	2:00	0	<1.00	0	<.009		est<.022	0	<.036		est<.40
conir	1000021144	8/28/96	6:00	0	<1.25	0	<.009		est<.027	0	<.045		est<.50
conir	1000021145	8/28/96	10:00	1.51		0	<.009	0	<.011	0	<.018		est<.20
conir	1000021146	8/28/96	14:00	1.194		0	<.009	0	<.027	0	<.045		est<.50
conir	1000021306	8/28/96	18:00	1.163		0	<.009	0	<.011	0	<.018	0	<.20
conir	1000021307	8/28/96	22:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.20
conir	1000021308	8/29/96	2:00	0	<.50	0.079		0.065	<.011	0	<.018	0	<.20
conir	1000021309	8/29/96	6:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.20
conir	1000021310	8/29/96	10:00	0	<.50	0	<.009	0.127	<.011	0	<.018	0	<.20
conir	1000021311	8/29/96	14:00	0	<.50	0	<.009	0.036		0.019		0	<.20
conir	1000021637	8/29/96	20:00	0	<.5		est<.009		est<.011		est<.018	0	<.2
conir	1000021638	8/30/96	2:00	1.904		0	<.009	0	<.011	0	<.018	0	<.2
conir	1000021639	8/30/96	8:00	0	<.5	0	<.009	0	<.011	0	<.018	0	<.2
conir	1000021640	8/30/96	14:00	0	<.5	0.882		0.085		0	<.018	0	<.2
conir	1000026427	1/29/97	18:00	2.29		0	ND <.018	0	ND <.022	0	ND <.036	0	ND <.40

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Pesticides

Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
conir	1000026428	1/29/97	22:00	0	ND <.50	0	ND <.02	0	ND <.025	0	ND <.040	0	ND <.44
conir	1000026429	1/30/97	2:00	2.69		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026430	1/30/97	6:00	2.77		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026431	1/30/97	10:00	1.63		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026432	1/30/97	14:00	1.31		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026434	1/30/97	18:00	2.22		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026435	1/30/97	22:00	1.21		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026436	1/31/97	2:00	0.99		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026437	1/31/97	6:00	0	ND <.50	0	ND <.018	0	ND <.022	0	ND <.036	0	ND <.40
conir	1000026438	1/31/97	10:00	2.02		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026439	1/31/97	14:00	2.55		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026446	1/31/97	18:00	2.83		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026447	1/31/97	22:00	1.28		0	ND <.018	0	ND <.022	0	ND <.036	0	ND <.25
conir	1000026448	2/1/97	2:00	1.1		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.40
conir	1000026449	2/1/97	6:00	0.79		0	ND <.018	0	ND <.022	0	ND <.036	0	ND <.25
conir	1000026450	2/1/97	10:00	1.85		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.40
conir	1000026451	2/1/97	14:00	0.73		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026458	2/1/97	18:00	0.89		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026459	2/2/97	0:00	1.18			EST<.009	0	ND <.011	0	ND <.018	0.24	
conir	1000026460	2/2/97	6:00	0.85			EST<.009	0	ND <.011	0	ND <.018	0	ND <.20
conir	1000026461	2/2/97	12:00	0	ND <.50		EST<.009	0	ND <.011	0	ND <.018	0.25	
conir	1000032689	6/14/97	2:00	0	<1.65		C97-228	0	<.011		EST.099	0	<.20
conir	1000032690	6/14/97	6:00	0	<1.78		C97-228	0	<.011		EST.306	0	<.20
conir	1000032691	6/14/97	10:00	0	<1.65		C97-228	0	<.011		EST.151	0.646	
conir	1000032698	6/14/97	14:00	10.1			C97-228	0	<.011	0	<.018	0	<.20
conir	1000032699	6/14/97	18:00	8.49			C97-228	0	<.011	0.071		0.515	
conir	1000032700	6/14/97	22:00	0	<1.64		C97-228	0	<.011	0	<.018	0	<.20
conir	1000032701	6/15/97	10:00	5.65			C97-228	0	<.011	0.097		0	<.20

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Site	Sample #	Date	Time	Prometryn value µg/L	Prometryn remark	Trifluralin value µg/L	Trifluralin remark	Comments
bmpdr	1000021631	8/31/96	16:00	0	<.06	0.054		
bmpdr	1000021727	8/31/96	18:00	0	<.06	0	<.05	
bmpdr	1000021728	8/31/96	20:00	0	<.06	0	<.05	
bmpdr	1000021729	9/1/96	0:00	0	<.06	0	<.05	
bmpdr	1000021730	9/1/96	2:00	0	<.06	0	<.05	
bmpdr	1000021731	9/1/96	4:00	0	<.12	0	<.10	
bmpdr	1000023114	9/27/96	23:00	0	<.06	0	<.05	
bmpdr	1000023115	9/28/96	1:00	0	<.06	0	<.05	
bmpdr	1000023180	10/5/96	0:00		EST<.06	0	<.05	
bmpdr	1000023181	10/5/96	2:00		EST<.12	0	<.1	
bmpdr	1000023182	10/5/96	4:00	0	<.06	0	<.05	
bmpdr	1000023183	10/5/96	6:00	0	<.06	0	<.05	
bmpdr	1000023184	10/5/96	8:00	0	<.06	0	<.05	
bmpdr	1000023185	10/5/96	10:00	0	<.06	0	<.05	
bmpdr	1000023192	10/5/96	20:00	0	<.06	0	<.05	
bmpdr	1000029149	3/11/97	9:00	0	<.06	0	<.05	
bmpdr	1000029150	3/11/97	11:00	0	<.06	0	<.05	
bmpdr	1000029151	3/11/97	13:00	0	<.06	0	<.05	
bmpir	1000018210	4/15/96	4:00	0	<.103	0	<.086	
bmpir	1000018211	4/15/96	16:00	0	<.060	0	<.05	
bmpir	1000018212	4/16/96	4:00	0	<.060	0	<.05	
bmpir	1000018439	5/14/96	6:00		IM	0	<.10	
bmpir	1000018440	5/14/96	9:00		IM	0	<.05	
bmpir	1000018441	5/14/96	12:00		IM	0	<.05	
bmpir	1000018442	5/14/96	18:00		IM	0	<.05	
bmpir	1000018443	5/15/96	0:00		IM	0	<.05	
bmpir	1000018444	5/15/96	6:00		IM	0	<.05	
bmpir	1000018445	5/15/96	12:00		IM	0	<.05	
bmpir	1000018451	5/15/96	18:00		IM	0	<.05	
bmpir	1000018452	5/16/96	0:00		IM	0	<.05	
bmpir	1000018453	5/16/96	6:00		IM	0	<.10	
bmpir	1000018454	5/16/96	12:00		IM	0	<.10	
bmpir	1000018465	5/16/96	18:00		IM	0	<.10	
bmpir	1000018466	5/17/96	0:00		IM	0	<.05	
bmpir	1000018467	5/17/96	6:00		IM	0	<.05	
bmpir	1000018468	5/17/96	12:00		IM	0	<.05	

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
bmpir	1000018459	5/17/96	18:00		IM	0	<0.05	
bmpir	1000018460	5/18/96	0:00		IM	0	<0.05	
bmpir	1000018461	5/18/96	12:00		IM	0	<0.05	
bmpir	1000019617	6/24/96	17:00		est<.2qc	0	<0.1	
bmpir	1000020510	8/14/96	8:00	0	<0.06	0.065		
bmpir	1000020511	8/14/96	12:00	0	<0.06	0.053		
bmpir	1000020512	8/14/96	16:00	0	<0.06	0	<0.05	
bmpir	1000020513	8/14/96	20:00	0	<0.06	0.07		
bmpir	1000020514	8/15/96	0:00	0	<0.06	0.094		
bmpir	1000020515	8/15/96	4:00	0	<0.06	0	<0.05	
bmpir	1000020678	8/16/96	9:00	0	<0.06	0	<0.05	
bmpir	1000020679	8/16/96	12:00	0	<0.06	0	<0.05	
bmpir	1000020680	8/16/96	15:00	0	<0.06	0	<0.05	
bmpir	1000020750	8/16/96	20:00	0	<0.12	0	<0.10	
bmpir	1000020751	8/17/96	2:00	0	<0.06	0	<0.05	
bmpir	1000020752	8/17/96	8:00	0	<0.06	0	<0.05	
bmpir	1000020753	8/17/96	14:00	0	<0.06	0	<0.05	
bmpir	1000020804	8/17/96	20:00	0.09		0	<0.05	
bmpir	1000020805	8/18/96	2:00	0	<0.06	0	<0.05	
bmpir	1000020806	8/18/96	8:00	0	<0.06		est<0.05	
bmpir	1000020807	8/18/96	14:00	0	<0.06	0	<0.05	
bmpir	1000020863	8/18/96	20:00	0	<0.06	0	<0.05	
bmpir	1000020864	8/19/96	2:00	0	<0.06	0	<0.05	
bmpir	1000020865	8/19/96	14:00	0	<0.06	0.066		
bmpir	1000020951	8/19/96	20:00	0	<0.06	0	<0.05	
bmpir	1000020952	8/20/96	2:00	0	<0.06	0.066		
bmpir	1000020953	8/20/96	8:00	0	<0.06	0.052		
bmpir	1000020954	8/20/96	14:00	0	<0.06	0.058		
bmpir	1000021089	8/26/96	18:00	0	<0.06	0.062		Broken
bmpir	1000021090	8/26/96	22:00	0	<.15	0	<.125	Broken
bmpir	1000021091	8/27/96	2:00	0	<.15	0	<.125	Broken
bmpir	1000021092	8/27/96	6:00	0	<.12	0.058		
bmpir	1000021093	8/27/96	10:00	0	<.06	0	<.05	
bmpir	1000021094	8/27/96	14:00	0	<.06	0	<.05	
bmpir	1000021135	8/27/96	18:00	0	ND <.06	0	<.05	
bmpir	1000021136	8/27/96	22:00	0	ND <.15	0	<.125	Broken
bmpir	1000021137	8/28/96	2:00	0	ND <.15	0	<.125	Broken

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
bmpir	1000021138	8/28/96	6:00	0	ND <.06	0	<.05	
bmpir	1000021139	8/28/96	10:00	0	<.06	0	<.05	
bmpir	1000021140	8/28/96	14:00	0	<.06	0	<.05	
bmpir	1000021312	8/28/96	18:00	0	<.06	0	<.05	
bmpir	1000021313	8/28/96	22:00	0	<.12	0	<.10	
bmpir	1000021314	8/29/96	2:00	0	<.06	0	<.05	
bmpir	1000021315	8/29/96	6:00	0	<.15	0	<.125	
bmpir	1000021316	8/29/96	10:00	0	<.06	0	<.05	
bmpir	1000021317	8/29/96	14:00	0	<.06	0	<.05	
bmpir	1000021632	8/29/96	20:00	0	<.06	0	<.05	
bmpir	1000021633	8/30/96	2:00	0	<.06	0	<.05	
bmpir	1000021634	8/30/96	8:00	0	<.06	0	<.05	
bmpir	1000021635	8/30/96	14:00	0	<.12	0	<.10	
bmpir	1000026440	1/31/97	18:00	0	ND <.075	0	ND <.06	
bmpir	1000026441	1/31/97	22:00	0	ND <.075	0	ND <.06	
bmpir	1000026442	2/1/97	2:00	0	ND <.075	0	ND <.06	
bmpir	1000026443	2/1/97	6:00	0	ND <.075	0	ND <.06	
bmpir	1000026444	2/1/97	10:00	0	ND <.075	0	ND <.06	
bmpir	1000026445	2/1/97	14:00	0	ND <.075	0	ND <.06	
bmpir	1000026452	2/1/97	16:00	0	ND <.06	0	ND <.05	
bmpir	1000026453	2/1/97	20:00	0	ND <.06	0	ND <.05	
bmpir	1000026454	2/2/97	0:00	0	ND <.06	0	ND <.05	
bmpir	1000026455	2/2/97	4:00	0	ND <.06	0	ND <.05	
bmpir	1000026456	2/2/97	8:00	0	ND <.06	0	ND <.05	
bmpir	1000026457	2/2/97	12:00	0	ND <.12	0	ND <.10	
bmpir	1000026462	2/2/97	18:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026463	2/2/97	20:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026464	2/3/97	2:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026465	2/3/97	6:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026466	2/3/97	10:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026467	2/3/97	14:00	0	ND <.12	0	ND <.10	RECEIVED PAST HOLDING TIME
bmpir	1000026468	2/3/97	18:00	0	ND <.06	0.25		
bmpir	1000026469	2/4/97	0:00		EST <.06	0.25		
bmpir	1000026470	2/4/97	6:00	0	ND <.06	0.19		
bmpir	1000026471	2/4/97	12:00	0	ND <.06	0.16		
bmpir	1000032683	6/13/97	18:00	0	<.12	0.247		RECEIVED WARM
bmpir	1000032684	6/13/97	22:00	0	<.06	0.292		RECEIVED WARM

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
bmpir	1000032685	6/14/97	2:00	0	<.06	0.15		RECEIVED WARM
bmpir	1000032686	6/14/97	6:00	0	<.06	0.182		RECEIVED WARM
bmpir	1000032687	6/14/97	10:00	0	<.06	0.212		RECEIVED WARM
bmpir	1000032688	6/14/97	14:00	0	<.06	0.154		RECEIVED WARM
bmpir	1000032693	6/14/97	22:00		EST<.12	0.352		
bmpir	1000032694	6/15/97	2:00		EST<.06	0.149		
bmpir	1000032695	6/15/97	6:00	0	<.06	0.083		
bmpir	1000032696	6/15/97	10:00	0	<.12	0.162		
bmpir	1000032697	6/15/97	14:00	0	<.06	0.081		
condr	1000021630	8/31/96	16:00	0	<.06		est<.05	
condr	1000023112	9/27/96	23:00	0	<.12	0	<.1	
condr	1000023113	9/28/96	1:00	0	<.06	0	<.05	
condr	1000023174	10/5/96	0:00	0	<.06	0	<.05	
condr	1000023175	10/5/96	2:00	0	<.06	0	<.05	
condr	1000023176	10/5/96	4:00	0	<.06	0	<.05	
condr	1000023177	10/5/96	6:00	0	<.06	0	<.05	
condr	1000023178	10/5/96	8:00	0	<.06	0	<.05	
condr	1000023179	10/5/96	10:00		EST<.06	0	<.05	
condr	1000023189	10/5/96	20:00	0	<.06	0	<.05	
condr	1000023190	10/6/96	0:00	0	<.06	0	<.05	
condr	1000023191	10/6/96	4:00	0	<.06	0	<.05	
condr	1000029148	3/11/97	8:00	0	<.12	0	<.10	
conir	1000018214	4/16/96	4:00	0	<.060	0	<.05	
conir	1000018213	4/16/96	16:00	0	<.060	0	<.05	
conir	1000018215	4/17/96	4:00	0	<.060	0.109		
conir	1000018455	5/16/96	0:00		IM	0	<.05	
conir	1000018456	5/16/96	3:00		IM	0	<.05	
conir	1000018457	5/16/96	6:00		IM	0	<.05	
conir	1000018458	5/16/96	12:00		IM	0	<.05	
conir	1000018469	5/16/96	18:00		IM	0	<.05	
conir	1000018470	5/17/96	0:00		IM	0	<.05	
conir	1000018471	5/17/96	6:00		IM	0	<.05	
conir	1000018472	5/17/96	12:00		IM	0	<.05	
conir	1000018462	5/17/96	18:00		IM	0	<.05	
conir	1000018463	5/18/96	0:00		IM	0	<.05	
conir	1000018464	5/18/96	12:00		IM	0	<.05	
conir	1000018473	5/18/96	18:00		IM	0	<.05	

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

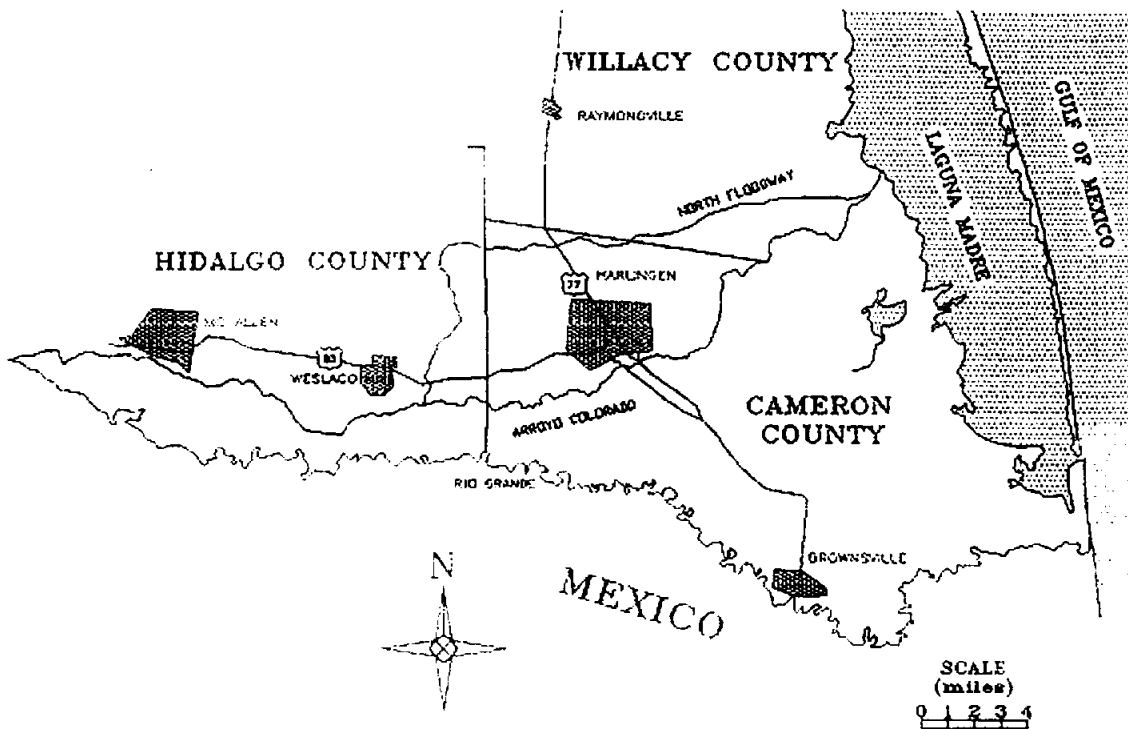
Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
conir	1000020803	8/18/96	16:00	0	<0.06	0	<0.05	
conir	1000020858	8/18/96	20:00	0	<0.06	0	<0.05	
conir	1000020859	8/18/96	23:00	0	<0.12	0	<0.10	
conir	1000020860	8/19/96	2:00	0	<0.06	0	<0.05	
conir	1000020861	8/19/96	8:00	0	<0.06	0	<0.05	
conir	1000020862	8/19/96	14:00	0	<0.06	0	<0.05	
conir	1000020947	8/19/96	20:00	0	<0.06	0.107		
conir	1000020948	8/20/96	2:00	0	<0.06	0	<0.05	
conir	1000020949	8/20/96	8:00	0	<0.06	0.053		
conir	1000020950	8/20/96	14:00	0	<0.12	0	<0.10	
conir	1000020966	8/20/96	20:00	0	<0.06	0	<0.05	
conir	1000020967	8/21/96	2:00	0	<0.06	0	<0.05	
conir	1000020968	8/21/96	8:00	0	<0.06	0	<0.05	
conir	1000020969	8/21/96	14:00	0	<0.06	0	<0.05	
conir	1000021095	8/26/96	18:00	0	<.06	0	<.05	
conir	1000021096	8/26/96	22:00	0	<.06	0	<.05	
conir	1000021097	8/27/96	2:00	0	<.06	0	<.05	
conir	1000021098	8/27/96	6:00	0	<.06	0	<.05	
conir	1000021099	8/27/96	10:00	0	<.15	0	<.125	
conir	1000021100	8/27/96	14:00	0	<.12	0	<.10	
conir	1000021141	8/27/96	18:00	0	<.06	0	<.05	
conir	1000021142	8/27/96	22:00	0	<.06	0	<.05	
conir	1000021143	8/28/96	2:00	0	<.12	0	<.1	
conir	1000021144	8/28/96	6:00	0	<.15	0	<.125	
conir	1000021145	8/28/96	10:00	0	<.06	0	<.05	
conir	1000021146	8/28/96	14:00	0	<.15	0	<.125	
conir	1000021306	8/28/96	18:00	0	<.06	0	<.05	
conir	1000021307	8/28/96	22:00	0	<.06	0	<.05	
conir	1000021308	8/29/96	2:00	0	<.06	0	<.05	
conir	1000021309	8/29/96	6:00	0	<.06	0	<.05	
conir	1000021310	8/29/96	10:00	0	<.06	0	<.05	
conir	1000021311	8/29/96	14:00	0	<.06	0	<.05	
conir	1000021637	8/29/96	20:00		est<.06	0	<.05	
conir	1000021638	8/30/96	2:00	0	<.06	0	<.05	
conir	1000021639	8/30/96	8:00	0	<.06	0	<.05	
conir	1000021640	8/30/96	14:00	0	<.06	0	<.05	
conir	1000026427	1/29/97	18:00	0	ND <.12	0	ND <.10	ONE BOTTLE RECEIVED BROKEN CAR# 97-0024

Results of Water Quality Monitor. g - Arroyo Colorado Project
Pesticides

Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
conir	1000026428	1/29/97	22:00	0	ND <.15	0	ND <.11	
conir	1000026429	1/30/97	2:00	0	ND <.075	0	ND <.06	
conir	1000026430	1/30/97	6:00	0	ND <.075	0	ND <.06	
conir	1000026431	1/30/97	10:00	0	ND <.075	0	ND <.06	
conir	1000026432	1/30/97	14:00	0	ND <.075	0	ND <.06	
conir	1000026434	1/30/97	18:00	0	ND <.075	0	ND <.06	
conir	1000026435	1/30/97	22:00	0	ND <.075	0	ND <.06	
conir	1000026436	1/31/97	2:00	0	ND <.075	0	ND <.06	
conir	1000026437	1/31/97	6:00	0	ND <.12	0	ND <.10	
conir	1000026438	1/31/97	10:00	0	ND <.075	0	ND <.06	
conir	1000026439	1/31/97	14:00	0	ND <.075	0	ND <.06	
conir	1000026446	1/31/97	18:00	0	ND <.075	0	ND <.06	
conir	1000026447	1/31/97	22:00	0	ND <.12	0	ND <.10	
conir	1000026448	2/1/97	2:00	0	ND <.075	0	ND <.06	
conir	1000026449	2/1/97	6:00	0	ND <.12	0	ND <.10	ONE BOTTLE IN TRANSIT
conir	1000026450	2/1/97	10:00	0	ND <.075	0	ND <.06	
conir	1000026451	2/1/97	14:00	0	ND <.075	0	ND <.06	
conir	1000026458	2/1/97	18:00	0	ND <.06	0	ND <.05	
conir	1000026459	2/2/97	0:00	0	ND <.06	0	ND <.05	
conir	1000026460	2/2/97	6:00	0	ND <.06	0	ND <.05	
conir	1000026461	2/2/97	12:00	0	ND <.06	0	ND <.05	
conir	1000032689	6/14/97	2:00	0	<.06	0.165		RECEIVED WARM
conir	1000032690	6/14/97	6:00	0	<.06	0.187		RECEIVED WARM
conir	1000032691	6/14/97	10:00	0	<.06	0.144		RECEIVED WARM
conir	1000032698	6/14/97	14:00	0	<.06	0.081		
conir	1000032699	6/14/97	18:00	0	<.06	0.103		
conir	1000032700	6/14/97	22:00	0	<.06	0.069		
conir	1000032701	6/15/97	10:00	0	<.06	0.115		

***Appendix C:
Arroyo Colorado
Water Quality
Web Site and
Report***

Arroyo Colorado Water Quality Database



As part of the project, *NPS Prevention in the Arroyo Colorado Watershed*, the Texas Agricultural Extension Service, under the direction of Dr. Guy Fipps, assembled a database of available water quality data on the Arroyo Colorado. This report summarizes the contents of the database and its suitability for accessing the water quality status and trends of the Arroyo Colorado. This web site is located on computers of the Agricultural Engineering Department at Texas A&M University.



Questions? Comments? Email us at g-fipps@tamu.edu

Texas A&M University System

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Maps of the Arroyo Colorado River

The following maps were created by Craig Pope at Texas A&M University. These maps detail the Arroyo, it's tributaries, and the tidal and non-tidal sections.

MAP 1 - ARROYO COLORADO

MAP 2 - ARROYO COLORADO, EASTERN PORTION

MAP 3 - ARROYO COLORADO, WESTERN PORTION

MAP 4 - ARROYO COLORADO, STATION LOCATIONS

Water Quality Indicators

Water Quality Indicators were analyzed for each of the three stations listed below. For Station 13036, data for each parameter was available for years 1984 to 1993. For Station 13071 and 13074, data for each parameter was available for years 1984 to 1994. Graphical charts for seven parameters are listed under the respective station.

Station 13036

Station 13071

Station 13074

(on Tributary Segment 2200) (on Tidal Segment 2201) (on Non-Tidal Segment 2202)

Dissolved Oxygen

Dissolved Oxygen

Dissolved Oxygen

Nitrate

Nitrate

Nitrate

Dissolved Phosphorous

Dissolved Phosphorous

Dissolved Phosphorous

Total Phosphorous

Total Phosphorous

Total Phosphorous

Sulfate

Sulfate

Sulfate

Fecal Coliform

Fecal Coliform

Fecal Coliform

Chloride

Chloride

Chloride

Arroyo Colorado River Water Quality Database

The Arroyo Colorado River Water Quality Database is now currently available as queriable on-line program or as a file that can be downloaded. The downloaded files are the original database files that were created with Paradox 4.0 and can be easily read with this version or a later version such as Paradox 7 for Windows 95 and Windows NT.

The water quality data is split into four databases, including one for each tidal and non-tidal segment of the river, one for the tributaries to the Arroyo Colorado River and one for a subsequent toxic study. The following links detail the information found in these databases.

[Watershed Station Listing by Location and Segment Identification](#)
[Field Descriptions of Files in Databases](#)
[List of Routine Water Quality Parameters in Database](#)

DATABASES

For On-line Query

[Database for Segment 2200](#)

[Database for Station Location for Segment 2200](#)

[Database for Segment 2201](#)

[Database for Station Location for Segment 2201](#)

[Database for Segment 2202](#)

[Database for Station Location for Segment 2202](#)

For Downloading

[Database for Segment 2200](#)

[Database for Station Location for Segment 2200](#)

[Database for Segment 2201](#)

[Database for Station Location for Segment 2201](#)

[Database for Segment 2202](#)

[Database for Station Location for Segment 2202](#)

[Database for Toxin Study](#)

[Database for Station Location for Toxin Study](#)

Analysis of the Arroyo Colorado Water Quality Database

FINAL REPORT

(<http://arroyo.tamu.edu/arroyo/progreport.html>)

October 1997

by

Guy Fipps, P.E.

Associate Professor and Extension Agricultural Engineer
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**PREPARED IN COOPERATION WITH THE U.S. ENVIRONMENTAL
PROTECTION AGENCY**

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from the U.S. Environmental Protection Agency
through the Texas Natural Resource Conservation Commission

EXECUTIVE SUMMARY

As part of the project: NPS Prevention in the Arroyo Colorado Watershed, the Texas Agricultural Extension Service assembled a database of available water quality data on the Arroyo Colorado, which is included on this Web Site. This report summarizes our analysis of the data base to determine its usefulness in defining water quality problems and trends in the Arroyo. Here we report on the long-term trends of 7 water quality indicators:

dissolved oxygen,
sulfate,
nitrate,
fecal coliform,
dissolved phosphorous,
total phosphorous,
and chloride;

and we review the toxic substance data.

While approximately 48 monitoring stations were used on the Arroyo during the period of record (1982-1994), only a few were used consistently and have complete sets of data. For this first analysis, we chose the three stations that had the most complete and longest periods of record. One station is located in the non-tidal reach, one in the tidal reach, and the third on the North Floodway, a tributary to the Arroyo.

We first compared the detected levels to the Surface Water Quality Criteria (SWQC). Since SWQC do not exist for phosphorous and nitrate, we used the Texas Natural Resource Conservation Commission's screening levels for total and dissolved phosphorous, nitrogen, and the safe drinking water standards for nitrate. The results were that all 7 parameters may be potential water quality problems in the Arroyo based on this criteria.

For the toxic substance data base, we found that most of the data is useless for determining water quality due to the sensitivity of the testing methods used; i.e., the lowest limit of the testing method is above the concentration found and above the standards established for aquatic life and human health protection. While the presence of about 55 substances were detected in the Arroyo during approximately 10 years of sampling and analysis, there were only two substances that exceeded standards, lead and cadmium, which occurred once in 1986 at one location.

Numerous analysis results from sediment and fish tissue samples are included in the database for which no standards exists. However, concentrations of 13 toxic substances appear elevated in the sediment and tissue samples. Sampling and analysis for toxic substances were performed erratically during the 10 year period considered here; and no trends can be determined.

INTRODUCTION

This study was conducted as part of the project *NPS Prevention in the Arroyo Colorado Watershed*, funded by the U.S. Environmental Protection Agency (EPA) through the Texas Natural Resource Conservation Commission (TNRCC) and the Texas State Soil and Water Conservation Board (TSSWCB). In addition to the Texas Agricultural Extension Service (TAEX), other participating agencies were the Texas Institute for Applied Environmental Research (TIAER), the Natural Resources Conservation Service (NRCS) and the Southmost Soil and Water Conservation District.

The project was better known as the "*Section 319 Arroyo Colorado Project*." Task 3.1 of the project work plan directed TAEX to organize available water quality data on the Arroyo Colorado into a database. This task was completed and the database is provided on this Web Site. The database is divided into two sections: routine water quality parameters and toxic substances. In this report, we examine 7 parameters which are often used as water quality indicators and for which sufficient analysis results were completed:

dissolved oxygen,
sulfate,
nitrate,
fecal coliform,
dissolved phosphorous,
total phosphorous, and
chloride.

In addition, we provide a summary analysis of the Toxic Substances Data Base.

WATER QUALITY DATA BASE

In assembling the Arroyo Colorado Database, we first contacted a number of state and federal agencies and requested any and all available water quality data collected for the Arroyo Colorado including data in electronic format and any written reports or publications. These contacts then lead to others. However, we limited our search to data files and publications that contain actual data that were not duplicated elsewhere.

The most extensive bibliography on water resources in the Lower Rio Grande Valley was put together by Judd (1994). A number of publications were found that contain actual water quality data and are included in Bibliography section of this progress report. Additional data requested but not provided to us: the *Coastal Monitoring Impact Study* conducted by the General Land Office, and *1993-94 Shrimp Farm Impacts Study and Coastal Fisheries Database* from the Texas Parks and Wildlife Department.

We found that most of the water quality data that has been collected since 1982 is already contained in the **Surface Water Quality Monitoring (SWQM) Paradox** database. This

database is a consolidation of water quality data collected by the TNRCC, USGS and International Boundary and Water Commission (IBWC), which is maintained by the TNRCC. From SWQM, we extracted the water quality data for the Arroyo Colorado and its tributaries and reorganized it into our database which is also in *Paradox* format which is located on this web site. In doing so, we simplified the database structure in order to facilitate the analysis of the information and developed a series of maps and tables to aid in its use.

Similarly the TNRCC's database on the *Rio Grande Toxic Substances Study for the Arroyo Colorado* was simplified and included in our database. It contains toxic substance data collected by the TNRCC from ten monitoring stations. The database contains some data from 1983, and data from 1986 to through 1994.

THE ARROYO COLORADO

The Arroyo Colorado flows through Hidalgo, Cameron and Willacy County in the Lower Rio Grande Valley of Texas into the Laguna Madre. The Arroyo Colorado waters include possible base flow from the Rio Grande River, urban runoff, agricultural runoff, irrigation return flow, municipal and industrial wastewater and effluent. Perennial flow is supported by municipal discharges from the cities of Mission, McAllen, Pharr, Donna, Harlingen, and San Benito (TDWR, 1981). During flood events, water is diverted from the Rio Grande into the Arroyo and North Floodway

Segment Numbers

See the Maps section of this Web Site for the location of the Arroyo and its three segments. The segment descriptions are as follows:

Segment 2200 identifies the tributaries to the Arroyo along segments 2201 and 2201, including the North Floodway. The North Floodway forks from the Arroyo in Hidalgo County below Weslaco, flows through the northwest portion of Cameron County into Willacy County, and joins the Arroyo near the Laguna Madre.

Segment 2201 (tidal segment) is east of FM. 510 and runs from a point 100 m downstream of Cemetery Road, south of Port Harlingen to the confluence with the Laguna Madre.

Segment 2202 (non-tidal segment) is west of F.M. 510. It runs from F.M. 2602 in Hidalgo County to a point 100 m downstream of Cemetery Road, south of Port **Harlingen Monitoring**

Stations

For routine monitoring, some 48 locations have been used for sampling of the Arroyo Colorado and tributaries over the period of record (see Appendix A and Table E-1). However, most of these locations were used for only for short periods of time and, in some cases, for single sampling events. Currently, 4 stations are being used for routine sampling and analysis: stations

13071, 13074, 13081 and 13782. For toxic analysis, a total of 10 stations have been used for various durations, although only 2 have been used consistently.

For this analysis, we chose the 3 stations that had the longest and most complete data sets of routine (i.e., not toxic) water quality data. These are:

Station 13036 on tributary segment 2200,
Station 13071 on tidal segment 2201, and
Station 13074 on non-tidal segment 2202.

WATER QUALITY PARAMETERS AND LEVELS IN THE ARROYO COLORADO

Routine Water Quality Parameters

Texas has established Surface Water Quality Criteria (SWQC) for many water bodies in the state based on designated uses (see Title 30, Chapter 307 of the Texas Administrative Code). The Arroyo Colorado is designated as "contact recreational," and SWQC have been established for 5 parameters on segment 2201 and for 7 parameters on 2202 (Table 1). Segment 2200, a tributary, has no SWQC. On the charts for Segment 2200 (see Charts section of this Web Site), we show the SWQC of segment 2202 to facilitate comparison of levels with other two segments of the Arroyo.

For a number of other parameters, the TNRCC has established "screening levels" which are used as a general indicator of potential water quality concerns. These are based on best professional judgement. For the parameters considered here, these are 0.1 mg/l for dissolved phosphorus, 0.01 for total phosphorus, and 1 mg/l for total nitrogen. For nitrates, we also used the EPA Safe Drinking Water Standard of 10 mg/l in our analysis..

Analysis Results by Individual Stations

In the Charts Section of this Web Site are figures which show the levels of each of the 7 parameters by station and sampling event during the period of record between 1982-1994. The actual sampling dates at each station varied from year to year. Location of the bars on these figures correspond to the dates the samples were taken. The results of this analysis are summarized below and in Table 2 and 3.

TABLE 1: Surface Water Quality Criteria (SWQC) for the Arroyo Colorado on Segment 2201 (Tidal) and Segment 2202 (Non-Tidal).

Parameter	Segment 2201	Segment 2202
Dissolved Oxygen (mg/L)	4.0	4.0
Temperature (F)	95.0	95.0
PH	6.5-9.0	6.5-9.0
Chloride (mg/L)	-----	1200
Sulfate (mg/L)	-----	1000
Total Dissolved Solids (mg/L)	-----	4000
Fecal Coliform (#/100 mL)	200	200

TABLE 2: Potential water quality problems in the Arroyo Colorado by segment number for 7 parameters considered in this report.

SEGMENT 2200 (NORTH FLOODWAY)	SEGMENT 2201 (TIDAL)	SEGMENT 2202 (NON-TIDAL)
Nitrate	Nitrate	Nitrate
Dissolved Phosphorous	Dissolved Phosphorous	Dissolved Phosphorous
Total Phosphorous	Total Phosphorous	Total Phosphorous
Sulfate	Sulfate	Sulfate
Chloride	Chloride	-----
-----	Dissolved Oxygen	Dissolved Oxygen
Fecal Coliform	-----	Fecal Coliform

Table 3: Comparison of 7 water Quality indicators to established screening criteria and standards in the Arroyo Colorado.

Sulfate levels at station 13036 (Floodway) exceeded the SWQC (non-tidal) in 8 of the 26 samples taken over the 10 years of record. Station 13074 had lower sulfate levels which exceeded the SWQC in only 3 of the 50 samples taken from 1982-1994. Sulfate levels for Station 13071 (tidal segment) had very high peaks, wide fluctuations in levels, and exceeded the SWQC 1000 mg/l (non-tidal criteria) in 37 of the 53 samples over the 13 years of record.

Chloride followed a similar pattern as sulfate. The non-tidal station 13074 only exceeded the SWQC two times during the 13 years of record. High chloride levels wide side fluctuations occurred at station 13071 (tidal), where only 5 of the samples were below the 1200 mg/l SWQC. Station 13036 (Floodway) had 12 out of 27 samples above the non-tidal SWQC.

Fecal coliform levels at station 13036 have fallen from peak levels (2000 to 3000 counts/100 ml) in 1985 and 1986 to well below the SWQC 1991 and 1992, but then rose again in 1993. At the tidal station 13071, only three samples were higher than the SWQC, the last occurring in early 1987. However, station 13074 (non-tidal) continues to show very high spikes of above 5000 counts/100 ml and large fluctuations.

Total **nitrogen** levels (ammonia + nitrate) nearly always exceed the TNRCC screening level of 1 mg/l. However, when compared to the EPA Safe Drinking Water Standards, nitrate values were almost always well below the 10 mg/l standard. Station 13036 recorded the highest nitrate levels and greatest fluctuations when compared to the other two stations.

Dissolved oxygen values never fell below the SWQC of 4 mg/l at station 13036 (Floodway) or station 13074 (non-tidal). However, at station 13071 (tidal), low dissolved oxygen levels occurred in 35 of the 132 samples taken over the 13 year period, and levels fluctuated from almost 0 to over 17 mg/l. A high frequency of low oxygen levels occurred most recently in 1992.

Dissolved phosphorous levels are compared to TNRCC screening levels since no SWQC or drinking waters standards exist for phosphorous. Relative low levels of dissolved phosphorous occurred at stations 13036 and 13071 (Floodway and tidal), although most samples exceeded this screening level. Station 13074 (non-tidal) saw consistently higher dissolved phosphorous levels, whose peaks have remained fairly constant since 1986.

Total phosphorous followed the same pattern as with dissolved phosphorous, with the lowest levels occurring at stations 13036 and 13071 (Floodway and tidal). Station 13074 (non-tidal) had the highest levels, with a single very high spike occurring in 1985, 1990, and 1994.

Correlation with Flow

We also examined the correlation of flow in the Arroyo to the detection levels of each parameter. We obtained flow measurement data from the International Boundary and Water Commission (IBWC) for stations 13071 (tidal) and 13074 (non-tidal). As no exact flow data is available for station 13036 (Floodway), we used the scale reported with the samples: 0 (no flow) to 5 (high flow).

This analysis was run for dissolved oxygen, fecal coliform, nitrate, sulfate, dissolved phosphorous and total phosphorous. The results are given in Table 3. No correlation existed ($R^2 < 0.1$, correlation $> \pm 0.4$) between flow and nitrate, dissolved and total phosphate, and fecal coliform.

Dissolved oxygen showed some correlation to flow at station 13036 with $R^2 = 0.19$ and correlation coefficient of 0.44. Flow vs. sulfate regression statistics give an $R^2 = 0.55$ and correlation coefficient of -0.75 suggesting that sulfate levels are consistent, thus concentrations increase with decreasing flow and vice-versa. However, to fully investigate the effect of flow on substance concentrations, a more rigorous sampling protocol should be implemented.

Table 4: Summary Table of Regression and Correlation Analysis for the Arroyo Colorado
(flow may be correlated to level detected for $R^2 > 0.1$ and correlation $> + 0.4$).

	Station Number					
	13036		13071		13074	
	<u>R square</u>	<u>Correlation</u>	<u>R square</u>	<u>Correlation</u>	<u>R square</u>	<u>Correlation</u>
Flow vs Dissolved Oxygen	0.1948	0.4414	0.0001	-0.0086	0.0868	-0.2946
Flow vs Fecal Coliform	0.0521	0.2283	0.0006	0.0257	0.0208	0.1444
Flow vs Nitrate	0.0417	0.2041	0.0172	0.1313	0.0013	-0.036
Flow vs Sulfate	0.0054	0.0732	0.3656	-0.6046	0.5602	-0.7485
Flow vs Dissolved Phosphorus	0.0009	0.0311	0.0001	-0.0032	0.0008	0.0286
Flow vs Total Phosphorus	0.1176	-0.3429	0.0004	-0.0206	0.0072	0.0849

TOXIC SUBSTANCES DATA BASE

The Toxic Substances Data Base (included on this Web Site) contains data collected by the TNRCC's *Rio Grande Toxic Substances Study for the Arroyo Colorado*. The data base contains data collected from ten monitoring stations in 1983 and 1986 through 1994. Here, we have restructured the data base to facilitate its use. Tables 5, 6 and 7 summarized our review of this data base.

For toxic substances, Texas has established standards for aquatic life protection (criteria in water for 34 substances) and for human health protection (criteria in water for water and fish for 60 substances). These can be found in Title 30, chapter 307 of the Texas Administrative Code (these regulations may be accessed through the INTERNET at TNRCC's Web Site).

Use of this data for evaluating the water quality status of the Arroyo is limited by the same factors discussed above for the surface water data. These include improper analytic method (i.e., lowest detection limit being above the standard) and erratic sampling frequency. For example, only 8 of the 37 substances analyzed for in Segment 2200 exceeded the test detection lower limit, 18 out of 49 for Segment 2201, and about 20 out of 55 for segment 2202. Of these, only 2 substances exceeded established standards: lead and cadmium, during one sampling event in 1986.

Numerous sediment and tissue samples were also taken and are reported in the data base. While no standards exist, the following substances appear elevated: for sediment, chlordane, DDE, PCB, oil and grease, Nickel, lead, DDT, dieldrin, zinc, silver; for tissue, chlordane, DDE, DDT.

Table 5. Toxic Substance Standards and Number of Substances Analyzed in the Arroyo Colorado Toxic Substance Data Base.
<p>STANDARDS EXIST FOR:</p> <p>Aquatic life protection - criteria in water 34 substances</p> <p>Human health protection - criteria in water for water and fish 60 substances</p>
<p>SUBSTANCES TESTED FOR:</p> <p>Segment 2202 - non-tidal segment 55 substances</p> <p>Segment 2201 - tidal segment 49 substances</p> <p>Segment 2200 - tributaries 37 substances</p>

Table 6. Analysis Results of the Arroyo Colorado Toxic Substance Data Base.		
Substances exceeding test detection "lower" limits		
	Sediment	Tissue
Segment 2202	18	20
Segment 2201	18	6
Segment 2200	8	0
Toxic concentrations, <u>in water</u> , that exceed standards		
Lead (07/14/1986)		
Cadmium (07/14/1986)		

Table 7. Toxic Substances in Sediment and Tissue Samples that Appear Elevated.	
<u>Sediment</u>	<u>Tissue</u>
Chlordane Lead	Chlordane
DDE DDT	DDE
PCB's Dieldrin	DDT
Oil & Grease Zinc	
Nickel Silver	

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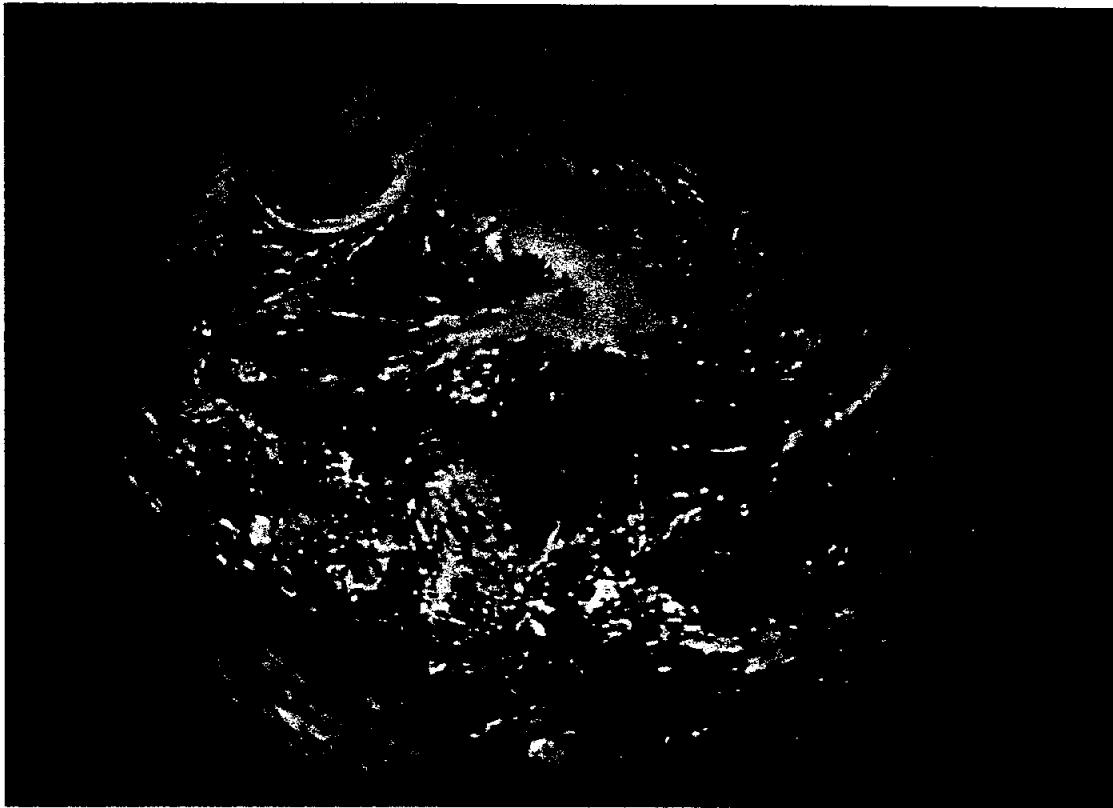
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***Appendix D:
Fact Sheets and
Educational Materials***

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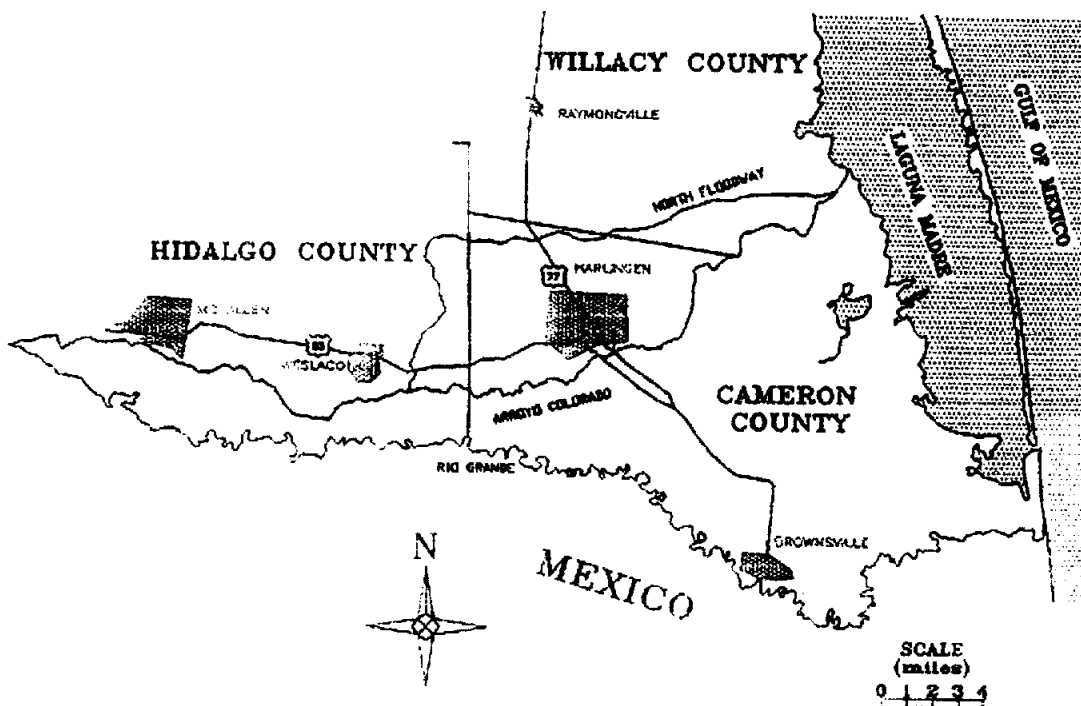
Help Yourself, Help the Environment

Today, you are learning about the benefits of no-till and reduced tillage for improving crop yields, reducing costs and maintaining soil productivity. However, there are other benefits - like helping our environment. Conservation tillage helps reduce runoff from agricultural land. Such runoff can carry with it sediment, nutrients and certain crop protection chemicals. By adopting a program including conservation tillage, and proper water and nutrient management, you will be doing your part to help protect the water quality in the Valley.



The Arroyo Colorado

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the Valley. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.



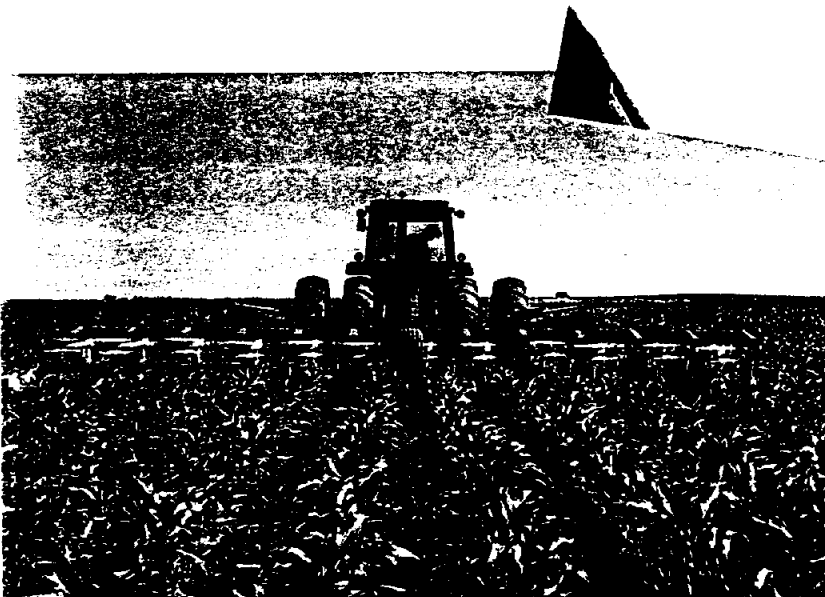
The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. Today's meeting is one of several educational events supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Texas Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at <http://arroyo.tamu.edu>.



Texas Agricultural Extension Service
The Texas A&M University System

Soil Fertility and Fertilizer Management



Prepared in Cooperation with the U.S. Environmental Protection Agency

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SOIL FERTILITY AND FERTILIZER MANAGEMENT¹

Mark L. McFarland and Guy Fipps

A sound soil fertility program is the foundation upon which a profitable farming business must be built. Agricultural fertilizers are necessary for producing abundant, high quality food, feed and fiber crops. Using fertilizer nutrients in the proper amounts and applying them correctly are both economically and environmentally important to the long-term profitability and sustainability of crop production. The fertilizer nutrients that have potential to become groundwater or surface water pollutants are nitrogen and phosphorus. In general, other commonly used fertilizer nutrients do not cause concern as pollutants.

Nitrogen

Nitrogen (N) is a part of all plant and animal proteins. Therefore, human survival depends on an abundant supply of N in nature. A crop well supplied with N can produce yields many times greater, with the same amount of water, than one starved for N. Properly fertilized crops use both N and water more efficiently, thus improving environmental quality and profitability.

The only part of the soil that supplies N to a crop is organic matter, since soil minerals do not contain N. In general, only 20 to 30 pounds per acre of N are supplied annually

for each 1 percent of organic matter in the soil. Since this N is released slowly and generally is not matched to crop needs, additional N is required. Soil testing is important to determine additional N needs. Relying on generalized recommendations for crop N requirements often results in poor N use efficiency and excessive application.

Decomposition of organic matter results in simpler inorganic N forms such as ammonium (NH_4^+) and nitrate (NO_3^-). Commercial inorganic fertilizers containing nitrogen also contain one or both of these forms. Both forms of nitrogen are soluble in soil water and readily available for plant uptake. Since clay soil particles are negatively charged and attract positively charged nutrients, much like a magnet.

Ammonium is positively charged and is attracted to and held by negatively charged soil particles, it does not readily move down through the soil with rainfall or irrigation water. Nitrates, on the other hand, are not attracted to soil particles, move downward with soil water and can be leached into groundwater.

Soil microbes can convert ammonium -N fertilizer to the nitrate form. Thus if nitrogen fertilizer is improperly applied to

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soils that have high infiltration rates, it can be leached through the root zone to contaminate groundwater. In addition these fertilizers can be dissolved and transported in rainfall runoff to contaminate surface waters. Excessive nitrate concentrations in water can accelerate algae and herbaceous plant growth in streams and lakes, resulting in oxygen depletion. Nitrate concentrations above a certain level in drinking water may be injurious to the health of some animals or human infants.

Even nontoxic nitrate levels may lower human resistance to environmental stresses and interfere with normal metabolism. Likewise, ammonia (NH_3) from fertilization, or from the natural breakdown of organic matter in lake bottoms, can kill fish.

Phosphorus

Phosphorus (P), like nitrogen, is essential for plant growth. Naturally occurring P exists as soluble inorganic phosphate ions, soluble phosphate, particulate phosphate or mineral phosphate. The mineral forms of phosphorus (calcium, iron and aluminum phosphates) are low in solubility and are readily adsorbed to clay particles.

The immediate source of phosphorus for plants is that which is dissolved in the soil solution. A soil solution containing only a few parts per million of phosphate ions is usually considered adequate for plant growth. The phosphate ions are absorbed from the soil solution and used by plants. These ions may be replaced from soil minerals, soil organic matter decomposition or applied fertilizers. Many soils have too little available P to support the needs of modern, high yielding crops without additional P fertilization.

Phosphate ions are not readily soluble. Most of the ions are either used by living plants or adsorbed to sediment, so the potential of their leaching to groundwater is low. That portion of phosphate bound to sediment particles is virtually unavailable to living organisms, but becomes available as it detaches from sediment. Only a small part of the phosphate moved with sediment into surface water is immediately available to aquatic organisms. However, additional phosphate can slowly become available through biochemical reactions. The slow release of large amounts of phosphate from sediment layers in lakes and streams could cause excessive algae blooms and excessive growth of herbaceous plants, thereby affecting water quality.

Nutrient Best Management Practices

Best management practices (BMPs) are defined as those practices or combinations of practices which are the most effective practical means of preventing pollution generated by nonpoint sources, or reducing it to a level compatible with good water quality. Because erosion and runoff are the two major ways nonpoint source pollutants move into surface water resources, practices which reduce erosion or runoff are considered BMPs. Similarly, practices which limit the buildup of nutrients that leach to groundwater and practices which ensure the safe use of agricultural chemicals also are considered best management practices. Both economic and environmental concerns should be considered.

1. Test the soil for nutrient status and pH to:
 - determine the amounts of additional nutrients needed to

reach designated yield goals, and the amount of lime needed to correct soil acidity problems;

- avoid excessive fertilization and reduce nutrient losses via leaching and runoff; and identify other yield limiting factors such as high levels of salts or sodium which may affect soil structure, infiltration rates, surface runoff and, ultimately, groundwater quality.

2. Base fertilizer applications on:

- realistic yield goals and moisture prospects;
- past fertilization practices; and previous cropping history.

3. Manage low soil pH by liming according to the soil test to:

- reduce soil acidity;
- improve fertilizer use efficiency;
- improve decomposition of crop residues and soil aggregate formation; and
- enhance the effectiveness of certain soil applied herbicides.

4. Time nitrogen applications to:

- correspond closely with crop uptake patterns;
- increase nutrient use efficiency; and
- minimize leaching and runoff losses.

5. Inject fertilizers or incorporate surface applications when possible to:

- increase accessibility of fertilizer nutrients to plant roots;
- reduce volatilization losses of ammonia N sources; and
- reduce nutrient losses from erosion and runoff.

6. Use animal manure and organic materials:

- when available and economically feasible;
- to improve soil tilth, water holding capacity, and soil structure; and
- to recycle nutrients and reduce the need for inorganic fertilizers.

7. Rotate crops when feasible to:

- improve total nutrient recovery with different crop rooting patterns;
- reduce erosion and runoff; and
- reduce diseases, insects and weeds.

8. Use cover crops and legumes where possible to:

- reduce erosion and nutrient losses;
- maintain residue cover on the soil surface; and

- replace part or all of crop needs for supplemental N fertilizer.

9. Control nutrient losses in erosion and runoff by:

- using appropriate structural controls;
- adopting conservation tillage practices where appropriate;
- properly managing crop residues;
- implementing other soil and water conservation practices where possible.

10. Skillfully handle and apply fertilizer by:

- properly calibrating and maintaining application equipment;
- properly cleaning equipment and disposing of excess fertilizers, containers and wash water; and
- storing fertilizers in a safe place.

Benefits of Soil Testing

Soil testing is the key to a sound fertility management program. A soil test is a chemical analysis of the soil which determines whether levels of essential plant nutrients are sufficient to produce a desired yield. When not taken up by a crop, some nutrients, particularly nitrogen, can remain in the soil or be lost from the soil by leaching or volatilization.

Soil Sampling

Proper soil sample collection is the most important step in obtaining a useful soil test. Samples must be taken very carefully to be representative of the area sampled.

Generally one “composite” soil sample should be collected from each uniform area (field or part of a field) of 10 to 40 acres. A composite sample is obtained by combining 10 to 15 individual soil cores taken randomly across each uniform area. These cores are placed in a clean plastic bucket, thoroughly mixed and then about 1 pint is sent to the laboratory for testing.

Individual soil cores can be taken using a regular spade, soil auger or soil sampling tube. First, scrape any plant litter from the surface and then make the core or boring 6 inches deep. When using a spade, dig a V-shaped hole and take a 1-inch slice from the smooth side of the hole. Next take a 1 by 1-inch core from the center of the shovel slice. By collecting 10 to 15 individual cores across the area, one can ensure that the soil test results will be representative of the site.

Clearly label each sample with a sample identification number. That number should correspond to the one listed on the sample identification sheet submitted with the sample to the laboratory. Place all samples, information sheets and payment into a sturdy paper box for shipment to the laboratory. Be sure to keep a record of the dates and locations the samples were collected. Complete sampling instructions and sample bags can be obtained from your local County Extension office.

To ensure good results, follow these recommendations:

- Submit samples immediately after

collection or allow them to air dry before storing.

- Never use heat to dry a sample.
- Keep accurate records of the area represented by each sample.
- Avoid sampling areas such as small gullies, depressions, terraced waterways and unusual spots.
- When sampling fertilized fields, do not sample in the fertilized band.
- Do not use metal buckets or containers with any residue in them since it might affect test results.

Soil test bags and instruction sheets may be obtained from the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory in College Station, Texas, or from various private laboratories across the state. Contact your local County Extension Agent for more information.

Interpreting Soil Test Results

On a typical soil test analysis, values for each nutrient are reported “very low”, “low”, “medium”, “high” or “very high”. These ratings do not evaluate the soil’s capacity to produce yields, but indicate the relative availability of the nutrient and likelihood of a crop response to fertilization. An economic response to fertilization can usually be expected for soils with very low nutrient levels, while those with high or very high levels will generally show little or no response.

The nutrient requirements of crops depend

largely on the type of crop and the yield goal. Based on many years of research, the average nutrient demands of most crops per unit of yield are reasonably well known. Table 1 shows the typical nitrogen fertilizer requirements for several major crops. When a crop and yield goal are specified on the soil information sheet, a fertilizer recommendation is provided.

Table 2 provides typical fertilizer recommendations for most major crops. These are maximum rates which would be recommended for a soil testing **very low** in nitrogen, phosphorus and potassium. Most fields will have higher residual levels of some nutrients, and fertilizer recommendations provided by the laboratory will be adjusted accordingly based on the soil test.

Other best management practices which should be followed when utilizing any fertilizer material include:

1. Time applications as closely as possible to periods of crop nutrient need.
2. Avoid applications when the ground is saturated or when the potential for heavy rainfall is great.
3. Band or incorporate fertilizers into the soil if possible to conserve nutrients and improve availability.
4. Avoid applications on steep (15%) slopes.
5. Use practices to control sediment losses.

Table 1. Suggested Nitrogen Fertilization Versus Crop Yield (Minus Nitrate-Nitrogen Identified by Soil Test)

Crop	Yield Goal/Acre	Pounds N/Unit Weight
Corn	75 - 99 bu	1.0/bu
	100 - 149 bu	1.1/bu
	150 - 200 bu	1.2/bu ¹
Cotton	0.5 - 2.5 bales	0.1/lb of lint ²
Grain Sorghum	1500 - 8000 lbs	2.0/cwt ³
Wheat	20 - 100 bu	1.5/bu grain only ⁴
		2.0/bu grazing/grain
Coastal Bermuda	1 - 6 cuttings	100/cutting
	(2 - 12 tons)	50/ton ⁵

¹One bushel of 8.4 and 9.0% crude protein corn would remove 0.75 and 0.80 lbs N, respectively. However, greater N recommendations (1.2 lbs) are required because of inefficiencies of N uptake and utilization.

²Actual fertilizer recommendations for cotton are 25% higher than crop requirements because of inefficiencies. (1 bale or 500 lbs x 0.1 = 50 lbs N, etc.)

³One cwt of 10.0 and 11.0% crude protein grain sorghum would remove 1.60 and 1.76 lbs N, respectively. However, recommendations are based on 2.0 lbs N/cwt.

⁴One bushel of 12.5% crude protein wheat removes about 1.2 lbs N. Because of inefficiencies of N uptake and utilization, 1.5 lbs N/bu is recommended for grain production only. However, 2.0 lbs N/bu is recommended for both grazing and grain production, followed by topdressing additional nitrogen at approximately 0.75 to 1.0 lb N/bu after livestock removal and prior to jointing.

⁵One ton of 12.5% crude protein hay contains 40 lbs of N (2000 x 2.0% N). However, higher N fertilization (50 lbs N/ton) is suggested because of inefficiencies of N uptake and utilization. Recommendations are based on the assumption that two (2) tons of forage are produced per cutting. If this is not the case, it may be better to base N fertilization on 50 lbs N/ton.

Table 2. Crop Yield Goals Versus Suggested Fertilization

CROP	Yield Goal	Suggested Fertilization ¹		
		N	P ₂ O ₅	K ₂ O
Corn	75 - 99 bu/A	(lbs/A) 75 - 100	(lbs/A) 60	(lbs/A) 80
	100 - 149 bu/A	110 - 165	80	130
	150 - 200 bu/A	180 - 240	80	140
Cotton	1.0 bale/A	40	40	30
	1.5 bales/A	60	60	50
	2.0 bales/A	80	80	80
	2.5 bales/A	100	80	80
Grain Sorghum	1500 - 2000 lbs/A	30 - 40	20	20
	2000 - 4000 lbs/A	40 - 80	40	80
	4000 - 6000 lbs/A	80 - 120	60	100
	6000 - 8000 lbs/A	120 - 160	80	120
Peanuts	dryland	20	40	40
	Irrigated	20	60	60
Soybeans	dryland/irrigated	10	40	125
Wheat (grain only)	20 - 30 bu/A	30 - 45 ²	20	20
	30 - 40 bu/A	45 - 60	40	30
	40 - 60 bu/A	60 - 90	40	40
	60 - 80 bu/A	90 - 120	60	60
	80 - 100 bu/A	120 - 150	60	60

¹Soils testing high in both phosphorus and potassium may require supplemental nitrogen only to attain yield goals. (Generally, no economic response to potassium fertilization would be expected west of I-35. Exceptions may be under intensively managed irrigated cropping systems or crops grown on sandy soils.)

²Grain Production Only: The above N rates for wheat are based on 1.5 lbs N/bushel. Apply approximately 1/3 of the total N suggested above preplant and topdress the remaining N prior to jointing.

Grazing and Grain Production: Apply 2.0 lbs N/bu preplant (for higher yield goals or on sandy soils, split N between preplant and late fall applications). Topdress with an additional 0.75-1.0 lb N/bu after livestock removal and prior to jointing.

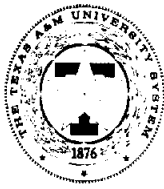
Table 2. (cont.) Crop Yield Goals Versus Suggested Fertilization

CROP	Yield Goal	Suggested Fertilization ¹		
		N (Lbs/A)	P ₂ O ₅ (Lbs/A)	K ₂ O (Lbs/A)
Alfalfa	Non-irrigated, annually	20	60	120
	Irrigated; 6T/A	20	100	160
	Irrigated; 8 - 12 T/A	20	140	200
Clover	Annually	20	80	120
	Sod seeded	20	80	120
	With ryegrass/small grains	40	80	120
Wheat	Light grazing	60 ²	60	60
	Moderate grazing	80	80	120
	Heavy grazing	80	80	120
Sorghum/ Sudan	1 cutting or light grazing	80 ³	40	40
	2 cuttings or med. grazing	80	60	60
	3 cuttings or heavy grazing	80	80	80

¹Generally, no economic response to potassium fertilization would be expected west of I-35. Exceptions may be under intensively managed irrigated forage systems or crops grown on sandy soils.

²Fertilizer rates suggested for grazing wheat pastures are for the higher rainfall, eastern one-third of Texas or where irrigation is possible. Dryland rates for all grazing intensities should be reduced by approximately 10% for each 50-mile increment west of I-35 to compensate for decreasing annual rainfall. Topdress with additional N in late fall and again in late winter at the following rates per acre per application: **Light** (50 lbs N), **Moderate** (60 lbs N) and **Heavy** grazing (80 lbs N) with adjustments for available moisture as suggested above for dryland production.

³Adjust fertilizer rates according to rainfall expectations as suggested above for wheat. For 2 cuttings of hay or moderate grazing, topdress with an additional 60 lbs N/A after first cutting or graze down. Where a third cutting or heavy grazing is possible, topdress with another 40 lbs N/A.



Texas Agricultural Extension Service

The Texas A&M University System

PEST AND BENEFICIAL ARTHROPODS

OF COTTON

IN THE LOWER RIO GRANDE VALLEY



**PEST AND BENEFICIAL ARTHROPODS
OF COTTON
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by

Alton N. Sparks, Jr. and John W. Norman, Jr.

Prepared in Cooperation with the U.S. Environmental Protection Agency

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**PEST AND BENEFICIAL ARTHROPODS
OF COTTON
IN THE LOWER RIO GRANDE VALLEY**

Alton N. Sparks, Jr. and John W. Norman, Jr.¹

Cotton is an important agricultural crop in the Lower Rio Grande Valley (LRGV). Our environment is well suited for cotton production and, unfortunately, is also well suited for the numerous arthropod pests that attack cotton and can severely impact yield. Cotton is subject to attack and damage by arthropods from planting through harvest; although the greatest potential for damage in the LRGV is from early squaring through boll maturity. In addition to the many arthropods that can damage cotton, cotton fields are also home to numerous arthropods which attack these pests. Although control of pests with insecticides is sometimes needed, good pest management relies on correct identification and a thorough understanding of the pests' biologies combined with a coordinated implementation of multiple management strategies. Insecticides generally are an effective tool in a management plan, but should be viewed as a last resort and used only when necessary.

Proper selection and use of pesticides, only when needed, will result in better control and lower production costs. However, there are other benefits - like helping our environment. Integrated pest management combined with proper pesticide application practices will ensure that the chemicals go and stay where they are needed, so as not to contribute to runoff¹ from agricultural land. Such runoff can carry with it sediment, nutrients and certain crop protection chemicals. By adopting a program including integrated pest management, proper chemical application, and sprayer calibration, you will be doing your part to help protect the water quality in the LRGV.

The purpose of this publication is to familiarize the reader with the appearance, basic biology and management of the major pests of cotton in the LRGV. Additional sections on occasional pests and beneficial organisms are included to aid in the identification of some of the more common of these organisms. For additional information on the pests of cotton and insecticide selection, should insecticide use become necessary, refer to Texas Agricultural Extension Service publications B-1210 (Managing Cotton Insects in the LRGV) and B-1210A (Suggested Insecticides for Managing Cotton Insects in the LRGV).

Early-season Pests

Early-season is the first few weeks of the season from planting until the first appearance of 1/3-grown squares. The major early-season insect pests of cotton in the LRGV are overwintered boll weevils, fleahoppers, and occasionally silverleaf whiteflies. Management of pests during the early season is targeted at obtaining early fruit set, which leads to early maturity and avoidance of potentially severe late season pest pressure. Occasional early-season pests include aphids, cutworms, thrips and spider mites.

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Mid-season and Late-season Pests

Mid-season is the 6-week fruiting period following the appearance of the first 1/3-grown squares. Proper crop management and frequent field inspection for pests and beneficials will eliminate unnecessary insecticide applications during this period. The major concern during this period is maintaining adequate fruit set and preserving beneficial insect populations.

Late-season is the remainder of the production season when the major concern is boll protection. Monitoring boll set and maturity will aid in making pest management decisions in the late-season period. The primary concern during this period is protection of immature bolls, that eventually will be harvested, but are young enough to still be susceptible to damage by insects.

The major mid- and late-season pests of cotton in the LRGV are the boll weevil and silverleaf whitefly. The bollworm/budworm complex is also considered a potential major pest at these times, but does not occur with the frequency of boll weevils and whiteflies. Occasional mid- and late-season pests include aphids, spider mites, beet armyworm, and loopers.

Fruit Development and Susceptibility to Damage

Cotton will generally start setting fruit at the fourth to sixth true leaf node. The process of fruit development starts in the terminal with the initiation of the development of squares. The size of square gives an indication of the age and susceptibility of the individual square to damage by certain pests. Square sizes generally referred to in pest management are pinhead squares, matchhead squares and 1/3 grown squares. Approximately 21 days after initiation of a square, blooming and fertilization occurs, resulting in formation of a boll. Once a boll is formed, it requires approximately 45 days for the fiber to develop and mature and the boll to open. Boll age also effects the susceptibility to damage by pests, with the greatest potential for damage occurring early in boll development.



Figure 1. Small square shown relative to pin head and match head.

MAJOR PESTS

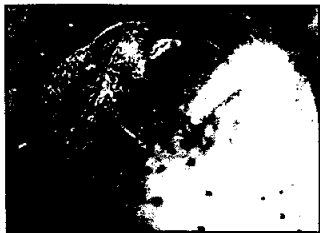


Figure 2. Adult boll weevil on a cotton square.

Boll Weevil

The adult weevil is about 1/4-inch long, grayish brown, and has a prolonged snout with chewing mouthparts at its tip. The presence of two distinct spurs on the lower part of the first segment of the front leg will distinguish the boll weevil from other weevils with which it might be confused. Both adult and immature weevils damage cotton. Adults cause damage by feeding on fruiting structures and through oviposition in these structures. Female weevils oviposit eggs in squares and young bolls. The female chews a hole into the square or boll (similar to



Figure 3. Boll weevil grub inside of a cotton square.

feeding) and then places an egg inside the fruit and refills the hole. This generally results in a characteristic 'wart' at the oviposition site. The egg hatches in about three days, and the legless white grub begins feeding within the fruit. Bracts on damaged squares typically open, which is referred to as flaring. Flared squares usually fall off the plant after the first molt of the grub, but may wither and dry while stuck on the plant. Grubs develop through three instars and a pupal stage within the fruit. The adult emerges inside the fruit and chews its way out. The complete life cycle requires 15 to

25 days. In managing weevils it is important to be aware that only the adults are exposed to potential control with insecticides. Thus, weevil management generally emphasizes cultural manipulations to reduce the density of overwintering adults and prevention or delay of damaging populations until late in the season. Once weevils become well established in a field, multiple insecticide applications generally are required to prevent severe economic damage.

Overwintered boll weevil

Overwintered boll weevils enter cotton early in the season. They occur in very low numbers and successful oviposition and development of larvae does not occur until the first squares are about 1/4-inch in diameter (1/3-grown). Insecticides applied at this time will help suppress boll weevil population buildup until after peak bloom. This allows the plant to set a large number of bolls early, while minimizing adverse effects on mid- and late-season beneficial insects.

Management and decision making. The value of making automatic insecticide applications for overwintered weevils has not been demonstrated in all areas of the Valley. **Research has shown that 40 overwintered boll weevils per acre can produce a damaging first generation population.** The first generation of boll weevils emerges and becomes active during the early fruiting period.

If weevils are noticed and the field has a history of heavy weevil infestation, early-season control applications may be economically feasible. The first application should be applied no earlier than 1/3-grown squares. The second application should be applied 3 to 5 days later if weevils continue moving into the field. When two early-season applications of insecticides were made in research and field tests in areas with heavy weevil pressure, damaging boll weevil levels were delayed 10 to 12 days. However, in other areas where similar spray tests were conducted, subsequent damaging weevil levels were not delayed because of unknown factors. These applications should not be made in fields where population buildup in past years has not occurred and weevils are not found. Avoid



Figure 4. Boll weevil oviposition puncture on a cotton square.

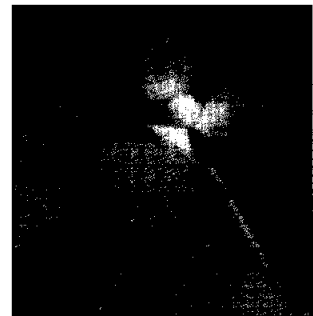


Figure 5. Flared cotton square.

making the final overwintered boll weevil insecticide application within 10 days of bloom to allow beneficial insect and spider populations time to reestablish in anticipation of bollworm infestations. Also, as boll weevils move into the edges of fields from overwintering sites, insecticide treatments may be effective when limited to treating along brush lines or corners where boll weevils are concentrating. By treating only these "hot spots," producers provide a refuge for beneficials in the non-treated areas and these beneficials can move back into treated areas more quickly.

Mid- and Late-season Boll Weevil

Management and decision making. To monitor damage by weevils, make weekly inspections of 100 1/3-grown squares randomly collected from four or more representative locations in the field from various portions of the plant. **If boll weevil-damaged square levels reach 15 to 25 percent from the time of squaring to peak bloom, the economic threshold level has been reached and an insecticide application is necessary.** Because insecticides only control adult weevils, established populations may require repeated treatments at 5-day intervals. This can also occur when weevil populations are high in a general area and field-to-field movement allows for rapid reinfestation. Under extremely heavy populations, it may be necessary to shorten application intervals to 3 days. However, if proper cultural considerations have been made under the short-season production system, the number of mid- to late-season insecticide applications can be greatly reduced and insecticide use may not be necessary.

Although boll weevils show a distinct preference for squares, they will also attack developing bolls. In late-season when few squares are present, young bolls can be damaged by weevils. The potential for damage to bolls decreases



Figure 6. Cotton boll size relative to days after bloom. (R. Parker)

with the age of the individual boll. Relatively little damage by weevils occurs in bolls more than 12 days old, particularly if an adequate supply of younger fruit forms is available. Thus, once the latest bolls targeted for harvest have reached 12 days, there no longer exists a reason to control weevils (for that years crop).

Cotton Stalk Destruction

One of the most useful tools available to cotton producers for management of boll weevils is the complete, timely destruction of cotton at the end of the season. Research has repeatedly shown that weevils entering overwintering at the end of the normal production season have much less chance of surviving the winter and infesting the next season's crop as compared to weevils that are allowed to feed on cotton in the fall and early winter months. Although adult weevils can feed on pollens from a variety of plants, only cotton provides the large acreage needed for development of large overwintering populations. Thus, through complete destruction of the crop residue at the end of the growing season, combined with elimination of escapes and volunteer cotton throughout the winter,

LRGV cotton producers can reduce the level of weevil populations they will battle the following season.

Silverleaf Whitefly

Silverleaf whitefly (SLWF), formerly known as sweetpotato whitefly (strain B), has been a pest of cotton in the LRGV since 1990. As adult whiteflies move into cotton fields, they congregate near the terminal of plants where most eggs are laid. The whitefly life cycle begins as a tiny yellow-orange, cigar-shaped egg laid on end in groups or clusters usually on the underside of leaves. The tip of the egg turns tan or dark prior to hatching. A small, nearly clear crawler stage emerges from the egg, finds a suitable place on the leaf, and inserts its needle-like mouthparts into the tissue and begins to feed. The crawler is the only

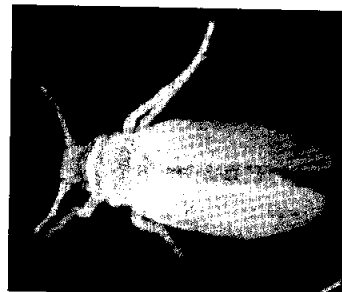


Figure 7. Silverleaf whitefly adult.

mobile immature. The scale-like immatures continue to feed, molt and grow as immobile insects until they emerge as adults (there is a short non-feeding pupal stage prior to adult emergence). The entire life cycle of SLWF lasts from 12 to 30 days, or longer, depending on temperature. On cotton, in the heat of the summer, SLWF can complete its life cycle in about 2 weeks. Because of its high reproductive rate (short life cycle, high egg production, high survival), SLWF can build large populations over a relatively short period.

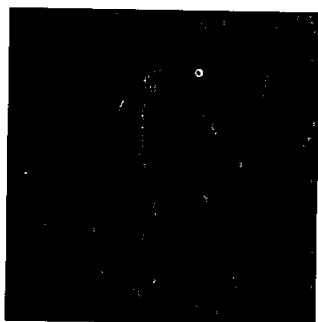


Figure 8. Silverleaf whitefly immatures on the underside of a cotton leaf.

Damage by SLWF ranges from honeydew deposits on open cotton lint, to reduced plant vigor, premature defoliation and reduced quantity and quality of lint. Experience in the LRGV has shown that in the heaviest infestations, yield reductions can be severe with losses of more than 500 pounds of lint per acre. Whiteflies also affect lint quality parameters such as reduced micronaire and length. Viral disease transmitted to cotton by SLWF has been a severe problem in some countries, but has not been a problem in Texas.

Management and decision making.

Sampling for SLWF is generally conducted by examining the underside of the third leaf from the top of the plant and counting adults, and/or counting immatures on the underside of the fifth leaf from the top. Older leaves are used for sampling immatures because whitefly immatures do not move during development and the plant continues to grow, thus, older nymphs are generally found lower on the plant than eggs and adults. **Currently, thresholds for whitefly treatment in cotton are not set. However, adult SLWF populations that have been observed to cause damage have ranged from 5 to 15 adults per leaf. Immature populations of 1 per square inch maintained for at least 6 weeks have been shown to cause yield losses of approximately 20 pounds per acre.**



Figure 9. Sooty mold fungus on cotton lint.

Cultural controls have provided the best approaches to management of the SLWF in the LRGV and form the foundation for effective integrated management of this pest. Proper management of SLWF in cotton actually starts in winter and spring vegetables and planting of the cotton. Management of the pest on alternate host crops (e.g. melons and cabbage) and separation of cotton from these source populations plays a key role in reducing potential problems in cotton. Timely destruction of vegetable crop residue that harbors active SLWF populations is one of the simplest methods of lowering potential levels of SLWF infestations in nearby cotton fields.

Host plant resistance is another key element of managing SLWF in cotton. In general, smooth-leaved varieties have far fewer whiteflies than hairy-leaved cotton varieties. Yield data from tests conducted in the LRGV show that higher yields can be achieved if smooth-leaved varieties are grown when SLWF are a threat to the crop.

Several species of naturally occurring parasites and predators will attack SLWF and can aid in the management of infestations. However, these beneficials must be preserved to maximize impact on SLWF populations. Applications of broad spectrum insecticides decrease the role of beneficial insects in managing SLWF. The impact of beneficials can also be easily overwhelmed by the presence of a nearby, large source population of SLWF.

Tests conducted in the LRGV during the last several years have shown that insecticidal control of SLWF populations is achievable, but is most efficacious and cost effective when used as part of an integrated management program. Insecticides alone have been found to be ineffective, or cost prohibitive, when populations are large and other management strategies are not being employed. Insecticidal control is not an effective stand-alone strategy for management of this pest. However, with a proper integrated management approach, it has been possible to manage SLWF in cotton in the LRGV with minimal insecticidal inputs.

Cotton Fleahopper

Adult cotton fleahoppers are about 1/8-inch long and pale green. Nymphs resemble adults but lack wings and are light green. They move very rapidly when disturbed. Adults move into cotton from host weeds when cotton begins to square. In the LRGV, wooly croton likely serves as the primary spring host for fleahoppers and elimination of these weeds can reduce pest pressure. Adults insert small yellowish-white eggs under the bark of the cotton plant. These eggs hatch in about one week. Both adults and nymphs suck sap from tender portions of the plant, including the terminal and small squares. Generally, squares are most susceptible to damage from pinhead through matchhead size. Small squares fed on by fleahoppers turn bronze to black and are shed by the plant. These are referred to as blasted squares.



Figure 10. Cotton fleahopper adult. (W. Sterling)

Management and decision making. After cotton begins producing the first small squares (4-to 6-leaf stage), examine the main stem terminal buds (about 3 to 4 inches of



Figure 11. Cotton fleahopper nymph on a small square.

plant top) of 25 randomly selected plants at each of four or more locations across the field. Examine plants closely as fleahoppers are highly mobile and will move around stems, effectively hiding from detection. **During the first 3 weeks of squaring, 15 to 25 cotton fleahoppers (nymphs and adults) per 100 terminals may cause economic damage.** As plants grow and increase fruit load, larger populations of fleahoppers may be tolerated without economic yield reduction. Fleahoppers are not considered a threat to cotton once sufficient bolls and large squares are present to produce the desired crop. Care



Figure 12. Small square damaged (blasted) by cotton fleahopper.

should be taken not to apply insecticides early in the blooming period as this will result in destruction of beneficial insects, possibly inducing an outbreak of bollworm or tobacco budworm.

Bollworm and Tobacco Budworm

Bollworm and tobacco budworm larvae are similar in appearance and cause similar damage. Full grown larvae are about 3/4 inches long and vary in color from pale green to pink or brownish to black, with longitudinal stripes along the back. They can be distinguished from other caterpillars attacking cotton by the presence of microspines covering their cuticle or skin. These microspines, which look like tiny spines under magnification, give these larvae a generally rough appearance.

Tobacco budworm and bollworm moths are attracted to and lay eggs in cotton that is producing an abundance of new growth. Moths usually lay eggs singly on the top of



Figure 13. Bollworm/tobacco budworm larvae on cotton leaf.

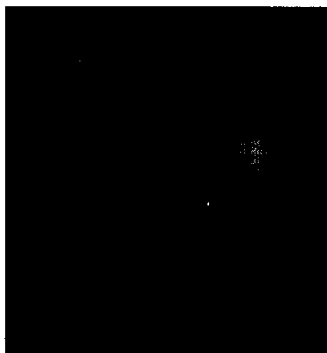


Figure 14. Bollworm/tobacco budworm eggs in cotton terminal.

young, tender terminal leaves in the upper third of the plant. Sometimes moths deposit eggs on squares, bolls, stems and, in general, on lower portions of the plant. This may occur when cotton plants are stressed and have little new growth or during periods of high temperatures and low humidity. Detection and control of eggs and small larvae are more difficult when eggs are deposited in these locations. Eggs are pearly white to cream colored and about half the size of a pinhead. These should not be confused with looper eggs which are flatter and usually laid singly on the underside of leaves. Eggs hatch in 3 to 4 days, turning light brown before hatching. Young larvae usually feed for a day or two on tender leaves, leafbuds and small squares in the plant terminal before

moving down the plant to attack larger squares and bolls. When small larvae are in the upper third of the plant they are most vulnerable to natural mortality and to insecticides.

Budworms are less susceptible to certain insecticides than bollworms, but generally are less numerous than bollworms until mid-June. Once applications of certain insecticides are used to control bollworms and budworms, the percentage of budworms in the population increases with each additional application because of higher mortality in the bollworm population. Aphid and other secondary pest infestations may increase following bollworm/budworm sprays, especially when pyrethroids are used.



Figure 15. Cotton square damaged by larvae.

Management and decision making. A major objective of a well-planned IPM program is to avoid having to treat for bollworm and tobacco budworm. Naturally occurring parasites, predators and, to a certain extent, weather conditions often suppress bollworm and budworm populations. Making applications of broad spectrum insecticides, for any reason, can eliminate beneficial arthropods and lead to the outbreak or resurgence of a variety of secondary or induced pests, including bollworm and budworm.

To monitor bollworm and budworm populations and damage, examine 100 green squares for larvae and damage, and 100 plant terminals for eggs and small larvae. In addition, examine a few plants in each field for eggs, larvae and damage on lower leaves, stems and fruiting forms. If eggs or larvae are found in these lower structures, intensify sampling in these areas.

Prior to initial chemical application. Fields should be scouted at least once a week prior to bloom and twice weekly thereafter. Fields should be divided into four quadrants and 25 green squares (1/2-grown or larger) should be selected at random in each quadrant. If fields are larger than 100 acres, additional scouting sites should be added to the sample.

Before bloom, the economic threshold is reached when larvae are present and 15 to 25 percent of the green squares are worm-damaged.

After bolls are present, the economic threshold has been reached when larvae are present and 8 to 10 percent of the green squares have been worm-damaged. When sampling, avoid selecting flared or yellowed squares.

After initiation of insecticide applications. The fields should be checked closely 2 to 3 days following the first application. **The economic threshold level has been reached when bollworm eggs and 6 to 10 young larvae are found per 100 terminals (3,000 to 4,000 young larvae/acre) and 5 percent of the squares and small bolls have been injured by small bollworms and budworms.** If control has not been obtained, another application will be necessary immediately.

Bt Transgenic cotton management. Research trials have determined the Bollgard® transgenic Bt gene technology to be highly effective against tobacco budworms. Bollgard® cottons

are also effective against cotton bollworm, but under heavy pressure from this species, insecticide treatment may be needed. **In Bt-cotton, the entire plant should be searched for tobacco budworm and bollworm larvae and injury.** Treatment should not be triggered by the presence of eggs alone, because hatching larvae must first feed on the cotton plant to receive a toxic dose. As in non-Bt cotton, predators and parasites are very important in reducing the number of eggs and larvae, and they complement the control provided by these varieties.

The use of a non-Bt cotton refuge is a requirement for planting Bt cotton and is an important component of resistance management. For additional information on the management of Bt cotton, refer to L-5169, "Bt Cotton Technology in Texas: A Practical View," available from your county Extension office.

OCCASIONAL PESTS

This section is not intended to provide the detailed information provided for major pests, but should serve to familiarize readers with some of the more common occasional pests and the type of damage they cause. These pests generally are considered to be secondary or induced pests, but can occur without any apparent causal factor.

Aphids

Two species of aphids, or plant lice, feed on cotton plants: the cotton or melon aphid and the black cowpea aphid. Aphids are small, mobile, soft bodied insects with piercing-sucking mouthparts for feeding on the sap of plants. They are usually found in colonies on the underside of leaves, on stems and in terminals. Aphids can be recognized by their pear-like shape and the pair of cornicles at the end of their abdomen. The cornicles are tube-like structures from which aphids excrete honeydew as they feed. Most adults do not have wings. Immature stages look like small adults. The cowpea aphids are shiny black with white patches on the legs and are common on seedling plants. Cotton aphids range in color from light yellow to dark green to almost black. Cotton aphids are also generally an early-season problem, but can occur at any time in the season. Aphid populations can increase rapidly following applications of certain insecticides, particularly the pyrethroid insecticides.



Figure 16. Cotton aphids on underside of cotton leaf.

Heavy prolonged infestations of aphids can cause younger leaves to curl downward, older leaves to turn yellow and shed, and can reduce yield quality and quantity. The honeydew associated with infestations occurring after bolls open can result in stained, sticky cotton of lower quality. This cotton can be difficult to harvest and process at the mill.

Fortunately, natural control by unfavorable weather, predators, parasites and pathogens generally are

effective at holding aphid populations below damaging levels, and can be effective at eliminating heavy infestations. Parasites and pathogens associated with aphids can be particularly effective in reducing or eliminating heavy populations, but may require more time to affect these populations than is acceptable.

Cutworms

The first sign of cutworm damage generally is a reduction in seedling stand, with plants cut off near the soil surface. The caterpillars are often missed because they feed primarily at night and hide in the soil during the day. Cutworms which attack cotton are brownish caterpillars that grow to about one inch long. Control of cutworms is only needed if plant stand density is threatened during the seedling stage. Cutworms are more of a problem in previously fallow fields, and keeping fields as weed-free as possible for 3 weeks prior to planting will minimize cutworm problems.

Thrips

Thrips are minute (about 1/16 inch), slender-bodied insects. Adults have four long wings fringed with long hairs. Immatures look like adults without wings. Thrips can attack cotton at any point in the season. Problems in seedling cotton in the LRGV generally occur in fields planted near maturing onion fields. As the onions mature and dry down, the thrips move into nearby fields in large numbers and can stunt seedling plants. This situation may justify use of a protective application of a systemic insecticide at planting. Later in the season, thrips are frequently encountered in the blooms and can be extremely difficult to control. Fortunately, thrips generally are not of economic importance late in the season.

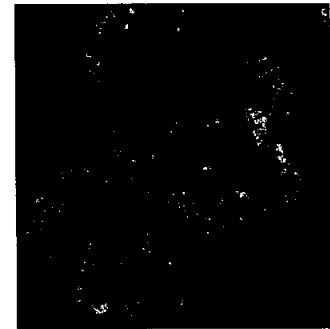


Figure 17. Cotton seedlings damaged by thrips.(A. Knutson)

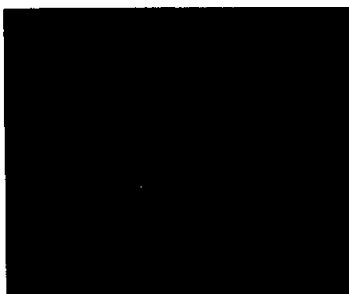


Figure 18. Spidermites and associated leaf speckling damage on underside of cotton leaf.

Spider mites

Spider mites are not insects. They are minute arthropods (about 1/60 inch in length). Like their close relatives, the spiders, spider mites have eight legs. They also produce silk threads which can form a web over entire plants when they reach heavy densities. Spider mites infest the underside of leaves where they feed on plant sap, and they may also infest bracts of squares and bolls. The damage they cause to plant cells first appears as yellowish-brown speckling of leaves. Heavy infestations can cause leaf discoloration (bronzing) and defoliation and cause bracts to desiccate and squares or small bolls to shed. Spider mites generally are more of a problem in dry weather and along field margins, particularly near dusty roads.

Loopers

Loopers are large caterpillars which get their common name from the characteristic looping action as they crawl. They can be distinguished from most other caterpillars by the presence of only two pairs of abdominal prolegs (plus the anal pair), whereas, most other common caterpillars in cotton will have four pair of abdominal prolegs (plus the anal pair). Their eggs are laid singly, mainly on the lower surfaces of the leaves. The eggs are commonly confused with bollworm/budworm eggs but are more flattened. Loopers are defoliators, with feeding damage characterized by leaf ragging or large holes in the leaves. Loopers are primarily a late-season pest in the LRGV, but can occur throughout the season. Looper larvae are often killed by disease before economic foliage loss occurs. Removal of leaf tissue by loopers just prior to application of defoliant can interfere with crop termination.

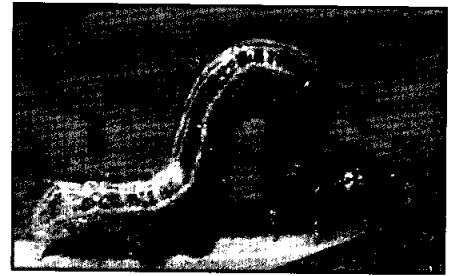


Figure 19. Looper larvae on cotton leaf.



Figure 20. BAW egg mass on underside of cotton leaf.

Beet Armyworm

Beet armyworm (BAW) eggs generally are laid on the underside of cotton leaves in masses and are covered by whitish scales from the moths abdomen. The early instar larvae feed together on leaves causing characteristic damage symptom often referred to as a "hit". The third instar larvae begin to disperse and become more solitary.

Larvae skeletonize leaves rather than chewing large holes in them. During early-season infestations, larvae feed on leaves and terminals. During late-season infestations, larvae will feed on leaves, terminals, squares, blooms and young bolls. Recent history with this pest has shown that severe BAW outbreaks depend on a variety of factors, with the one factor under producer control being the use of

early season organophosphate or pyrethroid insecticides. These broad spectrum insecticides eliminate the beneficial arthropods that apparently keep BAW under control, and if other conditions are favorable for the BAW, can lead to large pest population increases.

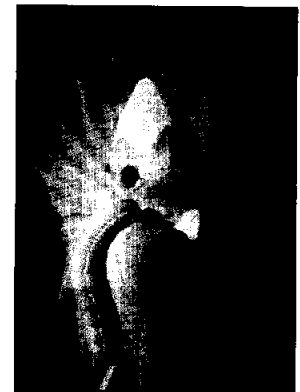


Figure 21. BAW larvae and damage on large cotton square.(A. Knutson)

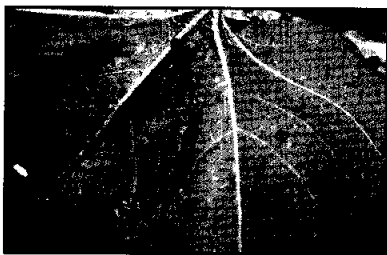


Figure 22. Young BAW larvae and feeding damage ("hit").

BENEFICIAL ORGANISMS

There are a variety of beneficial organisms that play key roles in management of pests in cotton. These organisms can prevent outbreaks of occasional pests and aid producers in management of most key pests. This section is intended to provide aid in identifying some of the more common beneficial organisms that play a role in the cotton ecosystem in the LRGV. For a more complete reference on this subject, refer to Texas Agricultural Extension Service publication no. B-6046, *Recognizing the Good Bugs in Cotton: Field Guide to Predators, Parasites and Pathogens Attacking Insect and Mite Pests of Cotton*.

The beneficial organisms discussed can be divided into three categories - predators, parasites and pathogens. Predators are organisms that kill and consume more than one prey to complete their development, and they are free-living as immatures and adults. Predators typically are not host-specific and may attack both pest and beneficial prey. Parasites destroy a single prey (host) to complete development, living in or on their host during immature development and are free-living only as adults. Many of the flies and wasps found in cotton fields are parasites of other arthropods in cotton. Most parasites are host-specific, attacking only a single species or a small closely related group of host species. In addition to parasitization of hosts, many parasite adults will kill and feed on hosts. Pathogens are organisms that cause disease. Most insect pathogens are fungi or viruses. Some pathogens are host-specific while others affect large groups of insects (i.e. caterpillars).

Predators

Lady beetles

There are several species of lady beetles found in cotton, with most being brightly colored round or oval beetles. Clusters of bright yellow, 1/8-inch long, football-shaped eggs are laid on the plant or on debris on the soil. Larvae are alligator-shaped with blue to black bodies with yellow or orange markings, except for one group which have white fuzzy appearing larvae. Both adults and larvae feed primarily on aphids, but will also prey on eggs and small caterpillars.

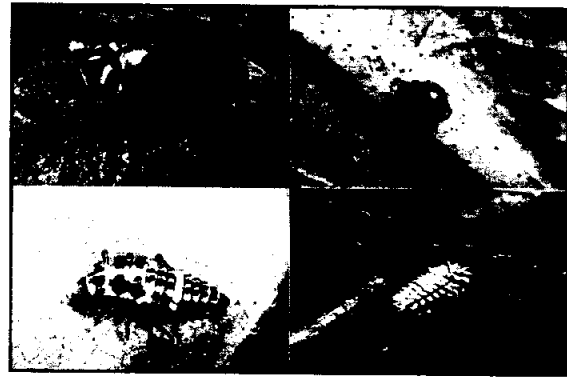


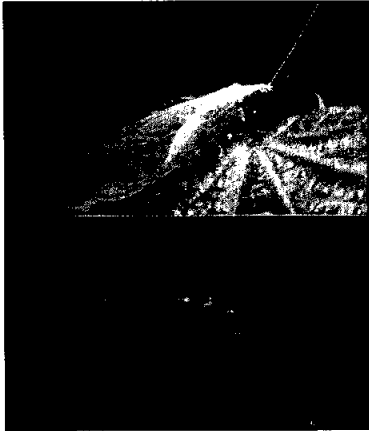
Figure 23. Lady beetle adults and larvae.



Figure 24. Big-eyed bug adult.

Big-eyed bugs

The big-eyed bugs' name comes from its characteristic broad head and large, bulging eyes. The color varies with species and age, but both adults and nymphs are readily identified by their eyes. Adults are about 1/8 inch long. Both adults and nymphs are predaceous and feed on a variety of cotton pests including moth eggs and small larvae, aphids, whiteflies, and spider mites.



Green lacewings

Adults are delicate, slender green insects (about 3/4-inch long) with long antennae and clear wings laced with veins. Eggs are laid on long slender stalks attached to leaves or stems. The larvae are alligator-shaped with long sickle-shaped mandibles projecting from the head. They pupate inside a spherical, white cocoon, which is often mistaken for a spider egg mass. Larvae of green lacewings prey on aphids, mites, whiteflies, and eggs and small larvae of lepidopterous pests. They will also feed on other beneficial organisms, including other lacewing larvae.

Figure 25. Green lacewing adult and larvae.

Minute pirate bug and insidious flower bug

Adults are small (1/8-inch long). They are black with a white X pattern on the back, and have a prominent, forward-projecting beak. Young nymphs are yellow-orange with a distinct orange gland in the abdomen. Later instar nymphs are tan to dark brown. Both adults and nymphs prey on aphids, thrips, mites, whiteflies, and eggs and small larvae of caterpillar pests.



Figure 26. Minute pirate bug adult. (W. Sterling)



Figure 27. Damsel bug adult.

Damsel Bugs and Assassin Bugs

Damsel bugs and assassin bugs are predatory bugs. They have piercing-sucking mouthparts and front legs modified for grasping prey (slightly enlarged femora and raptorial). Damsel bugs generally are smaller and less colorful than assassin bugs, but both predators can inflict a painful bite. Damsel bugs feed on a wide variety of prey including moth eggs and small larvae, aphids, fleahoppers, and whiteflies. Assassin bugs feed on

mobile prey including caterpillars, aphids and fleahoppers. Assassin bugs are one of the few predators that can prey on large caterpillars and adult boll weevils. Both damsel bugs and assassin bugs will attack other predators.



Figure 28. Assassin bug adult.



Figure 29. Syrphid fly larvae and aphids.

Syrphid flies

Adult syrphid flies most commonly encountered in cotton in the LRGV are small (about 1/4 inch) black flies with yellow markings (striped abdomen). The predaceous larvae are green to brown slug-like maggots. The head is located at the small end of the tapered body. Syrphid fly larvae pierce their prey and suck out body fluids. They are generally found feeding on aphids, but may also consume moth eggs and small larvae.

Spiders

A wide variety of spiders can be found in cotton, including lynx spiders, crab spiders and jumping spiders. The key predatory spiders in cotton do not catch their prey in a web, but are active, aggressive hunters which chase their prey or hide in wait and ambush their prey. Spiders feed on a variety of pests including fleahoppers, caterpillars and boll weevil adults, and they will occasionally feed on beneficial arthropods as well.



Figure 30. Spider.

Parasites

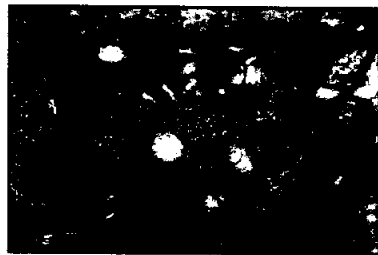


Figure 31. Parasitized aphids (mummies) on cotton.

Aphid parasites

The most common parasite of aphids in cotton is *Lysiphlebus testaceipes*. The presence of aphid parasites is most readily seen in the development of aphid mummies in the field. Aphid mummies are dead swollen aphids stuck to leaves. The mummies are tan to gold in color and contain a developing parasite or have a circular hole cut in the top from which the adult wasp emerged. This parasite often plays an important role in reducing or eliminating aphid populations.

Moth egg parasites

Trichogramma wasps are extremely small parasites which develop inside the eggs of moths and butterflies, and are the most abundant egg parasites of moths in cotton. They lay their eggs inside of the eggs of a variety of moths including bollworm, budworm and loopers. Parasitized eggs turn black as the wasp develops within. In healthy eggs, the dark head capsule of the developing larvae is seen as a dark spot, but can be distinguished from a parasitized egg which turns a uniform dark color.

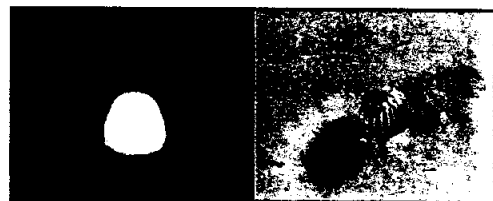


Figure 32. Healthy (white) and parasitized (dark) caterpillar eggs.

Caterpillar parasites

A wide variety of wasps and flies parasitize caterpillars in cotton. Most are internal parasites, which means that the larvae develop inside of the host. Estimation of parasite activity within a field is generally difficult, as parasitized larvae do not always show external signs of parasitism.

Silverleaf whitefly parasites

A variety of native and introduced parasites attack whiteflies in cotton in the LRGV. The most abundant are *Eretmocerus* and *Encarsia* species. The adult parasites are extremely small and are not likely to be noticed. The most apparent signs of parasite activity are seen by observing older whitefly nymphs and pupal cases. Parasitized whiteflies will turn black or the developing parasite can be seen through the cuticle of the whitefly, depending on the parasite involved. Pupal cases of parasitized whiteflies will have a hole chewed through the top where the adult parasite emerged. Significant whitefly mortality can also occur from host feeding, where the parasite stings the whitefly nymph and feeds on the fluids that flow out.



Figure 33. Silverleaf whitefly nymph with parasite exit hole.

Diseases

Cotton Aphid Fungus

Given enough time, a fungus disease generally breaks out in high density aphid populations. This fungus disease can eliminate infestations in 7 to 10 days. Aphids recently killed by the fungus, *Neozygites fresenii*, are covered with a velvety white to light gray growth. Aphid infestations should be monitored for presence of this disease prior to any pesticide application to evaluate the potential for avoiding the application.



Figure 34. Caterpillars showing disease symptoms. (W. Sterling)

Diseases of Caterpillars

Caterpillars can be attacked by a variety of fungal and viral diseases. Common fungi attacking caterpillars include *Beauveria bassiana*, *Nomuraea rileyi*, and *Erynia* species. Caterpillars infected by these fungi die within a few days as the fungi grow throughout their bodies. These larvae remain attached to the plant and the fungi grows and sporulates externally, giving the dead larvae a fuzzy appearance. In general, fungal diseases attack a variety of caterpillars, and *Beauveria* will attack other types of insects as well. Common viral diseases of caterpillars are nuclear polyhedrosis viruses (NPV), also called baculoviruses. Larvae killed by NPV's are dark and limp and generally hang from near the top of the plant.

The cuticle of these larvae is easily ruptured, releasing a cloudy liquid which contains millions of virus particles. NPV's are generally host specific, attacking only one or a few species.

THE ARROYO COLORADO

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the LRGV. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

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Table 2. (cont.) Fertilization of Warm Season Perennial Grasses. Note: Spring topdress

Forage Crop	Topdress in Spring N-P ₂ O ₅ -K ₂ O	Additional Fertilizer
	Lbs/A	
Coastal Bermuda (grazing)	60-50-90	Topdress with 60 lbs N/A after each 4-6 week graze down
Coastal Bermuda (1 hay cutting plus grazing)	100-50-150	Topdress with 60 lbs N/A after each 4-6 week graze down
Coastal Bermuda (3 hay cuttings)	100-100-300*	Topdress with 100 lbs N/A after each hay cutting
Coastal Bermuda (4 to 6 hay cuttings)	100-130-400*	Topdress with 100 lbs N/A after each hay cutting
Common Bermuda (1 A.U. per 1.5-2.0 A)	60-30-50	Topdress with additional 40 lbs N/A as needed.
Common Bermuda (1 A.U. per 1.0-1.5 A)	60-50-80	Topdress with 60 lbs N/A after each 4-6 week graze down
Common Bermuda (1 hay cutting plus grazing)	70-50-90	Topdress with 60 lbs N/A after each 4-6 week graze down
Common Bermuda (3 hay cuttings)	70-60-180	Topdress with 70 lbs N/A after each hay cutting
Common Bermuda (4-6 hay cuttings)	70-80-250*	Topdress with 70 lbs N/A after each hay cutting
Bahia Grass (1 A.U. per 1.5-2.0 A)	60-30-50	Topdress with additional 40 lbs N/A as needed
Bahia Grass (1 A.U. per 1.0-1.5 A)	60-50-80	Topdress with 60 lbs N/A after each 4-6 week graze down
Bahia (1 hay cutting plus grazing)	70-50-90	Topdress with 60 lbs N/A after each 4-6 week graze down
Bahia (3 hay cuttings)	70-60-180	Topdress with 70 lbs N/A after hay cutting
Bahia (4-6 hay cuttings)	70-80-250*	Topdress with 70 lbs N/A after each hay cutting

*At spring growth, apply all of the suggested nitrogen and phosphorus and ½ or more of the suggested potassium. Apply the remaining potassium with topdress nitrogen after the second cutting. Alternatively, all nutrients could be applied proportionally for each cutting.

Table 2. (cont.) Suggested Fertilization For Silage Production.

CROP (Yield Goal)	Fertilizer Rate (lbs/A)		
	N	P ₂ O ₅ ¹	K ₂ O ²
Silage-Corn (7-10 T/A) (11-15 T/A) (16-20 T/A) (21-25 T/A) (26-30 T/A)	100	60	55
	150	80	100
	200 ³	80	120
	250 ³	80	120
	300 ³	100	160
Silage-Sorghum (7-10 T/A) (11-15 T/A) (16-20 T/A) (21-25 T/A) (26-30 T/A)	70	60	55
	130	80	100
	180 ³	80	120
	220 ³	80	120
	260 ³	100	160

¹If soil test P - 1 ppm; then crop gets 100% P₂O₅ recommendation
 11 ppm; then crop gets 50% P₂O₅ recommendation
 ≥22 ppm; then crop gets No P₂O₅ recommendation

²If soil test K - 1 ppm; then crop gets 100% K₂O recommendation
 63 ppm; then crop gets 50% K₂O recommendation
 ≥126 ppm; then crop gets No K₂O recommendation

For other soil test values, take 1 minus ratio of soil test value to value if no fertilizer is recommended (P - 22 or K - 126 ppm).

EXAMPLE: If making phosphorus and potassium recommendations for silage-corn (7-10 T/A) and soil test values are P - 15 and K - 45 ppm; the suggested rates after rounding to the nearest 5 lb. increment would be:

$$P_2O_5 = 1 - (15/22) = 0.32 \times 60 = 20 \text{ lbs } P_2O_5/A$$

$$K_2O = 1 - (45/126) = 0.64 \times 55 = 35 \text{ lbs } K_2O/A$$

³Split nitrogen: ½ preplant along with all of phosphorus and potassium if recommended. Sidedress remainder of nitrogen prior to initiation of 5th leaf.

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The Texas A&M University System

Irrigated Grain Sorghum Production



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IRRIGATED GRAIN SORGHUM PRODUCTION

Charles Stichler and Guy Fipps¹

Water Requirements and Growth Stages

Water is the first factor limiting production in any crop. Up to a point, the more water made available to grains, the higher the production with adequate fertility to fully utilize the water. Grain sorghum is a very drought tolerant crop. It has the capacity to survive water stress better than corn.

Sorghum develops a diffuse root system that may extend to a depth of 4-6 feet. Table 1 shows the typical amount of water used by a sorghum crop from the various soil depths during a season.

Moisture stress early in the season will limit head size (number of seed per head) and delay maturity, requiring more time to complete the plant's life cycle. If stress occurs later in the season, the seed size is greatly reduced. The number of heads per acre is not effected by moisture stress unless there is not enough to produce a head.

During the seedling stage, only a small amount of moisture in the soil surface is required to establish the crop. More moisture is lost during this stage through evaporation from the soil surface than through the crop canopy. Water conserving practices such as residue management, timely planting for quick establishment, narrow row spacing and weed control will minimize soil moisture losses.

About 30-35 days after emergence, five to six true leaves are visible and the plant begins rapid growth. Nearly half of the total seasonal water will be used during this stage prior to heading. Near the end of this period, daily water use will be near maximum (about 0.35 inches/day/acre).

The most critical period for water availability for a sorghum plant begins about a week before head emergence or the "boot" stage, and continues two weeks past flowering. Sorghum plants require good soil moisture during this period for maximum yields. Adequate soil moisture prior to the "boot" stage will assure the highest potential seed set. The actual seed number and seed size depends on the availability of soil moisture following flowering.

Moisture demand drops rapidly after the grain has reached the "soft-dough" stage. The "soft-dough" stage has occurred when immature seeds squeezed between the thumb-nail and the index finger do not exude a "milk" or white juice. The combined drop in moisture demand, natural drought tolerance in sorghum, and the extensive root system generally make late irrigations unprofitable.

Since water is the first limiting factor to crop production in South Texas, yield goals should be based upon the amount of water available during the season. **Research in**

¹Extension Agronomist and Extension Agricultural Engineer, Texas Agricultural Extension Service, Uvalde and College Station, respectively.

Texas indicates that a minimum of 10 inches of available water are required for sorghum plants to produce a head. Each additional inch will yield approximately 500 pounds of grain. In other words, a sorghum crop that receives 20 inches of usable water during the growing season will use 10 inches to produce the head, while the other 10 inches will produce approximately 5,000 pounds of grain.

Maturity selection of hybrids is also important in water management. Table 2 suggests the maturity type based on the amount of expected water available to the crop.

Irrigation/Rainfall Timing

Besides the total amount of available water, the timing of irrigation (or rainfall) is also important. Research done on the Texas High Plains indicates that as the amount of water received by the crop increases, the grain yield/inch of water applied decreases. Results of two years of field studies at the Etter Experiment Station on the High Plains to determine the best combinations for irrigation timing are shown in Table 3. Sixteen irrigation treatments were used. In the first year of the test, 10.5 inches of rain fell in the growing season with 6.1 accumulating late during bloom and grain fill. During the second year of the test, 8.9 inches fell early in the growing season with 6 inches falling prior to and during bloom.

The average yields for the two years shows increasing yields with additional water. The results also show important year to year yield differences with the same irrigation timings when rain fell early or late. Irrigation timing is just as important as the

amount of water applied.

More recently, in the first year of experiments conducted at the Uvalde Research and Extension Center, support the Etter findings (Table 4). At Uvalde in 1966, no effective rain fell during the growing season. Results indicate only the effect of irrigations.

Not only is the amount of water applied important, but also the timing relative to the developmental stage of the crop. Based on the results of the experiments at Etter and Uvalde, several important conclusions can be drawn.

- Preplant irrigations alone did not provide sufficient yield.
- One irrigation at any time was equal in yield to two irrigations at heading and dough. **If an irrigation is missed during head initiation (45 DAE), later irrigations will not increase yields substantially.**
- If two in-season irrigations are possible, 45 DAE and heading will produce the highest yields.
- If three in-season irrigations are possible, 30, 45 DAE and heading produce higher yields than 45 DAE, heading and dough.
- Irrigations at the dough stage failed to substantially increase yields.
- Adequate water with 4 irrigations produced the highest yields.

Table 1. Total water withdrawn from various soil depths for sorghum growing in a deep, well-watered soil.

Soil Depth (feet)	Inches of Water Absorbed	Percent of Total
0 - 1	8.9	35
1 - 2	6.6	26
2 - 3	4.0	16
3 - 4	2.8	11
5 - 6	1.3	5

*USDA/ARS Report No. 29

Table 2. Approximate maturity and water use by seasonal types.

Maturity Range	Days to Bloom	Number of Leaves	Plant Height	Days to Maturity*	Inches of Water
Early	55 - 60	6 - 9	30 - 36	90 - 105	10 - 15
Medium	65 - 75	9 - 12	36 - 45	110 - 115	15 - 20
Medium Late	75 - 85	12 - 16	40 - 50	115 - 120	20 - 25
Full season or late	75 - 85	14 - 18	50 - 60	120 - 125	25+

*Physiological maturity - the point after which there is no increase in seed weight.

Table 3. Two year sorghum grain yield responses irrigations; 4 inch irrigations other than preplant ('69 late rains; '72 early rains).

Preplant	6-8 Leaf	Mid to Late Boot	Heading/ Flowering	Milk to Dough	1969 Yield	1972 Yield	2 Yr Average
X					1441	2786	2113
X	X				799	2842	1820
X		X			4019	4249	4134
X			X		3167	4908	4037
X				X	1141	3268	2204
X	X	X			3659	3907	3783
X	X		X		4181	5710	4945
X	X			X	1260	4201	2730
X		X	X		5237	5582	5409
X		X		X	3677	5097	4387
X			X	X	3954	4727	4340
X	X	X	X		6396	5990	6193
X	X	X		X	3716	5573	4644
X	X		X	X	4417	5932	5174
X		X	X	X	5956	5960	5958
X	X	X	X	X	6800	6782	6791

(Early = 6-8 Leaf; Boot = flag leaf; Heading = flowering to soft dough; M = milk to soft dough)

*Source: Texas Agricultural Experiment Station - Etter, Texas

Table 4. Yield Response of Sorghum to Irrigation at Uvalde.

Preplant	30 DAE	45 DAE	Heading	Dough	Grain Yield per Acre	Heads/ Acre	Grains/ Head	Weight/ Grain
X					1079	31914	627	22.6
X	X				2811	48076	1277	20.2
X		X			2890	51653	1406	17.5
X			X		3016	48283	1043	26.5
X	X	X			3387	50277	1548	19.1
X		X	X		4905	53923	1560	25.9
X			X	X	2704	47663	883	28.9
X	X	X	X		5404	52006	1746	26.2
X		X	X	X	5116	52478	1698	25.4
X	X	X	X	X	5773	53028	1804	27

DAE = days after emergence 30 DAE = head initiation; 45 DAE = rapid growth; Heading = Boot-Flowering; Dough = Soft dough stage

Table 5. The effects of furrow diking and subsoiling on sorghum grain yields.

Tillage Treatment	1979		1980		1981		Average Yield (Pounds/Acre)	% of Check
	Lbs/A	%	Lbs/A	%	Lbs/A	%		
Undiked	4353	100	547	100	1038	100	1979	100
Subsoiled	4941	114	580	106	1116	108	2212	112
Diked	4865	112	751	138	2240	216	2619	132
Subsoiled and Diked	5136	119	791	145	2248	217	2725	138

Furrow Diking

If the response of sorghum plants to an inch of irrigation water is an additional 500 pounds/acre of grain, every effort should be made to reduce water runoff. Not only do water conservation practices such as furrow diking reduce the chances of erosion and nutrient loss, they also increase grain yields. Three years of research on the Texas Rolling Plains demonstrate the potential for furrow diking to increase sorghum yields (Table 5).

The greatest impact from furrow diking was observed in the dry years (1980, 1981). Six years of studies in Uvalde on dryland grain sorghum production produced up to 72% higher yields in dry years when fields were diked. Table 6 shows the effects of various tillage systems on the average production between 1984 and 1990 which included wet and dry years.

Growth and Development of the Plant

Seedling Development

The seedling development stage begins at germination and ends 30-35 days after emergence when plants have five to six mature (fully expanded) leaves. Emergence and early plant growth are highly dependent upon growing conditions. Plant growth requires energy, but it takes time to produce carbohydrates with a few small leaves which are subject to destruction by wind, insects and pests. As plants slowly develop their root systems and absorb water and nutrients, leaf tissue expands and produces carbohydrate energy for future growth. During this period of development, water and nutrient uptake are low and only about

25% of the total crop nutrient demand will be absorbed.

Rapid Growth

In the rapid growth stage, growing point differentiation occurs and the panicle or head begins to develop. This stage continues through head exertion. Plants are especially sensitive to any type of stress during this period such as temperature extremes, nutrient deficiencies or water deficits or excesses, any of which may reduce potential seed numbers. Some herbicides (e.g., phenoxy or atrazine) applied at this time may cause florets to abort resulting in a "blasted" head. The rate of water and nutrient uptake increases rapidly during this period with about 70% of the nitrogen, 60% of the phosphorus and 80% of the potassium being absorbed into the plant.

Plants use a portion of these nutrients for growth while the remainder is stored in the leaves and stalks for later use. By the time the "flag leaf" is visible in the whorl, 80% of the total leaf area is capturing sunlight and converting it into energy. This stage is the most critical stage of plant development and the period during which growing conditions ultimately determine yield.

Reproduction

The final growth stage begins with booting or head exertion and ends with mature grain. Water stress during this period reduces the manufacturing of carbohydrates and yield. Water usage peaks shortly after flowering at 0.30 to 0.35 inches of water per day. The remaining portion of nutrients is absorbed during this high water use period. (R. L. Vanderlop describes in detail nine stages in *How a Sorghum Plant Develops*, Bulletin

No. S-3, Kansas State University.)

Fertility Needs of Sorghum

Like other grains, seed production in sorghum is a one time event and all root, leaf and stem development are directed toward completion of the reproductive cycle. Since both the number and weight of seed determine yield, it is important to understand the plant processes that influence seed development. Plant growth in each stage of development is dependent on the previous stage. Stress in any stage of development will reduce yield potential.

Many producers falsely believe that sorghum is "tough" and requires little management. Although sorghum can survive and produce seed under adverse conditions, yields can be greatly reduced by environmental stress and poor management. Like any other crop, sorghum responds to optimum growing conditions and good management.

The fertility needs of sorghum must be met in order to meet the yield goals relative to the amount of moisture available during the growing season. Table 7 indicates the approximate level of nutrients needed to produce a grain yield of 5,600 pounds per acre (100 bu/ac).

Table 8 shows the amount of nitrogen, phosphorus and potassium absorbed by grain sorghum plants during various stages of development in the process of producing 7,500 pounds of 14% moisture grain per acre. Nutrient distribution in dry matter between grain and stover is presented in Table 9. Note that very little phosphorus and potassium are present in the sorghum grain, relative to the amount of nitrogen.

Conversely, a substantial amount of potassium is contained in sorghum stover relative to nitrogen and phosphorus. If stover is removed repeatedly, soil phosphorus and potassium levels may be depleted.

Nitrogen

The standard nitrogen (N) recommendation for grain sorghum in Texas is 2 pounds per acre of elemental N for each 100 pounds per acre of grain production expected. Thus a 5,000-pound grain yield would need about 100 pounds of elemental nitrogen per acre. Nitrogen is by far the most important nutrient for sorghum to maximize production.

Nitrogen is normally used by plants for chlorophyll and protein production, which in turn are used in formation of new plant cells. The seed also store N to enable early growth after germination. Fifty-six percent of the N absorbed by sorghum plants may be found in the seed at harvest (Table 9). For maximum yields relative to the available water, N should not be lacking or grain development will be reduced.

Side-dress N applications should be made by 20 days after emergence. Later applications may excessively prune feeder roots; but more importantly, developmental potential of the grain head is determined between 30-40 days after emergence. Nitrogen stress during this period will greatly influence yield. Under center pivot irrigation, N fertilizer may be applied several times during the early part of the growing season.

Because N is relatively mobile in the soil, fertilizer placement is not as critical for N as it is most for other nutrients. Nonetheless, N must be absorbed into the plant before it is supportive of plant growth and grain

Table 6. Effect of furrow diking on dryland sorghum production.

Treatment	Average Yield	Percent of Bedded & no dikes
Bedded and no dikes	1747 a	
Flat (no beds formed)	1821 a	104
Bedded and diked during the growing season	1826 a	105
Bedded and diked during the fallow season	2128 b	122
Bedded and diked continuously	2321 b	133

Table 7. Approximate nutrient content of a 5,600 pounds/acre sorghum crop.

Plant Nutrient	Pounds in Grain	Pounds in Stover
Nitrogen (N)	84	95
Phosphorus (P ₂ O ₅)	42	20
Potassium (K ₂ O)	22	107
Sulfur (S)	8	13
Magnesium (Mg)	7	10
Calcium (Ca)	1.4	19
Copper (Cu)	.01	.02
Manganese (Mn)	.06	.11
Zinc (Zn)	.07	.14

*Source: Kansas State University

Table 8. Approximate amounts of nutrients absorbed by sorghum plants yielding 7,500 pounds of grain per acre during various growth stages.

Growth Stage	Days after Planting	Nitrogen		Phosphorus		Potassium	
		N (lb/A)	%	P ₂ O ₅ (lb/A)	%	K ₂ O (lb/A)	%
Seedling	0 - 20	9	5	2	3	18	7
Rapid Growth	21 - 40	61	33	18	3	103	40
Early Bloom	41 - 60	60	32	28	33	85	33
Grain Fill	61 - 85	27	15	21	26	39	15
Maturity	86 - 95	<u>28</u>	15	<u>11</u>	14	<u>13</u>	5
TOTALS	Harvest	185		80		285	

Table 9. Approximate nutrient distribution between grain and stover for a 7,500 lb/A sorghum crop.

Plant Part	Dry Matter distribution %	Nitrogen		Phosphorus		Potassium	
		(lbs/A)	% of Total	(lbs/A)	% of Total	(lbs/A)	% of Total
Grain	56	84	47	42	68	22	20
Stover	44	95	53	20	32	230	80

*Source: Kansas State University

production. Nitrate-nitrogen (NO_3^- , the form most available to plants) dissolves in soil water, but is negatively charged and thus not attracted to negatively-charged clay and organic matter particles. Hence, nitrate-nitrogen will move with water and can be readily brought into contact with crop roots for quick absorption. Ammonium-nitrogen (NH_4^+ , also available to plants) is positively charged and is held by negatively-charged clay and organic matter particles in the soil until it is converted by soil bacterial action into the nitrate form.

The conversion of N from the ammonium form to the nitrate form in the soil is referred to as "nitrification", and is most likely to occur when fields are arable. When fields are "water-logged", nitrate can be converted to nitrogen gas (referred to as "denitrification"), and lost from the soil by volatilization. Whether fertilizer N is applied as liquid or dry, ammonia, urea, ammonium sulfate, or N-32 should be incorporated into the soil as soon as possible to reduce potential loss of N to the atmosphere, especially where soil pH is above 7.

Phosphorus

Phosphorus (P) is the most controversial nutrient. Different soil testing laboratories utilize different chemical extractants to estimate "available P". As a result, there may be large differences between soil test values for the same soil sample obtained from different laboratories. In addition, fertilizer recommendations from different laboratories may also vary considerably.

In most cases, soil P levels are sufficient to meet early season needs of grain sorghum

plants. However, grain sorghum seed are small and contain only enough P to nourish young seedlings until emergence. If young seedlings develop under favorable conditions, P-deficiency symptoms often do not occur. Also, if growing conditions are unfavorable (i.e., cool and/or wet), seedlings may show temporary P-deficiency symptoms. In years where the planting environment is unfavorable for rapid growth and development, banding P fertilizer at low rates in the seed row may be beneficial. Also banding P two to three inches below and two to three inches to the side of the expected seed placement may be beneficial.

One key point to remember is that P is less available in cold soils. Most growers plant as early as possible to reduce sorghum midge damage and to minimize the effects of hot, stressful weather normally experienced later in the season. By doing so, sorghum seedlings often must establish and grow in much cooler soils than if planted later in the spring.

Since soil P is relatively immobile, or "fixed" in soils, placement in a concentrated form is particularly important in soils testing low to medium. By banding P near the seed, 2-4 inches below and 2-4 inches to the side, developing roots contact the fertilizer shortly after emergence. Placing P fertilizer in direct contact with sorghum seed at planting may cause emergence problems due to the salt effects caused by nitrogen in the fertilizer material. Research has shown that plants obtain a higher proportion of the needed P from soil reserves. Only about 30 percent of applied P is used by the crop following fertilization, even though it may have been banded. Once soils are warm, some of the "reserve" P becomes available for plant use. The rate at which fertilizer P

is converted to soil or “reserve” P depends upon several factors, but most important is the fertilizer P-to-soil contact. Confining P fertilizer to a band reduces fertilizer-to-soil contact and slows the rate of conversion, compared to mixing the same amount throughout the soil as with broadcast applications.

Phosphorus can also be applied as a “pop-up” fertilizer, sprayed in the seed furrow at planting. Corn and sorghum usually respond better than cotton to “pop-ups”. However, when using a product like 10-34-0 or 11-53-0 as a “pop-up”, it is important not to exceed the equivalent of 5 pounds of elemental N per acre in the seed furrow, or salt injury from the N is likely to occur. Under irrigated or high rainfall conditions, up to 10 pounds of N/acre may be applied without injury. A rain following planting will dilute the nitrogen and also lessen the chance of injury. High P to low N ratio specialty fertilizers, such as 4-29-2 or similar products, lend themselves to “pop-up” applications with minimal injury risk.

Potassium

Potassium (K) is needed in all plant parts for maintenance of water balance, disease resistance and stalk strength. However, as indicated in Table 5, very little K is removed from the field if only grain is harvested. If the stover is harvested for forage, then a much larger amount of potassium is removed. Most high pH soils in Texas are inherently high in potassium. Soil test levels should be monitored over years to look for any trends of reduced K.

Other Nutrients

Two of the other most important nutrients for grain sorghum production in Texas are zinc and iron. Where soil phosphorus levels are “high” or “very high” and zinc levels are “low” to “medium”, application of additional phosphorus may induce a zinc deficiency. If soil test results indicate a possible zinc deficiency, zinc fertilizer should be broadcast and incorporated preplant or banded at planting. Foliar applications of zinc should be used as a salvage measure since this will only prevent symptoms on new growth.

If iron chlorosis has been observed during previous years in a field, iron fertilizer materials should be applied to the foliage through multiple sprayings early in the season. Information on specific application rates of micro nutrients can be found in the following Texas Agricultural Extension Service manuscripts: *Correcting Iron and Zinc Deficiencies in Corn and Grain Sorghum* (W. Gass, Soil and Crop Science Dept.) and *Correcting Iron Deficiencies in Grain Sorghum*, L-5155.

Irrigation Scheduling Based on Potential Evapotranspiration (PET)

Evapotranspiration (ET) is a measurement of the total amount of water needed to grow plants and crops. This term comes from the words *evaporation* (i.e., evaporation of water from the soil) and *transpiration* (i.e., transpiration of water by plants). Different plants have different water requirements, so they have different ET rates.

Table 10. Sorghum Crop Coefficients.

Growth State¹	K_c	Days After Planting²
Seeding	0.40	3 - 4
Emerg	0.40	5 - 8
3-leaf	0.55	19 - 24
4-leaf	0.60	28 - 33
5-leaf	0.70	32 - 37
GPD	0.80	35 - 40
Flag	0.95	52 - 58
Boot	1.10	57 - 61
Heading	1.10	60 - 65
Flower	1.00	68 - 75
S Dough	0.95	85 - 95
H Dough	0.90	95 - 100
Blk lyr	0.85	110 - 120
Harvest	0.00	125 - 140

¹Sorghum will bloom at different times depending on locating, planting date, and maturity of the variety.

²The Days After Planting are for a medium-early to medium-late variety.

Crop Coefficients for Sorghum

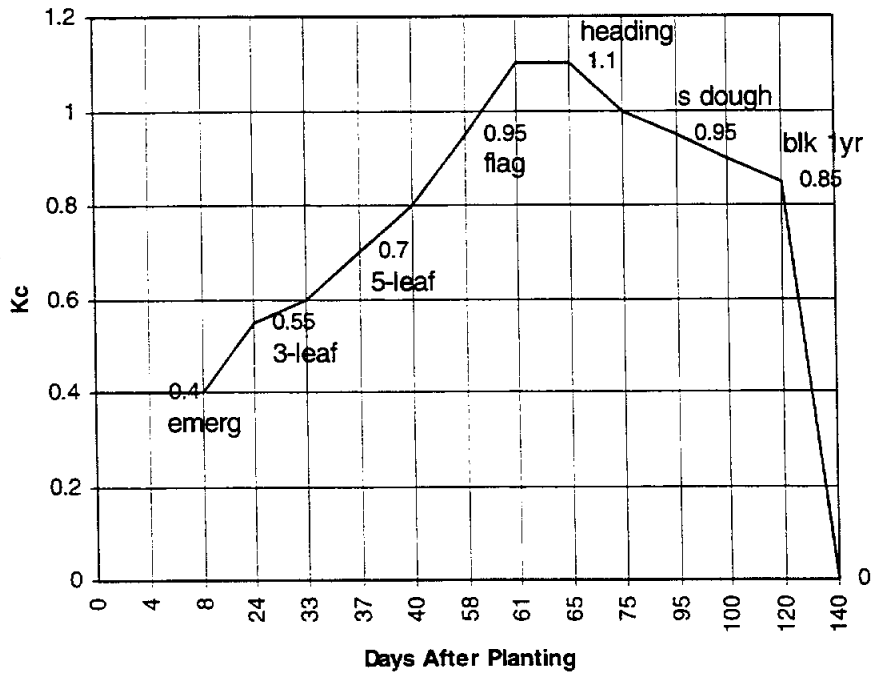


FIGURE 1. Crop Coefficient Curve for Sorghum.

Table 11. Typical overall on-farm efficiencies for various types of irrigation systems.

System	Overall Efficiency
<u>Surface</u>	<u>.50 - .80</u>
common	.50
land leveling and water volume per row meeting design standards	.70 - .80
surge	.60 - .90 ¹
<u>Sprinkler</u>	<u>.55 - .75³</u>
Center Pivot	.55 - .90 ³
LEPA	.90 - .95
<u>Drip/Trickle</u>	<u>.80 - .90²</u>

¹Surge has been found to increase efficiencies 8 to 28% over non-surge furrow systems.

²Trickle systems are typically designed at 80 to 90% efficiency.

³Higher efficiencies are for low wind conditions.

Since there are thousands of cultivated plants, we have tried to simplify matters by establishing a standard ET rate for general reference and use. The standard is coefficient (Kc). Crop coefficients depend on the type of crop and its stage of growth. The North High Plains crop coefficients for sorghum are listed by stage of growth in Table 10 and illustrated in Figure 1. Please note that these dates are provided as a general guide only, as crop growth rate is affected by many factors including variety, current weather, soil moisture conditions, etc.

How to Use PET

To calculate the water requirements of a crop, we multiply the PET times the crop coefficient using the following equation:

$$\text{PET} \times \text{Kc} = \text{crop water requirements} \quad (\text{equation 1})$$

where:

PET is the sum of daily PET over the time period of interest, such as the 3-day total, the weekly total, etc.

Kc is the crop coefficient corresponding to the current stage of crop growth.

Example 1: the 5-day PET total is 1.32 inches. My sorghum is in the "heading" growth stage. What are the water requirements? (Note: from Table 10, the "heading" crop coefficient is 1.10)

$$1.32 \text{ inches} \times 1.10 = 1.45 \text{ inches}$$

Thus, I need to apply 1.45 inches to replace the water used by the sorghum in the last 5 days.

Adjusting for Irrigation System Efficiency

It may be necessary to increase the amount of irrigation water in order to compensate for poor irrigation system efficiency. Table 11 gives the typical ranges of on-farm irrigation systems. To adjust for irrigation system efficiency, use the following equation:

$$\text{PET} \times \text{Kc} \div \text{Eff} = \text{irrigation water requirements} \quad (\text{equation 2})$$

where:

Eff is the overall efficiency of the irrigation system.

Example 2. I am irrigating with a low-pressure center pivot. I estimate that my overall system efficiency is 85%. What are my irrigation water requirements for the sorghum in example 1?

$$1.32 \text{ inches} \times 1.10 \div 0.85 = 1.71 \text{ inches.}$$

Adjusting for Rainfall and Soil Moisture

Rainfall reduces the amount of water we must supply by irrigation to meet plant water requirements. However, not all rainfall becomes available for use by plants and crops. Depending on such factors as soil type, duration and intensity of rainfall, soil moisture levels, etc., a portion of the rainfall will be lost to runoff and deep percolation (water moving below the root zone). In irrigation scheduling, the term "*effective rainfall*" refers to that portion of rainfall which infiltrates and is stored in the root zone. Effective rainfall must be estimated for each field and rainfall event. The irrigation requirement determined with equations (1) or (2) should be reduced by the

amount of effective rainfall.

Alternatively, soil moisture monitoring devices can be used to determine soil moisture levels and to determine when irrigations should be re-started following rains. The following two publications by the Texas Agricultural Extension Service discuss this in detail: *Soil Moisture Management B-1670*, and *Soil Moisture Monitoring-1610*.

Where to Find PET Information

For persons with Internet access, PET and weather information is provided for about 12 locations in Central and South Texas, including 3 locations in the Lower Rio Grande Valley, on the Texas PET Web Site. The address is:

<http://www.agen.tamu.edu/pet>

Persons without Internet access should contact their water district or County Extension Agent to see if this information is being provided locally in another way.

Irrigation Volumes and Soil Types

The amount or depth of water that is applied at each irrigation depends greatly on soil type. This is because soils vary in their ability to hold or store water. For example, clays can hold about 2 inches of water per foot, while sands hold less than an inch. This is referred to on the "available holding capacity". Table 12 provides recommended irrigation depths in terms of inches of water per foot of root zone. Note from Table 1, the majority of water is withdrawn from the top two feet of the root zone.

Maximizing Irrigation Water Use Efficiency

"Irrigation return flow" is that portion of water which returns to its source after being used to irrigate crops. A good example is found in the Texas rice industry, where water is usually diverted from a river, used to flood the field and then released back into the river before harvest. With increasing environmental concern, the term "irrigation return flow" has been extended to include irrigation water that makes its way to any body of water after its use on a crop.

There are many examples of this broader definition in Texas. Tailwater from furrow irrigation and runoff caused by excessive irrigation or poor system design can make its way into small creeks and draws which eventually lead to our major rivers and reservoirs. Water from irrigated land that is artificially drained must go somewhere, often into the same river it was taken from or to major drainage outlets which flow into coastal bays.

Irrigation return flow is becoming an important issue because of its potential to be a nonpoint source of pollution. However, this is not the only reason irrigators should use return flow management practices. Excessive runoff is a symptom of poor irrigation system design or poor management of irrigation water. It is also water wasted. Wasting water not only has immediate financial ramifications, but also threatens the long-term availability of water for irrigation. Sound management practices can reduce irrigation return flow while ensuring the most efficient use of our water resources.

The major concern is the direct runoff which may occur from irrigated land. Many of the fertilizer nutrients and chemicals used in agriculture, as well as soluble salts contained in the irrigation water, are easily adsorbed onto soil particles. When runoff occurs, soil particles containing these adsorbed pollutants are picked up and transported out of the field. Eroded sediments constitute the major potential for pollution from surface return flows. In addition, soluble chemicals are dissolved by runoff and carried with the water as it flows over the soil.

Preventing Return Flow

There are three basic approaches to eliminating pollutants in surface return flows:

- eliminating or reducing surface runoff;
- eliminating or reducing soil loss; and
- removing pollutants from irrigation return flow.

The first two approaches are achieved by properly designing, operating and managing irrigation systems. Following the directions on the pesticide label will usually solve any problems associated with chemigation (the application of agricultural chemicals through the irrigation system). The third approach involves the use of grass buffer strips, artificial wetlands, settling basins and ponds, and similar structures to remove pollutant bearing sediments. Treating return flow is more costly and troublesome than preventing it.

Practices which may be used to reduce

subsurface return flow include:

1. proper leaching; and
2. Impervious conveyance systems.

Irrigation System Design

Sprinkler and Drip Irrigation

Emitters and nozzles should be sized so that the irrigation application rate does not exceed the water intake rate of the soil. For center pivot systems, conservation practices such as furrow diking and planting in a circle may be needed.

Furrow Irrigation

Furrow irrigation is used on more than half the total irrigated land in Texas. Proper system design improves the distribution and uniformity of applied water, reduces water use and produces higher yields. The U.S. Natural Resources Soil Conservation Service (NRCS) has developed furrow system design standards and guidelines, based on soil type, for most areas of the state. The important factors are proper slopes, proper stream size and proper furrow run length. Furrow run length and stream size both depend on the slope, and should be selected to minimize tailwater while providing a good distribution of water in the entire furrow.

Proper slopes - Excessive slopes may cause severe erosion that transports sediment and adsorbed pollutants. Slope recommendations for reducing return flows vary from location to location because of differences in soils and rainfall conditions. Generally, furrow grade should not exceed 0.8 percent. In areas of intense rainfall,

furrow grades may need to be 0.5 percent or less. Proper slopes sometimes can be obtained by changing the direction of the furrows. On smooth, uniformly sloping fields, furrows may be run across the slope of the field as long as they are deep enough and the soil stable enough so that irrigation water or rainfall runoff does not break over one furrow to another. In other situations, land leveling may be the only method of obtaining proper slopes.

Proper stream size - Proper stream size may prevent potential erosion. For graded furrows, the stream size should be kept as small as possible to provide reasonable efficiency while minimizing the soil loss. From an erosion standpoint, the maximum stream size in gallons per minute (not to exceed 50 gpm) can be calculated as:

$$\text{stream (gpm)} = \frac{10}{\text{percent furrow slope}}$$

Cut back irrigation and surge - An effective practice for reducing tailwater is the use of cut back irrigation. A greater initial flow is normally required to push the water to the end of the furrow. Once the water has reached the end of the furrow, the stream size is reduced or cut back so that the flow correspond more closely to the intake rate of the soil. A less labor intensive practice is to use automatic surge valves to release water into the furrow in a series of on-off cycles; this can reduce tailwater and improve distribution efficiencies. Surge irrigation appears to work because of the natural surface sealing properties of many soils during wetting and drying cycles. Properly managed surge irrigation has been found to increase efficiencies from 6 to 30 percent over nonsurge furrow irrigation,

depending on soil type.

Transporting irrigation water through pipelines has proven to be the most trouble free and cost effective method. Gated pipe in furrow irrigation can reduce water and labor costs 35 to 50 percent over siphon tubes and unlined canals. As with other return flow management practices, reducing seepage losses not only helps prevent pollution problems, but has direct economic benefits.

Irrigation Water Management

Proper irrigation water management means timing and regulating water applications in a way that will satisfy the needs of a crop and efficiently distribute the water without applying excessive amounts of water or causing erosion, runoff or percolation losses. Good irrigation water management can reduce moisture extremes and associated plant disease problems, which in turn may reduce the need for pesticides. The irrigator should have a good understanding of the factors influencing proper irrigation scheduling and water management (Table 13). The timing of irrigation and the total amount applied per irrigation should be based on both the crop's water use and the moisture content of the soil, as well as on expected rainfall and any additional amounts needed for leaching to maintain a specific salt balance. Monitoring soil moisture with gypsum blocks or tensiometers can help take the guess work out of irrigation scheduling.

Table 12. Approximate Water Holding Capacity of soils in inches of water per foot of soil and recommended depth of irrigation in inches of water per foot of root zone and total inches.

Soil Texture	Available Moisture (in/ft)	Water to be replaced at each irrigation*		
		per ft (in/ft)	2-ft root zone (in)	4-ft root zone (in)
Sands	0.8 - 1.0	0.5 - 0.8	1.3	2.8
Sandy Loams	1.3 - 1.5	0.8 - 1.2	2	4
Loams	1.6 - 1.8	1.1 - 1.3	2.4	4.8
Silt Loams	1.7 - 1.9	1.2 - 1.5	2.8	5.4
Clay Loams	1.9 - 2.1	1.3 - 1.7	3.0	6
Clays	2.0 - 2.2	1.4 - 1.8	3.2	6.4

*based on application of irrigation when 50 to 60 percent of the available water in the root zone has been depleted assuming 75 percent overall irrigation efficiency.

Table 13. Factors important in proper irrigation water management and irrigation scheduling.

Soil Factors	Crop Factors
Soil water holding capacity	Rooting depth
Soil intake rate	Water depletion tolerance
Current moisture deficit	Peak consumptive use
Depth of soil profile	Variations in consumptive use during each growth stage

THE ARROYO COLORADO

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the LRGV. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is to provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. This is one of several publications supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Tarleton Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at <http://www.agen.tamu.edu/arroyo>.

Educational programs conducted by the Texas Agricultural Extension Service serve people of all ages regardless of socioeconomic level, race, color, sex, religion, handicap, or national origin.

Cooperative Extension work in agriculture and family and consumer sciences, The Texas A&M University System, and the United States Department of Agriculture cooperative. Distributed in furtherance of the acts of Congress of May 8, 1914, as amended June 30, 1914.
8/97

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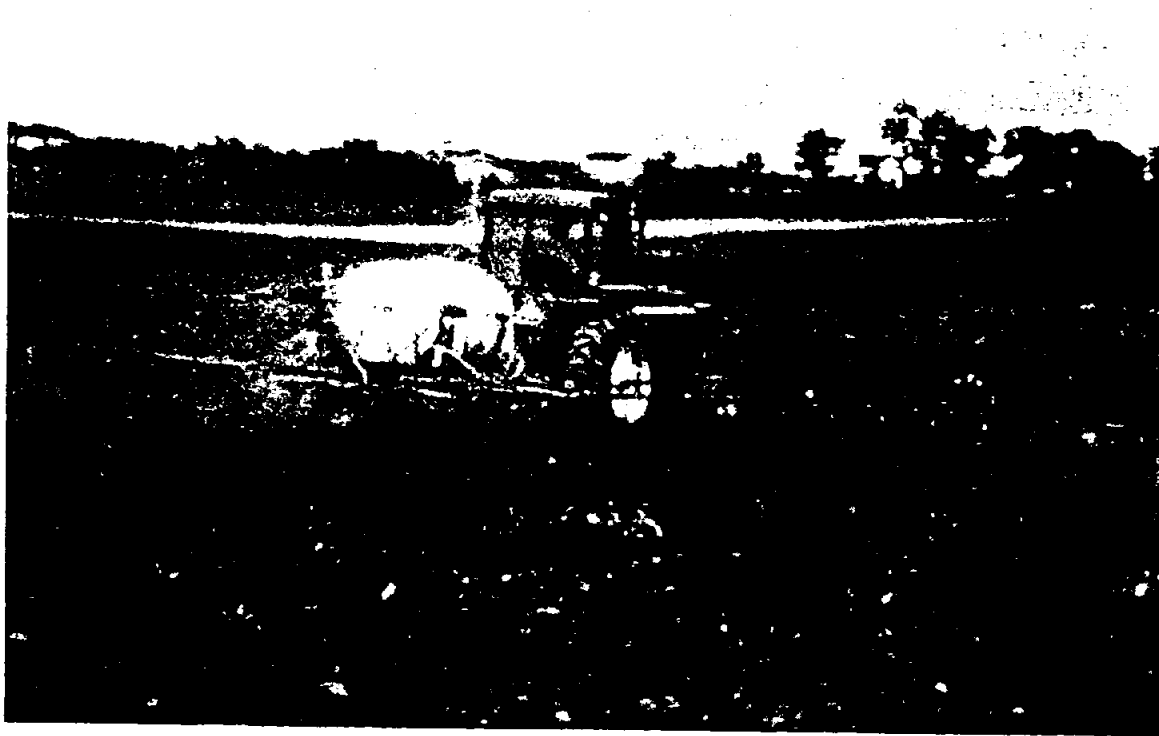
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Texas Agricultural Extension Service
The Texas A&M University System

Calibrating Pesticide Application Ground Equipment



Calibration Guide and Software

PREPARED IN COOPERATION WITH THE U.S. ENVIRONMENTAL PROTECTION AGENCY

The preparation of this report was 60% financed through \$443,630 in grant funds from the U.S. Environmental Protection Agency through the Texas Natural Resource Conservation Commission.

PESTICIDE APPLICATION GROUND EQUIPMENT CALIBRATION GUIDE

Bryan W. Shaw and Guy Fipps¹

Precise application of a specific rate of pesticides is an important factor in efficient, economical pest control. This guide includes suggested methods for equipment calibration in a convenient, easy-to-use form. Calibrate equipment carefully and accurately as a part of your pesticide application program.

Application Program Checklist

- Maintain a complete record of the operation.
- Inform those working with the pesticide and others in the area of the precautions necessary in handling the chemical.
- Begin with clean equipment. Residues in the spray rig can cause serious problems. To clean the rig, use either a strong household detergent or a commercial decontaminate formulation (most contain a combination of soda ash, detergent, and alkaline chlorine). Rinse thoroughly with clean water. Remove nozzles to clean screens and tips. Dispose of rinse water safely. Clean and lubricate pump.

IMPORTANT: Equipment used to apply certain pesticides should not be used to apply others. EXAMPLE: Do not use equipment used to apply 2,4-D, MCPA, 2,4-DP, MCPP, and 2,4-DB for any other purpose because of difficulty in removing all traces of the pesticide.

- Check all hoses. Hoses in good condition save time and eliminate possible spray mixture losses.
- Use screens upstream of the pump and each nozzle. Check screens *often* to avoid clogged nozzles.
- Use recommended nozzle types and attach nozzles firmly, using the correct height and angle to ensure proper application.
- Calibrate the sprayer and check each nozzle for output uniformity. Replace any nozzle that varies more than 10% from the average flow rate. For application of some chemicals (e.g., certain potent sulfonyl urea herbicides), nozzles should be replaced if they deviate more than 5% from the average flow rate.

Nozzle pressure should follow nozzle manufacturer's recommendation for each application type. Operating near the lower recommended pressure will produce larger droplets and minimize drift potential. Recommended nozzle pressure ranges from 10 to 60 psi for weed control. For insect control, pressure between 50 and 60 psi is typically recommended. Disease control typically requires that a pressure of 100 psi be maintained. Select nozzles which will deliver the calculated volume at the recommended pressure. If the sprayer is already equipped and the nozzles will not deliver the gallons per acre in the desired time, changing speed, gallons per acre (GPA) or nozzles will allow a desired nozzle pressure.

¹ Extension Agricultural Engineers, Department of Agricultural Engineering, Texas A&M University System, College Station, Texas 77843-2117

Calibration of Ground Sprayers

Method I

Step 1:

Fill the tank with water to a predetermined level.

Step 2:

Drive in a straight line for 660 feet, operating at the same pressure and tractor speed planned for field use. Record the tractor throttle and gear settings.

Step 3:

Stop spraying at the 660 foot mark and measure the gallons of water needed to refill the tank.

Step 4:

Measure the width of actual area sprayed. For band applications, this equals the sum of the width of all bands.

Calculate as follows:

$$\frac{\text{gallons used} \times 66}{\text{width of sprayed area in feet}} = \text{gallons per acre}$$

EXAMPLE:

When 7 gallons of water are required to refill tank to predetermined level for a boom sprayer (14 feet wide) after spraying a 660 feet long swath, the calculations are as follows:

$$\frac{7 \text{ gallons} \times 66}{14 \text{ feet}} = 33 \text{ gallons per acre}$$

After calibrating the sprayer, add the correct amount of pesticide to the sprayer tank in the correct amount of carrier for the area to be sprayed. Tables 4-9 provide forms to assist with mixing calculations.

Recalibrate the sprayer after each 10 hours of operation or anytime there is a change in the formulation of pesticide used. Recalibrate more often when using wettable powders than when liquid formulations are used. Wettable powders cause wear of pumps and nozzles made of soft metals.

Method II (See Tables 1-3 for calibration forms)

Step 1:

With the sprayer and other attachments (planters, applicators, etc.) mounted on the tractor, you are ready to calibrate.

Step 2:

In the field, with all attachments in operation, determine the speed you wish to travel. For tractors with accurate speed sensors, skip to step "5." Speed indicators that do not directly measure ground speed may indicate speed with as much as 30% error due to variation in tire slip, tire size, etc. If in doubt, perform steps "3" and "4."

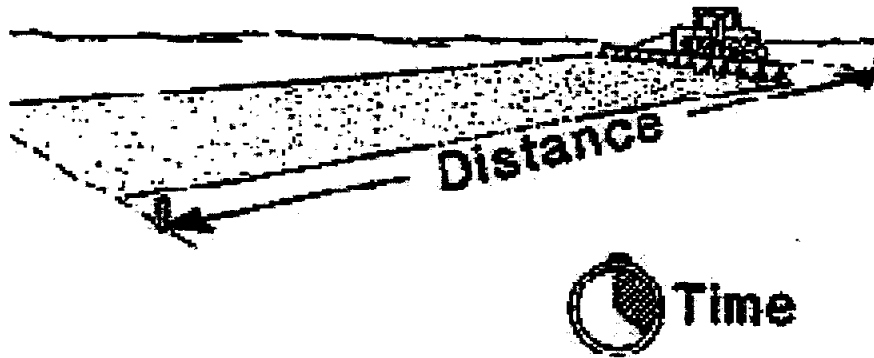
Step 3:

Measure and mark off a course. A longer course gives more accurate speed determination. A course 300 feet long is adequate. Measure in seconds how long it takes to travel the distance. *Mark throttle and gear setting. NOTE: A tractor travels slower in a soft field than on hard ground under the same settings.*

Step 4:

Substitute the number of seconds to travel the course and the length of the course in the following formula to determine MPH.

$$MPH = \frac{\text{feet traveled} \times 60}{\text{seconds traveled} \times 88}$$



EXAMPLE:

If it requires 51 seconds to cross a course 300 feet long, the speed is calculated as follows:

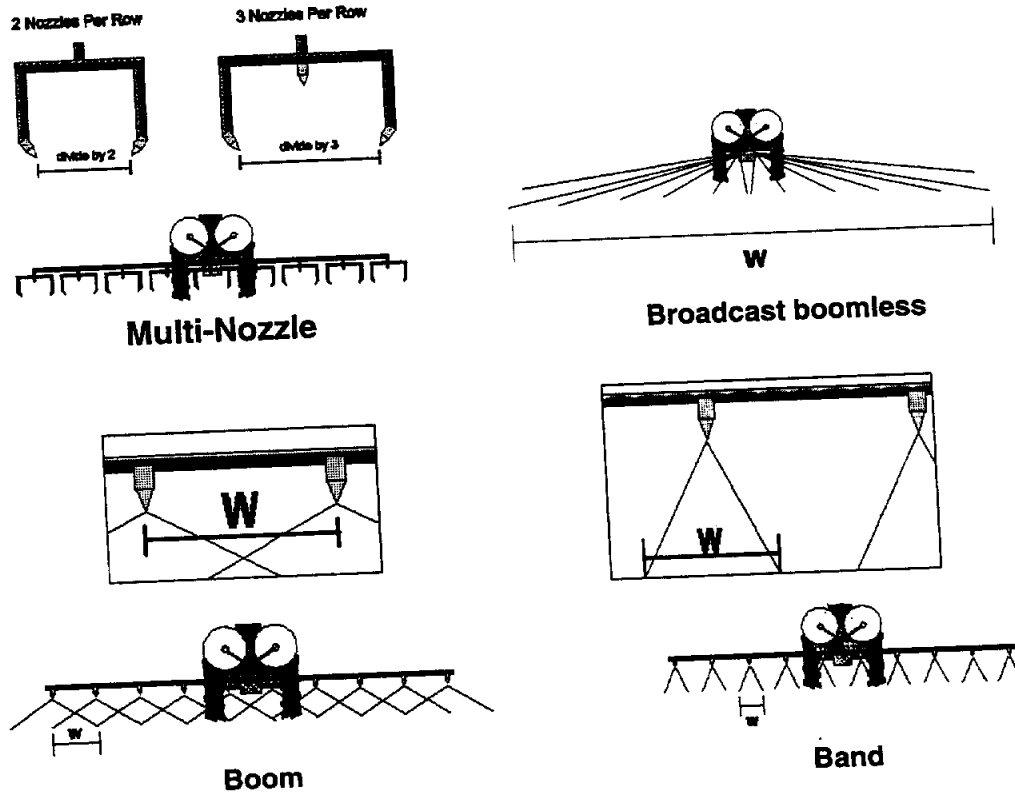
$$\frac{300 \times 60}{51 \times 88} = 4 \text{ MPH}$$

If the desired speed is selected, the seconds to travel the course can be determined as follows:

$$\text{seconds traveled} = \frac{\text{feet traveled} \times 60}{MPH \times 88}$$

Step 5:

Determine spray delivery from each nozzle in gallons per minute (GPM) for the desired speed, effective spray width, and gallons per acre (GPA). Effective spray width is determined as follows: nozzle spacing for boom spraying, band width for band spraying, spray swath for broadcast boomless spraying, width of band divided by number of nozzles for multi-nozzle band spraying, measured in inches.



Calculate the nozzle delivery rate with the following formula

$$GPM \text{ per nozzle} = \frac{GPA \times MPH \times W}{5940 \text{ (constant)}}$$

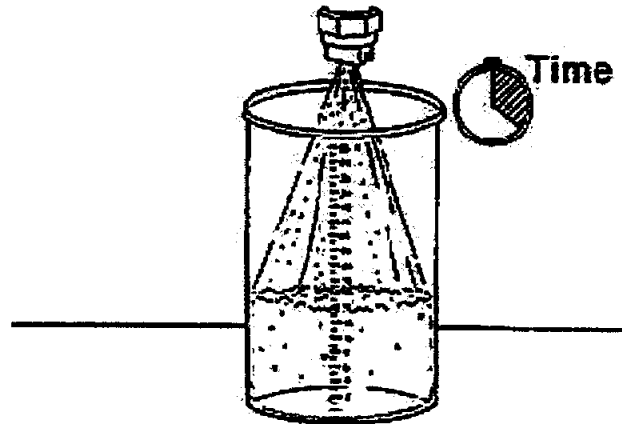
GPA = gallons per acre on the area treated
W = effective spray width in INCHES

Nozzle pressure should follow nozzle manufacturer's recommendation for each application type. Operating near the lower recommended pressure will produce larger droplets and minimize drift potential. Recommended nozzle pressure ranges from 10 to 60 psi for weed control. For insect control, pressure between 50 and 60 psi is typically recommended. Disease control typically requires that a pressure of 100 psi be maintained. Select nozzles which will deliver the calculated volume at the recommended pressure. If the sprayer is already equipped and the nozzle will not deliver the gallons per acre in the desired time, a change in speed, GPA or change to a larger nozzle will allow a desired nozzle pressure.

Step 6:

With tractor out of gear and engine running at the throttle setting selected, adjust the pressure regulator so that each nozzle delivers the calculated flow rate.

The flow rate can be measured with a tip tester that indicates flow rate in gallons per minute or by measuring the time required to collect one quart from the nozzles.



The number of seconds to collect a quart of spray mixture, or 32 fluid ounces, is determined by the following formula.

Step 7:

$$\text{sec lqt lnozzle} = \frac{15}{\text{GPM per nozzle}}$$

Adjust height and direction of nozzles to give the desired spray pattern overlap or band width as recommended by the nozzle manufacturer.

Step 8:

You must recalibrate if you change speed or pressure. Nozzles wear and sprayers should be recalibrated after each 10 hours of operation or anytime there is a change in the formulation of pesticide used.

Step 9:

After calibrating the sprayer, add the correct amount of pesticide to the sprayer tank in the correct amount of carrier for the area to be sprayed. Tables 4-9 provide forms to assist with mixing calculations.

EXAMPLES

1. *Boom spraying, broadcast.* Spray 30 GPA at 5 mph with a 20-inch nozzle spacing on the boom.

a.

$$\text{GPM per nozzle} = \frac{30 \times 5 \times 20}{5940} = 0.51$$

Select an 80° or 90° flat spray nozzle to deliver 0.51 GPM at suggested psi.

b.

$$\text{sec lqt lnozzle} = \frac{15 \text{ (constant)}}{\text{GPM per nozzle}}$$

$$\text{sec lqt lnozzle} = \frac{15}{0.51} = 29.4$$

Adjust the pressure regulator to deliver 0.38 GPM per nozzle or to deliver one quart in 40 seconds.

2. *Band spraying with one nozzle.* GPA is the amount applied to the *area actually treated*. If the 40 GPA rate is applied at 4 MPH on a 14-inch band, the 40 GPA would be used with 4 MPH and 14-inch band width in the formula given below.

a.

$$\text{GPM per nozzle} = \frac{40 \times 4 \times 14}{5940} = 0.38$$

Select an 80° even spray nozzle to deliver .38 GPM at suggested psi.

b.

$$\text{sec lqt lnozzle} = \frac{15}{.38} = 40$$

3. *Band spraying with two or more nozzles per band.* If two nozzles are used to spray the 40-gallon per acre rate on a 14 inch band, calibrate by using width (W) of 7 inches (14 inches ÷ 2) in formula given in Step 5 above. Collect the quart from one nozzle in the time calculated with the formula given in step 6 above.

4. *Boomless spraying, broadcast.* Spray 20 GPA at 4 MPH and cover a 40-foot swath (40 feet X 12 inches/foot).

With the tractor out of gear and the engine running at the throttle setting selected, adjust the pressure regulator so that 6.5 gallons is sprayed in one minute from the nozzle assembly. Follow steps 7 through 9 to complete calibration.

$$\text{GPM per nozzle} = \frac{20 \times 4 \times (40 \times 12)}{5940} = 6.5$$

Select a single assembly of nozzles to deliver 6.5 GPM at suggested psi.

5. *Spraying at a broadcast rate above 40 GPA.* Spray 50 GPA at 40 MPH with nozzles spaced 20 inches apart on the boom.

a.
$$GPM \text{ per nozzle} = \frac{50 \times 4 \times 20}{5940} = .67$$

 Select an 80° or 95° flat spray nozzle to deliver .67 GPM at suggested psi.

The time in seconds to catch one gallon from each nozzle may be determined by this formula:

b.
$$Sec \text{ /gal /nozzle} = \frac{60 \text{ (constant)}}{GPM \text{ per nozzle}} = \frac{60}{.67} = 89.6$$

With the tractor out of gear and the engine running at the throttle setting selected, adjust the pressure regulator so that one gallon of spray mixture is sprayed by each nozzle in 90 seconds. Follow steps 7 through 9 to complete calibration.

Step	Example	(Yours)
1. Mark off and measure length of course (Feet Traveled)	300 feet	_____
2. Time the spray rig as it crosses the course. Use gear and throttle setting you plan to use during application. (Seconds Traveled)	51 seconds	_____
3. Calculate Speed (MPH) = (#1 × 60) ÷ (#2 × 88), or $MPH = \frac{\text{Feet Traveled} \times 60}{\text{Seconds Traveled} \times 88}$	4 mph	_____

Step	Example	(Yours)
1. Gallons per acre of spray solution to be applied (GPA)	30 gpa	_____
2. Application speed (Table 1, Step 3)	4 mph	_____
3. Effective width (W) (Effective width: nozzle spacing for boom spraying, band width for banding, spray swath for broadcast boomless, width of band divided by number of nozzles for multi-nozzle banding)	20 in	_____
4. Flow rate needed from each tip (GPM) = (#1 × #2 × #3 ÷ 5940), or $GPM = \frac{GPA \times MPH \times W}{5940}$	0.4 gpm	_____

Table 3. Calibration		
Step	Example	(Yours)
1. Flow rate needed from each tip (GPM) (Table II, Step 4)	0.4 gpm	_____
2. Time required to collect 1 quart (32 ounces) (15 ÷ #1), or $\text{sec /qt /nozzle} = \frac{15}{\text{GPM}}$	37 sec	_____
3. With tractor out of gear and engine running at the throttle setting selected, adjust pressure regulator to deliver flow rate calculated in steps 1 & 2 above.		

Table 4. Calculating amount of pesticide to add to tank for liquid pesticide (given pints per 100 gal recommended by label)		
Step	Example	(Yours)
1. Gallons in tank (GAL)	200 gal	_____
2. Pints per 100 gallon recommended by label (pt/100gal wanted)	2 pints	_____
3. Pints pesticide needed per tank (#1 × #2 ÷ 100), or $\frac{\text{GAL} \times \text{pt/100 gal wanted}}{100 \text{ gal}} = \frac{200 \times 2}{100} = 4 \text{ pints needed}$	4 pints	_____

Table 5. Calculating amount of pesticide to add to tank (given pints per acre recommended by label)		
Step	Example	(Yours)
1. Gallons in tank (GAL)	300 gal	_____
2. Pints per acre pesticide recommended by label (pt/acre wanted)	2 pt/acre	_____
3. Gallons spray per acre to be applied (gal/acre)	20 gal/acre	_____
4. Acres sprayed per tank (#1 ÷ #3), or $\frac{\text{GAL}}{\text{gal/acre}} = \frac{300}{20} = 15 \text{ acres /tank}$	15 acres/tank	_____
5. Pints pesticide needed per tank (#4 × #2), or $\text{pints needed} = \text{Acres /tank} \times \text{pt/acre}$ $15 \times 2 = 30 \text{ pints needed}$	30 pints needed (3 gal, 6 pints)	_____

Table 6. Calculating amount of pesticide to add to tank for wettable powders (given lbs per acre recommended by label)

Step	Example	(Yours)
1. Gallons in tank (GAL)	300 gal	_____
2. Pounds per acre recommended by label (lb/acre)	2 lb/acre	_____
3. Gallons spray per acre to be applied (gal/acre)	20 gal/acre	_____
4. Acres sprayed per tank (#1 ÷ #3), or $GAL / (gal \text{ acre}) = 300 / 20 = 15 \text{ acres / tank}$	15 acres/tank	_____
5. Pounds needed (#4 × #2), or $lb \text{ needed} = \text{Acres / tank} \times lb \text{ acre} = 15 \times 2 = 30 \text{ lb needed}$	30 lb needed	_____

Table 7. Calculating amount of pesticide to add to tank for wettable powders (given lbs per 100 gal recommended by label)

Step	Example	(Yours)
1. Gallons in tank (GAL)	300 gal	_____
2. Pounds per 100 gal recommended by label (lb/100 gal)	2 lb/100 gal	_____
3. Pounds needed (#1 × #2 ÷ 100), or $lb \text{ needed} = \frac{GAL \times lb / 100 \text{ gal}}{100 \text{ gal}} = \frac{300 \times 2}{100} = 6 \text{ lb needed}$	6 lb needed	_____

Table 8. Calculating amount of pesticide to add to tank for wettable powders (given percent active ingredient recommended by label)

Step	Example	(Yours)
1. Gallons in tank (GAL)	200 gal	_____
2. Percent active ingredient recommended by label (% a.i. wanted)	3.5%	_____
3. Specific weight of carrier (water - 8.34 lb/gal)	8.34 lb/gal	_____
4. Percent active ingredient in formulation, from label (%a.i. form.)	80%	_____
5. Pounds needed (#1 × #2 × #3 ÷ #4), or $lb \text{ needed} = \frac{GAL \times \% \text{ a.i. wanted} \times lb / gal}{\% \text{ a.i. form.}} = \frac{200 \times 3.5 \times 8.34}{80} = 73 \text{ lb needed}$	73 lb needed	_____

Table 9. Calculating amount of pesticide to add to tank (given percent active ingredient recommended by label)

Step	Example	(Yours)
1. Gallons in tank (GAL)	100 gal	_____
2. Percent active ingredient recommended by label (% a.i. wanted)	1%	_____
3. Specific weight of carrier (water - 8.34 lb/gal)	8.34 lb/gal	_____
4. Pounds active ingredient per gallon in formulation, from label (lb a.i./gal form.)	2 lb a.i./gal	_____
5. Gallons emulsifiable concentrate needed (#1 × #2 × #3) ÷ (#4 × 100), or $\text{gallons needed} = \frac{\text{GAL} \times \% \text{ a.i. wanted} \times \text{lb /gal}}{\text{lb /gal a.i. form.} \times 100} =$ $\frac{100 \times 1 \times 8.34}{2 \times 100} = 4.17 \text{ gal needed}$	4.17 gal needed	_____
6. Need 4 gallons plus (0.17 gal x 128 ounces/gal =22 ounces)	4 gal, 22 ounces	_____

THE ARROYO COLORADO

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the Valley. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

The US Environmental Protection Agency has provided funding for the *Non-point Source Prevention in the Arroyo Colorado* Project. The purpose of this project is to provide education and to demonstrate management practices which will help prevent nutrients and chemicals from leaving cultivated fields and urban landscapes. This is one of several publications supported, in part, from these project funds.

Cooperating agencies include the Texas State Soil and Water Conservation Board, Southmost Soil and Water Conservation District, Natural Resources Conservation Service, the Tarleton Institute for Applied Environmental Research, Texas Natural Resource Conservation Commission, and the Texas Agricultural Extension Service. For more information, contact any of the above agencies, or the visit the Arroyo Colorado web site at <http://www.agen.tamu.edu/arroyo>.

Educational programs conducted by the Texas Agricultural Extension Service serve people of all ages regardless of socioeconomic level, race, color, sex, religion, handicap, or national origin.

Cooperative Extension work in agriculture and family and consumer sciences, The Texas A&M University System, and the United States Department of Agriculture cooperative. Distributed in furtherance of the acts of Congress of May 8, 1914, as amended June 30, 1914.

10/96

APPENDIX C

Approved Quality Assurance Project Plan



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 ROSS AVENUE, SUITE 1200
DALLAS, TX 75202-2733

FEB 5 1996

Mr. Arthur Talley, Team Leader
Nonpoint Source Program (MC 150)
Water Planning and Assessment Division
Texas Natural Resource Conservation Commission
P.O. Box 13087
Austin, TX 78711-3087

Re: Approval of the Quality Assurance Project Plans (QAPPs) for
the Pace Bend Park Watershed Restoration, Assistance ID No.
C9-996146-02-0 FY 94 Nonpoint Source Grant and The Arroyo
Colorado Project, Assistance ID No. C9-006975-92-2, FY 92

Dear Mr. Talley:

The above QAPPs which were sent to us on November 28 and
November 30, 1996, respectively have been reviewed and are
approved. Any extra copies of the QAPPs we received, and the
completed signature pages are enclosed.

We appreciate your efforts in support of generating quality
data for the Nonpoint Source Program. If you have any questions,
please call me at (214) 665-8086.

Sincerely yours,

Len A. Pardee

Len A. Pardee
Texas Nonpoint Source Program
U.S. EPA Region 6

Enclosures (4)

cc: Carol Whittington, TNRCC



TEXAS STATE SOIL AND WATER CONSERVATION BOARD

311 North 5th
P.O. Box 658
Temple, Texas 76503-0658
(817) 773-2250
Fax (817) 773-3311

June 24, 1997

Mr. Kelvin Moore
Program Administrator (MC-150)
Watershed Assessments and Planning Section
Texas Natural Resource Conservation Commission
P.O. Box 13087
Austin, TX 78711-3087

RE: Annual QAPP Revision for FY92 319(h) Project Entitled "Arroyo Colorado NPS Project"

Dear Mr. Moore:

Enclosed for your review and approval is the annual QAPP revision for above-referenced project along with (4) signed approval pages. I believe this QAPP meets all of the requirements for a Category III QAPP as outlined in the EPA QA/R-5 document issued by Region 6.

In addition, I have not received an official reply to my letter sent to you on April 21, 1997 regarding the last date that bills can be processed for this project. Please respond to this letter as soon as possible.

Thank you for your assistance in this matter. Please call if you have any questions.

Sincerely,

A handwritten signature in black ink, appearing to read "Justin Hester", written over a circular stamp or mark.

Justin Hester
Planner I

Enclosures

**1st Annual Revision to the Quality Assurance Project Plan for the
Environmental Measurement Activities Relating to
Arroyo Colorado NPS Project Located in
Cameron County, Texas**

**Texas State Soil and Water Conservation Board
Temple, Texas**

**Quality Assurance Management Plan (Q-97-102)
Texas State Soil and Water Conservation Board**

United States Environmental Protection Agency, Region VI

Name: Len Pardee

Title: Texas Nonpoint Source Project Manager

Signature: _____ Date: _____

Name: Richard G. Hoppers

Title: Quality Assurance Manager

Signature: _____ Date: _____

Texas Natural Resources Conservation Commission

Name: Kelvin Moore

Title: Grant Manager

Signature: _____ Date: _____

Name: Clyde E. Bohmfalk

Title: Quality Assurance Officer

Signature: _____ Date: _____

Texas State Soil and Water Conservation Board

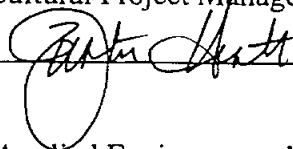
Name: Byron Spoonts

Title: Agricultural Project Administrator

Signature:  Date: 6/23/97

Name: Justin Hester

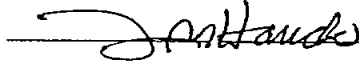
Title: Agricultural Project Manager

Signature:  Date: 6/28/97

Texas Institute for Applied Environmental Research

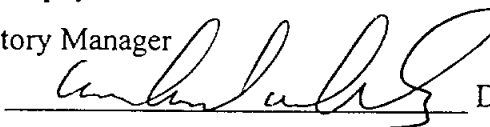
Name: Larry Hauck

Title: Assistant Director of Environmental Sciences

Signature:  Date: 5/28/97

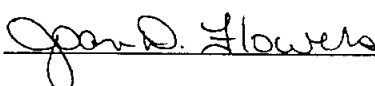
Name: Mark Murphy

Title: Laboratory Manager

Signature:  Date: 5/29/97

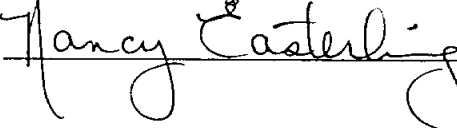
Name: Joan Flowers

Title: Project Manager

Signature:  Date: 5/28/97

Name: Nancy Easterling

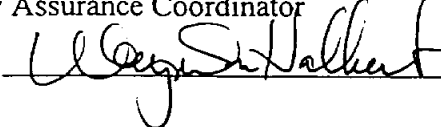
Title: Quality Assurance Manager

Signature:  Date: 5/28/97

Southmost Soil and Water Conservation District

Name: Wayne Halbert

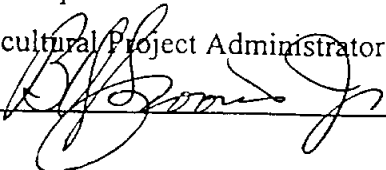
Title: Quality Assurance Coordinator

Signature:  Date: 6/12/97

Texas State Soil and Water Conservation Board

Name: Byron Spoons

Title: Agricultural Project Administrator

Signature:  Date: 6/23/97

Name: Justin Hester

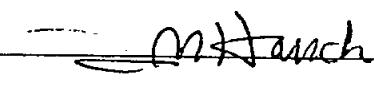
Title: Agricultural Project Manager

Signature:  Date: 6/23/97

Texas Institute for Applied Environmental Research

Name: Larry Hauck

Title: Assistant Director of Environmental Sciences

Signature:  Date: 5/28/97

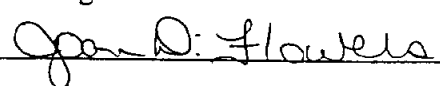
Name: Mark Murphy

Title: Laboratory Manager

Signature:  Date: 5/29/97

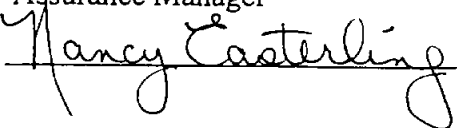
Name: Joan Flowers

Title: Project Manager

Signature:  Date: 5/28/97

Name: Nancy Easterling

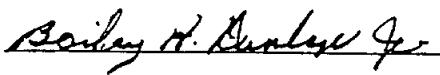
Title: Quality Assurance Manager

Signature:  Date: 5/28/97

Southmost Soil and Water Conservation District

Name: Bailey Dunlap, Jr.

Title: Quality Assurance Coordinator

Signature:  Date: 6-12-97

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Section A3: Distribution List

Organizations, and individuals within, which will receive copies of the approved QAPP and any subsequent revisions include:

- United States Environmental Protection Agency, Region VI
 - Name: Len Pardee
 - Title: Texas Nonpoint Source Project Manager

 - Name: Richard G. Hoppers
 - Title: Quality Assurance Manager

- Texas Natural Resource Conservation Commission
 - Name: Kelvin Moore
 - Title: Grant Manager

 - Name: Clyde E. Bohmfalk
 - Title: Quality Assurance Officer

- Texas State Soil and Water Conservation Board
 - Name: Byron Spoons
 - Title: Agricultural Project Administrator

 - Name: Justin Hester
 - Title: Agricultural Project Manager

 - Name: Bobbie Stephens
 - Title: Contract Manager

- Texas Institute for Applied Environmental Research
 - Name: Larry Hauck
 - Title: Assitant Director of Environmental Sciences

 - Name: Mark Murphy
 - Title: Laboratory Manager

 - Name: Joan Flowers
 - Title: Project Manager

 - Name: Nancy Easterling
 - Title: Quality Assurance Manager

- Southmost Soil and Water Conservation District
 - Name: Wayne Halbert
 - Title: Quality Assurance Coordinator

Section A4: Project/Task Organization

The following is a list of individuals and organizations participating in the project with their specific roles and responsibilities:

Len Pardee, Nonpoint Source Project Manager

United States Environmental Protection Agency (EPA)
Region VI, Dallas

Responsible for overall performance and direction of the project at the Federal level.
Approves the final products and deliverables.

Richard G. Hoppers, Quality Assurance Manager

United States Environmental Protection Agency (EPA)
Region VI, Dallas

Responsible for determining that the Project Plan meets the Federal requirements for planning, quality control, quality assessment, and reporting.

Kelvin Moore, Grant Manager (512) 239-4548

Texas Natural Resource Conservation Commission (TNRCC)
Water Planning and Assessment Division

Responsible for tracking project progress and expenditures.
Reports project status to the EPA.

Clyde Bohmfalk, Quality Assurance Officer (512) 239-4623

Texas Natural Resource Conservation Commission (TNRCC)
Water Planning and Assessment Division

Responsible for determining that the project activities meet the federal Quality Assurance Project Plan (QAPP) requirements.

Bo Spoonts, Agricultural Project Administrator (817) 773-2250

Texas State Soil and Water Conservation Board (TSSWCB)

Responsible for tracking project administration.

Justin Hester, Agricultural Project Manager (817) 773-2250

Texas State Soil and Water Conservation Board (TSSWCB)

Responsible for overseeing the implementation of the proposed demonstration sites.

Bobbie Stephens, Contract Manager (817) 773-2250

Texas State Soil and Water Conservation Board (TSSWCB)

Responsible for tracking project progress and expenditures

Larry Hauck, Assistant Director of Environmental Sciences (817) 968-9561

Texas Institute for Applied Environmental Research (TIAER)

Tarleton State University

Responsible for project administration.

Joan Flowers, Project Manager

Texas Institute for Applied Environmental Research

Responsible for coordination of field sampling, monitoring, laboratory analysis and modeling portions of project.

Nancy Easterling, Quality Assurance Manager (817) 968-9548

Texas Institute for Applied Environmental Research (TIAER)

Tarleton State University

Responsible for determining that the Project Plan meets the requirements for planning, quality control, quality assessment and reporting.

Mark Murphy, Laboratory Manager (817) 968-9564

Texas Institute for Applied Environmental Research (TIAER)

Tarleton State University

Responsible for TIAER analytical laboratory operations for this project.

Wayne Halbert, Quality Assurance Coordinator (210) 423-7015

Southmost Soil and Water Conservation District (SWCD)

Responsible for overseeing the performance of water sampling and shipment of water samples on the demonstration sites in Cameron county according to guidelines outlined in the QAPP.

Allan Moore, Engineer (210) 399-2522

Natural Resources Conservation Service (NRCS)

Responsible for overseeing the location, design, and installation of monitoring equipment on the demonstration sites.

Guy Fipps, Extension Specialist (409) 845-3977

Texas Agricultural Extension Service (TAEX)

Responsible for overseeing the evaluation of BMP effectiveness and implementation of educational workshops and seminars.

Technical Advisory Committee

This committee was formed to ensure that the technical activities of this project are properly addressed.

Local Advisory Committee

This committee was formed to ensure that the citizens along the Arroyo are informed on the progress of the project and have a opportunity to provide input and express concerns on the activities and direction of the project.

Section A4: Project Organization Chart

Len Pardee (EPA)	
	Richard Hoppers (EPA)
Kelvin Moore (TNRCC)	
	Clyde Bohmfalk (TNRCC)
Bo Spoons (TSSWCB)	
	Justin Hester (TSSWCB)
	Bobbie Stephens (TSSWCB)
Larry Hauck (TIAER)	
	Nancy Easterling (TIAER)
	Mark Murphy (TIAER)
	Joan Flowers (TIAER)
Wayne Halbert (Southmost SWCD)	
Allan Moore (NRCS)	
Guy Fipps (TAEX)	
Technical Advisory Committee	
Local Advisory Committee	

Section A5: Problem Definition/Background

The Lower Rio Grande Valley serves as an intensive agricultural region of Texas. Major crops, grown predominantly under irrigation, include citrus, grain, sugar cane, cotton and vegetables. The source of irrigation water is the Rio Grande River. Area soils are naturally saline and this problem is complicated by a shallow, saline water table (five to seven feet). Drawdown of the water table is conducted by sub-surface drainage systems which have been installed to much of the irrigated land to mitigate toxic salt buildup. This water is then released to the Arroyo Colorado.

The Arroyo Colorado is one of the more complex watercourses in the state. From its headwaters to its mouth, it has been extensively modified by the activities of man, which is reflected in both its hydrology and its water quality. Its lowest reach is estuarine, and issues into the Laguna Madre, an extremely productive, high-salinity embayment lying behind the barrier of Padre Island. The lower reach of the Arroyo is terminated by a fluvial delta system. However, the main channel of the Arroyo itself has been dredged for navigation, accommodating light draft traffic such as commercial fishing boats, barges and pleasure craft.

The watershed of the Arroyo Colorado is principally agricultural, though the Arroyo also drains the urban areas of Harlingen, McAllen and intervening areas, and therefore is subject to urban runoff as well. Under low flows, the river is dominated by municipal effluents from these communities. Under storm flow, it receives runoff from both municipal and agricultural areas. Both types of runoff are highly influenced by alterations to the watershed. The low-relief, arid region is artificially plumbed by canals, aqueducts, siphons and pumping stations to provide irrigation water for the vast agricultural enterprises of the region. This same plumbing greatly influences the timing and volume of runoff. Similarly, the drainage of the urbanized areas consists of rectified, levied, intersecting channels with gates for controlling and directing the flow. The runoff response of the Arroyo is therefore quite different from what one would expect on the basis of natural runoff processes.

This is further complicated by the extreme events which create flood stages on the Rio Grande River. Such events activate floodway systems that divert floodwaters through the upper Arroyo Colorado channel, making the Arroyo watershed, effectively, that of the Rio Grande. Quality of water in the Arroyo has been historically variable. At low stage, it exhibits all the problems expected of an effluent-dominated system in a hot, arid climate: high coliforms, low dissolved oxygen and high algal concentrations. In the estuarine reach these are exacerbated by the circulations associated with salinity intrusion in a deepened channel. These same areas act as sinks for silt and muds, which frequently bind hygroscopic contaminants. During flood events, the water may be affected (depending upon the characteristics of the storm and the operations of the drainageways) by urban and agricultural contaminants, especially pesticides. Past studies of the Corps

of Engineers and Texas Water Development Board have demonstrated the accumulation of pesticides in the deltaic sediments such as Malathion degradation products.

There are several agricultural BMPs that are commonly used on agricultural fields in the Arroyo Colorado Watershed which include:

- The use of conservation cropping rotations to maintain or improve soil conditions.
- The use of crop plant residues to protect fields during critical erosion periods.
- The use of pest management to control agricultural pest infestations such as weeds and insects that effect plant growth and crop production.
- The use of nutrient management to control the amount, form, and placement of nutrients applied to agricultural fields.

This project will encourage the voluntary adoption of best management practices (BMPs) for controlling and preventing non-point source pollution from dryland and irrigated croplands. The approach is to establish demonstration sites on area dryland and irrigated farms where local farmers and organizations can observe the benefits and effectiveness of specific BMPs.

There will be three best management practices implemented on the dryland demonstration site. The first BMP that will be used is nutrient management which prescribes split-application of nutrients and determination of residual amount of nutrients in the soil. The second BMP that will be utilized is crop plant residue management. The project will determine if crop plant residues left on the treated field result in less constituents leaving the site. The final BMP that will be utilized is precision land forming which is reshaping the surface of a field into planned grades.

There will be two best management practices implemented on the irrigated demonstration site. The first BMP that will be used is irrigation management. This management practice will focus on how improved irrigation technology, the frequency that the fields are irrigated, and the volume of water placed on the fields affect the quality and quantity of water discharged from site. The other BMP that will be used is nutrient management and will utilize split-application of nutrients and determine the residual amount of nutrients in the soil.

The project will also develop educational materials and support the transfer of demonstration results to other sites and areas.

Section A6: Project/Task Description

The NPS Prevention in the Arroyo Colorado Watershed Project will be a multidiscipline effort to demonstrate and evaluate the effectiveness of selected BMPs to reduce nutrient and pesticide loading of the Arroyo Colorado Watershed.

The purpose of this project is to collect sufficient data on two demonstration sites to determine if the installation of BMPs significantly improves water quality. The concentration of nutrient and pesticide levels before and after installation of BMPs will be used to determine the effectiveness of selected BMPs in reducing nutrient and pesticide loading to the Arroyo Colorado Watershed.

The Arroyo Colorado project will implement two demonstration sites and determine their effectiveness in abating nonpoint source pollution associated with agricultural runoff. The first demonstration site will be on 60 acres of dryland cropland in Cameron County. A map of the dryland demonstration site (Attachment B1-4) is shown on page 22 of the QAPP. This demonstration site will have a control field with conventional practices and a treated field with the benefit of BMPs.

There will be three best management practices implemented on the dryland demonstration site. The first BMP to be used is nutrient management. On the control site standard nutrient application methods will be utilized. On the treated site split-application of nutrients will be applied and the residual amount of nutrients in the soil will be identified to determine correct nutrient application rates. The use of split-applications of nutrients allows the application to occur during a plants growing cycle when the plants can use the nutrients most efficiently. The second BMP that will be utilized is crop plant residue management. At the dryland demonstration site, crop plant residue management will be utilized on the treated fields at a minimum rate of 2000 pounds per acre. On the control field, the crops will be tilled into the soil and will not be left remaining on the surface of the field as a residue. The final BMP that will be utilized is precision land forming which is reshaping the surface of a field into planned grades. The control site will not have precision land forming implemented on the site. However, the treated site will have precision land forming implemented on the site which will control erosion and constituents leaving the site.

The second demonstration site will be on 40 acres of irrigated cropland in Cameron County. A map of the irrigated demonstration site (Attachment B1-5) is shown on page 23 of the QAPP. This demonstration site will have a control field with conventional practices and a treated field with the benefit of BMPs. The project will utilize a subsurface drainage monitoring system located on the treated and control field to monitor the impact of BMPs on the irrigated cropland.

There will be two best management practices implemented on the irrigated demonstration site. The first BMP that will be used is irrigation management. This management practice

will focus on how improved irrigation technology, the frequency that the fields are irrigated, and the volume of water placed on the fields effect the quality of water discharged from site. The other BMP that will be used is nutrient management. On the control site standard nutrient application methods will be utilized on the site. On the treated site split-applications of nutrients will be applied to the site and the residual amount of nutrients in the soil will be identified to determine correct application rates of nutrients. The use of split-applications of nutrients allows the application of nutrients to occur during a plants growing cycle when the plants can use the nutrients most efficiently.

Water samples collected from the two demonstration sites in Arroyo Colorado Watershed will be analyzed for the presence of nitrates, orthophosphates, pesticides, and total suspended solids. The pesticides that will be analyzed during this project have been used on the dryland and irrigated demonstration sites in the past few years and will be used on these sites during the project. Water samples will be collected on the dryland site when a rainfall runoff event occurs and on the irrigated site when an irrigation or rainfall event results in subsurface drainage.

During the course of the project, BMPs will be designed and implemented prior to water sampling. At the conclusion of water sampling, BMPs will be evaluated to determine their effectiveness in limiting NPS pollution. Mathematical model(s) will also be applied to individual fields and agriculturally dominated regions of the project area to show BMP system efficiency. The models that will be used include EPIC, EPIC-WT, and DRAINMOD and the models will be verified using data from the demonstration sites. The model(s) used in the final analysis will depend upon the validated individual model(s) performance. Edge-of-field load reductions for nutrients, pesticides and sediment will be calculated for the demonstration sites and estimated for the project area.

The Southmost SWCD will be primarily responsible for the installation of demonstration sites. The NRCS will be primarily responsible for the installation of monitoring equipment. Water sample collection will be performed by the Southmost SWCD. TIAER will be primarily responsible for laboratory analysis of water samples. TAEX will analyze the monitoring data and determine the effectiveness of the BMPs. TIAER will apply mathematical model(s) to individual fields and agriculturally dominated regions of the project area. Edge-of-field load reductions for nutrients, pesticides and sediment from BMPs will be calculated for the demonstration sites and estimated for the project area. The educational and technology activities will be done by TAEX. Table A6-1 lists the monitoring plan milestones.

Table A6-1 Monitoring Plan Milestones

Nov	1995	Install BMPs on treated fields
Nov	1995	Monitoring equipment installed and monitoring initiated
July	1997	Conclusion of water quality sampling
July	1997	Draft Project reports on modeling results and BMP effectiveness submitted.
Aug	1997	Final Project reports on modeling results and BMP effectiveness submitted.

Section A7: Data Quality Objectives for Measurement Data

Nonpoint source pollution generated from the agriculture industry has the potential for contaminating surface water resources in the Arroyo Colorado Watershed. The project's data quality objective is to demonstrate water quality improvements from BMPs designed to reduce nutrient and pesticide stormwater loadings from agricultural fields. BMPs will be evaluated in their effectiveness to a confidence level of 90 percent. The project hosts a number of participants including:

- 1) US Environmental Protection Agency, Region VI (EPA)
- 2) Texas State Soil and Water Conservation Board (TSSWCB)
- 3) Texas Natural Resource Conservation Commission (TNRCC)
- 4) Texas Institute for Applied Environmental Research (TIAER)
- 5) Texas Agricultural Extension Service (TAEX)
- 6) Natural Resources Conservation Service (NRCS)
- 7) Southmost Soil and Water Conservation District (SWCD)
- 8) Local landowners

This project will demonstrate the effectiveness of selected agricultural BMPs to reduce nutrient and pesticide loading in the Arroyo Colorado Watershed. For the two demonstration sites, when sufficient overland water flow exists, water samples will be collected from the sites. To aid in evaluating BMPs, mathematical model(s) will be used. Edge-of-field load reductions for nutrients, pesticides and sediment will be calculated for the demonstration sites and estimated for the project area.

Automatic ISCO water samplers will be utilized to collect water samples during stormwater runoff events. Water samples will be collected from the demonstration sites (a maximum of 8 runoff events or 48 samples / year and a minimum of 3 runoff events or 18 samples / year for each demonstration site). However, the number of samples that can be collected at the demonstration sites is totally dependent upon the weather conditions. Concurrent flow data will provide information to locate the beginning, peak and end of stormwater runoff events at each site. Concurrent flow data will be estimated from water levels with standard open-channel flow equations such as the Chezy-Manning equation for the irrigated demonstration site and wier discharge equations for the dryland demonstration sites. The ISCO 3700 water samplers will be set up to catch the first flush of runoff from the demonstration sites when sufficient flow exist. The automatic sampler timers will be programmed with different time sampling regimes for each demonstration site (Table B1-3). Samples for analysis will be selected based on the following criteria: Samples will be analyzed within the estimated accuracy and precision limits of measured parameters to insure data quality (Table A7-1). The accuracy limits shown in (Table A7-) are for the laboratory data quality and not water quality.

Because generalized fertilizer recommendations often result in an increased risk in excessive fertilizer application, soil samples will be taken at each treatment site and analyzed for nutrients and texture in order to determine the appropriate fertilizer rates. These soil samples will be analyzed by the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory. Estimated determinations for precision and accuracy for laboratory analyses, based on an extensive database, are outlined in Table A7-2.

Table A7-1 Estimated Accuracy and Precision Limits of Measured Water Parameters

Nutrient/pollutant	Processing Agency	Precision Limits (PD)*	Accuracy Limits **	Estimated Practical Quantity Limits ***
Conductivity	TIAER	10%	90-110%	10 µmhos/cm
Total Suspended Solids	TIAER	10%	NA	50 mg/L
Chemical Oxygen Demand	TIAER	10%	80-120%	30 mg/L
Nitrate-Nitrite Nitrogen	TIAER	10%	80-120%	0.030 mg/L
Orthophosphate - Phosphorous	TIAER	10%	80-120%	0.050 mg/L
Ammonia Nitrogen	TIAER	10%	80-120%	0.185 mg/L
Total Kjeldahl Nitrogen	TIAER	10%	80-120%	0.97 mg/L
Total Phosphorus	TIAER	10%	80-120%	0.505 mg/L
Parathion (methyl)	TIAER	12%	61- 123%	0.059 µg/L
Azinphos-methyl	TIAER	10%	37- 127%	0.03 µg/L
Malathion	TIAER	10%	66- 118%	0.036 µg/L
Permethrin (cis)	TIAER	29%	41- 157%	0.66 µg/L
Permethrin (trans)	TIAER	29%	41- 157%	0.66 µg/L
Trifluralin	TIAER	15%	3- 177%	0.16 µg/L
Prometryn	TIAER	30%	10-110%†	0.20 µg/L
Atrazine	TIAER	20%	31- 132%	0.500 µg/L
* Percent Deviation			NA	Not applicable
** These represent the maximum allowable accuracy limits. Typically the actual accuracy limits will be narrower.			mg/L µg/L	milligrams per liter micrograms per liter
*** PQL determined by multiplying MDL by 5.0			µmhos/cm	miromhos per centimeter
† Determined in the TIAER laboratory				

Table A7-2 Accuracy and Precision Limits of Measured Soil Parameters

Parameter	Processing Agency	Precision Limits	Accuracy Limits	PQL
Nitrate-nitrogen	TAEX	4%	30%	0.05 mg/kg
Phosphorus	TAEX	4%	5% (acid soils)	0.05 mg/kg
pH	TAEX	0.3%	1%	4-10
Potassium	TAEX	22%	8%	5 mg/kg
Calcium	TAEX	2%	15% (acid soils)	1 mg/kg
Magnesium	TAEX	4%	6% (acid soils)	1 mg/kg
Sodium	TAEX	25%	9%	5 mg/kg
Sulfate	TAEX	14%	not determined	0.500 µg/L

PQL = Practical Quantity Limits

Data collection and analyses will meet an 90 percent data completeness. These data will be presented as mean levels for evaluation. Statistical comparison of BMPs will include analysis of variance with a 90 percent level of confidence. Although 100 percent of collected data should be available, accidents, insufficient sample volume, or other problems must be expected. A goal of 90 percent data completeness will be required for data usage. If less than 90 percent data completeness occurs, the Program Manager will initiate corrective action. Data completeness will be calculated as a percent value and evaluated with the following formula:

$$\% \text{ completeness} = \frac{SV}{ST} \times 100$$

Where: SV = number of samples with a valid analytical report
ST = total number of samples collected

The TIAER Laboratory will determine the precision of its analyses. This will be

accomplished by repeating the entire analysis of a sample once per batch or once per 10 samples which ever is the greater frequency. Percent deviation of duplicate analyses (X_1 and X_2) will be calculated using the formula:

$$\text{Percent Deviation} = \frac{(X_1 - X_2)}{(X_1 + X_2)} \times 100\%$$

Where: X_1 = larger of the two observed values
 X_2 = smaller of the two observed values

The accuracy of the analytical process will be monitored by determining the percent recovery of a spike quantity of the parameter in question once per batch or once per 10 samples which ever is the greater frequency. The following formula will be utilized to determine percent recovery:

$$\% \text{ Recovery} = \frac{\text{SSR} - \text{SR}}{\text{SA}} \times 100$$

Where: SSR = spiked sample result
SA = spike added
SR = sample un-spiked result

The accuracy of water samples collected will be reviewed by taking equipment blanks on 5% of the samples collected. This would amount to collecting a equipment blank once per 20 samples collected at each demonstration site. This will be accomplished by taking samples of deionized water through the ISCO samplers and sending the samples to the TIAER Laboratory for analyzes.

The Quality Assurance Manager will review the data for abnormalities or any unusual results. Any of these that occur will be traced back looking for sources of error. In the event no error is found, the data will be assumed normal and appropriate for decision determinations. If an error is found and cannot be resolved then the data will be discarded.

The Quality Assurance Manager will coordinate with the Project Manager and the laboratory supervisor to ensure that proper protocols are utilized. Table A7-1 shows the study limits established for accuracy and precision.

Section A10: Documentation and Records

Reporting will include quarterly progress reports, reimbursement requests, and a final report at the culmination of the project.

Quarterly progress reports will note activities conducted throughout the quarter, items or areas identified as potential problems. Any changes or amendments to the QAPP will be submitted for approval prior to implementation. Corrective Action Report forms (CARs) will be utilized by TIAER when necessary (Attachment A10-1). CARs will be included in TIAER's annual quality assurance report and will be available to project participants, upon request.

Laboratory results with a summary of data to date will be prepared periodically and distributed to project participants upon request. Variations from the QAPP and subsequent CARs will be filed by the responsible agency. CARs relating to analysis of water samples will be filed by the TIAER laboratory manager.

Reimbursement requests for TIAER will be handled by the Tarleton State University accounting office in Stephenville. Reimbursement requests for NRCS will be handled by the NRCS Financial Management Section in Temple. Reimbursement requests for SWCD will be handled by the SWCD staff in Harlingen.

The final report will include results of laboratory and statistical analyses with a summary of the data that was collected during the course of the project. Hard copies of all raw data, laboratory analyses, documentation records, calibration logs, and other pertinent information will be available for inspection. All original data, both hardcopy and electronic forms, will be archived by TIAER for at least 5 years.

Attachment A10-1 Corrective Action Report (CAR) Form

Corrective Action Report

CAR #: _____

Date: _____

Area/Location: _____

Reported by: _____

Activity: _____

State the nature of the problem, nonconformance or out-of-control situation:

Possible causes:

Recommended Corrective Actions:

CAR routed to: _____

Received by: _____

Corrective Actions taken:

Has problem been corrected: YES NO

Quality Assurance Coordinator: _____

Project Manager: _____

Quality Assurance Officer: _____

Laboratory Manager: _____

Section B1: Sampling Process Design (Experimental Design)

This project is designed to target two demonstration sites within segment 2202 of the Arroyo Colorado Watershed. Work to be completed on the demonstration sites includes: implementing appropriate NPS pollution control BMPs, identifying the levels of contamination after BMP implementation, and demonstrating any resultant changes in water quality. The waterborne constituents which will be measured to demonstrate BMP effectiveness are shown in Table B1-1.

Two demonstration sites will be installed and their effectiveness in abating nonpoint source pollution associated with agricultural runoff will be determined. The first demonstration site will be on 60 acres of dryland cropland. A map of the dryland demonstration site (Attachment B1-4) is shown on page 22 of the QAPP. This demonstration site will have a control field with conventional practices and a treated field with the benefit of BMPs (see section A-6 for list of BMPs).

The second demonstration site will be on 40 acres of irrigated cropland in Cameron County. A map of the irrigated demonstration site (Attachment B1-5) is shown on page 23 of the QAPP. This demonstration site will have a control field with conventional practices and a treated field with the benefit of BMPs. The project will utilize a subsurface drainage monitoring system located on the treated and control field to monitor the application of BMPs on the irrigated cropland (see section A-6 for list of BMPs).

In order to assess whether selected BMPs will reduce nutrient and pesticide loading of the Arroyo Colorado Watershed, water samples will be taken at the two demonstration sites. Stormwater runoff will be collected in these locations with ISCO automatic sampling devices during each rainfall event that is of sufficient intensity and duration to trigger the automatic sampling devices. Stormwater runoff samples will be collected from each demonstration site up to a maximum of 8 runoff events or 48 samples / year and a minimum of 3 runoff events or 18 samples / year for each demonstration site (Table B1-2). Sampling on the demonstration sites will be completely weather dependent so fewer than 48 samples may occur. The automatic sampler timers will be programmed with different time sampling regimes for each demonstration site (Table B1-3). The timing of when samples are collected may be adjusted based upon individual site response. The dryland demonstration site will have earthen berms separating the site from other adjacent fields and a earthen berm separating the control and treated fields from each other.

In order to determine appropriate fertilizer application rates at the two treatment sites, soil samples will be collected and analyzed. Approximately 30 random samples will be taken per treatment site for a total of 60 samples each year and a 120 samples for two years. Samples will be taken at depths of 0 to 6", 6 - 12", 12 - 18", 18 - 24", and 24-36".

This project will evaluate BMP effectiveness at a confidence level of 90 percent over the sampling period. Water quality data collected from the irrigated and dryland sites with and without BMP implementation will be compared to demonstrate BMP effectiveness.

Table B1-1 Waterborne Constituents

Parameter	Reporting Units
Conductivity	µmhos/cm
Chemical Oxygen Demand	mg/L
Total Suspended Solids	mg/L
Ammonia Nitrogen	mg/L
Total Kjeldahl Nitrogen	mg/L
Nitrate-Nitrite Nitrogen	mg/L
Orthophosphate Phosphorous	mg/L
Total Phosphorous	mg/L
Methyl Parathion	µg/L
Azinphos-methyl	µg/L
Malathion	µg/L
Permethrin (cis/trans)	µg/L
Trifluralin	µg/L
Prometryn	µg/L
Atrazine	µg/L

Table B1-2 Number of Samples

Sample Type	Agency	Maximum Number of Samples per Year	Minimum Number of Samples per Year
Runoff Treated Irrigated Site	SWCD	48/year	18/year
Runoff Control Irrigated Site	SWCD	48/year	18/year
Runoff Treated Dryland Site	SWCD	48/year	18/year
Runoff Control Dryland Site	SWCD	48/year	18/year

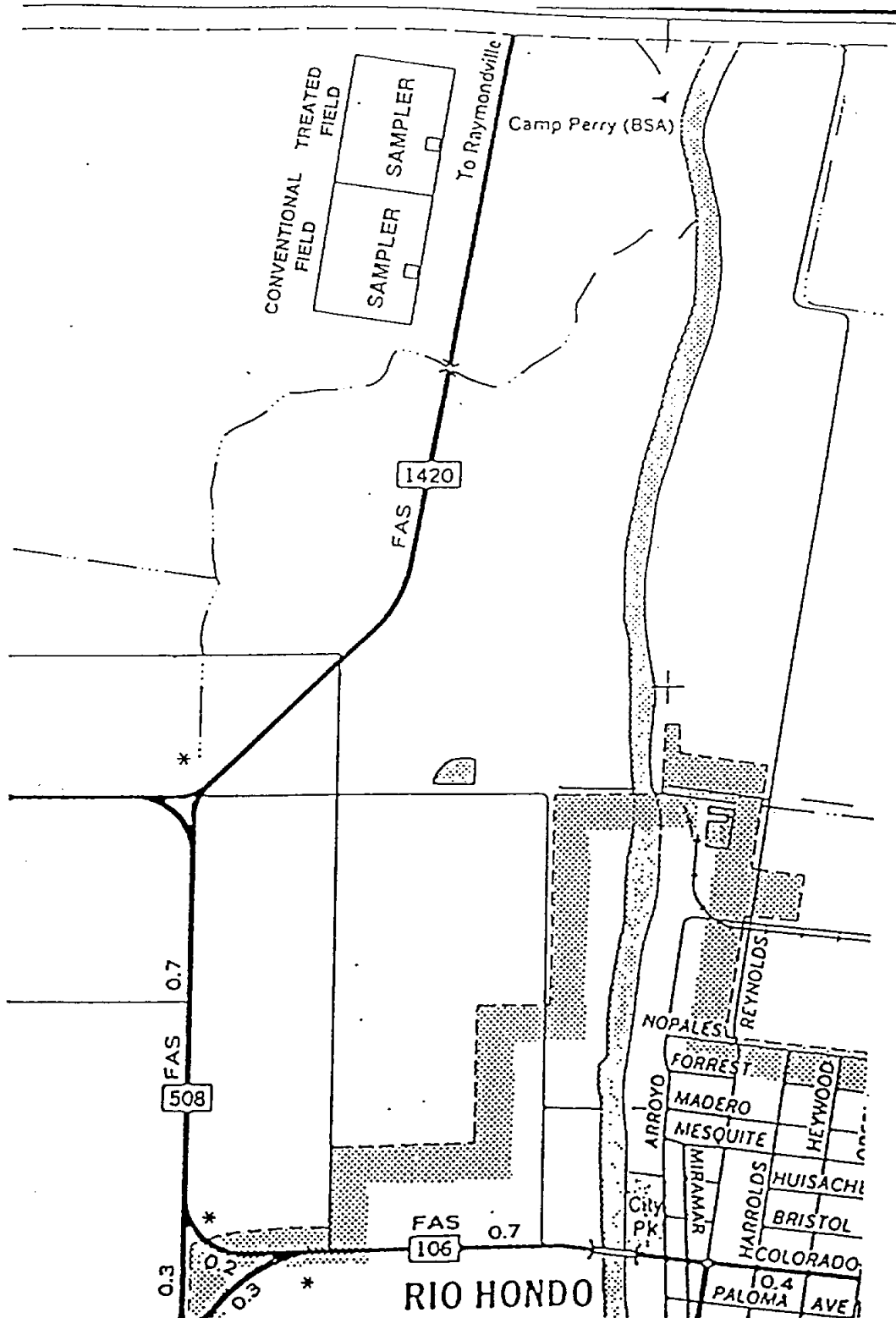
* Minimum desired number of samples; however, actual number of samples is dependent upon weather conditions.

Table B1-3 Demonstration Sites Time Sampling Regimes

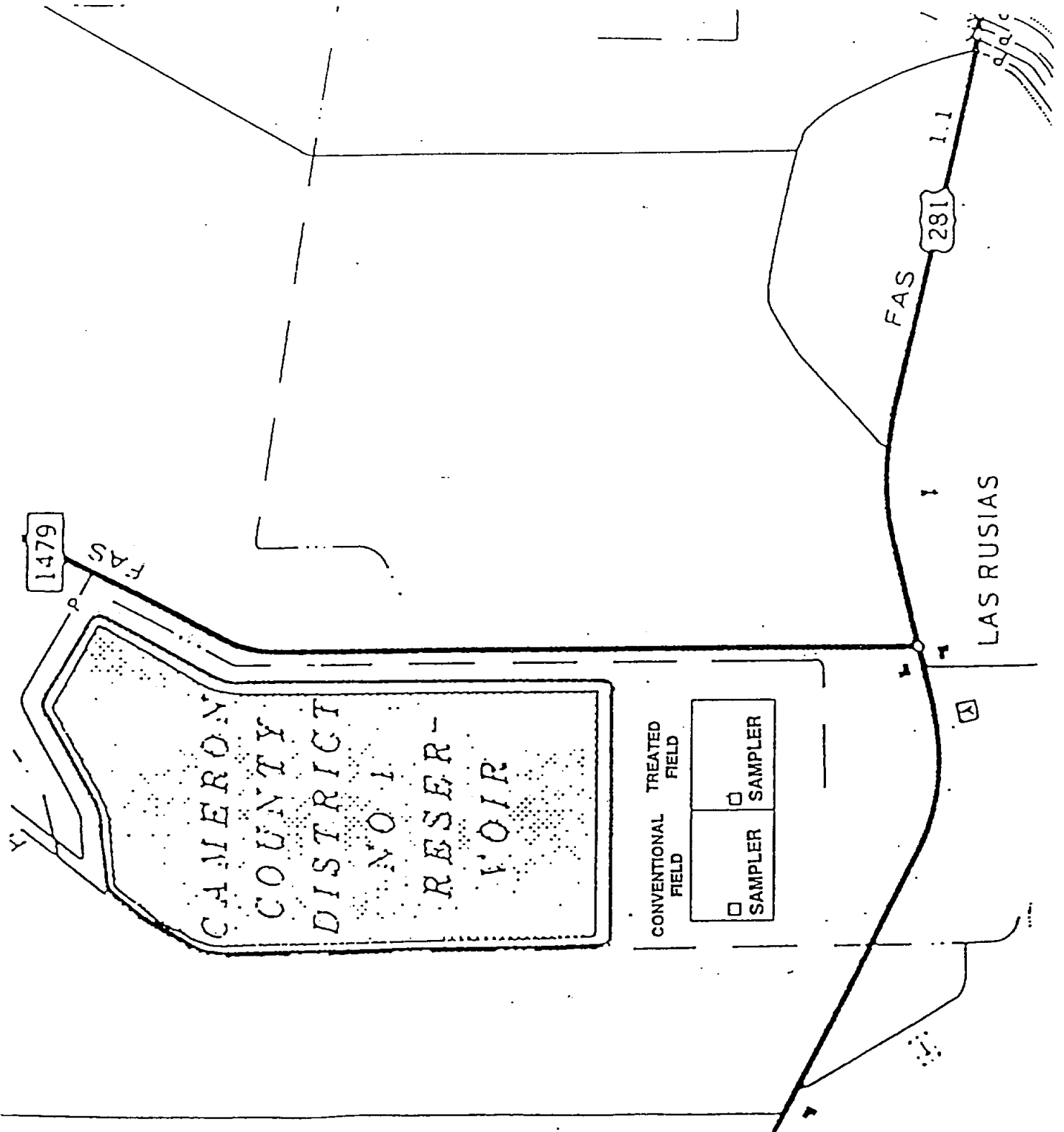
Sample Number	Dryland Site Overland Flow *	Irrigated Site Subsurface Flow *
# 1	Time 0.0 Hours	Time 0.0 Hours
# 2	Time 1.0 Hours	Time 3.0 Hours
# 3	Time 3.0 Hours	Time 6.0 Hours
# 4	Time 6.0 Hours	Time 12.0 Hours
# 5	Time 9.0 Hours	Time 18.0 Hours
# 6	Time 12.0 Hours	Time 24.0 Hours

* All times referenced to sampler activation time of 0.0 hours.

Attachment B1-4 Location Map for Dryland Demonstration Site



Attachment B1-5 Location Map for Irrigated Demonstration Site



Section B2: Sampling Methods Requirements

Emphasis during this project will be placed on sampling stormwater runoff from two agricultural demonstration sites. Stormwater runoff samples will be collected with automatic sampling equipment. Each unit will consist of a weatherproof, lockable instrument shelter; a solar / battery powered system and a timer controlled ISCO Model 3700 Water Sampler. A pressure transducer will be used on the dryland demonstration sites to activate the samplers when the water rises to a predetermined level. The pressure transducers will be used to measure the elevation of water above the transducer and this data will be stored on a data logger on a continual basis. A float and pulley system will be used on the irrigated demonstration site to activate the samplers when the water rises to a predetermined level. The float and pulley system will be connected to a data logger which will record the water level elevation within the drainage tile on a continual basis.

Up to 6 samples may be collected as the ISCO 3700 water sampler contains a set of 12 one liter glass bottles. For the laboratory to analyze the samples received one liter of water must be collected for pesticides and one liter of water for other constituents, i.e., two one liter bottles comprise a single sample.

Water samples will be collected with the automated water samplers when the water level rises to a predetermined point. Concurrent flow data will provide information to locate the beginning, peak and end of stormwater runoff events at each site. Flow will be estimated from water levels with standard open-channel flow equations such as the Chezy-Manning equation for the irrigated demonstration site and wier discharge equations for the dryland demonstration sites. The ISCO 3700 water samplers will be set up to catch the first flush of runoff from the demonstration sites when sufficient flow exist. The automatic sampler timers will be programmed with different time sampling regimes for each demonstration site (Table B1-3).

Soil samples will be taken at depths of 0-6", 6-12", 12-18", 18-24" and 24-36". Samples will be mailed to the TAMU Soil Testing Lab at College Station for analysis. Soil samples will be collected following recommendations made by TAEX (attachment B2-1)

All automatic sampling equipment will be inspected at least once every two weeks and serviced as needed. Sample collection at the demonstration sites will be performed by the Southmost SWCD Quality Assurance Coordinator or his representative. After a rainfall event, the ISCO samplers will be inspected within 24 hours to see if water samples have been collected. If the ISCO samplers properly collected water samples, then the samples will be transported to the TIAER laboratory for analysis.

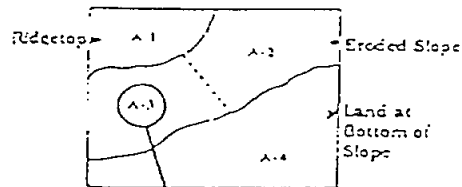
Any problems encountered during the collection of water samples will be documented with a Corrective Action Report (See Attachment A10-1). Corrective Action Reports must be documented in writing and is the responsibility of the Southmost SWCD Quality Assurance Coordinator or his representative.

Attachment B2-1 Procedure for Taking Soil Samples

Procedure For Taking Soil Samples

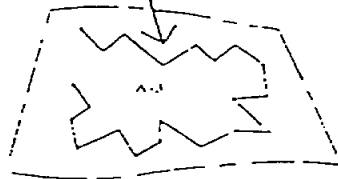
Soil tests can be only as accurate as the samples on which they are made. Proper collection of soil samples is extremely important. Chemical tests of poorly taken samples may actually be misleading because they do not represent the area to be cropped.

Step 1.



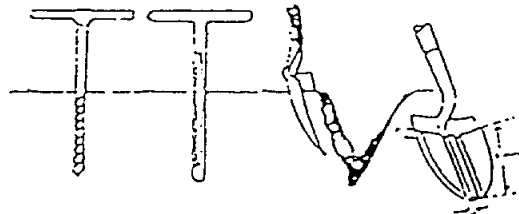
Take one composite soil sample from each uniform area of 10 to 40 acres in a field. In areas such as East Texas, one sample should represent only 10 to 20 acres; whereas, in areas where soils are more uniform, one sample can represent up to 40 acres.

Step 2.



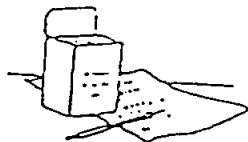
The composite sample should be taken from each area. This can be done by taking small cores or slices from 10 to 15 different places. Place these in a clean container (plastic bucket, paper sack, etc.), mix thoroughly and take out approximately 1 pint for the composite sample.

Step 3.



When taking soil samples, use a spade, soil auger or soil sampling tube as illustrated. Scrape the litter from the surface. Make the core or boring 6 inches deep in the soil. (For permanent sod, sample to a depth of 3 to 4 inches) To use a spade, dig a V-shaped hole and take a 1 inch slice of soil from the smooth side of the hole. Then take a 1 X 1 inch core from the center of the shovel slice as illustrated. Repeat in 10 to 15 different places, put in a clean plastic bucket, thoroughly mix and remove a pint as a composite sample representing the field or area.

Step 4.



Complete the information form on the opposite side. Enclose the completed information form and payment inside the package containing samples. Make check payable to Soil Testing. **DO NOT SEND CASH.** Address the letter and package to one of the following addresses:

Extension Soil, Water, and Forage Testing Laboratory
 Texas A&M University - Soil & Crop Sciences
 College Station, Texas 77843-2474
 Phone 409/845-4815

Soil Testing Laboratory
 Texas Agricultural Extension Service
 Lubbock, Texas 79401-9745
 Phone 806/746-6101

Precautions

1. Avoid sampling spots in the field such as small gullies, slight field depressions, terrace waterways and unusual spots.
2. When sampling fertilized fields, avoid sampling directly in fertilized band.
3. Do not use old vegetable cans, tobacco cans, match boxes, etc., to submit samples.
4. Do not use heat to dry samples.
5. Be sure to keep a record for yourself as to the area represented by each sample.
6. Be sure sample numbers on the boxes correspond with sample numbers on the information sheet.

For Further Details Consult Your County Extension Agent

Educational programs conducted by the Texas Agricultural Extension Service serve people of all ages regardless of socioeconomic level, race, color, sex, religion, handicap or national origin.

Section B3: Sample Handling and Custody Requirements

Requirements for sample handling include collection, preservation, shipping, transfer of sample custody, and storage in a manner that does not compromise sample integrity or exceed holding times for analyses. Table B3-1 delineates sample container, preservation and holding time information for parameters of interest in this project. A sample COC is included in Attachment B3-2. The sampling team will, upon collection, labeling and preservation of the samples, complete the sample description, date/time of collection information and sign the COC to transfer custody. The COC, sealed in a water proof bag, will be packed with the samples in coolers with ice, sealed with tape and shipped to the laboratory. Custody seals on sample bottles and shipping coolers will not be used on this project because the potential for litigation or fines is not expected to exist. Shipment of samples from the Harlingen area will be accomplished overnight to the Stephenville laboratory using Greyhound Bus Lines as the primary carrier. Federal Express and United Parcel Service priority shipments will be used as backup methods.

Once the samples are received at the laboratory, they will be inventoried against the accompanying COC, any discrepancies noted, and the COC will be signed for acceptance of custody. The sample numbers will then be recorded into a laboratory sample log, checked for preservation (as allowed by the specific analytical procedure), filtered or pretreated as necessary, and placed in a refrigerated cooler dedicated to sample storage.

The Laboratory Manager has the responsibility to ensure that all holding times are met. This is documented on COC for sample dates and times and on analytical run logs for analysis dates and times.

Table B3-1 Sample Preservation and Holding Times

Parameter	Method	Sample Size	Container	Preservation	Holding Time
Ammonia Nitrogen	EPA 350.1	1 liter	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Nitrate-Nitrite Nitrogen	EPA 353.2	1 liter	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Total Kjeldahl Nitrogen	EPA 351.1, EPA 351.2	1 liter	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Orthophosphate Phosphorus	EPA 365.2	1 liter	AW-GB	4°C	28 days
Total Phosphorus	EPA 365.4, EPA 365.2	1 liter	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Total Suspended Solids	EPA 160.2	1 liter	AW-GB	4°C	7 days
Conductivity	EPA 120.1	1 liter	AW-GB	4°C	28 days
Chemical Oxygen Demand	Hach 8000	1 liter	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Azinphos (methyl)	EPA 1657	1 liter	AW-GTLL	4°C *	7 days **
Malathion	EPA 1657	1 liter	AW-GTLL	4°C *	7 days **
Parathion (methyl)	EPA 1657	1 liter	AW-GTLL	4°C *	7 days **
Prometryn	EPA 1657	1 liter	AW-GTLL	4°C *	7 days **
Atrazine	EPA 1656	1 liter	AW-GTLL	4°C *	7 days **
Trifluralin	EPA 1656	1 liter	AW-GTLL	4°C *	7 days **
Permethrin (cis/trans)	EPA 1656	1 liter	AW-GTLL	4°C *	7 days **

AW-GB=aluminum foil wrapped glass bottles

H₂SO₄=concentrated sulfuric acid

4°C= 4 degrees centigrade

AW-GTLL=aluminum foil wrapped glass with Teflon lined lid

* sodium thiosulfate must be added to 0.008% if sample contains chlorine residual

** 7 days until extraction, 40 days to analyze after extraction

Chain of Custody Form (Attachment B3-2)
(located on the following pages)

Section B4: Analytical Methods Requirements

Only EPA approved methods shall be used for analytical data collection in accordance with 40 CFR 136. Documentary logs shall be maintained for instrument maintenance and calibration, sample extractions, standard and matrix spiking preparations. Table B4-1 delineates specific methods of analyses with equipment and instruments to be used and estimated method detection limits. Sample analysis will be performed by the Texas Institute for Applied Environmental Research, Tarleton State University, Stephenville, Texas. Glassware and labware shall be cleaned according to the specific method requirements. Corrective actions shall be initiated and resolved as described in section B5.

Table B4-1 Laboratory Analytical Methods

Parameter	Method	Equipment Used	Estimated MDL *
Ammonia Nitrogen	EPA 350.1	Perstorp Analytical Autoanalyzer	0.037 mg/L
Nitrate-Nitrite Nitrogen	EPA 353.2	Perstorp Analytical Autoanalyzer	0.006 mg/L
Total Kjeldahl Nitrogen	EPA 351.1, 351.2	Perstorp Analytical Autoanalyzer with Tecator block digester	0.194 mg/L
Orthophosphate Phosphorus	EPA 365.2	Bechman DU64 Spectrophotometer	0.010 mg/L
Total Phosphorus	EPA 365.4, 365.2	Perstorp Analytical Autoanalyzer with Tecator block digester	0.101 mg/L
Total Suspended Solids	EPA 160.2	Sartorius AC21P or Mettler AT261 Analytical Balance, Oven	10 mg/L
Conductivity	EPA 120.1	Platinum electrode, Hach conductivity meter, model 44600	2.0 µmhos/cm
Chemical Oxygen Demand	Hach 8000	Hach DR 2000	6 mg/L
Azinphos (methyl)	EPA 1657	Thermionic Bead Nitrogen - Phosphorus Detector 5% carbowax packed primary with % carbowax Gas Chrom Q confirmation column	0.009 µg/L
Malathion			0.011 µg/L
Parathion (methyl)			0.018 µg/L
Prometryn			0.020 µg/L
Trifluralin	EPA 1656	Electron Capture Detector, DB-608 primary column with a DB1701 confirmation column	0.05 µg/L
Permethrin (cis/trans)			0.02 µg/L
Atrazine			0.50 µg/L

* MDL - Method Detection Limit, redetermined periodically.
MDLs determined October 1996
Pesticide MDLs determined September 1996

Soil samples collected during this project will be analyzed by the Texas Agricultural Extension Service Soil, Water and Forage Testing Laboratory in College Station, TX. There are no EPA approved methods for these sample matrices. Accepted procedures are listed in Table B4-2.

Table B4-2 Soil Analytical Methods

Parameter	Method	Equipment Used	Estimated MDL1
Nitrate-nitrogen	Colorimeter, 410nm	TRAACS ²	---
Phosphorus	ICP ^{3,4}	Perkin-Elmer	---
pH	Electometric	Orion Digital	0.1
Potassium	ICP	Perkin-Elmer or Spectro	---
Calcium	ICP	Perkin-Elmer or Spectro	10 ug/L
Magnesium	ICP	Perkin-Elmer or Spectro	30 ug/L
Sodium	ICP	Perkin-Elmer or Spectro	29 ug/L
Sulfate	ICP	Perkin-Elmer or Spectro	---
Conductivity	Conductivity bridge	Horizon Ecology	N/A

¹ MDL is the Method Detection Limit.

² TRAACS autoanalyzer by Braun and Luebe.

³ ICP is Inductively Coupled Plasma Spectroscopy.

⁴ Analysis of P using ICP has comparable results to colorimeter analysis, as per Donaho and Alto, 1992.

Section B5: Quality Control Requirements

Samples shall be acquired using automated ISCO samplers with glass bottles and silicon tubing to assure integrity of pesticide analytes.

Data acceptance criteria shall be based upon precision and accuracy monitoring as described in Table B5-1. Method Detection Limit (MDL) estimates are listed in Table B4-1 above. MDLs are determined by analyzing a low level standard at 3-5 times the estimated MDL. This standard is analyzed 7 times using normal calibration and instrument operating conditions. The standard deviation of the 7 readings is determined and multiplied by 3.14 to obtain the MDL for the parameter of interest. Analytical precision shall be determined through the use of laboratory duplicate samples. For pesticides, matrix spikes (MS) and matrix spike duplicates (MSD) are used. The Percent Deviation is determined from the duplicate values. Sample matrix spiking, the addition of a known amount of the analyte of interest to a sample aliquot, is used to determine interferences present in the sample matrix. Accuracy is determined by percent recoveries of matrix spikes and of a Laboratory Control Sample (known spike of deionized water). Acceptance limits are listed in Table B5-1. In the event that a pesticide is detected in a sample from an unfamiliar site, the use of a secondary column analysis is required. This is a separate gas chromatographic column with different operating parameters used to confirm the presence of the pesticide. In the analysis of pesticides, surrogate standards are also added to all samples, calibration standards and method blanks. Surrogates are similar in chemical composition to the pesticides of interest, but are not likely to be present. This method shows that no pesticide loss occurs during sample preparation steps or GC operation. The use of method blanks, deionized water carried through all processes, will demonstrate that no contamination of samples occurs through laboratory handling or operation. Method blanks shall be used with every parameter in this project except conductivity and will be done on a 10% basis. Spikes and duplicate analyses will be performed will be done on a 10% basis for each set of samples collected..

In the event that a situation arises which may indicate a compromise of sample integrity or data quality, a Corrective Action Report (CAR) shall be initiated (Attachment A10-1). The person who first identifies the out-of-control situation shall initiate a Corrective Action by completing the first portion of the form and presenting it to his/her immediate supervisor. Out-of-control situations include, but are not limited to, automated stormwater sampler malfunction, broken sample bottles, missed holding times, instrument malfunction, improper preservation, or acceptance criteria for precision and accuracy not met. An attempt shall be made to correct the problem at the source level, supervisory levels, or the Project Manager may decide on what action to take if further action is deemed necessary. CARs initiated by TIAER Laboratory Manager will be included in TIAER's annual quality assurance report and will be available to project participants, upon request.

Table B5-1 QC Acceptance Criteria

Parameter	Percent Deviation (PD)	Spike Recovery	Surrogate Used	Surrogate Recovery	LCS Recovery
Ammonia Nitrogen	10%	80-120%	NA	NA	80-120%
Nitrate-Nitrite Nitrogen	10%	80-120%	NA	NA	80-120%
Total Kjeldahl Nitrogen	10%	80-120%	NA	NA	80-120%
Orthophosphate Phosphorus	10%	80-120%	NA	NA	80-120%
Total Phosphorus	10%	80-120%	NA	NA	80-120%
Total Suspended Solids	10%	NA	NA	NA	80-120%
Conductivity	10%	NA	NA	NA	80-120%
Chemical Oxygen Demand	10%	80-120%	NA	NA	80-120%
Azinphos (methyl)	10%	37-127%	TBP, TPP	40-120%	83-119%
Malathion	10%	66-118%	TBP, TPP	40-120%	82-108%
Parathion (methyl)	12%	70-130%	TBP, TPP	40-120%	89-114%
Prometryn	30%	10-110% †	TBP, TPP	40-120%	70-130%
Atrazine	20%	31-132%	DBC	40-120%	70-130%
Trifluralin	15%	3-177%	DBC	40-120%	47-134%
Permethrin (cis)	29%	41-157%	DBC	40-120%	70-130%
Permethrin (trans)	29%	41-157%	DBC	40-120%	80-120%

DBC= dibutyl chlorendate

TBP= tributyl phosphate

TPP= triphenyl phosphate

† Determined in the TIAER laboratory

Once matrix effects have been established for parameters, control charts will be used to establish more narrow acceptance criteria for LCS, duplicates and spikes.

Section B7: Instrument Calibration and Frequency

Instruments and laboratory equipment used in the analyses of these samples are listed in table B4-1 above. All instruments are calibrated prior to use with the exception of the COD system which maintains a stored calibration curve and is functionally checked with a laboratory control standard prior to use. Calibration is normally performed with a 5 point standard curve. The exception is for conductivity which uses a two point LCS check for the platinum cell electrode. TSS also requires no standard other than class "S" weights used to check the balance. Stock standards are made from ACS certified materials where possible. Pesticides standards are made from NIST traceable sources. All certified standards are maintained traceable with certificates on file in the laboratory. Dilutions from all standards are recorded in the standards log book and given unique identification numbers. The date, analyst initials, stock sources with lot number and manufacturer, and how dilutions are made are also recorded in the standards log book. The flow meters used on the irrigated and dryland demonstration sites will be calibrated according to manufacturers directions.

All automatic sampling equipment will be inspected at least once every two weeks and serviced as needed. After a rainfall event, the ISCO samplers will be inspected within 24 hours to see if water samples have been collected. If the ISCO samplers properly collected water samples, then the samples will be transported to the TIAER laboratory for analysis.

Section B9: Data Acquisition Requirements (Non-direct Measurements)

There is a weather station located on the irrigated demonstration site. This project will make use of weather data collected at this site as an input for the mathematical models. The mathematical models will determine the effectiveness of the BMPs in reducing edge-of-field loadings.

Section C1: Assessments and Response Actions

The commitment to use approved equipment and approved methods when obtaining environmental samples and when producing field or laboratory measurements requires periodic verification that the equipment and methods are, in fact, being employed and being employed properly. This verification will be provided through an annual field performance audit performed by TSSWCB. Individual field personnel will be observed during the actual field investigation to verify that equipment and procedures are properly applied. If any problems are discovered in the monitoring procedures that would affect the quality of data collected at the demonstration sites than the problems will be addressed by the project participants and followed up with a Corrective Action Report. The TIAER laboratory will not undergo a performance audit by TSSWCB. The TIAER laboratory has an internal system of quality assurance and assessment to ensure the quality of data produced. Also, TNRCC and EPA may conduct a performance audit for this project.

All laboratory analyses will have the precision and accuracy of data determined on the particular day that the data were generated. Depending on the analysis, certain methodologies require that water blanks, standards, and reagent blanks be analyzed to verify that no instrument or chemical problem will affect the quality of the data. The specific requirements are presented in Section B5 of the QAPP.

To minimize downtime of all measurement systems, all field measurement and sampling equipment, and all laboratory equipment must be maintained in a working condition. Also, backup equipment or common spare parts will be available if any piece of equipment fails during use so that repairs or replacement can be made quickly and the measurement tasks resumed.

Section C2: Reports to Management

The field measurement and sampling for the project will be done according to the QAPP. However, if the procedures and guidelines established in this QAPP are not successful, corrective action is required to ensure that conditions adverse to quality data are identified promptly and corrected as soon as possible. Corrective actions include identification of root causes of problems and successful correction of identified problem. Corrective Action Reports will be filled out to document the problems and the remedial action taken. Laboratory CARs initiated by TIAER Laboratory Manager will be included in TIAER's annual quality assurance report and will be made available to project participants, upon request.

Section D1: Data Review, Validation, and Verification

The project manager, laboratory manager and monitoring team personnel will be responsible for reviewing, validating, and verifying the measurement and sample data and the routine assessment of measurement procedures for precision and accuracy.

The Laboratory Manager shall be responsible for reviewing raw data produced by the TIAER laboratory. The Laboratory Manager shall check calculations on a 10% basis to verify that data is entered into the database correctly and be responsible for internal lab error corrections. Corrective Action Reports will be initiated in cases where invalid or incorrect data has been determined to have left the laboratory. Data outlier will be determined by constructing box plots and all data points that fall outside the inner fence will be considered outliers. The outliers will be checked for error in data transmission. Since most water quality data is not normally distributed, a natural log transformation on the data will be completed before construction of the box plots. Extreme outliers from the dataset (data points outside the outer fence) will be removed only if an error in data transmission can not be found. Nutrient data determined to be non-detected shall be reported as one-half the method detection limit. Pesticide data determined to be non-detected shall be reported as zero. The Quality Assurance Manager will review the project data prior to its usage in modeling and determination of BMP effectiveness for abnormalities or any unusual results. Any of these that occur will be traced back looking for sources of error. In the event no error is found, the data will be assumed normal and appropriate for decision determinations. If an error is found and cannot be resolved then the data will be discarded.

Whenever the procedures and guidelines established in this QAPP do not meet the specified levels of data quality, corrective actions will be required. Corrective action shall be initiated if variances from proper protocol are noted. Implementation of corrective actions will be the responsibility of the Quality Assurance Coordinator or the Laboratory Manager. Each manager may also initiate corrective action on his own initiative, if situations arise that require immediate attention. Documentation of any corrective action procedures through the Corrective Action Report (Attachment A10-1) will be provided by the appropriate manager, along with the results of implemented changes.

Section D3: Reconciliation with Data Quality Objectives

Data completeness in this project will be relative to the number of stormwater and irrigation events sampled as compared to the number of proposed sampling events. Unforeseen weather conditions or equipment unreliability may reduce the number of events sampled. Accidents in handling, shipping, and laboratory analysis may also reduce the completeness of the sampling program. It will be the goal of this project to achieve 90% completeness in data collected. The validity of data collected will be analyzed using a t-test. However the data may need to be transformed using a natural log transformation since most water quality data contains unequal variances (variances that increase with the size of the mean). Nonparametric test such as the Wilcoxon test on median values could be used if there is a concern that the data does not meet the assumptions for parametric analysis even after transformation.

Representativeness and comparability of data, while unique to each individual collection site, is the responsibility of the Project Manager and the General Manager. By following the guidelines described in this QAPP, and through careful sampling design, the data collected in this project will be representative of the actual field conditions and comparable to similar applications. Representativeness and comparability of laboratory analyses is the responsibility of the Laboratory Manager.

The Project Manager will review the final data to ensure that it meets requirements as described in this QAPP.

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APPENDIX D

TIAER Laboratory Audit

TEXAS STATE SOIL & WATER CONSERVATION BOARD

319 NPS PROJECT QUAPP AUDIT

QA Inspector: Maria G. Pinto

Project Name: Environmental Measurement Activities Relating to Arroyo Colorado NPS Project

By: TAES, Southmost SWCD

Location Visited: TIAER lab, Stephenville, TX

Person Visited: Mark Murphy, Lab Manager

Inspection Date: 9/30/96

Report Date: 10/08/96

Observations: A. Lab Conditions

Effective utility services and ideal environmental conditions such as proper lighting, ventilation, temperature and minimum noise levels were observed. Lab equipment was observed to be in good condition with thermometers where necessary (refrigerator and incubator) temperature log books are also kept by personnel, clean sinks and counters. Lab personnel is responsible for lab maintenance and warranties are always kept on expensive equipment. Lab safety is currently practiced: safety glasses, safety signs, emergency shower, etc. are available. The Lab uses standard "A" equipment. Since my last visit in November 1995, the lab has added a new piece of equipment that improves the data handling process, that is the PE Nelson 1022 which increases test results accuracy and might save up to half the time compared to the old method. This equipment is being used for the analysis of pesticides listed on the project's QAPP. The lab follows a QA/QC procedures manual approved by Mark Murphy (Lab Manager) and Nancy Easterling (Q/A Manager), approved SOP Manual, and *EPA-Methods for the Determination of Non conventional Pesticides in Municipal and Industrial Wastewater, EPA 821 RR-92-002*. The lab has improved the statistical analyses of the data by developing and incorporating a macro in the Microsoft excel spreadsheet software.

B. Testing, Lab Procedures, QC/QA

TSS, COD, Nitrate-Nitrite Nitrogen, Orthophosphate-Phosphorus, Ammonia Nitrogen, Total Kjeldahl Nitrogen, Total Phosphorus, Methyl Parathion, etc. as listed on *Table A7-1 Estimated Accuracy and Precision Limits of Measured Parameters* on p.14, rev. No. 1, are being analyzed at this location as mentioned in the project QAPP, except for Conductivity. It is a matter of concern whether such parameter needs to be determined at the Lab or out in the field, the QAPP needs to be corrected to show which processing agency is responsible for Conductivity.

All parameters are tested using the equipment and the EPA approved methods listed on *Table B4-1 Laboratory Analytical Methods* on p.28, QAPP revision No. 1, with the exception of COD which is determined by using the Hach 8000 instead of the Hach 2000, EPA method 410.4. The method used is equivalent to the EPA 410.4 listed on the Table B4-1. QA/QC is ensured by following QC requirement. The standard is analyzed 7 times using normal calibration every 6 months as instructed by the Lab Manager. Sample Matrix spiking is performed every 10 samples. Method blanks are used for every parameter and are done on a 10% basis. Log books are

kept on every procedure. Additional practices such as always keeping ovens at right temperature, running blanks, preventing loose data sheets by recording data in log books, running duplicates at least every 10th sample to calculate deviation, using statistical methods to accept data are all QC practices followed by lab personnel.

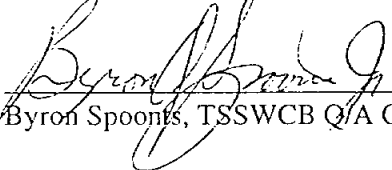
The lab manger has expressed concern on the current sample handling procedures being followed by the contractor. The lab has received samples past the allowable preservation time, whether it is due to shipping, preservation or transfer of sample custody problems is yet to be investigated. The lab still analyzes such samples but the results are not being considered statistically. Corrective action report forms (CARs) are being utilized but are not being submitted every quarter as part of the project quarterly reports (which are not being submitted either) as stated on *Section A10: Documentation and Records* p. 17 rev. No.1, but annually, as part of an annual report. The CAR form displayed on p.18 is currently being used to document such actions. The lab follows Sample handling and custody procedures as stated on p. 25 revision No. 1 and uses the Chain of Custody form-Attachment B3-2, on p. 27.

C. Corrective Action

Another lab audit will be performed to ensure that current problems are corrected. Such problems to be addressed are:

1. Conductivity test - responsible agency
2. Quarterly reports - are not being turned in
3. Sample handling procedures by contractor - preservation times

REVIEWED AND APPROVED BY


Byron Spoons, TSSWCB Q/A OFFICER

10-15-96
DATE

APPENDIX E

TIAER Laboratory Data from Monitoring

Arroyo Colorado Monitoring Data

Variable - format:

Site - *alpha numeric site designation (see abbreviations)* 5.
Sample # - *numeric* 10.0
Date - *mm/dd/yy*
Time - *hh:mm [military, central standard time]*
NH3-N value - *numeric* 8.4
NH3-N remark - *alpha numeric*
NO2-N value - *numeric* 6.3
NO2-N remark - *alpha numeric*
NO3-N value - *numeric* 7.3
NO3-N remark - *alpha numeric*
TKN value - *numeric* 6.2
TKN remark - *alpha numeric*
PO4-P value - *numeric* 6.3
PO4-P remark - *alpha numeric*
TP value - *numeric* 7.3
TP remark - *alpha numeric*
TSS value - *numeric* 8.2
TSS remark - *alpha numeric*
COD value - *numeric* 6.1
COD remark - *alpha numeric*
Atrazine value - *numeric* 8.3
Atrazine remark - *alpha numeric*
Azinphos (methyl) value - *numeric* 8.3
Azinphos (methyl) remark - *alpha numeric*
Malathion value - *numeric* 8.3
Malathion remark - *alpha numeric*
Parathion (methyl) value - *numeric* 8.3
Parathion (methyl) remark - *alpha numeric*
Permethrin (cis/trans) value - *numeric* 8.3
Permethrin (cis/trans) remark - *alpha numeric*
Prometryn value - *numeric* 8.3
Prometryn remark - *alpha numeric*
Trifluralin value - *numeric* 8.3
Trifluralin remark - *alpha numeric*
Comments - *alpha numeric field containing general comments relating to the sample*

NOTE: For each constituent, a value field and a remark field is listed. The value field contains numeric concentration values. Missing data is denoted with a period (.). The remark field contains explanatory notes relating to the data point such as the method detection limit. When the analyte concentration was below the method detection limit (MDL) for the analytical procedure, the MDL is denoted in the remark column. One-half (1/2) the MDL was reported for concentration values for the following constituents: NH3-N, NO2-N, NO3-N, TKN, PO4-P, TP, TSS, COD. When pesticide concentrations were below the MDL, concentration values were reported as zero (0). If no concentration value is reported, the remark field usually contains an explanation for the missing data. If a quality assurance test fails for a group of samples, no value is assigned to the sample for the affected parameters. A period is entered into the value field and "est. < MDL" is entered into the remark field. When a reduced sample volume was used for a test, the associated MDL was doubled.

Abbreviations and Reporting Units:

<u>Constituent</u>	<u>Abbreviation</u>	<u>Units Reported</u>
Ammonia Nitrogen	NH3-N	mg/L
Nitrite Nitrogen	NO2-N	mg/L
Nitrate Nitrogen	NO3-N	mg/L
Total Kjeldahl Nitrogen	TKN	mg/L
Orthophosphate Phosphorus	PO4-P	mg/L
Total Phosphorus	TP	mg/L
Total Suspended Solids	TSS	mg/L
Chemical Oxygen Demand	COD	mg/L
Atrazine	ATRAZ	µg/L
Azinphos (methyl)	AZINP	µg/L
Malathion	MALAT	µg/L
Parathion (methyl)	PARAT	µg/L
Permethrin (cis/trans)	PERME	µg/L
Prometryn	PROME	µg/L
Trifluralin	TRIFL	µg/L

Abbreviations

bmpdr = Dryland Site with BMP
condr = Dryland Site (Control, without BMP)
bmpir = Irrigated Site with BMP
conir = Irrigated Site (Control, without BMP)
HTEF = Holding time exceeded (field)
EST = Estimated value and/or quality control test(s) fail
IM = Instrument Malfunction
mg/L = milligram per liter
µg/L = microgram per liter
STAT = statistically close
ND = no detection, i.e., concentration is below method detection limit

C97-### or car97### - indicates the reference number (###) of the corrective action report submitted for the sample

Inquiries:

If you have any questions regarding the data reported, please direct inquiries to one of the following individuals.

Joan Flowers	(254) 968-9554	flowers@tiaer.tarleton.edu	Project Manager
Nancy Easterling	(254) 968-9548	easterl@tiaer.tarleton.edu	Quality Assurance Officer
Larry Hauck	(254) 968-9561	hauck@tiaer.tarleton.edu	Project Administrator

These data are also available in digital format by directing a written request to:

Texas Institute for Applied Environmental Research
Tarleton State University
Box T0410, Tarleton Station
Stephenville, Texas 76402
Attention: Joan Flowers
email: flowers@tiaer.tarleton.edu

Results of Water Quality Monitoring - Arroyo Colorado Project
Nutrient and Conventional Constituents

Site	Sample #	Date	Time	NH3-N value mg/L	NH3-N remark	NO2-N value mg/L	NO2-N remark	NO3-N value mg/L	NO3-N remark	TKN value mg/L	TKN remark	PO4-P value mg/L	PO4-P remark	TP value mg/L	TP remark	TSS value mg/L	TSS remark	COD value mg/L	COD remark
bmpdr	1000021631	8/31/96	16:00	0.09		0.001	<.002	0.42		16.5		0.36		8.82		8120		204	
bmpdr	1000021727	8/31/96	18:00	0.1		0.001	<.002	0.11		0.72		0.39		0.68		162		22	
bmpdr	1000021728	8/31/96	20:00	0.12		0.001	<.002	0.1		0.91		0.38		0.64		86		18	
bmpdr	1000021729	9/1/96	0:00	0.11		0.001	<.002	0.1		0.9		0.37		0.64		68		22	
bmpdr	1000021730	9/1/96	2:00	0.14		0.001	<.002	0.11		0.9		0.38		0.69		66		16	
bmpdr	1000021731	9/1/96	4:00	0.14		0.001	<.002	0.09		0.93		0.38		0.74		100		8	
bmpdr	1000023114	9/27/96	23:00	0.28			HTEF		HTEF	15.8			HTEF	8.12		6260		124	
bmpdr	1000023115	9/28/96	1:00	0.15			HTEF		HTEF	3.95			HTEF	2.75		1590		42	
bmpdr	1000023180	10/5/96	0:00	0.14		0.008		0.12		8.71		0.45		4.44		2500		132	
bmpdr	1000023181	10/5/96	2:00	0.15		0.004		0.06		4.71		0.42		3.01		1920		68	
bmpdr	1000023182	10/5/96	4:00	0.16		0.005		0.05		2.26		0.37		1.6		719		26	
bmpdr	1000023183	10/5/96	6:00	0.16		0.006		0.08		4.58		0.36		2.81		1950		66	
bmpdr	1000023184	10/5/96	8:00	0.13		0.004		0.06		1.9		0.3		1.28		781		21	
bmpdr	1000023185	10/5/96	10:00	0.13		0.003		0.03		1.77		0.21		0.96		574		15	
bmpdr	1000023192	10/5/96	20:00	0.09		0.001	<.002	0.008	<.015	0.91		0.25		0.57		587		6	
bmpdr	1000029149	3/11/97	9:00	0.53		0.01		0.08		4.53		0.52		2.06		1260		11	
bmpdr	1000029150	3/11/97	11:00	0.08		0.014		0.08		1.96		0.27		1.19		726		9	
bmpdr	1000029151	3/11/97	13:00	0.08		0.011		0.08		1.21		0.35		0.75		210		8	
bmpir	1000018210	4/15/96	4:00	0.03		0.005		16.6		0.7		0.08		0.055	<.11	21		36	
bmpir	1000018211	4/15/96	16:00	0.03		0.005		15.7		0.84		0.11		0.055	<.11	39		23	
bmpir	1000018212	4/16/96	4:00	0.0075	<.015	0.02		13.2		0.75		0.08		0.055	<.11	18.7		24	
bmpir	1000018439	5/14/96	6:00	0.11		0.04		11.6		0.78		0.06		0.19		17		19	
bmpir	1000018440	5/14/96	9:00	0.31		0.05		12		0.85		0.06		0.15		5	<.10	15	
bmpir	1000018441	5/14/96	12:00	0.09		0.02		11.4		1.02		0.06		0.14		25		18	
bmpir	1000018442	5/14/96	18:00	0.0075	<.015	0.05		12.9		0.81		0.06		1.21		26		19	
bmpir	1000018443	5/15/96	0:00	0.06		0.05		13		1.09		0.07		0.17		32		21	
bmpir	1000018444	5/15/96	6:00	0.0075	<.015	0.03		12.8		0.84		0.07		0.055	<.11	14		18	
bmpir	1000018445	5/15/96	12:00	0.0075	<.015	0.02		13.8		0.98		0.08		0.11		17		20	
bmpir	1000018451	5/15/96	18:00	0.0075	<.015	0.018		13.5		0.51		0.07		0.16		12		22	
bmpir	1000018452	5/16/96	0:00	0.0075	<.015	0.004		13.2		0.46		0.07		0.14		12		20	
bmpir	1000018453	5/16/96	6:00	0.0075	<.015	0.004		13.2		0.55		0.07		0.055	<.11	84		18	
bmpir	1000018454	5/16/96	12:00	0.0075	<.015	0.009		12.7		0.7		0.06		0.055	<.11	11		16	
bmpir	1000018465	5/16/96	18:00	0.0075	<.015		HTEF		HTEF	0.46			HTEF	0.055	<.11	5	<.10	19	
bmpir	1000018466	5/17/96	0:00	0.05			HTEF		HTEF	0.53			HTEF	0.055	<.11	11		26	
bmpir	1000018467	5/17/96	6:00	0.06			HTEF		HTEF	0.36			HTEF	0.055	<.11	20		16	
bmpir	1000018468	5/17/96	12:00	0.0075	<.015		HTEF		HTEF	0.7			HTEF	0.055	<.11	5	<.10	16	

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Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
bmpir	1000018459	5/17/96	18:00	0.0075	<.015		HTEF		HTEF	0.47			HTEF	0.055	<.11	10		21	
bmpir	1000018460	5/18/96	0:00	0.0075	<.015	0.003		11.4		0.67		0.07		0.11		12		21	
bmpir	1000018461	5/18/96	12:00	0.0075	<.015	0.006		11.5		0.54		0.07		0.055	<.11	19		21	
bmpir	1000019617	6/24/96	17:00	1.03		0.001	<.002	0.3		2.18		0.07		0.24		43		12	
bmpir	1000020510	8/14/96	8:00	0.12			HTEF		HTEF	0.99			HTEF	0.33		52		32	
bmpir	1000020511	8/14/96	12:00	0.1			HTEF		HTEF	1.08			HTEF	0.22		19		24	
bmpir	1000020512	8/14/96	16:00	0.12		0.014		2.69		1.07		0.05		0.2		53		23	
bmpir	1000020513	8/14/96	20:00	0.12		0.01		2.47		1.15		0.05		0.21		11		17	
bmpir	1000020514	8/15/96	0:00	0.16		0.08		3.21		1.28		0.04		0.2		35		21	
bmpir	1000020515	8/15/96	4:00	0.11		0.04		3.26		1.09		0.05		0.23		18		20	
bmpir	1000020678	8/16/96	9:00	0.11			HTEF		HTEF	0.91			HTEF	0.16		19		15	
bmpir	1000020679	8/16/96	12:00	0.11		0.001	<.002	4.36		0.77		0.09		0.14		10		15	
bmpir	1000020680	8/16/96	15:00	0.12		0.001	<.002	4.58		0.86		0.09		0.13		5	<10	15	
bmpir	1000020750	8/16/96	20:00	0.13			HTEF		HTEF	0.78			HTEF	0.13		26		11	
bmpir	1000020751	8/17/96	2:00	0.07			HTEF		HTEF	0.53			HTEF	0.16		14		17	
bmpir	1000020752	8/17/96	8:00	0.06			HTEF		HTEF	0.79			HTEF	0.13		10		13	
bmpir	1000020753	8/17/96	14:00	0.07		0.08		0.008	<.015	0.89		4.17		0.055	<.11	14		13	
bmpir	1000020804	8/17/96	20:00	0.08		0.04		4.56		0.69		0.08		0.13		16		15	
bmpir	1000020805	8/18/96	2:00	0.05		0.03		4.71		0.69		0.08		0.12		18		19	
bmpir	1000020806	8/18/96	8:00	0.14		0.017		4.72		0.74		0.08		0.11		11		18	
bmpir	1000020807	8/18/96	14:00	0.06		0.001	<.002	4.54		0.67		0.09		0.055	<.11	12		20	
bmpir	1000020863	8/18/96	20:00	0.11		0.001	<.002	4.47		0.86		0.08		0.24		24		9	
bmpir	1000020864	8/19/96	2:00	0.09		0.001	<.002	4.55		0.76		0.09		0.19		14		10	
bmpir	1000020865	8/19/96	14:00	0.1		0.002		4.32		0.73		0.09		0.18		28		9	
bmpir	1000020951	8/19/96	20:00	0.0075	<.015	0.004		4.41		0.94		0.08		0.055	<.11	24		13	
bmpir	1000020952	8/20/96	2:00	0.0075	<.015	0.004		4.48		0.66		0.08		0.055	<.11	21		17	
bmpir	1000020953	8/20/96	8:00	0.05		0.003		4.49		0.68		0.08		0.055	<.11	15		14	
bmpir	1000020954	8/20/96	14:00	0.16		0.012		3.98		1.07		0.08		0.055	<.11	27		13	
bmpir	1000021089	8/26/96	18:00	0.1		0.001	<.002	5.98		1.32		0.07		0.26		29		22	
bmpir	1000021090	8/26/96	22:00		EST .72	0.001	<.002	5.75		0.96		0.08		0.21		16		20	
bmpir	1000021091	8/27/96	2:00		EST .56	0.001	<.002	5.69		0.81		0.09		0.17		11		24	
bmpir	1000021092	8/27/96	6:00		EST .64	0.001	<.002	5.57		0.94		0.08		0.17		16		22	
bmpir	1000021093	8/27/96	10:00	0.47		0.001	<.002	5.82		0.96		0.08		0.12		16		15	
bmpir	1000021094	8/27/96	14:00	0.61		0.001	<.002	5.43		0.9		0.17		0.055	<.11	12		17	
bmpir	1000021135	8/27/96	18:00	0.12		0.001	<.002	6.22		0.63		0.07		0.17		11		20	
bmpir	1000021136	8/27/96	22:00	0.3		0.001	<.002	6.32		0.67		0.08		0.18		15		21	
bmpir	1000021137	8/28/96	2:00	0.17		0.001	<.002	5.86		0.65		0.07		0.13		5	<10	21	

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Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
bmpir	1000021138	8/28/96	6:00	0.16		0.001	<.002	5.97		0.75		0.07		0.12		5	<.10	21	
bmpir	1000021139	8/28/96	10:00	0.12		0.001	<.002	5.6		0.88		0.08		0.12		5	<.10	21	
bmpir	1000021140	8/28/96	14:00	0.45		0.001	<.002	5.64		0.88		0.08		0.2		5	<.10	22	
bmpir	1000021312	8/28/96	18:00	0.07		0.011		4.61		0.57		0.08		0.12		25		25	
bmpir	1000021313	8/28/96	22:00	0.09		0.011		5.05		0.7		0.08		0.13		14		23	
bmpir	1000021314	8/29/96	2:00	0.09		0.008		4.89		0.77		0.08		0.055	<.11	15		22	
bmpir	1000021315	8/29/96	6:00	0.08		0.011		5.08		0.43		0.08		0.055	<.11	16		22	
bmpir	1000021316	8/29/96	10:00	0.08		0.018		5.15		0.43		0.08		0.26		5	<.10	19	
bmpir	1000021317	8/29/96	14:00	0.14		0.011		5.29		0.44		0.09		0.28		11		18	
bmpir	1000021632	8/29/96	20:00	0.03			HTEF		HTEF	1			HTEF	0.28		19		17	
bmpir	1000021633	8/30/96	2:00	0.03			HTEF		HTEF	0.99			HTEF	0.18		16		17	
bmpir	1000021634	8/30/96	8:00	0.04			HTEF		HTEF	0.77			HTEF	0.15		5	<.10	16	
bmpir	1000021635	8/30/96	14:00	0.05			HTEF		HTEF	0.73			HTEF	0.13		26		13	
bmpir	1000026440	1/31/97	18:00	0.1		0.04		4.27		0.71		0.07		0.14		32		17	
bmpir	1000026441	1/31/97	22:00	0.08		0.04		4.78		0.87		0.09		0.051	<.101	12		12	
bmpir	1000026442	2/1/97	2:00	0.11		0.04		5.1		0.79		0.08		0.051	<.101	5	<.10	11	
bmpir	1000026443	2/1/97	6:00	0.1		0.04		5.52		0.62		0.08		0.051	<.101	5	<.10	10	
bmpir	1000026444	2/1/97	10:00	0.15		0.03		5.12		0.53		0.08		0.051	<.101	5	<.10	9	
bmpir	1000026445	2/1/97	14:00	0.09		0.03		4.62		0.73		0.09		0.051	<.101	5	<.10	7	
bmpir	1000026452	2/1/97	16:00	0.06		0.05		5.89		1.2		0.07		0.19		5	<.10	17	
bmpir	1000026453	2/1/97	20:00	0.07		0.06		5.95		1.22		0.09		0.14		10		19	
bmpir	1000026454	2/2/97	0:00	0.06		0.05		6.22		1.31		0.08		0.13		5	<.10	20	
bmpir	1000026455	2/2/97	4:00	0.05		0.05		6		1.25		0.08		0.15		5	<.10	16	
bmpir	1000026456	2/2/97	8:00	0.0185	<.037	0.05		5.9		0.69		0.08		0.051	<.101	5	<.10	12	
bmpir	1000026457	2/2/97	12:00	0.06		0.05		5.93		0.72		0.08		0.051	<.101	5	<.10	17	
bmpir	1000026462	2/2/97	18:00	0.0185	<.037		HTEF		HTEF	1.08			HTEF	0.051	<.101	5	<.10	15	
bmpir	1000026463	2/2/97	20:00	0.0185	<.037		HTEF		HTEF	1.57			HTEF	0.051	<.101	5	<.10	16	
bmpir	1000026464	2/3/97	2:00	0.0185	<.037		HTEF		HTEF	0.89			HTEF	0.051	<.101	5	<.10	16	
bmpir	1000026465	2/3/97	6:00	0.04			HTEF		HTEF	0.82			HTEF	0.051	<.101	5	<.10	16	
bmpir	1000026466	2/3/97	10:00	0.04			HTEF		HTEF	0.86			HTEF	0.051	<.101	5	<.10	19	
bmpir	1000026467	2/3/97	14:00	0.05		0.05		6.03		0.87		0.13		0.051	<.101	5	<.10	17	
bmpir	1000026468	2/3/97	18:00	0.04		0.05		6.08		0.81		0.13		0.051	<.101	5	<.10	16	
bmpir	1000026469	2/4/97	0:00	0.0185	<.037	0.05		6.05		0.78		0.16		0.051	<.101	5	<.10	17	
bmpir	1000026470	2/4/97	6:00	0.04		0.05		5.84		0.84		0.13		0.051	<.101	5	<.10	17	
bmpir	1000026471	2/4/97	12:00	0.05		0.05		5.8		0.66		0.14		0.051	<.101	5	<.10	17	
bmpir	1000032683	6/13/97	18:00	0.07			car97201		car97201	1.17			car97201	0.039	<.077	22		11	
bmpir	1000032684	6/13/97	22:00	0.05			car97201		car97201	1.08			car97201	0.1	STAT	14		2	<.4

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Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
bmpir	1000032685	6/14/97	2:00	0.07			car97201		car97201	1.21			car97201	0.08		5	<10	2	<4
bmpir	1000032686	6/14/97	6:00	0.09			car97201		car97201	0.76			car97201	0.34			C97-203	2	<4
bmpir	1000032687	6/14/97	10:00	0.14			car97201		car97201	0.77			car97201	0.28			C97-203	2	<4
bmpir	1000032688	6/14/97	14:00	0.05			car97201		car97201	0.67			car97201	0.26		5	<10	9	
bmpir	1000032693	6/14/97	22:00	0.07		0.011		6.04		0.59		0.11		0.16		5	<10	2	<4
bmpir	1000032694	6/15/97	2:00	0.04		0.006		5.88		0.57		0.13		0.15		16		5	
bmpir	1000032695	6/15/97	6:00	0.05		0.007		6.01		0.69		0.11		0.14		5	<10	4	
bmpir	1000032696	6/15/97	10:00	0.08		0.014		4.9		0.76		0.1		0.29		5	<10	2	<4
bmpir	1000032697	6/15/97	14:00	0.18		0.01		5.31		0.88		0.11		0.45		5	<10	9	
condr	1000021630	8/31/96	16:00	0.11		0.001	<.002	0.77		25.2		0.39		10.5		11700		380	
condr	1000023112	9/27/96	23:00	0.31			HTEF		HTEF	17.2			HTEF	5.48		5760		117	
condr	1000023113	9/28/96	1:00	0.15			HTEF		HTEF	4.9			HTEF	2.48		1660		53	
condr	1000023174	10/5/96	0:00	0.64		0.006		0.11		7.6		0.37		3.83		3050		108	
condr	1000023175	10/5/96	2:00	0.2		0.006		0.1		4.45		0.37		2.5		1760		55	
condr	1000023176	10/5/96	4:00	0.16		0.005		0.06		3.67		0.45		2.22		1600		54	
condr	1000023177	10/5/96	6:00	0.16		0.004		0.06		1.81		0.39		1.25		471		16	
condr	1000023178	10/5/96	8:00	0.15		0.004		0.06		1.89		0.35		1.02		593		8	
condr	1000023179	10/5/96	10:00	0.13		0.001	<.002	0.05		1.46		0.27		0.98		626		20	
condr	1000023189	10/5/96	20:00	0.13		0.001	<.002	0.018		0.47		0.21		0.29		70		2.5	<5
condr	1000023190	10/6/96	0:00	0.09		0.001	<.002	0.02		0.59		0.23		0.35		110		2.5	<5
condr	1000023191	10/6/96	4:00	0.09		0.001	<.002	0.016		0.51		0.23		0.31		35		2.5	<5
condr	1000029148	3/11/97	8:00	0.19		0.02		0.18		3.77		0.38		2.08		1540		13	
conir	1000018214	4/16/96	4:00	0.04		0.015		15.7		0.63		0.07		0.055	<.11	74		36	
conir	1000018213	4/16/96	16:00	0.06		0.04		16.4		0.91		0.07		0.13		197		30	
conir	1000018215	4/17/96	4:00	0.17		0.001	<.002	16		0.74		0.08		0.18		176		27	
conir	1000018455	5/16/96	0:00	0.0075	<.015	0.003		13.6		0.84		0.08		0.2		119		20	
conir	1000018456	5/16/96	3:00	0.0075	<.015	0.004		13.4		0.65		0.07		0.16		60		20	
conir	1000018457	5/16/96	6:00	0.0075	<.015	0.002		13.2		0.98		0.08		0.11		31		20	
conir	1000018458	5/16/96	12:00	0.0075	<.015	0.002		12.6		0.67		0.08		0.055	<.11	40		16	
conir	1000018469	5/16/96	18:00	0.0075	<.015		HTEF		HTEF	0.42			HTEF	0.14		16		16	
conir	1000018470	5/17/96	0:00	0.0075	<.015		HTEF		HTEF	0.34			HTEF	0.055	<.11	5	<10	21	
conir	1000018471	5/17/96	6:00	0.0075	<.015		HTEF		HTEF	0.63			HTEF	0.055	<.11	5	<10	22	
conir	1000018472	5/17/96	12:00	0.0075	<.015		HTEF		HTEF	0.43			HTEF	0.055	<.11	10		21	
conir	1000018462	5/17/96	18:00	0.04			HTEF		HTEF	0.79			HTEF	0.14		27		23	
conir	1000018463	5/18/96	0:00	0.02		0.07		12.5		0.6		0.09		0.12		14		20	
conir	1000018464	5/18/96	12:00	0.0075	<.015	0.003		14.1		0.46		0.07		0.055	<.11	13		20	
conir	1000018473	5/18/96	18:00	0.0075	<.015	0.003		11.7		0.61		0.07		0.055	<.11	14		34	

Results of Water Quality Monitoring - Arroyo Colorado Project

Nutrient and Conventional Constituents

Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
conir	1000020803	8/18/96	16:00	2.81		0.07		1.35		4.4		0.06		0.29		81		19	
conir	1000020858	8/18/96	20:00	1.67		0.09		1.92		3.11		0.09		0.2		56		12	
conir	1000020859	8/18/96	23:00	1.03		0.019		2.8		2.05		0.08		0.17		16		13	
conir	1000020860	8/19/96	2:00	0.74		0.014		3.12		1.68		0.08		0.17		5	<10	14	
conir	1000020861	8/19/96	8:00	0.32		0.008		3.58		1.28		0.07		0.14		5	<10	10	
conir	1000020862	8/19/96	14:00	0.1		0.003		3.52		0.88		0.06		0.22		14		11	
conir	1000020947	8/19/96	20:00	0.07		0.006		3.2		0.85		0.06		0.055	<.11	19		10	
conir	1000020948	8/20/96	2:00	0.06		0.006		3.03		0.93		0.06		0.14		5	<10	11	
conir	1000020949	8/20/96	8:00	0.37		0.019		2.66		1.54		0.06		0.055	<.11	14		11	
conir	1000020950	8/20/96	14:00	0.06		0.009		2.85		0.57		0.06		0.055	<.11	12		11	
conir	1000020966	8/20/96	20:00	0.04		0.001	<.002	2.78		0.6		0.07		0.055	<.11	5	<10	16	
conir	1000020967	8/21/96	2:00	0.11		0.001	<.002	2.75		0.59		0.06		0.055	<.11	5	<10	14	
conir	1000020968	8/21/96	8:00	0.06		0.001	<.002	2.79		0.91		0.06		0.055	<.11	5	<10	18	
conir	1000020969	8/21/96	14:00	0.06		0.001	<.002	2.82		0.92		0.06		0.055	<.11	5	<10	12	
conir	1000021095	8/26/96	18:00	0.54		0.001	<.002	6.41		1.13		0.2		0.18		86		11	
conir	1000021096	8/26/96	22:00	0.51		0.001	<.002	6.31		1.01		0.21		0.19		18		20	
conir	1000021097	8/27/96	2:00	0.34		0.001	<.002	6.11		0.9		0.18		0.27		12		18	
conir	1000021098	8/27/96	6:00	0.25		0.001	<.002	6.16		0.98		0.08		0.24		16		20	
conir	1000021099	8/27/96	10:00	0.13		0.001	<.002	6		0.76		0.09		0.2		5	<10	21	
conir	1000021100	8/27/96	14:00	0.27		0.07		5.5		1		0.09		0.17		11		21	
conir	1000021141	8/27/96	18:00	0.17		0.001	<.002	5.28		0.78		0.08		0.14		11		20	
conir	1000021142	8/27/96	22:00	0.17		0.001	<.002	5.19		0.86		0.08		0.055	<.11	5	<10	22	
conir	1000021143	8/28/96	2:00	0.08		0.001	<.002	5.02		0.63		0.08		0.055	<.11	5	<10	18	
conir	1000021144	8/28/96	6:00	0.14		0.001	<.002	5.33		0.65		0.08		0.055	<.11	36		18	
conir	1000021145	8/28/96	10:00	0.1		0.001	<.002	5.13		0.6		0.08		0.055	<.11	16		18	
conir	1000021146	8/28/96	14:00	0.0075	<.015	0.001	<.002	5.05		0.71		0.08		0.055	<.11	12		23	
conir	1000021306	8/28/96	18:00	0.11		0.014		5.94		0.59		0.07		0.27		5	<10	23	
conir	1000021307	8/28/96	22:00	0.14		0.014		5.79		0.78		0.07		0.22		24		25	
conir	1000021308	8/29/96	2:00	0.12		0.011		5.45		0.34		0.08		0.17		5	<10	22	
conir	1000021309	8/29/96	6:00	0.09		0.008		5.75		0.9		0.08		0.15		5	<10	22	
conir	1000021310	8/29/96	10:00	0.12		0.011		5.89		0.41		0.08		0.13		5	<10	20	
conir	1000021311	8/29/96	14:00	0.11		0.011		5.42		0.47		0.08		0.13		5	<10	21	
conir	1000021637	8/29/96	20:00	0.03	HTEF		HTEF		HTEF	0.85			HTEF	0.12		5	<10	15	
conir	1000021638	8/30/96	2:00	0.02	HTEF		HTEF		HTEF	1.03			HTEF	0.055	<.11	5	<10	17	
conir	1000021639	8/30/96	8:00	0.018	HTEF		HTEF		HTEF	0.85			HTEF	0.15		5	<10	18	
conir	1000021640	8/30/96	14:00	0.0075	HTEF		HTEF		HTEF	1.14			HTEF	0.15		16		16	
conir	1000026427	1/29/97	18:00	0.09		0.13		5.43		1.76		0.13		0.73		490		31	

Results of Water Quality Monitoring - Arroyo Colorado Project

Nutrient and Conventional Constituents

Site	Sample #	Date	Time	NH3-N value	NH3-N remark	NO2-N value	NO2-N remark	NO3-N value	NO3-N remark	TKN value	TKN remark	PO4-P value	PO4-P remark	TP value	TP remark	TSS value	TSS remark	COD value	COD remark
conir	1000026428	1/29/97	22:00	0.1		0.11		5.15		1.28		0.1		0.33		198		13	
conir	1000026429	1/30/97	2:00	0.09		0.1		6.38		1.27		0.12		0.27		156		14	
conir	1000026430	1/30/97	6:00	0.07		0.12		5.9		1.5		0.26		0.25	STAT	137		13	
conir	1000026431	1/30/97	10:00	0.06		0.12		6.57		1.57		0.12		0.24		126		29	
conir	1000026432	1/30/97	14:00	0.05		0.11		6.45		1.45		0.12		0.24		119		12	
conir	1000026434	1/30/97	18:00	0.0185	<.037	0.08		5.25		1.42		0.09		0.37		330		16	
conir	1000026435	1/30/97	22:00	0.11		0.07		4.38		1.38		0.1		0.31		207		14	
conir	1000026436	1/31/97	2:00	0.1		0.06		5.67		1.09		0.1		0.6		515		15	
conir	1000026437	1/31/97	6:00	0.16		0.05		5.74		1.38		0.1		0.44		356		12	
conir	1000026438	1/31/97	10:00	0.11		0.04		5.31		0.9		0.1		0.28		205		13	
conir	1000026439	1/31/97	14:00	0.13		0.04		5.3		0.84		0.1		0.46		438		10	
conir	1000026446	1/31/97	18:00	0.09		0.03		4.63		0.77		0.08		0.24		251		19	
conir	1000026447	1/31/97	22:00	0.09		0.03		4.39		1.39		0.09		0.19		114		25	
conir	1000026448	2/1/97	2:00	0.12		0.03		4.41		1.44		0.09		0.34		245		22	
conir	1000026449	2/1/97	6:00	0.1		0.03		5.33		1.52		0.09		0.35		226		19	
conir	1000026450	2/1/97	10:00	0.09		0.05		6.46		1.41		0.08		0.29		107		20	
conir	1000026451	2/1/97	14:00	0.11		0.05		6.84		1.27		0.1		0.19		69		19	
conir	1000026458	2/1/97	18:00	0.0185	<.037	0.05		7.1		0.92		0.08		0.051	<.101	14		16	
conir	1000026459	2/2/97	0:00	0.04		0.04		7.06		1		0.08		0.051	<.101	22		17	
conir	1000026460	2/2/97	6:00	0.08		0.04		7.35		0.95		0.08		0.051	<.101	5	<10	18	
conir	1000026461	2/2/97	12:00	0.0185	<.037	0.04		7.38		0.97		0.08		0.051	<.101	5	<10	18	
conir	1000032689	6/14/97	2:00	0.11			car97201		car97201	0.82			car97201	0.29		13		9	
conir	1000032690	6/14/97	6:00	0.07			car97201		car97201	0.71			car97201	0.25	STAT	45		12	
conir	1000032691	6/14/97	10:00	0.06			car97201		car97201	0.79			car97201	0.16		12		2	<4
conir	1000032698	6/14/97	14:00	0.36		0.03		5.28		1.18		0.1		0.38		5	<10	6	
conir	1000032699	6/14/97	18:00	0.09		0.011		7.45		0.93		0.11		0.39		48		2	<4
conir	1000032700	6/14/97	22:00	0.1		0.017		7.4		0.86		0.11		0.4		90		7	
conir	1000032701	6/15/97	10:00	0.1		0.008		7.18		0.81		0.12		0.32		44		4	

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Atrazine value µg/L	Atrazine remark	Azinphos (methyl) value µg/L	Azinphos (methyl) remark	Malathion value µg/L	Malathion remark	Parathion (methyl) value µg/L	Parathion (methyl) remark	Permethrin (cis/trans) value µg/L	Permethrin (cis/trans) remark
bmpdr	1000021631	8/31/96	16:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021727	8/31/96	18:00	1.087		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021728	8/31/96	20:00	0.638		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021729	9/1/96	0:00	1.18		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021730	9/1/96	2:00	0.522		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000021731	9/1/96	4:00	0	<1.00	0	<.009	0	<.022	0	<.036	0	<.4
bmpdr	1000023114	9/27/96	23:00	0	<.5	0	<.009	0.016		0	<.018	0	<.2
bmpdr	1000023115	9/28/96	1:00	0	<.5	0	<.009	0.016		0	<.018	0	<.2
bmpdr	1000023180	10/5/96	0:00	0	<.5		EST<.009		EST<.011		EST<.018	0	<.2
bmpdr	1000023181	10/5/96	2:00	1.056			EST<.018		EST<.022		EST<.036	0	<.4
bmpdr	1000023182	10/5/96	4:00	0.994		0	<.009	0	<.011	0	<.018	0	<.2
bmpdr	1000023183	10/5/96	6:00	0	<.5	0.055		0.016		0.019		0.506	
bmpdr	1000023184	10/5/96	8:00	2.063		0	<.009	0.014		0	<.018	0.548	
bmpdr	1000023185	10/5/96	10:00	0.912		0	<.009	0.016		0	<.018	0.5	
bmpdr	1000023192	10/5/96	20:00	0	<.5	0	<.009	0	<.011	0	<.018	0.478	
bmpdr	1000029149	3/11/97	9:00	1.45		0	<.009	0	<.011	0	<.018	0	<.20
bmpdr	1000029150	3/11/97	11:00	10.8		0	<.009	0	<.011	0	<.018	0	<.20
bmpdr	1000029151	3/11/97	13:00	6.33		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000018210	4/15/96	4:00	0	<.86	0	<.016	0	<.019	0	<.031	0	<.34
bmpir	1000018211	4/15/96	16:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000018212	4/16/96	4:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000018439	5/14/96	6:00	5.94		0	<.018	0	<.022		IM	1.1	
bmpir	1000018440	5/14/96	9:00	7.76		0	<.009	0	<.011		IM	2.04	
bmpir	1000018441	5/14/96	12:00	4.69		0	<.009	0	<.011		IM	1.05	
bmpir	1000018442	5/14/96	18:00	2.77		0	<.009	0	<.011		IM	1.24	
bmpir	1000018443	5/15/96	0:00	2.77		0	<.009	0	<.011		IM	0	<.2
bmpir	1000018444	5/15/96	6:00	1.18		0	<.009	0	<.011		IM	0	<.2
bmpir	1000018445	5/15/96	12:00	1.06		0	<.009	0	<.011		IM	0.96	
bmpir	1000018451	5/15/96	18:00	4.85		0	<.009	0	<.011		IM	0	<.2
bmpir	1000018452	5/16/96	0:00	0	<.5	0	<.009	0	<.011		IM	0	<.2
bmpir	1000018453	5/16/96	6:00	0	<1.0	0	<.018	0	<.022		IM	0	<.4
bmpir	1000018454	5/16/96	12:00	9.11		0	<.018	0	<.022		IM	1.12	
bmpir	1000018465	5/16/96	18:00	1.18		0	<.018	0	<.022		IM	1.17	
bmpir	1000018466	5/17/96	0:00	1.4		0	<.009	0	<.011		IM	2.7	
bmpir	1000018467	5/17/96	6:00	1.63		0	<.009	0	<.011		IM	1.16	
bmpir	1000018468	5/17/96	12:00	1.56		0	<.009	0	<.011		IM	1.98	

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
bmpir	1000018459	5/17/96	18:00	0	<.5	0	<.009	0	<.011	.	IM	0	<.2
bmpir	1000018460	5/18/96	0:00	0	<.5	0	<.009	0	<.011	.	IM	0.95	
bmpir	1000018461	5/18/96	12:00	0	<.5	0	<.009	0	<.011	.	IM	0	<.2
bmpir	1000019617	6/24/96	17:00	0	<1.0	0	<.018	0	<.022	0	<.2	0	<.4
bmpir	1000020510	8/14/96	8:00	11.4		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020511	8/14/96	12:00	6.44		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020512	8/14/96	16:00	3.2		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020513	8/14/96	20:00	2.27		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020514	8/15/96	0:00	5.93		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020515	8/15/96	4:00	5.17		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020678	8/16/96	9:00	1		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020679	8/16/96	12:00	0.645		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020680	8/16/96	15:00	0.552		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020750	8/16/96	20:00	0	1	0	<.018	0	<.022	0	<.036	0.222	
bmpir	1000020751	8/17/96	2:00	0	<.50	0.298	<.009	0	<.011	0	<.018	0	0.2
bmpir	1000020752	8/17/96	8:00	0	<.50	0	<.009	0.028		0	<.018	0	0.2
bmpir	1000020753	8/17/96	14:00	0	<.50	0	<.009	0	<.011	0	<.018	0	0.2
bmpir	1000020804	8/17/96	20:00	3.95		0	<.009	0.028		0.019		0.212	
bmpir	1000020805	8/18/96	2:00	2.36		0	<.009	0	<.011	0	<.018	0.292	
bmpir	1000020806	8/18/96	8:00	.	est<.50	0	<.009	0	<.011	0	<.018	.	est<.20
bmpir	1000020807	8/18/96	14:00	2.46		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020863	8/18/96	20:00	2.32		0	<.009	0	<.011	.	est<.018	.	est<.20
bmpir	1000020864	8/19/96	2:00	2.1		0	<.009	0	<.011	.	est<.018	.	est<.20
bmpir	1000020865	8/19/96	14:00	5.95		0	<.009	0	<.011	.	est<.018	.	est<.20
bmpir	1000020951	8/19/96	20:00	1.85		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000020952	8/20/96	2:00	2.19		0	<.009	0	<.011	0	<.018	0.368	
bmpir	1000020953	8/20/96	8:00	1.4		0.211	<.009	0.022		0	<.018	0	<.20
bmpir	1000020954	8/20/96	14:00	3.89		0	<.009	0.027		0	<.018	0.333	
bmpir	1000021089	8/26/96	18:00	8.03		0	<.009	0	<.011	0	<.018	1.77	
bmpir	1000021090	8/26/96	22:00	3.4		0	<.0225		est<.027	0	<.045	.	est<.5
bmpir	1000021091	8/27/96	2:00	0	<1.25	0	<.0225		est<.027	0	<.045	.	est<.5
bmpir	1000021092	8/27/96	6:00	2.51		0	<.018	0	<.022	0	<.036	.	est<.2
bmpir	1000021093	8/27/96	10:00	0	<.5	0	<.009		est<.011	0	<.018	.	est<.2
bmpir	1000021094	8/27/96	14:00	0	<.5	0	<.009		est<.011	0	<.018	.	est<.2
bmpir	1000021135	8/27/96	18:00	1.92		0	<.009		est<.011	0	<.018	.	est<.20
bmpir	1000021136	8/27/96	22:00	1.77		0	<.0225		est<.027	0	<.045	.	est<.50
bmpir	1000021137	8/28/96	2:00	1.463		0	<.0225		est<.027	0	<.045	.	est<.50

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
bmpir	1000021138	8/28/96	6:00	0.954		0	<.009		est<.011	0	<.018		est<.20
bmpir	1000021139	8/28/96	10:00	0	<.50	0	<.009		est<.011	0	<.018		est<.20
bmpir	1000021140	8/28/96	14:00	0	<.50	0	<.009		est<.011	0	<.018		est<.20
bmpir	1000021312	8/28/96	18:00	0.705		0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000021313	8/28/96	22:00	0	<1.00	0	<.018	0	<.022	0	<.036	0	<.40
bmpir	1000021314	8/29/96	2:00	0	<.50	0.109		0.033		0	<.018	0	<.20
bmpir	1000021315	8/29/96	6:00	0	<1.25	0.603		0	<.027	0	<.045	0.665	
bmpir	1000021316	8/29/96	10:00	0.542		0	<.009	0.025		0	<.018	0	<.20
bmpir	1000021317	8/29/96	14:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.20
bmpir	1000021632	8/29/96	20:00	11.486		0	<.009	0	<.011	0	<.018	0	<.2
bmpir	1000021633	8/30/96	2:00	11.373		0	<.009	0	<.011	0	<.018	0.266	
bmpir	1000021634	8/30/96	8:00	0	<.50	0	<.009	0	<.011	0	<.018	0	<.2
bmpir	1000021635	8/30/96	14:00	0	<1.00	0	<.018	0	<.022	0	<.036	0	<.4
bmpir	1000026440	1/31/97	18:00	0	ND <.50	0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026441	1/31/97	22:00	1.7		0	ND <.011	0	ND <.014	0	ND <.022	0.22	
bmpir	1000026442	2/1/97	2:00	2.88		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026443	2/1/97	6:00	3.4		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026444	2/1/97	10:00	1.06		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026445	2/1/97	14:00	1.08		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
bmpir	1000026452	2/1/97	16:00	1.75		0	ND <.009	0	ND <.011	0	ND <.018	0.22	
bmpir	1000026453	2/1/97	20:00	1.12		0	ND <.009	0	ND <.011	0	ND <.018	0	ND <.20
bmpir	1000026454	2/2/97	0:00	0.87		0	ND <.009	0	ND <.011	0	ND <.018	0	ND <.20
bmpir	1000026455	2/2/97	4:00	0.81		0	ND <.009	0	ND <.011	0	ND <.018	0.24	
bmpir	1000026456	2/2/97	8:00	0.82			EST<.009	0	ND <.011	0	ND <.018	0	ND <.20
bmpir	1000026457	2/2/97	12:00	0.89			EST<.011	0	ND <.022	0	ND <.036	0.22	
bmpir	1000026462	2/2/97	18:00	1.07			EST<.009	0	ND <.011	0	ND <.018	0.26	
bmpir	1000026463	2/2/97	20:00	1.06			EST<.009	0	ND <.011	0	ND <.018	0.3	
bmpir	1000026464	2/3/97	2:00	1.12			EST<.009	0	ND <.011	0	ND <.018	0.23	
bmpir	1000026465	2/3/97	6:00	1.14			EST<.009	0	ND <.011	0	ND <.018	0.28	
bmpir	1000026466	2/3/97	10:00	1.28			EST<.009	0	ND <.011	0	ND <.018	0.22	
bmpir	1000026467	2/3/97	14:00	1.09		0	ND <.011		EST<.022	0	ND <.018	0.28	
bmpir	1000026468	2/3/97	18:00	2.14		0	ND <.009	0	ND <.011	0	ND <.018	0	ND <.20
bmpir	1000026469	2/4/97	0:00	2.16			EST<.009		EST<.011		EST<.018	0	ND <.20
bmpir	1000026470	2/4/97	6:00	1.85		0	ND <.009		EST<.011	0	ND <.018	0.24	
bmpir	1000026471	2/4/97	12:00	1.97		0	ND <.009		EST<.011	0	ND <.018	0.22	
bmpir	1000032683	6/13/97	18:00	0	<3.28		C97-228	0	<.022		EST1.48	0	<.40
bmpir	1000032684	6/13/97	22:00	0	<1.65		C97-228	0	<.011		EST.724	0	<.20

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
bmpir	1000032685	6/14/97	2:00	0	<1.65		C97-228	0	<.011		EST.733	0	<.20
bmpir	1000032686	6/14/97	6:00	0	<1.65		C97-228	0	<.011		EST.684	0	<.20
bmpir	1000032687	6/14/97	10:00	0	<1.65		C97-228	0	<.011		EST.396	0	<.20
bmpir	1000032688	6/14/97	14:00	0	<1.65		C97-228	0	<.011		EST.583	0	<.20
bmpir	1000032693	6/14/97	22:00	0	<3.45		C97-228		EST<.022		EST<.036	0	<.40
bmpir	1000032694	6/15/97	2:00	0	<1.65		C97-228		EST<.011		EST.36	0	<.20
bmpir	1000032695	6/15/97	6:00	8.45			C97-228	0	<.011	0.265		0	<.20
bmpir	1000032696	6/15/97	10:00	12.6			C97-228	0	<.022	0	<.036	0	<.40
bmpir	1000032697	6/15/97	14:00	5.78			C97-228	0	<.011	0	<.018	0	<.20
condr	1000021630	8/31/96	16:00		est <.5	0	<.009	0.027		0	<.018		est<.20
condr	1000023112	9/27/96	23:00	1.005		0.051		0	<.022	0	<.036	0	<.4
condr	1000023113	9/28/96	1:00	2.853		0	<.009	0	<.011	0	<.018	0.318	
condr	1000023174	10/5/96	0:00	1.968		0	<.009	0	<.011	0	<.018	0	<.2
condr	1000023175	10/5/96	2:00	1.274		0.014		0.018		0.02		0	<.2
condr	1000023176	10/5/96	4:00	0.855		0	<.009	0.014		0.018		0	<.2
condr	1000023177	10/5/96	6:00	0	<.5	0	<.009	0	<.011	0	<.018	0	<.2
condr	1000023178	10/5/96	8:00	0	<.5	0	<.009	0.014		0	<.018	0	<.2
condr	1000023179	10/5/96	10:00	0	<.5		EST<.009		EST.016		EST<.018	0	<.2
condr	1000023189	10/5/96	20:00	0	<.5	0	<.009	0	<.011	0	<.018	0.698	
condr	1000023190	10/6/96	0:00	2.089		0	<.009	0	<.011	0	<.018	0.649	
condr	1000023191	10/6/96	4:00	2.427		0	<.009	0	<.011	0	<.018	0.257	
condr	1000029148	3/11/97	8:00	1.15		0	<.011	0	<.022	0	<.036	0	<.40
conir	1000018214	4/16/96	4:00	2.29		0	<.009	0	<.011	0	<.018	0	<.20
conir	1000018213	4/16/96	16:00	4.54		0	<.009	0	<.011	0	<.018	0	<.20
conir	1000018215	4/17/96	4:00	10.9		0	<.009	0	<.011	0	<.018	0	<.20
conir	1000018455	5/16/96	0:00	7.27		0	<.009	0	<.011		IM	0.95	
conir	1000018456	5/16/96	3:00	1.76		0	<.009	0	<.011		IM	0	<.2
conir	1000018457	5/16/96	6:00	1.33		0	<.009	0	<.011		IM	1.01	
conir	1000018458	5/16/96	12:00	0	<.5	0	<.009	0	<.011		IM	0.95	
conir	1000018469	5/16/96	18:00	1.3		0	<.009	0	<.011		IM	1.23	
conir	1000018470	5/17/96	0:00	1.15		0	<.009	0	<.011		IM	0.85	
conir	1000018471	5/17/96	6:00	0.93		0	<.009	0	<.011		IM	0.86	
conir	1000018472	5/17/96	12:00	1.06		0	<.009	0	<.011		IM	0.85	
conir	1000018462	5/17/96	18:00	0	<.5	0	<.009	0	<.011		IM	0	<.2
conir	1000018463	5/18/96	0:00	2.36		0	<.009	0	<.011		IM	1.99	
conir	1000018464	5/18/96	12:00	1.28		0	<.009	0	<.011		IM	1.33	
conir	1000018473	5/18/96	18:00	0.92		0	<.009	0	<.011		IM	1.98	

Results of Water Quality Monitor, Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
conir	1000020803	8/18/96	16:00	1.83		0.217	<0.009	0.024	<0.011	0	<0.018	0.212	
conir	1000020858	8/18/96	20:00	1.25		0	<0.009	0	<0.011	0	<0.018	0	<0.20
conir	1000020859	8/18/96	23:00	0	<1.00	0.185	<0.009	0	<0.022	0	<0.036	0	<0.40
conir	1000020860	8/19/96	2:00	0	<0.50	0.428	<0.009	0.025			est<0.018		est0.739
conir	1000020861	8/19/96	8:00	0.551		0	<0.009	0.025			est<0.018		est0.202
conir	1000020862	8/19/96	14:00	2.109		0	<0.009	0	<0.011		est<0.018		est<0.20
conir	1000020947	8/19/96	20:00	1.9		0	<0.009	0	<0.011		est<0.018		est0.369
conir	1000020948	8/20/96	2:00	0	<0.50	0	<0.009	0	<0.011		est<0.018		est<0.20
conir	1000020949	8/20/96	8:00	4.74		0	<0.009	0.023			est<0.018		est0.434
conir	1000020950	8/20/96	14:00	5.9		0	<0.018	0	<0.022		est<0.036		est<0.40
conir	1000020966	8/20/96	20:00	0	<0.50	0	<0.009	0.032		0	<0.018	0.281	
conir	1000020967	8/21/96	2:00	0	<0.50	0	<0.009	0.025		0	<0.018	0	<0.20
conir	1000020968	8/21/96	8:00	0.722		0	<0.009	0.03		0	<0.018	0.212	
conir	1000020969	8/21/96	14:00	0.924		0	<0.009	0.025		0	<0.018	0	<0.20
conir	1000021095	8/26/96	18:00	0.531		0	<0.009		est<.011	0	<0.018		est<.2
conir	1000021096	8/26/96	22:00	3.06		0	<0.009		est<.011	0	<0.018		est<.2
conir	1000021097	8/27/96	2:00	1.299		0	<0.009		est<.011	0	<0.018		est<.2
conir	1000021098	8/27/96	6:00	0	<.5	0	<0.009		est<.011	0	<0.018		est<.2
conir	1000021099	8/27/96	10:00	0	<1.25	0	<0.0225		est<.027	0	<0.045		est<.5
conir	1000021100	8/27/96	14:00	0	<1.00	0	<0.018		est<.022	0	<0.036		est<.4
conir	1000021141	8/27/96	18:00	0	<.50	0	<0.009		est<.011	0	<0.018		est<.20
conir	1000021142	8/27/96	22:00	0	<.50	0	<0.009		est<.011	0	<0.018		est<.20
conir	1000021143	8/28/96	2:00	0	<1.00	0	<0.009		est<.022	0	<0.036		est<.40
conir	1000021144	8/28/96	6:00	0	<1.25	0	<0.009		est<.027	0	<0.045		est<.50
conir	1000021145	8/28/96	10:00	1.51		0	<0.009	0	<.011	0	<0.018		est<.20
conir	1000021146	8/28/96	14:00	1.194		0	<0.009	0	<.027	0	<0.045		est<.50
conir	1000021306	8/28/96	18:00	1.163		0	<0.009	0	<.011	0	<0.018	0	<.20
conir	1000021307	8/28/96	22:00	0	<.50	0	<0.009	0	<.011	0	<0.018	0	<.20
conir	1000021308	8/29/96	2:00	0	<.50	0.079	<0.009	0.065		0	<.018	0	<.20
conir	1000021309	8/29/96	6:00	0	<.50	0	<0.009	0	<.011	0	<.018	0	<.20
conir	1000021310	8/29/96	10:00	0	<.50	0	<0.009	0.127		0	<.018	0	<.20
conir	1000021311	8/29/96	14:00	0	<.50	0	<0.009	0.036		0.019	<.018	0	<.20
conir	1000021637	8/29/96	20:00	0	<.5		est<.009		est<.011		est<.018	0	<.2
conir	1000021638	8/30/96	2:00	1.904		0	<0.009	0	<.011	0	<.018	0	<.2
conir	1000021639	8/30/96	8:00	0	<.5	0	<0.009	0	<.011	0	<.018	0	<.2
conir	1000021640	8/30/96	14:00	0	<.5	0.882	<0.009	0.085		0	<.018	0	<.2
conir	1000026427	1/29/97	18:00	2.29		0	ND <.018	0	ND <.022	0	ND <.036	0	ND <.40

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

Site	Sample #	Date	Time	Atrazine value	Atrazine remark	Azinphos (methyl) value	Azinphos (methyl) remark	Malathion value	Malathion remark	Parathion (methyl) value	Parathion (methyl) remark	Permethrin (cis/trans) value	Permethrin (cis/trans) remark
conir	1000026428	1/29/97	22:00	0	ND <.50	0	ND <.02	0	ND <.025	0	ND <.040	0	ND <.44
conir	1000026429	1/30/97	2:00	2.69		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026430	1/30/97	6:00	2.77		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026431	1/30/97	10:00	1.63		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026432	1/30/97	14:00	1.31		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026434	1/30/97	18:00	2.22		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026435	1/30/97	22:00	1.21		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026436	1/31/97	2:00	0.99		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026437	1/31/97	6:00	0	ND <.50	0	ND <.018	0	ND <.022	0	ND <.036	0	ND <.40
conir	1000026438	1/31/97	10:00	2.02		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026439	1/31/97	14:00	2.55		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026446	1/31/97	18:00	2.83		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026447	1/31/97	22:00	1.28		0	ND <.018	0	ND <.022	0	ND <.036	0	ND <.40
conir	1000026448	2/1/97	2:00	1.1		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026449	2/1/97	6:00	0.79		0	ND <.018	0	ND <.022	0	ND <.036	0	ND <.40
conir	1000026450	2/1/97	10:00	1.85		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026451	2/1/97	14:00	0.73		0	ND <.011	0	ND <.014	0	ND <.022	0	ND <.25
conir	1000026458	2/1/97	18:00	0.89			EST<.009	0	ND <.011	0	ND <.018	0.24	
conir	1000026459	2/2/97	0:00	1.18			EST<.009	0	ND <.011	0	ND <.018	0	ND <.20
conir	1000026460	2/2/97	6:00	0.85			EST<.009	0	ND <.011	0	ND <.018	0.25	
conir	1000026461	2/2/97	12:00	0	ND <.50		EST<.009	0	ND <.011	0	ND <.018	0.25	
conir	1000032689	6/14/97	2:00	0	<1.65		C97-228	0	<.011		EST.099	0	<.20
conir	1000032690	6/14/97	6:00	0	<1.78		C97-228	0	<.011		EST.306	0	<.20
conir	1000032691	6/14/97	10:00	0	<1.65		C97-228	0	<.011		EST.151	0.646	
conir	1000032698	6/14/97	14:00	10.1			C97-228	0	<.011	0	<.018	0	<.20
conir	1000032699	6/14/97	18:00	8.49			C97-228	0	<.011	0.071		0.515	
conir	1000032700	6/14/97	22:00	0	<1.64		C97-228	0	<.011	0	<.018	0	<.20
conir	1000032701	6/15/97	10:00	5.65			C97-228	0	<.011	0.097		0	<.20

Results of Water Quality Monito. - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Prometryn value µg/L	Prometryn remark	Trifluralin value µg/L	Trifluralin remark	Comments
bmpdr	1000021631	8/31/96	16:00	0	<.06	0.054		
bmpdr	1000021727	8/31/96	18:00	0	<.06	0	<.05	
bmpdr	1000021728	8/31/96	20:00	0	<.06	0	<.05	
bmpdr	1000021729	9/1/96	0:00	0	<.06	0	<.05	
bmpdr	1000021730	9/1/96	2:00	0	<.06	0	<.05	
bmpdr	1000021731	9/1/96	4:00	0	<.12	0	<.10	
bmpdr	1000023114	9/27/96	23:00	0	<.06	0	<.05	
bmpdr	1000023115	9/28/96	1:00	0	<.06	0	<.05	
bmpdr	1000023180	10/5/96	0:00	.	EST<.06	0	<.05	
bmpdr	1000023181	10/5/96	2:00	.	EST<.12	0	<.1	
bmpdr	1000023182	10/5/96	4:00	0	<.06	0	<.05	
bmpdr	1000023183	10/5/96	6:00	0	<.06	0	<.05	
bmpdr	1000023184	10/5/96	8:00	0	<.06	0	<.05	
bmpdr	1000023185	10/5/96	10:00	0	<.06	0	<.05	
bmpdr	1000023192	10/5/96	20:00	0	<.06	0	<.05	
bmpdr	1000029149	3/11/97	9:00	0	<.06	0	<.05	
bmpdr	1000029150	3/11/97	11:00	0	<.06	0	<.05	
bmpdr	1000029151	3/11/97	13:00	0	<.06	0	<.05	
bmpir	1000018210	4/15/96	4:00	0	<.103	0	<.086	
bmpir	1000018211	4/15/96	16:00	0	<.060	0	<.05	
bmpir	1000018212	4/16/96	4:00	0	<.060	0	<.05	
bmpir	1000018439	5/14/96	6:00	.	IM	0	<.10	
bmpir	1000018440	5/14/96	9:00	.	IM	0	<.05	
bmpir	1000018441	5/14/96	12:00	.	IM	0	<.05	
bmpir	1000018442	5/14/96	18:00	.	IM	0	<.05	
bmpir	1000018443	5/15/96	0:00	.	IM	0	<.05	
bmpir	1000018444	5/15/96	6:00	.	IM	0	<.05	
bmpir	1000018445	5/15/96	12:00	.	IM	0	<.05	
bmpir	1000018451	5/15/96	18:00	.	IM	0	<.05	
bmpir	1000018452	5/16/96	0:00	.	IM	0	<.05	
bmpir	1000018453	5/16/96	6:00	.	IM	0	<.10	
bmpir	1000018454	5/16/96	12:00	.	IM	0	<.10	
bmpir	1000018465	5/16/96	18:00	.	IM	0	<.10	
bmpir	1000018466	5/17/96	0:00	.	IM	0	<.05	
bmpir	1000018467	5/17/96	6:00	.	IM	0	<.05	
bmpir	1000018468	5/17/96	12:00	.	IM	0	<.05	

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
bmpir	1000018459	5/17/96	18:00		IM	0	<.05	
bmpir	1000018460	5/18/96	0:00		IM	0	<.05	
bmpir	1000018461	5/18/96	12:00		IM	0	<.05	
bmpir	1000019617	6/24/96	17:00		est<.2qc	0	<.05	
bmpir	1000020510	8/14/96	8:00	0	<.06	0.065		
bmpir	1000020511	8/14/96	12:00	0	<.06	0.053		
bmpir	1000020512	8/14/96	16:00	0	<.06	0	<.05	
bmpir	1000020513	8/14/96	20:00	0	<.06	0.07		
bmpir	1000020514	8/15/96	0:00	0	<.06	0.094		
bmpir	1000020515	8/15/96	4:00	0	<.06	0	<.05	
bmpir	1000020678	8/16/96	9:00	0	<.06	0	<.05	
bmpir	1000020679	8/16/96	12:00	0	<.06	0	<.05	
bmpir	1000020680	8/16/96	15:00	0	<.06	0	<.05	
bmpir	1000020750	8/16/96	20:00	0	<.12	0	<.10	
bmpir	1000020751	8/17/96	2:00	0	<.06	0	<.05	
bmpir	1000020752	8/17/96	8:00	0	<.06	0	<.05	
bmpir	1000020753	8/17/96	14:00	0	<.06	0	<.05	
bmpir	1000020804	8/17/96	20:00	0.09		0	<.05	
bmpir	1000020805	8/18/96	2:00	0	<.06	0	<.05	
bmpir	1000020806	8/18/96	8:00	0	<.06		est<.05	
bmpir	1000020807	8/18/96	14:00	0	<.06	0	<.05	
bmpir	1000020863	8/18/96	20:00	0	<.06	0	<.05	
bmpir	1000020864	8/19/96	2:00	0	<.06	0	<.05	
bmpir	1000020865	8/19/96	14:00	0	<.06	0.066		
bmpir	1000020951	8/19/96	20:00	0	<.06	0	<.05	
bmpir	1000020952	8/20/96	2:00	0	<.06	0.066		
bmpir	1000020953	8/20/96	8:00	0	<.06	0.052		
bmpir	1000020954	8/20/96	14:00	0	<.06	0.058		
bmpir	1000021089	8/26/96	18:00	0	<.06	0.062		Broken
bmpir	1000021090	8/26/96	22:00	0	<.15	0	<.125	Broken
bmpir	1000021091	8/27/96	2:00	0	<.15	0	<.125	Broken
bmpir	1000021092	8/27/96	6:00	0	<.12	0.058		
bmpir	1000021093	8/27/96	10:00	0	<.06	0	<.05	
bmpir	1000021094	8/27/96	14:00	0	<.06	0	<.05	
bmpir	1000021135	8/27/96	18:00	0	ND <.06	0	<.05	
bmpir	1000021136	8/27/96	22:00	0	ND <.15	0	<.125	Broken
bmpir	1000021137	8/28/96	2:00	0	ND <.15	0	<.125	Broken

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
bmpir	1000021138	8/28/96	6:00	0	ND <.06	0	<.05	
bmpir	1000021139	8/28/96	10:00	0	<.06	0	<.05	
bmpir	1000021140	8/28/96	14:00	0	<.06	0	<.05	
bmpir	1000021312	8/28/96	18:00	0	<.06	0	<.05	
bmpir	1000021313	8/28/96	22:00	0	<.12	0	<.10	
bmpir	1000021314	8/29/96	2:00	0	<.06	0	<.05	
bmpir	1000021315	8/29/96	6:00	0	<.15	0	<.125	
bmpir	1000021316	8/29/96	10:00	0	<.06	0	<.05	
bmpir	1000021317	8/29/96	14:00	0	<.06	0	<.05	
bmpir	1000021632	8/29/96	20:00	0	<.06	0	<.05	
bmpir	1000021633	8/30/96	2:00	0	<.06	0	<.05	
bmpir	1000021634	8/30/96	8:00	0	<.06	0	<.05	
bmpir	1000021635	8/30/96	14:00	0	<.12	0	<.10	
bmpir	1000026440	1/31/97	18:00	0	ND <.075	0	ND <.06	
bmpir	1000026441	1/31/97	22:00	0	ND <.075	0	ND <.06	
bmpir	1000026442	2/1/97	2:00	0	ND <.075	0	ND <.06	
bmpir	1000026443	2/1/97	6:00	0	ND <.075	0	ND <.06	
bmpir	1000026444	2/1/97	10:00	0	ND <.075	0	ND <.06	
bmpir	1000026445	2/1/97	14:00	0	ND <.075	0	ND <.06	
bmpir	1000026452	2/1/97	16:00	0	ND <.06	0	ND <.05	
bmpir	1000026453	2/1/97	20:00	0	ND <.06	0	ND <.05	
bmpir	1000026454	2/2/97	0:00	0	ND <.06	0	ND <.05	
bmpir	1000026455	2/2/97	4:00	0	ND <.06	0	ND <.05	
bmpir	1000026456	2/2/97	8:00	0	ND <.06	0	ND <.05	
bmpir	1000026457	2/2/97	12:00	0	ND <.12	0	ND <.10	
bmpir	1000026462	2/2/97	18:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026463	2/2/97	20:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026464	2/3/97	2:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026465	2/3/97	6:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026466	2/3/97	10:00	0	ND <.06	0	ND <.05	RECEIVED PAST HOLDING TIME
bmpir	1000026467	2/3/97	14:00	0	ND <.12	0	ND <.10	
bmpir	1000026468	2/3/97	18:00	0	ND <.06	0.25		
bmpir	1000026469	2/4/97	0:00		EST<.06	0.25		
bmpir	1000026470	2/4/97	6:00	0	ND <.06	0.19		
bmpir	1000026471	2/4/97	12:00	0	ND <.06	0.16		
bmpir	1000032683	6/13/97	18:00	0	<.12	0.247		RECEIVED WARM
bmpir	1000032684	6/13/97	22:00	0	<.06	0.292		RECEIVED WARM

Results of Water Quality Monitoring - Arroyo Colorado Project

Pesticides

Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
bmpir	1000032685	6/14/97	2:00	0	<.06	0.15		RECEIVED WARM
bmpir	1000032686	6/14/97	6:00	0	<.06	0.182		RECEIVED WARM
bmpir	1000032687	6/14/97	10:00	0	<.06	0.212		RECEIVED WARM
bmpir	1000032688	6/14/97	14:00	0	<.06	0.154		RECEIVED WARM
bmpir	1000032693	6/14/97	22:00		EST<.12	0.352		
bmpir	1000032694	6/15/97	2:00		EST<.06	0.149		
bmpir	1000032695	6/15/97	6:00	0	<.06	0.083		
bmpir	1000032696	6/15/97	10:00	0	<.12	0.162		
bmpir	1000032697	6/15/97	14:00	0	<.06	0.081		
condr	1000021630	8/31/96	16:00	0	<.06		est<.05	
condr	1000023112	9/27/96	23:00	0	<.12	0	<.1	
condr	1000023113	9/28/96	1:00	0	<.06	0	<.05	
condr	1000023174	10/5/96	0:00	0	<.06	0	<.05	
condr	1000023175	10/5/96	2:00	0	<.06	0	<.05	
condr	1000023176	10/5/96	4:00	0	<.06	0	<.05	
condr	1000023177	10/5/96	6:00	0	<.06	0	<.05	
condr	1000023178	10/5/96	8:00	0	<.06	0	<.05	
condr	1000023179	10/5/96	10:00		EST<.06	0	<.05	
condr	1000023189	10/5/96	20:00	0	<.06	0	<.05	
condr	1000023190	10/6/96	0:00	0	<.06	0	<.05	
condr	1000023191	10/6/96	4:00	0	<.06	0	<.05	
condr	1000029148	3/11/97	8:00	0	<.12	0	<.10	
conir	1000018214	4/16/96	4:00	0	<.060	0	<.05	
conir	1000018213	4/16/96	16:00	0	<.060	0	<.05	
conir	1000018215	4/17/96	4:00	0	<.060	0.109		
conir	1000018455	5/16/96	0:00		IM	0	<.05	
conir	1000018456	5/16/96	3:00		IM	0	<.05	
conir	1000018457	5/16/96	6:00		IM	0	<.05	
conir	1000018458	5/16/96	12:00		IM	0	<.05	
conir	1000018469	5/16/96	18:00		IM	0	<.05	
conir	1000018470	5/17/96	0:00		IM	0	<.05	
conir	1000018471	5/17/96	6:00		IM	0	<.05	
conir	1000018472	5/17/96	12:00		IM	0	<.05	
conir	1000018462	5/17/96	18:00		IM	0	<.05	
conir	1000018463	5/18/96	0:00		IM	0	<.05	
conir	1000018464	5/18/96	12:00		IM	0	<.05	
conir	1000018473	5/18/96	18:00		IM	0	<.05	

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
conir	1000020803	8/18/96	16:00	0	<0.06	0	<0.05	
conir	1000020858	8/18/96	20:00	0	<0.06	0	<0.05	
conir	1000020859	8/18/96	23:00	0	<0.12	0	<0.10	
conir	1000020860	8/19/96	2:00	0	<0.06	0	<0.05	
conir	1000020861	8/19/96	8:00	0	<0.06	0	<0.05	
conir	1000020862	8/19/96	14:00	0	<0.06	0	<0.05	
conir	1000020947	8/19/96	20:00	0	<0.06	0.107		
conir	1000020948	8/20/96	2:00	0	<0.06	0	<0.05	
conir	1000020949	8/20/96	8:00	0	<0.06	0.053		
conir	1000020950	8/20/96	14:00	0	<0.12	0	<0.10	
conir	1000020966	8/20/96	20:00	0	<0.06	0	<0.05	
conir	1000020967	8/21/96	2:00	0	<0.06	0	<0.05	
conir	1000020968	8/21/96	8:00	0	<0.06	0	<0.05	
conir	1000020969	8/21/96	14:00	0	<0.06	0	<0.05	
conir	1000021095	8/26/96	18:00	0	<0.06	0	<0.05	
conir	1000021096	8/26/96	22:00	0	<0.06	0	<0.05	
conir	1000021097	8/27/96	2:00	0	<0.06	0	<0.05	
conir	1000021098	8/27/96	6:00	0	<0.06	0	<0.05	
conir	1000021099	8/27/96	10:00	0	<0.15	0	<0.125	
conir	1000021100	8/27/96	14:00	0	<0.12	0	<0.10	
conir	1000021141	8/27/96	18:00	0	<0.06	0	<0.05	
conir	1000021142	8/27/96	22:00	0	<0.06	0	<0.05	
conir	1000021143	8/28/96	2:00	0	<0.12	0	<0.1	
conir	1000021144	8/28/96	6:00	0	<0.15	0	<0.125	
conir	1000021145	8/28/96	10:00	0	<0.06	0	<0.05	
conir	1000021146	8/28/96	14:00	0	<0.15	0	<0.125	
conir	1000021306	8/28/96	18:00	0	<0.06	0	<0.05	
conir	1000021307	8/28/96	22:00	0	<0.06	0	<0.05	
conir	1000021308	8/29/96	2:00	0	<0.06	0	<0.05	
conir	1000021309	8/29/96	6:00	0	<0.06	0	<0.05	
conir	1000021310	8/29/96	10:00	0	<0.06	0	<0.05	
conir	1000021311	8/29/96	14:00	0	<0.06	0	<0.05	
conir	1000021637	8/29/96	20:00		est<0.06	0	<0.05	
conir	1000021638	8/30/96	2:00	0	<0.06	0	<0.05	
conir	1000021639	8/30/96	8:00	0	<0.06	0	<0.05	
conir	1000021640	8/30/96	14:00	0	<0.06	0	<0.05	
conir	1000026427	1/29/97	18:00	0	ND <.12	0	ND <.10	ONE BOTTLE RECEIVED BROKEN CAR# 97-0024

Results of Water Quality Monitoring - Arroyo Colorado Project
Pesticides

Site	Sample #	Date	Time	Prometryn value	Prometryn remark	Trifluralin value	Trifluralin remark	Comments
conir	1000026428	1/29/97	22:00	0	ND <.15	0	ND <.11	
conir	1000026429	1/30/97	2:00	0	ND <.075	0	ND <.06	
conir	1000026430	1/30/97	6:00	0	ND <.075	0	ND <.06	
conir	1000026431	1/30/97	10:00	0	ND <.075	0	ND <.06	
conir	1000026432	1/30/97	14:00	0	ND <.075	0	ND <.06	
conir	1000026434	1/30/97	18:00	0	ND <.075	0	ND <.06	
conir	1000026435	1/30/97	22:00	0	ND <.075	0	ND <.06	
conir	1000026436	1/31/97	2:00	0	ND <.075	0	ND <.06	
conir	1000026437	1/31/97	6:00	0	ND <.12	0	ND <.10	
conir	1000026438	1/31/97	10:00	0	ND <.075	0	ND <.06	
conir	1000026439	1/31/97	14:00	0	ND <.075	0	ND <.06	
conir	1000026446	1/31/97	18:00	0	ND <.075	0	ND <.06	
conir	1000026447	1/31/97	22:00	0	ND <.12	0	ND <.10	
conir	1000026448	2/1/97	2:00	0	ND <.075	0	ND <.06	
conir	1000026449	2/1/97	6:00	0	ND <.12	0	ND <.10	ONE BOTTLE IN TRANSIT
conir	1000026450	2/1/97	10:00	0	ND <.075	0	ND <.06	
conir	1000026451	2/1/97	14:00	0	ND <.075	0	ND <.06	
conir	1000026458	2/1/97	18:00	0	ND <.06	0	ND <.05	
conir	1000026459	2/2/97	0:00	0	ND <.06	0	ND <.05	
conir	1000026460	2/2/97	6:00	0	ND <.06	0	ND <.05	
conir	1000026461	2/2/97	12:00	0	ND <.06	0	ND <.05	
conir	1000032689	6/14/97	2:00	0	<.06	0.165		RECEIVED WARM
conir	1000032690	6/14/97	6:00	0	<.06	0.187		RECEIVED WARM
conir	1000032691	6/14/97	10:00	0	<.06	0.144		RECEIVED WARM
conir	1000032698	6/14/97	14:00	0	<.06	0.081		
conir	1000032699	6/14/97	18:00	0	<.06	0.103		
conir	1000032700	6/14/97	22:00	0	<.06	0.069		
conir	1000032701	6/15/97	10:00	0	<.06	0.115		

APPENDIX F

**TIAER Final Report:
Prediction of Effects of Best Management
Practices on Agricultural Nonpoint Source
Pollution in the Arroyo Colorado Watershed**

TIAER

**PREDICTION OF EFFECTS OF BEST MANAGEMENT PRACTICES
ON AGRICULTURAL NONPOINT SOURCE POLLUTION
IN THE ARROYO COLORADO WATERSHED**

Joan Flowers, Nancy Easterling and Larry Hauck

February 1998

Final Report to the Texas State Soil and Water Conservation Board
on the FY92 319(h) Agricultural/Silvicultural Nonpoint Source Project:
NPS Prevention in the Arroyo Colorado Watershed
Contract No. 994-592-713-4200000051

and

Final Report to the Texas Water Development Board
on the Fate and Transport Modeling for the Section 319 Project:
NPS Prevention in the Arroyo Colorado Watershed
Contract No. 92-483-339

Texas Institute for Applied Environmental Research
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TIAER

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EXECUTIVE SUMMARY

This section 319(h) project was designed to promote the adoption of best management practices (BMPs) to abate nonpoint source pollution from agricultural sources in the Arroyo Colorado study area. The project was funded by the U.S. Environmental Protection Agency through Texas Natural Resource Conservation Commission (TNRCC) and Texas State Soil and Water Conservation Board (TSSWCB), with some matching funding for mathematical modeling efforts provided by Texas Water Development Board. Project participants included the Texas Agricultural Extension Service (TAEX), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), Southmost Soil and Water Conservation District (SWCD), and Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University. Primary tasks of the project included the establishment of coordinating committees, the installation of BMPs and monitoring of demonstration sites, mathematical modeling of the study area, and education and technology transfer.

TIAER's involvement, in addition to performing laboratory analyses on water samples collected at the demonstration sites, dealt primarily with the fate and transport modeling component of the project and is the main focus of this report. The modeling analysis of best management practices within the Arroyo Colorado study area applied the Environmental Policy Integrated Climate (EPIC) model to estimate the effects of BMP implementation throughout the study area. The EPIC model was applied to the demonstration sites and to agricultural regions of the study area. Water quality data obtained from the monitoring activities at the demonstration sites were used for calibration and testing of the EPIC model prior to its application.

A multi-layer GIS database for the study area was assembled as part of the mathematical modeling efforts. Data layers included soil type, land use/vegetative cover, topographical information, monitoring wells, and geographic/cartographic features. The agricultural portion of the study area was separated into categories based on soil type, crop, and farming practices (dryland or irrigation). Individual simulations were performed for each grouping, which were then aggregated into a representative picture of the agricultural portion of the study area. Simulations were performed to estimate changes in edge-of-field loading for scenarios with and without BMPs. BMPs appropriate for crops grown in the study area were selected by the project's advisory committees. Average annual loads of nutrients, pesticides and sediment were estimated for the study area based on the modeling results for the six BMPs listed below:

1. improved nutrient management.
2. improved residue management.
3. improved irrigation water management.
4. improved irrigation technology,
5. irrigation land leveling/precision land forming, and
6. integrated pest management (IPM).

A seventh scenario represented the implementation of appropriate combinations of the six BMPs for each category.

Mathematical modeling results, presented in the following table, indicated that substantial reductions in nutrient and pesticide loadings would be achieved from BMP implementation within the study area. Percent reductions in total nitrogen loads exceeding 30 percent were

estimated for improved nutrient management, improved irrigation water management and improved irrigation technology. Improved nutrient management also had the greatest impact on total phosphorus loads with an estimated 15 percent reduction attributed to this BMP. With respect to pesticide and sediment losses from cropland areas, the two BMPs dealing with irrigation practices (improved irrigation water management and improved irrigation technology) showed the greatest potential in reducing contributions from the study area. Percent reductions estimated for total nitrogen, pesticide and sediment losses exceeded 60 percent for all BMPs combined.

Although BMPs dealing with land leveling practices and integrated pest management (IPM) practices both displayed rather minor reductions in constituent loads, it should be kept in mind that these practices are largely implemented under the baseline condition, and this evaluation merely dealt with increasing the implementation in each case to 95 percent. It cannot and should not be concluded that these BMPs are not successful in reducing nonpoint pollution, but rather than much of the environmental benefits associated with these BMPs has already been realized. It would appear that educational and planning efforts by TAEX, NRCS, TSSWCB and other organizations in promoting integrated pest management and land leveling practices have been largely successful in effecting implementation among area producers.

Percent Reduction in Losses¹ From BMP Implementation in the Arroyo Colorado Study Area

BMP	Nitrogen Loss	Phosphorus Loss	Pesticide Loss	Sediment Loss ²
Improved Nutrient Management	34	15	0	0
Improved Residue Management	0	2	8	18
Improved Irrigation Water Management	30	4	30	30
Improved Irrigation Technology	45	5	28	43
Increase in Land Leveling to 95%	0	5	5	21
Increase in IPM Implementation to 95%	0	0	1	0
Implementation of all applicable BMPs	64	27	62	62

¹Represents total edge-of-field losses including surface and subsurface transport pathways

²Represents loss due to water erosion

ACKNOWLEDGMENTS

EPIC (Environmental Policy Integrated Climate), formerly the Erosion Productivity Impact Calculator, was developed by United States Department of Agriculture Agricultural Research Service (USDA-ARS) scientists at the Grassland, Soil and Water Research Laboratory, collocated at Blackland Research Center (BRC). Modification and refinement of model processes in the development of the current version (version 5300) were performed by J.R. Williams at BRC.

TIAER also wishes to recognize the following Extension specialists at the Texas Agricultural Experiment Station, Research and Extension Center in Weslaco, who assisted in developing the crop management schedules used in the modeling analyses: John W. Norman, Jr., Extension Agent-IPM; Julian Sauls, Extension Horticulturist (Citrus); and Alton N. Sparks, Jr., Extension Entomologist.

Other specialists who provided assistance to TIAER in developing the crop management assumptions include John Bremer, Professor and Extension Weed Control Expert with the Texas A&M University System in Corpus Christi; Norman Rozeff, Agriculturist for the Rio Grande Valley Sugar Growers, Inc. in Santa Rosa; and Jack Garner, irrigation engineer of the Harlingen Irrigation District.

TIAER would also like to thank David Petit of the United States Army Corps of Engineers, Galveston District for providing land-use and soil GIS coverages for the area and Gerald Anderson with the Remote Sensing Research Unit of the USDA-ARS Subtropical Agricultural Research Laboratory (SARL) in Weslaco for providing the land-use data for citrus groves in Cameron County.

TIAER also wishes to recognize and thank the private landowners who participated in this project. These landowners permitted access to their property for monitoring and demonstration activities and tolerated the imposition of both the equipment and personnel required for this study. These landowners were also willing to manage portions of their fields differently for the sake of demonstration which no doubt required additional labor.

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Evaluation of Best Management Practices for Reduction of Nonpoint Source Pollution in the Arroyo Colorado Watershed

1.0 INTRODUCTION

The Arroyo Colorado watershed, located in the coastal border region of southern Texas, has experienced numerous water quality problems in recent years. Evidence points to agriculture, one of the primary industries of the area, as one possible source of the pollution. This U.S. Environmental Protection Agency (USEPA) funded section 319(h) project serves to demonstrate best management practices (BMPs) to abate nonpoint source pollution from agricultural sources in the project area, to promote their adoption among area producers, and to estimate the effects of BMP implementation on local water quality.

The project was developed by the Texas Natural Resource Conservation Commission (TNRCC), Texas State Soil and Water Conservation Board (TSSWCB) and the Southmost Soil and Water Conservation District. Cooperating agencies include the Texas Agricultural Extension Service (TAEX), the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), and Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University. The project was funded by the USEPA through TNRCC and TSSWCB, with some matching funding for modeling efforts provided by Texas Water Development Board (TWDB). This project addresses the impact of nonpoint source pollution resulting from agricultural sources, while the TNRCC has also developed a companion project addressing nonpoint source pollution resulting from urban runoff to the Arroyo Colorado. In addition to the cooperating agencies, local citizens and technical experts were involved with the project through coordinating committees established early in the project. Local and technical advisory committees were established to provide guidance for research and educational activities.

The overall objective of the project was to promote the adoption of BMPs to abate nonpoint source pollution from agricultural sources in the project area. Specific objectives of this project were to:

- demonstrate improved nutrient and pesticide management practices;
- evaluate the effectiveness of selected BMPs through monitoring of edge-of-field losses, both surface and subsurface, at the demonstration sites;
- estimate the environmental benefits of widespread BMP implementation through the use of mathematical models to predict pollutant load reductions for the study area; and
- promote increased cooperation and exchange of information between agricultural interest groups through the technical advisory committee and the local advisory committee.

Two fields were selected for implementation and demonstration of BMPs suitable to the project area. One demonstration field employed dryland cropping practices while the other was irrigated. To evaluate the effectiveness of selected BMPs in abating nonpoint source pollution associated with agricultural drainage, each field was divided into a control section which was managed according to conventional practices and a treatment section utilizing improved management practices. Samples of surface runoff and subsurface drainage were collected from the control and treatment sections of the fields for chemical analyses.

This report addresses TIAER's work elements which dealt specifically with the modeling analysis of best management practices within the Arroyo Colorado study area. The Environmental Policy Integrated Climate (EPIC) model, version 5300, formerly known as the Erosion Productivity Impact Calculator (Williams, 1995) was applied to estimate the effects of BMP implementation throughout the project area. Water quality data obtained from the monitoring activities at the demonstration sites were used for calibration and testing of the EPIC model prior to its application to the study area. Companion reports prepared by TAEX address the demonstration and educational activities associated with this project.

2.0 BACKGROUND

The Arroyo Colorado River (Figure 1) drains the flat coastal plain in southernmost Texas, as part of the Nueces-Rio Grande Coastal basin. Approximately 143 kilometers (89 miles long), the river stretches from its headwaters in Hidalgo County, across Cameron County, and empties into the Laguna Madre, just north of the Cameron-Willacy County line. The land in the Arroyo Colorado watershed was originally deposited by the ancient Rio Grande. Unlike other areas of the Texas coastal plain, the Arroyo Colorado watershed is not characterized by swamps and marshes (Brown *et al.*, 1980). Resacas, i.e., shallow abandoned meandering watercourses, are distinguishing features of the landscape.

Rainfall across the watershed averages 56 to 66 centimeters (22 to 26 inches) annually, categorizing it as a semi-arid region (TDWR, 1984). Municipal wastewater treatment plant effluent and irrigation return flows supersede rainfall runoff as the major contributors to the river's flow. Average annual lake evaporation in the Arroyo Colorado watershed is approximately 81 centimeters (32 inches) greater than average annual precipitation (USDA, 1977).

Much of the soil in the Arroyo Colorado watershed is fertile, easily cultivated, and suitable for irrigation if adequate drainage is available (USACE, 1990a). The alluvial soils of the watershed serve to make the area one of the most productive agricultural regions of Texas. According to the 1992 Census of Agriculture, one-third of Cameron County's 300,190 hectares (741,760 acres) are used as cropland. Cotton and grain sorghum are the most prominent crops in the county (Texas Agricultural Statistics, 1996). Corn, sugarcane, and citrus fruits represent other important crops in the area.

Although agriculture is the major economic activity, oil and gas production also support the area's economy. Harlingen, Mission, Donna, San Benito and other communities add urban influences within the watershed.

Surface water serves almost exclusively as the source of irrigation water for the vast agricultural enterprises of the area. The surface water derives primarily from streamflow diverted from the Rio Grande through leveed floodways and stored in constructed reservoirs in the Arroyo Colorado watershed. A limited amount of groundwater is used in the western part of the watershed, although it is typically of poorer quality than is the surface water (USACE, 1990a). In years of insufficient flow in the Rio Grande, however, up to 25 percent of the total water demand has been supplied by groundwater (USACE, 1990a). The western half of the Arroyo Colorado watershed is underlain by the shallow Gulf Coast aquifer. No major nor minor aquifers underlie the eastern half of the Arroyo Colorado watershed, although shallow, variably saline groundwater is found in the area. A review of the Texas Water Development Board's Ground Water Data System from 1990 - 1996 reveals that water table depths varied from 3.8 to 4.8 meters (12.5 to 15.6 feet) for area wells.

The Arroyo Colorado is one of the more complex watercourses in the state. From its headwaters to its mouth, it has been extensively modified by human activity, which affects both its hydrology and water quality. The low-relief, arid watershed is artificially plumbed by canals, aqueducts, siphons and pumping stations to provide irrigation water for the vast agricultural enterprises of the region. Similarly, the drainage of the basin's urban areas consists of rectified, leveed intersecting channels with gates for controlling and directing flow to alleviate chronic flooding problems common to the region. Numerous reservoirs have been constructed as catchment basins for irrigation water. Leveed floodways divert excess water caused by upland flooding from the Rio Grande to the Arroyo Colorado channel. The runoff response of the river is, therefore, quite different from what would be expected on the basis of natural runoff processes.

This system of floodways, in fact, complicates designation of the headwaters of the Arroyo Colorado. The floodway system begins in western Hidalgo County near Mission, Texas where water flows from the Rio Grande to the Main Floodway. The Main Floodway widens to become the Llano Grande Lake near Mercedes, Texas, in eastern Hidalgo County. A constructed channel sends flow from the lake to the Arroyo Colorado. In times of high water and flood conditions, a divisor dike also diverts flood water to the North Floodway, which traverses the northern part of Cameron County to Willacy County and empties into the Laguna Madre near the mouth of the Arroyo Colorado. The U.S. Army Corps of Engineers (USACE) and the USDA Natural Resources Conservation Service (NRCS) refer to the Arroyo Colorado as the waterway beginning east of the Llano Grande Lake. For regulatory purposes, the Texas Natural Resources Conservation Commission (TNRCC), however, considers the Arroyo Colorado to begin as the Main Floodway near Mission in western Hidalgo County.

The TNRCC recognizes three designated segments of the river: Segment 2200, the North Floodway, Segment 2201, Arroyo Colorado Tidal, and Segment 2202, Arroyo Colorado above Tidal. Segment 2201 extends approximately 42 kilometers (26 miles) from the Laguna Madre to roughly Port Harlingen, just east of the city of Harlingen. This segment, which is tidally influenced, has been dredged to accommodate barge traffic. Segment 2202 encompasses the remaining river from Port Harlingen to the headwaters. The North Floodway, designated at Segment 2200, is a distributary of the Arroyo Colorado river extending from the divisor dike near Llano Grande Lake to its terminus in the Laguna Madre.

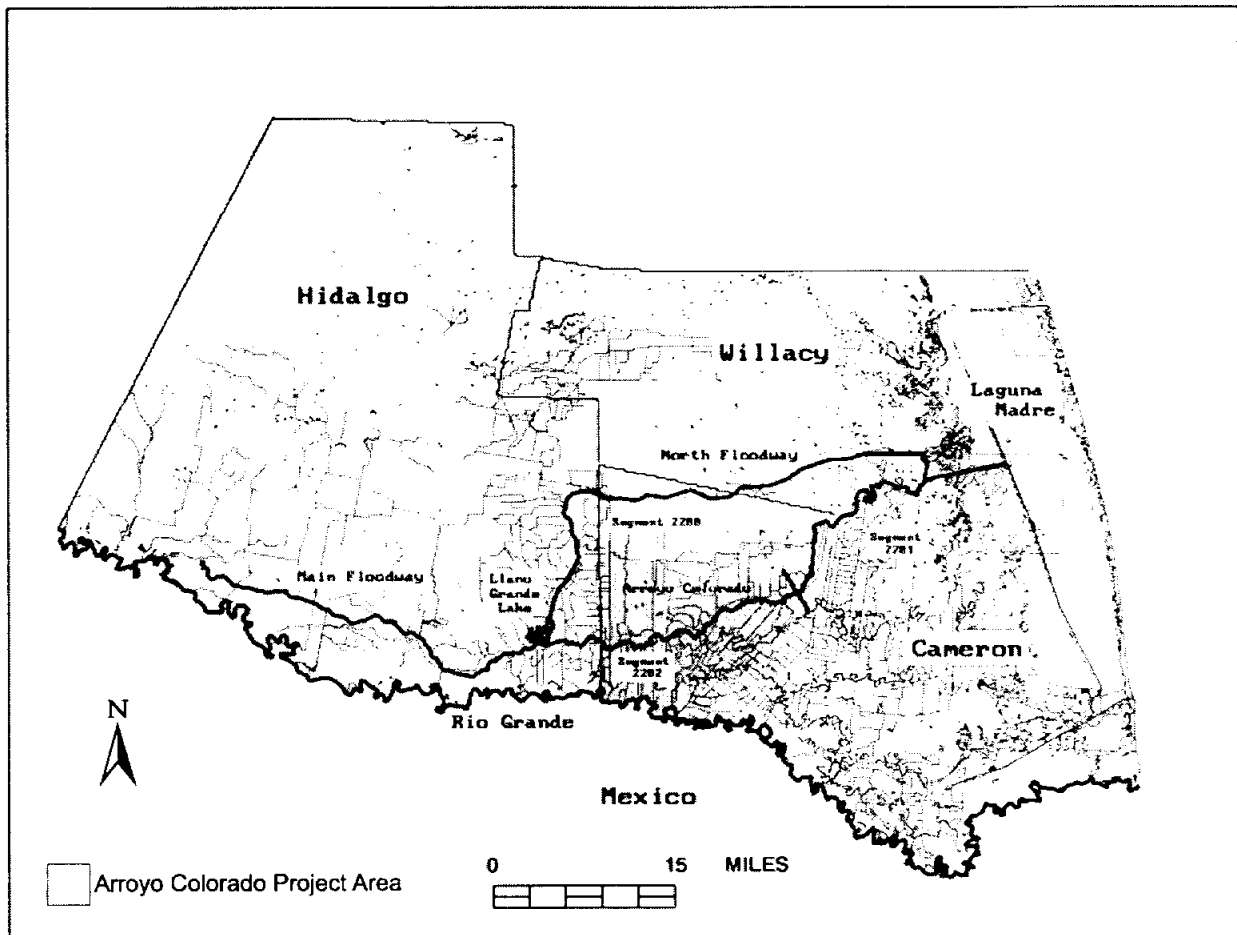


Figure 1. The Arroyo Colorado River and its Tributaries

2.1 Water Quality Issues in the Area

A review of the literature documents the numerous water quality problems plaguing the region. Over the years, various State agencies have investigated water quality-related issues in the Arroyo Colorado. Water quality problems in the Arroyo Colorado derive from various sources. The tidal segment experiences the expected saltwater intrusion and concomitant lower dissolved oxygen and higher salt content (Twidwell, 1978). Agricultural applications of

pesticides and fertilizers, in conjunction with the irrigation and drainage systems of the area, have been implicated by various studies as contributing to water quality problems. Urban runoff and effluent from 26 wastewater treatment facilities in Segment 2202 and 6 facilities in Segment 2201 have also been cited as contributing to lower water quality in the Arroyo Colorado. It should be noted that some of these facilities receive wastewater that has been used to process agricultural products, further complicating the "source" issue. In fact, the *1990 Update to the Nonpoint Source Water Pollution Assessment Report for the State of Texas* (TWC & TSSWCB, 1991) listed the status of Segment 2202 as "Known Concern" due to elevated phosphorus, nitrogen, nutrients, fecal coliform, and chlordane in fish tissue. The potential sources identified for the segment were irrigated crop production, septic tanks, and urban sewers. A 1987 intensive priority monitoring of the Arroyo Colorado concluded that nonpoint sources, primarily agriculture, contribute the majority of the toxic pollutants to the Arroyo Colorado (TWC, 1989b).

Data collected from Segment 2201 by the Texas Department of Water Resources in 1976 indicated eutrophic conditions and the presence of pesticides in sediments (Twidwell, 1978). In 1980, the Texas Department of Health issued an advisory recommending restricted consumption of all fish from the Arroyo Colorado above Port Harlingen. Intensive surveys of Segment 2201, conducted by the Texas Department of Water Resources in the early to mid 1980s, consistently found evidence of eutrophication and pesticides. National Oceanic and Atmospheric Administration has reported that the Lower Laguna Madre watershed, which consists primarily of the Arroyo Colorado watershed, has the most intensively applied herbicides and insecticides of any watershed in Texas (TNRCC, 1994a). In addition, soil loss from cropland in the Lower Laguna Madre watershed exceeds that of the U.S. side of the Rio Grande Watershed, a decidedly larger area (TNRCC, 1994a).

The U.S. Army Corps of Engineers (USACE) performed a feasibility investigation during the late 1980s to determine the potential for reducing flood damage in the Cameron County, Texas (USACE, 1990a). Factors contributing to the area's frequent flooding include flat topography and poorly defined drainage courses. Human activities frequently increase the amount of accumulated rainfall remaining on the land for extended periods. Standing water can cause a subsequent rise in the water table which ultimately increases soil salinity, leading to non-productive soils. (USACE, 1990a). Corps engineers analyzed a full array of plans to provide flood damage reduction for the urban watersheds and agricultural watersheds, but determined that Federal participation would not be economically justified at that time (USACE, 1990a). The study found that

[p]esticide contamination has been identified as a widespread problem of inland waters of the project area. The quality is also influenced by sewage effluent, cannery and food processing wastes, canal seepage and storm run-off. Increased runoff associated with any flood control or drainage project has the potential to increase these problems if proper planning efforts are not accomplished. Proper drainage design of agricultural land and implementation of various farming practices could significantly improve water quality of the area (USACE, 1990a).

The numerous above-ground irrigation canals in the watershed block natural drainage and increase flooding potential. The Corps recommends water

conservation techniques and farming practices which could reduce the level of pesticides and improve water quality.

After a cluster of neural tube deficient babies were born in Cameron County in 1991, an evaluation by the Texas Department of Health (TDH) of data concerning air quality, soil constituents, drinking water quality, surface water quality and pesticide use revealed no clear causative agent (TNRCC, 1994a). A subsequent intensive small-scale pilot project conducted by the TDH in 1993 on nine families in the area found higher-than-average urinary arsenic levels yet relatively low levels of pesticides in participant blood and urine. Analysis of participants' food samples during this pilot project revealed that one fish caught in Donna Reservoir in the Arroyo Colorado watershed contained polychlorinated biphenyl (PCB) levels of 500 parts per million (ppm), well above the U.S. Food and Drug Administration action level of 2 ppm. Donna Reservoir receives water from the Rio Grande which is used for irrigation in the Arroyo Colorado watershed. Continuing investigations have consistently found PCBs in fish from the Arroyo Colorado but not from the Rio Grande (TNRCC, 1994a).

Water quality data have been collected by the TNRCC since 1982. Designated river segments were assigned to one of the following four categories with respect to each parameter: Concern, Possible Concern, No Concern and Insufficient Data. Table 1 presents all the parameters designated as a Concern or a Possible Concern for either of the two Arroyo Colorado segments for data collected from January 1983 through December 1992. Note: Insufficient data were collected from the Arroyo segments for all analyzed toxic substances, which accounts for their absence from this table.

Table 1. TNRCC Water Quality Concerns for the Arroyo Colorado Segments

Parameter	Segment 2201	Segment 2202
Ammonia Nitrogen	Concern	Possible Concern
Nitrate Nitrogen	Concern	Concern
Total Kjeldahl Nitrogen	Not applicable to marine segments	Concern
Orthophosphate Phosphorus	Concern	Concern
Total Phosphorus	Possible Concern	Concern
Dissolved Phosphorus	Concern	Concern
Dissolved Oxygen	Concern	Possible Concern
Fecal Coliform	No Concern	Possible Concern

From TNRCC, 1994a

A 1987 intensive monitoring study conducted by the Texas Water Commission (TWC, predecessor to the TNRCC) found relatively poor conditions for macrobenthic integrity in the above-tidal segment of the Arroyo Colorado, with pollution-tolerant species predominating and sensitive species absent (TWC, 1989b). Most sampling stations were rated as having "limited" aquatic life uses. The TWC researchers judged that the macrobenthic community was affected more by toxic chemicals found in the water and sediments in the upper portion of the watershed, rather than by the generally poor habitat conditions (TWC, 1989b). The tidal section of the river did not appear to have the toxic chemical effects of the upper portion. The 1987 study found that fish communities exhibited characteristics similar to those of macroinvertebrate communities, with physical habitat limitations and toxic conditions at sampling sites in the upper section of the river but more healthy fish communities in the lower section.

Fewer types of chemicals were detected in water, tissue, and sediment samples than were detected in a similar 1981 study. Concentrations of some of those chemicals decreased over time between the two studies, while concentrations of others increased. Toxicity tests were performed on water samples from various river sites and wastewater treatment plant effluent outfalls. Poor survival rates resulted from elevated chlorine and ammonia in effluent from Harlingen Wastewater Treatment Plant #2. The causative agent in the zero survival rate in a *Ceriodaphnia dubia* test from the Llano Grande Lake, however, could not be determined, although pesticides were suspected (TWC, 1989b). Concentrations of the following toxic chemicals found in tissue samples from the Arroyo Colorado fish present human health implications: methylene chloride, dieldrin, DDE, and chlordane. In addition, dacthal, a suspected human carcinogen, was found in very high levels in several tissue samples (TWC, 1989b).

In 1994, the Texas State Soil and Water Conservation Board named the Arroyo Colorado as one of only nine watersheds in the State identified with agricultural or silvicultural nonpoint source pollution concerns (TNRCC, 1994a). Segments 2201 and 2202 are both included on the State's 1996 303(d) list of priority watersheds (TNRCC, 1997). The 303(d) list notes that neither segment supports its designated aquatic life use and that Segment 2202 does not support its contact recreation use. In the 1994 *State of Texas Water Quality Inventory*, Segment 2202 was designated as number 7 out of 366 State watersheds with respect to priority action, while Segment 2201 was designated as number 20. The Inventory listed five fish kills from 1989 through 1992 in Segment 2202 and noted that fish contain elevated levels of chlordane, toxaphene and DDT. The summary for Segment 2202 in the 1994 *State Inventory* is as follows:

This segment is not supporting its use for contact recreation due to the high fecal coliform levels. Phosphorus, nitrate and chlorophyll- α levels exceed the screening criteria in almost all of the samples collected in the segment. Elevated phosphorus and nitrogen levels promote excessive algal growth as indicated by elevated chlorophyll- α levels. Domestic effluents are the major contributor of nutrients to the segment during periods of normal flow. A wasteload evaluation has been completed and recommends advanced waste treatment to maintain stream standards. Concerns about toxic substances include manganese, selenium and DDE (a byproduct of DDT decomposition) in sediment and PCBs in fish tissue (TNRCC, 1994b).

The 1994 *Regional Assessment of Water Quality in the Rio Grande Basin* (TNRCC, 1994a) noted that of all the segments of the Rio Grande basin and associated watersheds, only Segments 2202 and 2201 indicated dissolved oxygen problems. In a TNRCC ranking of the Rio Grande basin, including the Arroyo Colorado, the pollutants/stressors listed for both Arroyo segments were fish kills, relatively large number of permitted point source discharges, toxic conditions, depressed dissolved oxygen, and elevated levels of chlorophyll- α + pheophytin- α , nitrogen, and phosphorus (TNRCC, 1994a).

The summary for segment 2202 in the 1996 *State of Texas Water Quality Inventory* states:

Nitrate plus nitrite nitrogen, orthophosphate, and total phosphorus concentrations exceed screening levels throughout the segment, promoting high primary productivity in the lower 35 miles, as indicated by elevated chlorophyll- α concentrations. In sediment,

angles. A 1990 feasibility report concerning flood damage prevention conducted by U.S. Army Corps (USACE, 1990a) contains detailed maps of the area's drainage channels and elevated irrigation canals. These maps were used to delineate the border of the project area.

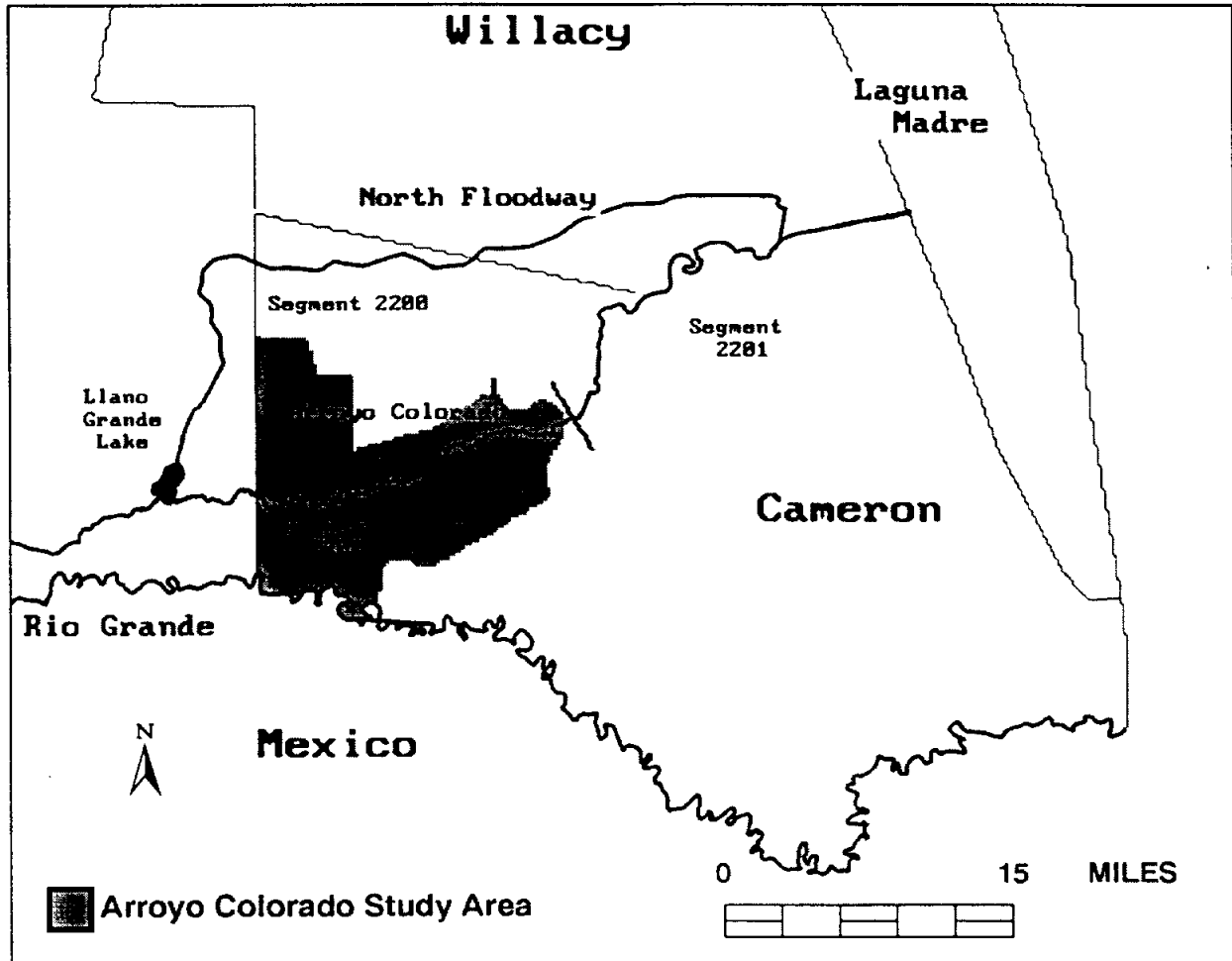


Figure 2. Arroyo Colorado Project Study Area

2.3 Demonstration Sites

In order to demonstrate best management practices that enable area farmers to reduce their contributions of pollutants to surface and ground water, project staff established two demonstration fields. Row crop operations in the project area include both irrigated and dryland farming, so one demonstration site of each type was implemented. On both sites, grain sorghum was grown for the first year and cotton was grown during the second year. Half of each site was set aside to serve as a control for comparisons of BMP effectiveness. The treatment and control fields were separated from surrounding fields and from each other by earthen berms. The location of the irrigated and dryland demonstration sites are denoted in Figure 3.

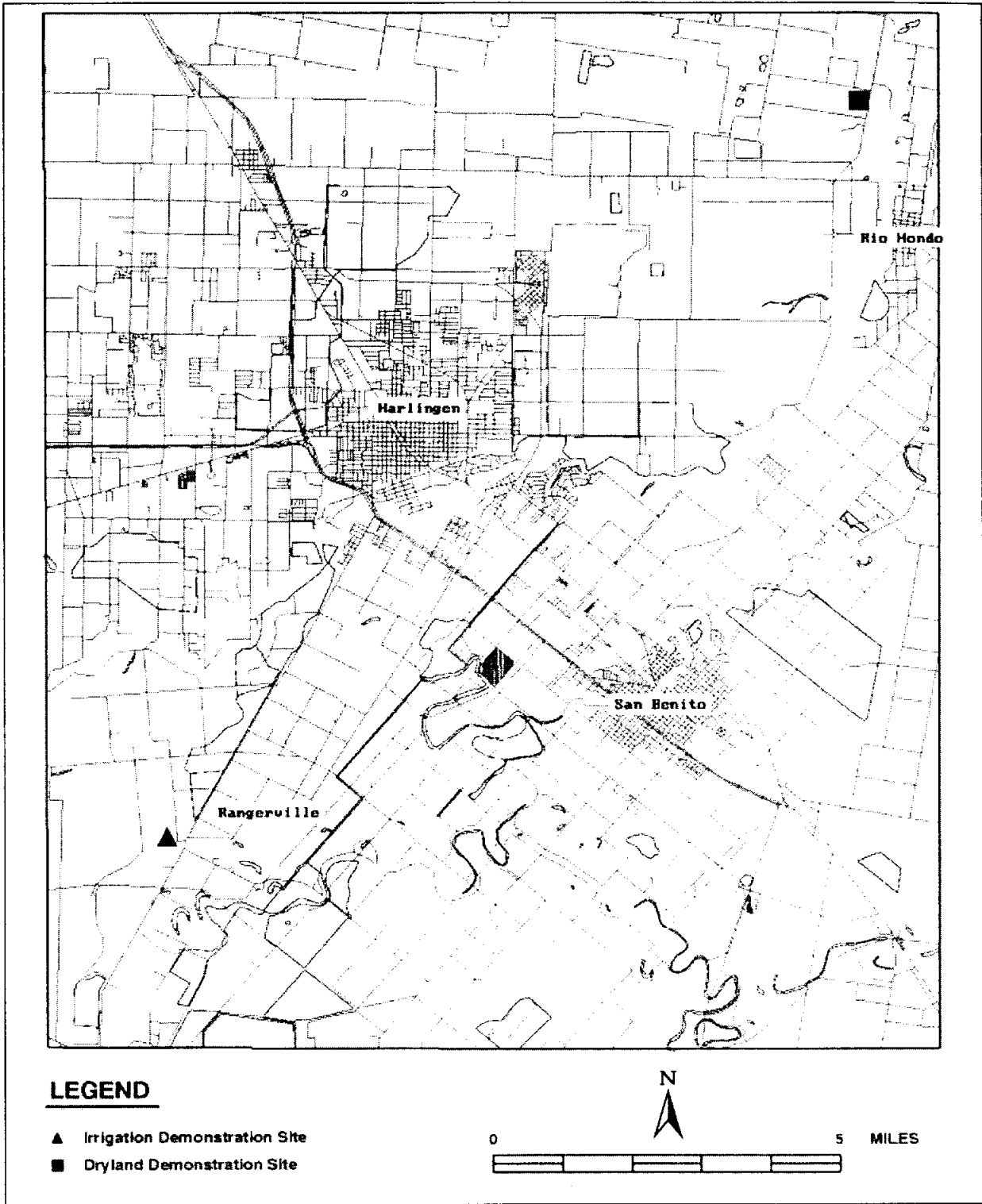


Figure 3. Location of BMP Demonstration Sites

2.3.1 Dryland Demonstration Site

The dryland site was located on 24 hectares (60 acres) north of Rio Hondo off FM1420, near Fort Perry in Segment 2202 (Figure 4). The site was divided into two fields of 12 hectares (30 acres) each, one field to demonstrate BMPs and the other to serve as a control. Both fields were underlain by Hidalgo silty clay loam and Raymondville clay loam. The Raymondville loam predominated in the control field, while the Hidalgo loam predominated in the BMP field. Atrazine was applied to the site for weed control during the spring of the first year. Roundup was applied to the grain sorghum in the fall to control post-harvest regrowth.

The BMPs employed on the dryland treatment site were the following:

- nutrient management utilizing split fertilizer applications, based on soil test results.
- crop residue management, and
- precision land forming.

Nutrient management includes soil tests to determine the correct amount of nutrients to use and splitting the applications of the nutrients. Two applications of nutrients (fertilizer) were applied during the plants' growing cycle on the treated field, one prior to planting and the other as a side dressing after crops had emerged. Split application of nutrients allows plants to use the nutrients more efficiently, resulting in optimum forage and crop yields, while minimizing the loss of nutrients to surface and groundwater. On the control field, all nutrients were applied prior to planting. Analyses of nutrients in surface runoff from this site were used to demonstrate the efficacy of this management practice.

The fertilizer applied to the field both years was a 32-0-0 commercial fertilizer, which was 32 percent nitrogen ($\frac{1}{2}$ urea and $\frac{1}{2}$ ammonium-nitrate). Based on soil test analysis of the 0 to 30.5 centimeter (0-to-12 inch) layer for the first year's grain sorghum crop, 67 kilograms per hectare (60 pounds per acre) of nitrogen were recommended for the BMP area. For the control area, 90 kilograms per hectare (80 pounds per acre) of nitrogen were recommended as a typical rate used by producers without benefit of a soil test. For the second year's crop, with a projected cotton yield of 4.9 bales per hectare (two bales per acre), 101 kilograms per hectare (90 pounds per acre) of nitrogen, with no phosphorus nor potassium, were recommended for the dryland BMP field, with 56 kilograms per hectare (50 pounds per acre) applied at planting and 45 kilograms per hectare (40 pounds per acre) applied as the side dressing. The recommended rate of nitrogen for the dryland control area was 123 to 134 kilograms per hectare (110 to 120 pounds per acre) in a single application at planting, which was considered to be the normal application, without benefit of a soil sample.

Crop residue management was another BMP implemented on the dryland site to demonstrate the benefits of crop residues in reducing soil loss from both wind and water erosion. This practice involves the delaying of fall tillage operations to allow crop residues to remain on the field following harvest. By providing soil cover between growing seasons, crop residues serve to reduce both the runoff and sediment losses from cropland areas. Consequently a reduction in soluble and sediment-bound pollutants may be realized. To demonstrate this BMP, crop residues remaining after harvesting of the 1996 grain sorghum crop

were allowed to remain on the treated field, while the residues were tilled into the soil of the control field.

Precision land forming refers to reshaping the surface of the field into planned, uniform grades. Land forming is designed to reduce the amount of excess surface water standing on the land, which can lead to elevated ground water and subsequent increased soil salinity. Reduction in surface ponding provides more uniform distribution of rainfall to subsurface soils. Precision land forming also helps to control erosion and reduce the amount of pesticides and nutrients leaving the site. The natural grade (slope) of the control side was 0.0013 (0.13 meters per 100 meters), while the slope on the BMP field was 0.00025 (0.025 meters per 100 meters).

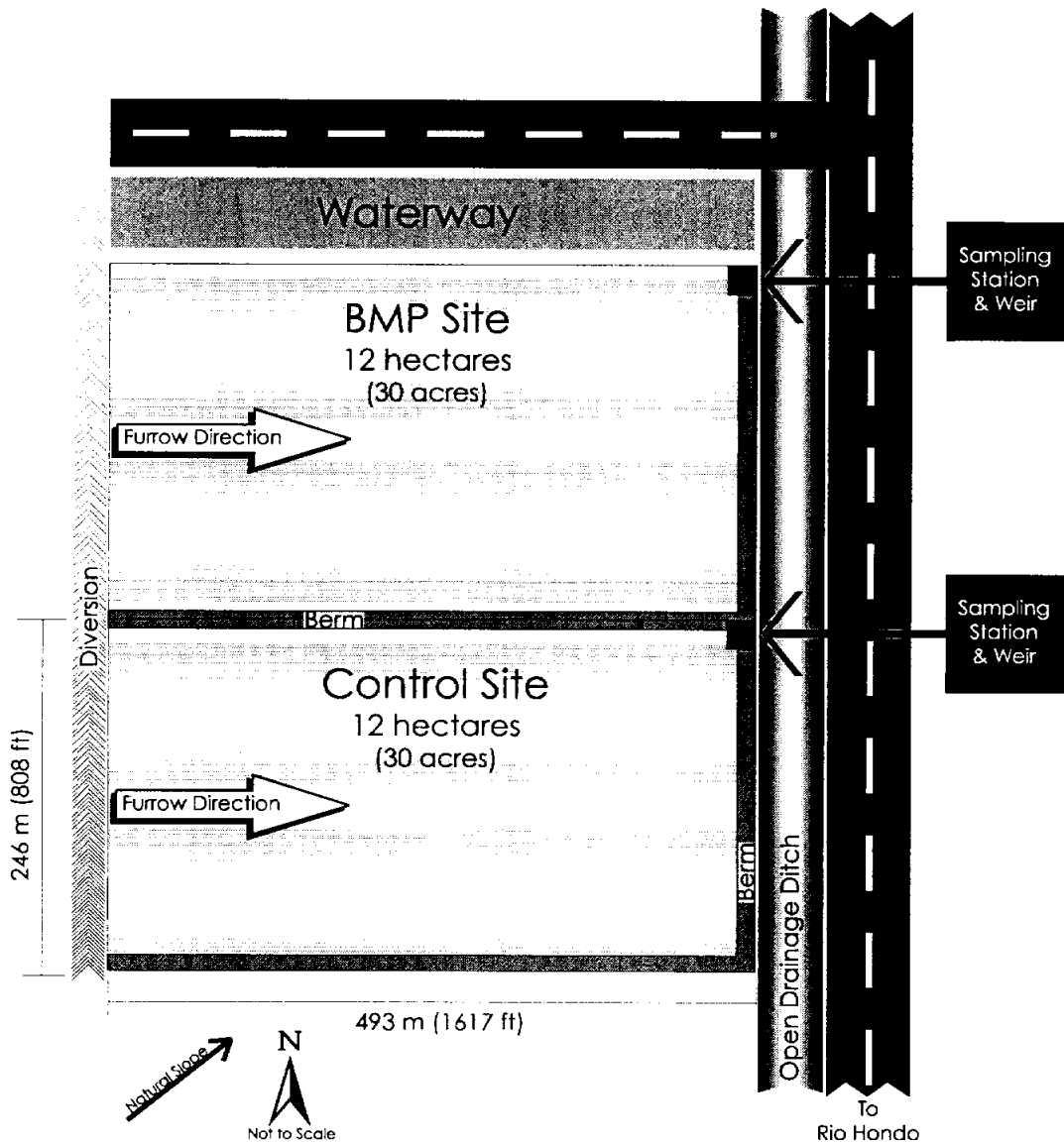


Figure 4. Dryland Demonstration Site

2.3.2 Irrigated Demonstration Site

The irrigated site was located on 16 hectares (40 acres) near Las Rusias off U.S. 281 and FM1479 in Segment 2202 (Figure 5). A subsurface drainage monitoring system was in place on this field prior to the project. Harlingen clay and Olmito silty clay are the dominant soils underlying the irrigated site, which was divided into two equal sections to serve as the BMP demonstration (treatment) and control sites.

The BMPs identified by project participants and recommended for irrigated cropland areas were the following:

- nutrient management by split fertilizer applications, based on soil test results,
- irrigation land leveling,
- proper irrigation water management, and
- improved irrigation technology.

Nutrient management was practiced on the irrigated site in the same manner as on the dryland site: split applications before and after plant emergence on the BMP plot and only prior to planting on the control plot. Residual amounts of nutrients in the soil were measured to determine fertilizer needs based on expected crop yields. For the first year's grain sorghum crop, based on the soil test, 56 kilograms per hectare (50 pounds per acre) of nitrogen were applied before planting the irrigated BMP area and 34 kilograms per hectare (30 pounds per acre) of nitrogen were applied as a side dress after the plants emerged. The irrigated control area was fertilized with 112 kilograms per hectare (100 pounds per acre) of nitrogen, considered as a typical rate, i.e., not based on a soil test, for grain sorghum. For an expected cotton yield of 4.9 bales per hectare (2 bales per acre) the second year, 67 kilograms per hectare (60 pounds per acre) of nitrogen were recommended for pre-planting and 45 kilograms per hectare (40 pounds per acre) of nitrogen as a side dressing on the irrigated BMP area. The recommended rate for the irrigated control area was 123 to 134 kilograms per hectare (110 to 120 pounds per acre) of nitrogen for the cotton crop.

Irrigation land leveling, is similar to the practice of precision land forming of dryland areas, which involves reshaping the land surface to planned, uniform grades. While the objective of precision land forming is to improve surface drainage of excess rainfall thereby reducing ponding of water in low lying areas, irrigation land leveling aids in the uniform distribution of irrigation water. Irrigation land leveling improves the efficiency of furrow irrigation systems which may reduce the amount of irrigation water required for crop production. Irrigation land leveling was implemented at this demonstration field prior to initiation of monitoring for this project and had been implemented for the entire field, both the treatment and control sections. Although this site demonstrates the practice of irrigation land leveling, monitoring activities could not be used to demonstrate the effectiveness of this practice in reducing pollutant losses since both the treatment and control sections were affected by this practice.

Two irrigation management practices which were evaluated for this project include improved irrigation water management and improved irrigation

technology. Both practices influence the frequency, timing and volume of irrigation water applied to cropland areas. Improved irrigation water management typically involves a reduction in the irrigation volume applied during a single application. The timing of irrigation applications may also be adjusted based on crop water needs and soil moisture. Improved irrigation technology encompasses several newer irrigation methods which have been proven to increase system efficiency by reducing surface and subsurface losses including cut back irrigation, surge flow irrigation, and the use of gated pipe instead of siphon tubes for furrow irrigation systems. These irrigation BMPs are discussed in educational material developed by TAEX as part of this project (Stichler and Fipps, 1997).

Of the four practices recommended for irrigated cropland areas, only nutrient management and irrigation land leveling were implemented at this site. Although, the use of proper irrigation water management and improved irrigation technology were not demonstrated, these BMPs were evaluated through modeling analyses as part of this project.

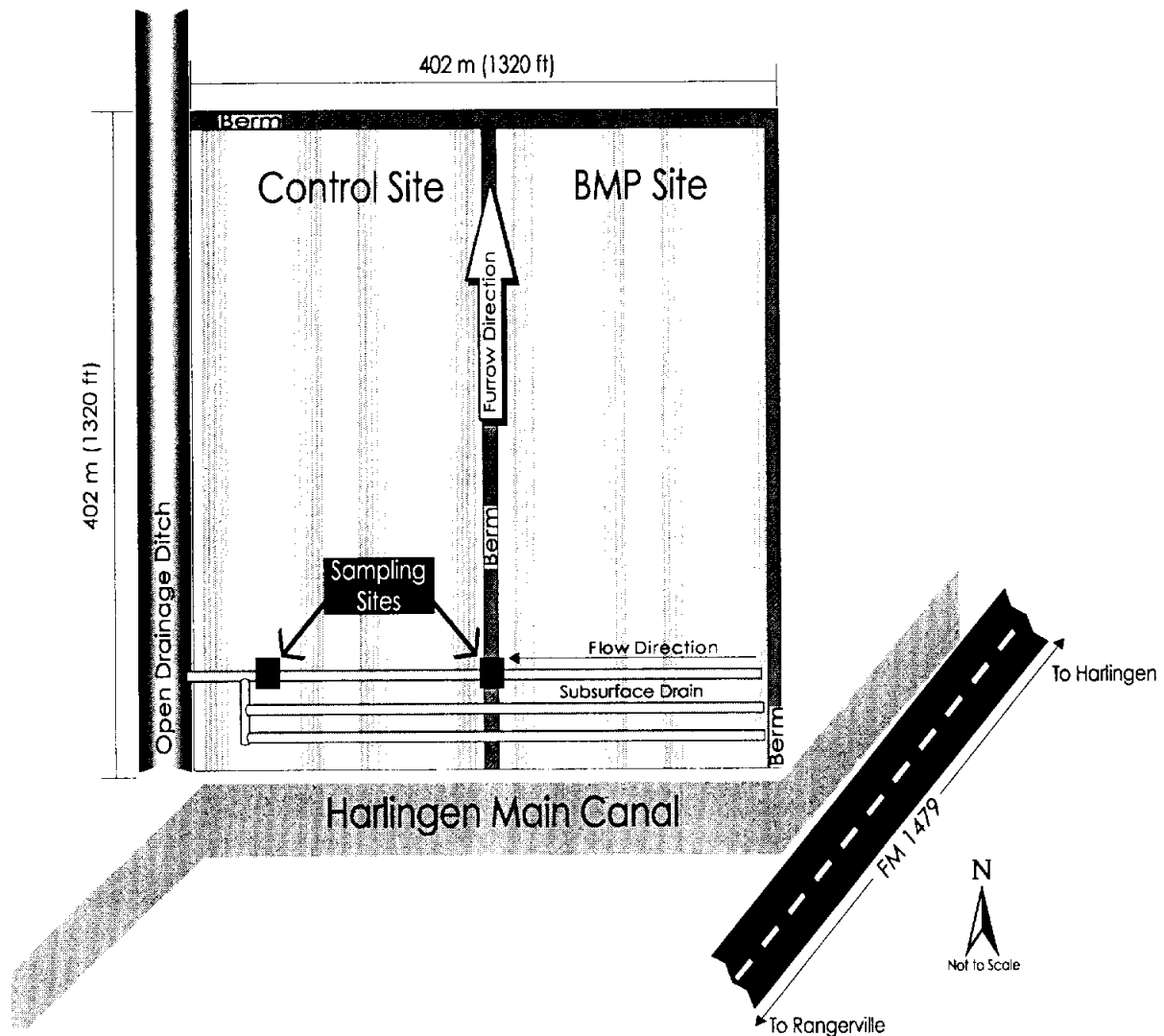


Figure 5. Irrigated Demonstration Site

3.0 INFORMATIONAL REQUIREMENTS FOR MODEL APPLICATION

Data assembled for the project model consisted of three types of data which were stored in digital format in TIAER databases. These data include geographically referenced data that were assembled to characterize the Arroyo Colorado study area, historical weather data for the area and water quality data collected during the course of this study. The methodology used to generate these data and the software and hardware configurations that were used to store and manipulate these data are discussed in the following sections.

3.1 Geographical Information System (GIS) Database

The geographic information system (GIS) employed by TIAER for the Arroyo Colorado project was the Geographical Resources Analysis Support System (GRASS), version 4.1.4 (U.S. Army, 1988). The GRASS system is a public domain GIS package developed by the Environmental Division of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). GIS data assembled for this project include vector and raster map layers describing area soils, land use, vegetative cover, topography, topology, hydrography and the location of groundwater monitoring wells. The most current data available for the study area was obtained from appropriate sources, then each layer was converted into a consistent projection system. All project GIS data were converted to Albers Equals-Area Conic projection.

3.1.1 Soils

The soil data for the Arroyo Colorado study area were obtained from the U.S. Army Corps of Engineers (USACE, 1990b). The soil data, digitized from county soil maps at a 1:24,000 scale, is comparable to the Soil Survey Geographic (SSURGO) database maintained by the USDA-Natural Resources Conservation Service (NRCS). With the assistance of local NRCS personnel, the 21 soil series occurring in the study area were grouped according to their textural properties, intake curve and moisture holding capacity. The resulting GIS soil layer for the project contained seven general soil categories and is depicted in Figure 6 (see Appendix A for soils and characteristics included in each category).

Supplemental soil information characterizing the soil horizons, such as horizon thickness, depth, texture, and water holding capacity, are components used by the EPIC model in determining rainfall runoff, drain flow, and the movement of nutrients and pesticides. These data were obtained from the NRCS Soil Interpretations Record (SIR or SOIL-5) database and NRCS Map Unit Interpretive Database (MUIR). The soil extraction program, Map Unit Use File (MUUF, version 2.14, Baumer *et al.*, 1997), was used to extract and process soil information from the databases and to generate soil input required by the EPIC model. These data are also included in Appendix A.

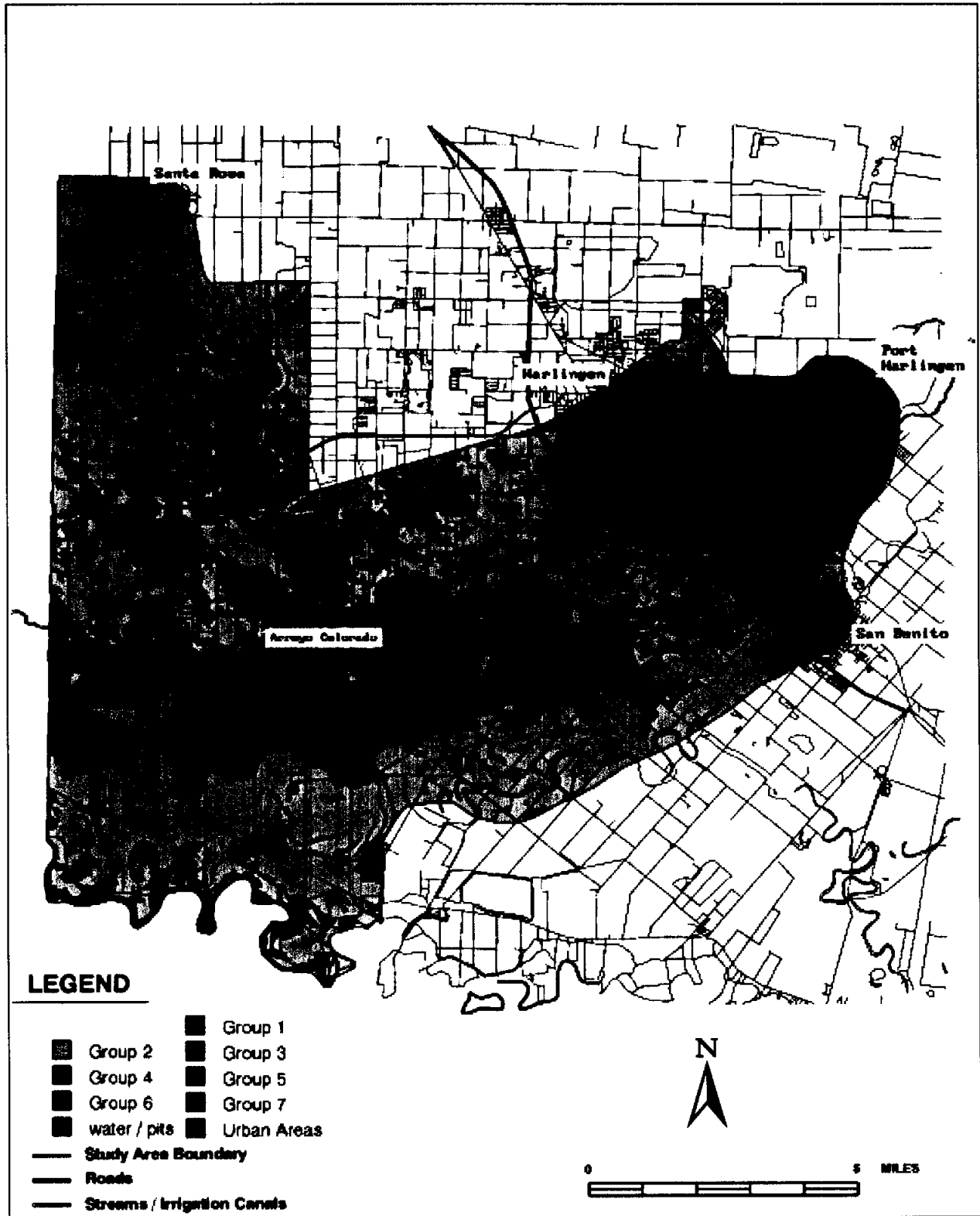


Figure 6. Soil Classifications for the Arroyo Colorado Project Area

3.1.2 Land-Use/Vegetative Cover Classification

Runoff from rainfall and irrigation are affected by land use and vegetative cover. Since land use is generally defined by broad categories such as urban, industrial, and agricultural, this information is often combined with vegetative cover information into a single GIS data layer. The most recently updated land-use data from the USACE, Galveston Office, at a 1:24,000 scale, provided the basis for the land-use/vegetative cover layer.

As the objective of the GIS data collection efforts was to characterize pertinent features of the study area for use in the modeling analysis, it was desirable to identify specific crop types and rotational patterns which could be used to generate EPIC datasets. Areas which were not targeted for modeling analysis of BMP implementation, including rangeland and pastureland, were lumped into a single category (non-row crop agriculture).

The original land-use coverage obtained from the USACE did not identify vegetable crops in any of their categories. Based on discussions with local project participants, it was determined that vegetables represent a very minor portion of the cropland in Cameron County. Acreage of all vegetables listed for Cameron County in the 1992 Agricultural Statistics database (Census of Agriculture, 1992), i.e., cantaloupes, watermelons, cabbages, onions, and bell peppers, represented less than one percent of the county's agricultural land in 1992. Furthermore, because soil types occurring in the study area are less suitable to cultivation of vegetables, it was assumed that most of the county's vegetable crops are grown outside of the project study area (Moore, 1997). For this reason, vegetable crops were not included in the modeling for the study area.

With the assistance of local NRCS personnel from the district office in San Benito, the land-use categories were modified to reflect current vegetative cover. The land-use/vegetative cover layer was also revised to reflect updated information on the location of citrus orchards in Cameron County using data obtained from the USDA-ARS Remote Sensing Lab in Weslaco. Five categories based on crop type, and one non-agricultural category comprise the land-use/vegetative cover GIS layer depicted in Figure 7. These categories include the following:

- irrigated cotton in rotation with either grain sorghum or corn,
- dryland cotton in rotation with either grain sorghum or corn,
- irrigated sugarcane,
- irrigated citrus,
- non-row crop agriculture/perennial vegetation (includes rangeland and pastureland), and
- non-agricultural areas (includes urban areas, surface water and excavated areas).

Although the amount of dryland farming in the region is very small in comparison to the amount of irrigated farmland, these areas were included in the modeling because of their potential to impact the results of Best Management Practice (BMP) analyses. The management practices characteristic of the two types of farming can result in large differences in response to runoff events. Furrows of irrigated farmland are bermed to block the ends and retain irrigation water, minimizing the required volume of irrigation water. The water percolates through the soil to the subsurface drainage system, then empties into drainage canals. The blocked ends also maximize soil moisture from rainfall, while the subsurface drainage system diminishes potential oversaturation.

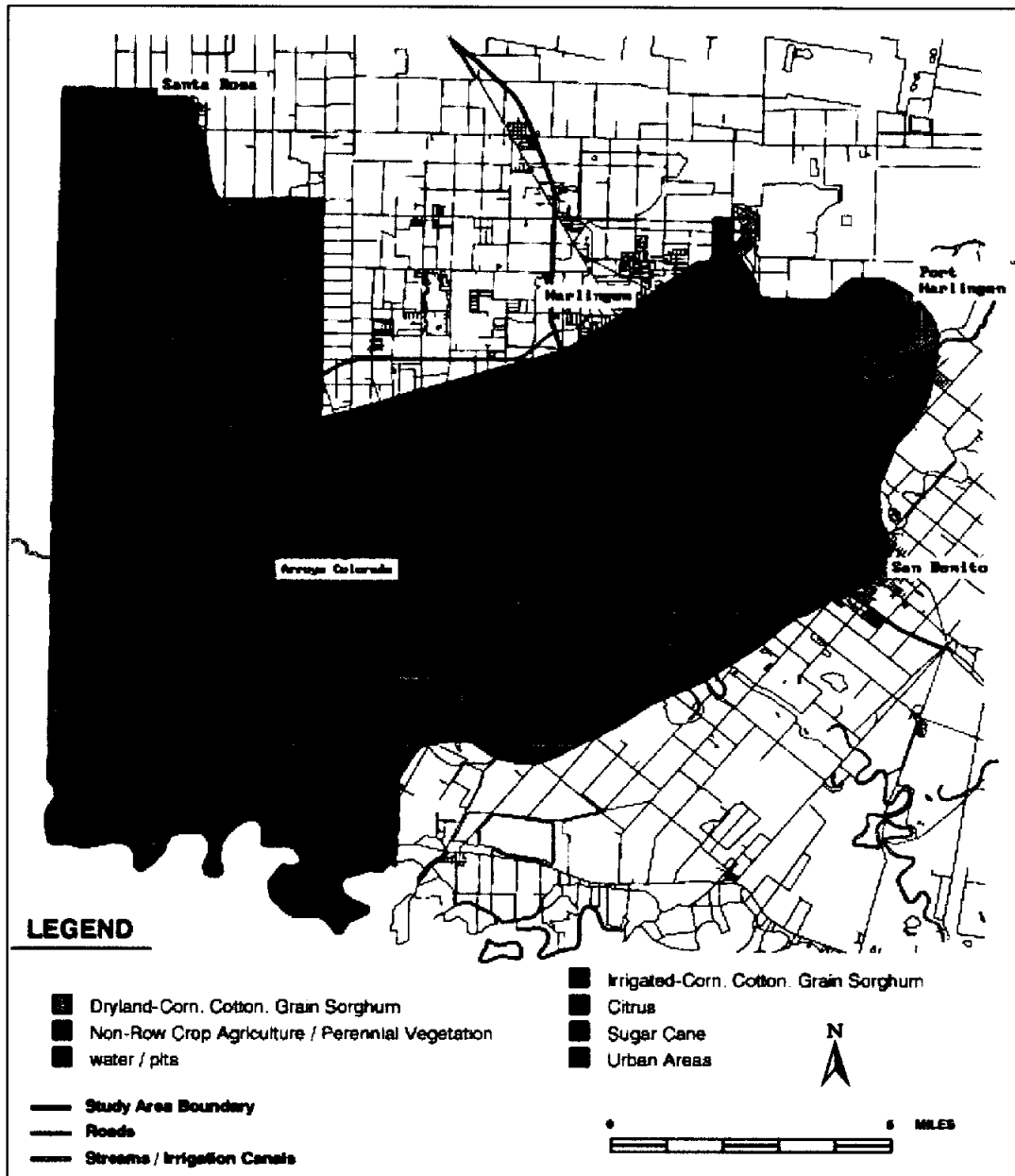


Figure 7. Land Use/Vegetative Cover Classifications for the Arroyo Colorado Project Area

The Non-Row Crop Agriculture/Perennial Vegetation category includes native and improved pastureland and rangeland maintaining a combination of perennial grasses, trees and shrubs. Vegetation in this category include forage sorghum, buffalograss, grama, blue grama, bluestem, guinea grass, bermuda grass, greasewood, big sage, acacia, granjeno, mesquite, saltbush, and willows.

GIS data relating to crop cover and soil type were used to identify selected crop production areas and the extent of their occurrence on various soil types within the study area. Based on crop cover and soil data, cropland acreages within the study area were calculated (see Appendix B). Non-cropland areas such as urban areas, rangeland and pastureland were excluded in the modeling of the effect of BMP implementation on nutrient and pesticide losses from intensively cultivated cropland areas (i.e., row crops) in the study area. Based on recommendations from the Project Technical Advisory Committee, a land-use assumption designated that 85 percent of area cotton crops were rotated with grain sorghum and the remaining 15 percent were rotated with corn (Moore, 1997).

Land uses in the Arroyo Colorado study area are summarized in Table 2. The vast majority of land (89 percent) in the Arroyo Colorado study area is used for crop production. Irrigated row crop production accounts for more than 68 percent of the study area land use, while dryland row crops occupy less than 1 percent. Cotton is the most widely grown crop, representing approximately 59 percent of the study area. Non-agricultural applications include urban areas, which occupy approximately 7 percent of the area, and water and excavation pits, which occupy almost 4 percent.

Table 2. Land Uses in the Arroyo Colorado Study Area

Agricultural Land Uses	
Row crops	
Irrigated	
Cotton-Grain Sorghum	49%
Cotton-Corn	9%
Sugar Cane	8%
Citrus	<u>2%</u>
Total Irrigated	68%
Dryland	
Cotton-Grain Sorghum	0.7%
Cotton-Corn	<u>0.1%</u>
Total Dryland	<u>0.8%</u>
Total Row Crops	69%
Non-row crops	<u>20%</u>
Total Agricultural Land Uses	89%
Non-agricultural Land Uses	<u>11%</u>
Total Land Uses	<u>100%</u>

3.1.3 Topographical Data

Topographical data traditionally is one of the determining factors in predicting rainfall runoff. A topographical GIS layer comprised of USGS DEM (digital elevation model) in the form of elevation contour lines on a 1:250,000 scale was obtained for the project study area. The units of measure for DEM data are 3 arc-seconds (300 meter grid cells). These data are commonly used to define drainage basins and determine land slopes. However, the artificial plumbing of the watershed renders topographical data ineffective in predicting runoff direction. The topographical GIS layer was therefore not used in the modeling efforts.

3.1.4 Monitoring Wells

Monitoring well data were used to estimate depth to groundwater. Location (latitude and longitude) of groundwater monitoring wells in the study area were obtained from Texas Water Development Board UM-50 Ground-Water Data System (Nordstrom and Quincy, 1993). Nineteen wells for which groundwater level data are available for 1990 through 1996 were identified and plotted to examine the occurrence of groundwater encroachment into the crop root zone.

3.1.5 Geographic and Cartographic Features

This GIS data layer consists of highways, roads, streets, streams, rivers, county lines and irrigation networks for the project study area. U.S. Census Bureau TIGER/Line™ Files (Topologically Integrated Geographic Encoding and Referencing system) depict the basic 1990 Census geography including census tract and block boundaries, transportation routes, political boundaries and limited water features. TIGER files at a 1:100,000 scale were used for the three county area, i.e., Hidalgo, Cameron and Willacy Counties.

3.2 Climatic Database

Climatic data from various sources were compiled and stored in a SAS database (version 6.09, SAS Institute, Inc., Cary, North Carolina, USA) for use in the modeling analysis. Historical weather data for the Harlingen area were obtained from the National Climatic Data Center's (NCDC's) Summary of the Day West2 CD-ROM, (NOAA, 1993). The data set consists of daily minimum and maximum temperatures and accumulated daily rainfall for the Harlingen National Weather Service station.

Historical weather data for the period of record (1948-1992) contained on the CD-ROM were supplemented with data collected by the NRCS for a weather station located at the project's dryland demonstration site. In order to generate a continuous weather data set for the modeling analysis, missing data points were replaced by information collected at the closest station (NOAA, 1993-1996). The daily climatic dataset assembled for 1948-1997 represents (in order of preference) NRCS weather data collected at the dryland demonstration site, NCDC data for Harlingen, and NCDC data for Weslaco.

Based on discussions with TAEX experts, it was determined that the amount of pesticides applied to various crops within the study area would be influenced by

climatic conditions due to an increase in pest pressure during wet years (Fipps, 1997a). For this reason, an analysis of annual precipitation was performed for the Harlingen area based on assembled data for the period of record from 1948 through 1996. Since rainfall data for 1997 constituted only a partial record it was not used in the climatic analysis. A frequency analysis of annual rainfall data for the 49-year period of record was performed to categorize years as either wet, dry or normal rainfall years. The analysis was performed based on rainfall during the growing season of crops grown in the study area. Classification of years into wet, dry and normal rainfall years was based on the following:

- Wet Year (accumulated rainfall during growing season $> 75\%$ quartile),
- Normal Year (25% quartile \leq accumulated rainfall during growing season $\leq 75\%$ quartile), and
- Dry Year (accumulated rainfall during growing season $< 25\%$ quartile).

For cotton, grain sorghum and corn, the growing season was defined as February through July. February was included as part of the growing season because the preplant soil moisture determines the need for a preplant irrigation of these crops. The classification scheme used to categorize the growing season (February- July) with respect to rainfall for these crops are as follows:

- Wet year > 379.9 mm of rain in growing season,
- Normal year receives between 186.5 mm and 379.9 mm of rain in growing season, and
- Dry year < 186.5 mm of rain in growing season.

For citrus and sugarcane, a 365-day growing season (January-December) was used to determine wet, dry and normal conditions. The classification scheme used to categorize the growing season with respect to rainfall for these crops are as follows:

- Wet year > 767.9 mm of rain in growing season,
- Normal year receives between 546.1 mm and 767.9 mm of rain in growing season, and
- Dry year < 546.1 mm of rain in growing season.

As a result of these analyses, a 24 year period extending from 1954 through 1977 was selected for the model application to the study area to estimate the benefits of BMP implementation. This shorter period reflected a frequency of wet, dry and normal years similar to the 49-year period of record. This information was also used to specify the crop management/pesticide applications under wet, dry and normal rainfall conditions with crop management varying on an annual basis depending on the rainfall condition. As EPIC limits the number of individual crop rotations within a given simulation run to 30, a 24-year simulation period was determined to be of sufficient length to compute average annual losses while accommodating the differing crop rotational patterns.

The results of climatic analysis are depicted in Figures 8 and 9. Monthly summaries of temperature minimum and maximums and rainfall for the selected simulation period (1954-1977) are included in Appendix C.

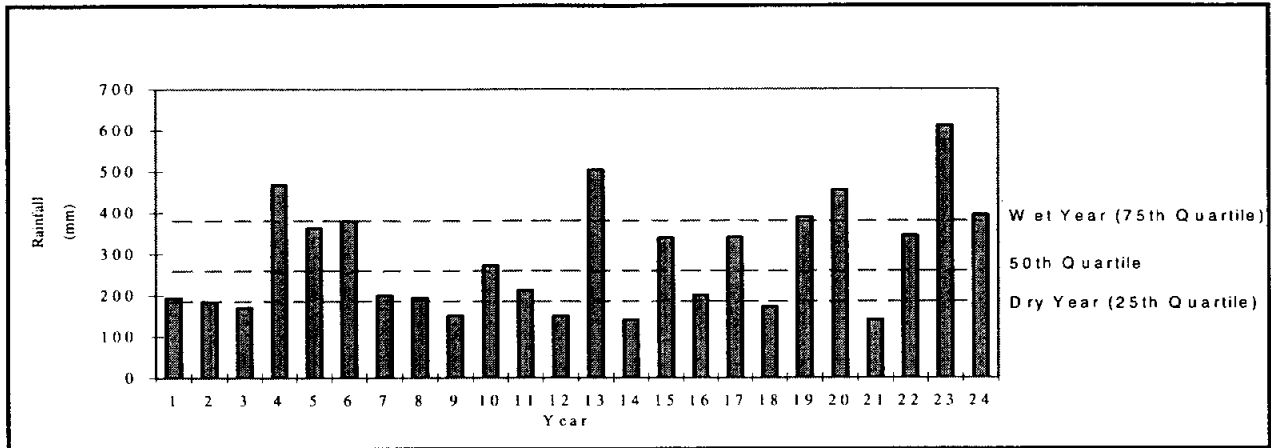


Figure 8. Climatic Analysis of Harlingen Rainfall Data
(24-Year Simulation Period, February - July Growing Season)

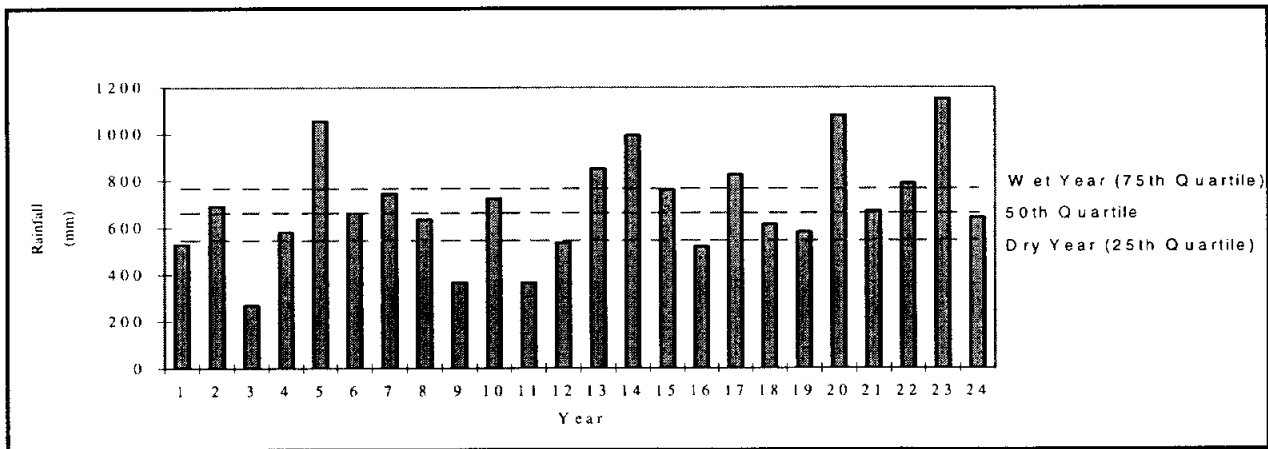


Figure 9. Climatic Analysis of Harlingen Rainfall Data
(24-Year Simulation Period, January - December Growing Season)

3.3 Water Quality Monitoring

Water samples were collected from the treated and control sides of both demonstration sites whenever runoff or subsurface drainage from the fields occurred. The orientation of demonstration sites and the location of sampling equipment are depicted in Figures 4 and 5, for the dryland and irrigated sites, respectively. Water quality monitoring was performed as specified in the USEPA-approved quality assurance project plan (TSSWCB, 1994 and 1997).

For the dryland site, surface runoff flowed down the furrows to the down slope border where it was diverted through a control structure to a drainage channel.

Two fabricated sharp-crested weirs were installed on site to measure flow. The level of water exiting the treatment and control sections of the field was monitored through the weirs. Pressure transducers connected to dataloggers recorded water level at the sites. Problems with the dataloggers installed at the treatment and control sections, however, limited the water level data available from the dryland site.

For the irrigated site, samples were collected following irrigation applications and rainfall events which resulted in subsurface drainage. The drainage system at the irrigated site (Figure 5) consisted of 10-centimeter (4-inch) corrugated polyethylene pipes with nylon sock filters. Each pipe was 366 meters (1200 feet) long and was buried at a depth of 1.7 meters (5.5 feet). The drainage lateral lines run east to west, 46 meters (150 feet) apart. Each lateral drains an area approximately 46 meters by 402 meters or 1.8 hectares (150 feet by 1320 feet or 4.4 acres). The lateral lines drain to a ditch on the western border which discharges to a constructed drainage channel. A single lateral line in the field was instrumented with automatic samplers. The two monitoring sites are not hydraulically distinct. The subsurface drainage from the BMP portion of the field, after being sampled, flows through the drain line under the control portion of the field before being discharged into the drainage ditch. During this time the drainage from the BMP portion may mix with drainage from the control portion and may be sampled again if the control sampler is triggered.

Automated water samplers (ISCO 3700)¹ were utilized to collect the water samples at both demonstration sites during the monitoring period which extended from April 1, 1996 through June 30, 1997. Each ISCO sampler was housed in a weatherproof, lockable instrument shelter to which a solar-powered battery was connected. The ISCO samplers were programmed to begin taking samples when moisture was detected by a level actuator. A datalogger, also housed within the shelter, recorded water levels within the subsurface drains at the irrigated sites and the depth of runoff through weirs at the outlet of the dryland sites. The original dataloggers installed at the demonstration sites were replaced with new Campbell Scientific, Inc. Model 21X dataloggers due to problems encountered early in the project.

Each ISCO sampler holds 12 liter-sized (0.264 gallon) glass sample bottles. Because pesticides were being analyzed, the sample bottles were glass, rather than plastic, were wrapped in foil to exclude light, and had Teflon-lined lids. The number of analyses performed on each sample required more than one liter of water; therefore, two bottles were required per sample. Thus, six samples could be obtained prior to refilling the sampler. The automatic samplers were programmed to take samples according to the regimes shown in Table 3.

¹ Mention or display of a trademark, proprietary product, or firm in the text or figures does not constitute an endorsement by TIAER, and does not imply approval to the exclusion of other suitable products or firms.

Table 3. Automatic Sampling Regimes

Sample #	Dryland Site*	Irrigated Site*
1	0.0 hours	0.0 hours
2	1.0 hours	3.0 hours
3	3.0 hours	6.0 hours
4	6.0 hours	12.0 hours
5	9.0 hours	18.0 hours
6	12.0 hours	24.0 hours

*All times referenced to a sampler activation time of 0.0 hours

The automatic samplers were inspected within 24 hours following rainfall events by representatives of the Southmost Soil and Water Conservation District. Water samples were preserved as necessary, sealed and labeled appropriately, packed in ice, and shipped to the TIAER laboratory for analysis. Chain-of-custody documentation was included, as required by the project's quality assurance project plan.

The TIAER laboratory, upon receipt of the samples, continued the appropriate chain-of-custody procedures, and took measures to meet holding times of the analytical procedures being performed. Table 4 lists the required container, preservation, and holding time for analysis of each parameter measured for this project.

Table 4. Sample Collection, Preservation, and Holding Times

Parameter	Container	Preservation	Holding Time
Ammonia Nitrogen	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Nitrate-Nitrite Nitrogen	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Total Kjeldahl Nitrogen	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Orthophosphate Phosphorus	AW-GB	4°C	28 days
Total Phosphorus	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Total Suspended Solids	AW-GB	4°C	7 days
Chemical Oxygen Demand	AW-GB	pH<2 H ₂ SO ₄ , 4°C	28 days
Azinphos (methyl)	AW-GT	4°C *	7 days **
Malathion	AW-GT	4°C *	7 days **
Parathion (methyl)	AW-GT	4°C *	7 days **
Prometryn	AW-GT	4°C *	7 days **
Atrazine	AW-GT	4°C *	7 days **
Trifluralin	AW-GT	4°C *	7 days **
Permethrin (cis/trans)	AW-GT	4°C *	7 days **

AW-GB=aluminum foil wrapped glass bottles

H₂SO₄=concentrated sulfuric acid

4°C= 4 degrees centigrade

AW-GT=aluminum foil wrapped glass with Teflon lined lid

* sodium thiosulfate must be added to 0.008% if sample contains chlorine residual

** 7 days until extraction, 40 days to analyze after extraction

The approved EPA method, estimated detection limit, and the equipment used for analysis of each parameter are listed in Table 5.

Table 5. Laboratory Analytical Methods

Parameter	Method	Equipment Used	Estimated MDL *
Ammonia Nitrogen	EPA 350.1	Perstorp Analytical Autoanalyzer	0.037 mg/L
Nitrate-Nitrite Nitrogen	EPA 353.2	Perstorp Analytical Autoanalyzer	0.006 mg/L
Total Kjeldahl Nitrogen	EPA 351.1, EPA 351.2	Perstorp Analytical Autoanalyzer with Tecator block digester	0.194 mg/L
Orthophosphate Phosphorus	EPA 365.2	Bechman DU64 Spectrophotometer	0.010 mg/L
Total Phosphorus	EPA 365.4, EPA 365.2	Perstorp Analytical Autoanalyzer with Tecator block digester	0.101 mg/L
Total Suspended Solids	EPA 160.2	Sartorius AC21P or Mettler AT261 Analytical Balance, Oven	10 mg/L
Chemical Oxygen Demand	Hach 8000	Hach DR 2000	6 mg/L
Azinphos (methyl)	EPA 1657	Thermionic Bead Nitrogen - Phosphorus Detector 5% carbowax packed primary	0.009 µg/L
Malathion		with % carbowax Gas Chrom Q	0.011 µg/L
Parathion (methyl)		confirmation column	0.018 µg/L
Prometryn			0.020 µg/L
Trifluralin	EPA 1656	Electron Capture Detector, DB-608	0.05 µg/L
Permethrin (cis/trans)		primary column with a DB1701	0.02 µg/L
Atrazine		confirmation column	0.50 µg/L

* MDL - Method Detection Limit, redetermined periodically.
MDLs determined October 1996
Pesticide MDLs determined September 1996

A water quality database for the project was maintained in SAS (version 6.09). This database contains the results of laboratory analyses conducted on water samples collected from the demonstration sites. The precision, accuracy, estimated practical quantity limits and data completeness for the TIAER chemistry laboratory can be found in the annual TIAER Laboratory Quality Assurance Reports, which are available from TIAER upon request. Copies of all raw data, laboratory analyses, documentation records, calibration logs, and other pertinent information are available for inspection upon request. All original data, both hardcopy and electronic forms, will be archived by TIAER for at least five years.

The number of events monitored for each of the demonstration sites during the study period (4/1/96 - 6/30/97) are listed in Table 6. The number of water samples collected and the timeframe of sampled events are also noted. A total of seven sampling events were monitored at the BMP portion of the irrigated demonstration site. Five of the seven sampling events (event numbers one, two, four, six and seven) represent subsurface drainage resulting from furrow irrigation. Two of the events (event numbers three and five) resulted from infiltration of rainfall at the site. The irrigated control site did not receive sufficient infiltration from event number three to trigger the sampler, so that site has data for only six events. Four rainfall runoff events were monitored at the dryland sites during the monitoring period.

Chemical constituent concentrations monitored during each of these events were used in model calibration. Water quality results are presented in this report as they relate to model calibration and testing. Results of laboratory analyses for individual samples are included in a companion report prepared by TAEX which also includes a qualitative analysis of the monitoring data for evaluation of BMP effectiveness.

Table 6. Events Monitored at the Dryland and Irrigated Demonstration Sites

Site	Treatment	Sampling Event	Beginning Time of Sample Collection	Ending Time of Sample Collection	# of Water Samples Collected	Accompanying Flow Data Available	
Irrigated	BMP	1	4/15/96 4:00	4/16/96 4:00	3	NO	
		2	5/14/96 6:00	5/18/96 12:00	18	NO	
		3	6/24/96 17:00	6/24/96 17:00	1	NO	
		4	8/14/96 8:00	8/20/96 14:00	24	NO	
		5	8/26/96 18:00	8/30/96 14:00	22	NO	
		6	1/31/97 18:00	2/4/97 12:00	22	NO	
		7	6/13/97 18:00	6/15/97 14:00	11	NO	
Irrigated	Control	1	4/16/96 4:00	4/17/96 4:00	3	YES	
		2	5/16/96 0:00	5/18/96 18:00	15	YES	
		3	No samples were collected from control portion				
		4	8/18/96 16:00	8/21/96 14:00	14	NO	
		5	8/26/96 18:00	8/30/96 14:00	22	NO	
		6	1/29/97 18:00	2/2/97 12:00	22	NO	
		7	6/14/97 2:00	6/15/97 10:00	7	NO	
Dryland	BMP	1	8/31/96 16:00	9/1/96 4:00	6	NO	
		2	9/27/96 23:00	9/28/96 1:00	2	NO	
		3	10/5/96 0:00	10/5/96 20:00	7	NO	
		4	3/11/97 9:00	3/11/97 13:00	3	NO	
Dryland	Control	1	8/31/96 16:00	8/31/96 16:00	1	NO	
		2	9/27/96 23:00	9/28/96 1:00	2	NO	
		3	10/5/96 0:00	10/6/96 4:00	9	NO	
		4	3/11/97 8:00	3/11/97 8:00	1	NO	

3.4 Characterization of Baseline Conditions

In preparation for the modeling assessment of BMP implementation, it was necessary to define the current conditions and crop management practices employed in the study area. Numerous assumptions were made based on discussions with experts familiar with local farming practices (Moore, 1997; Fipps, 1997b; Norman, 1997; Sauls, 1997; Sparks, 1997; Bremer, 1997; Rozeff, 1997). These assumptions were used to define current conditions as a baseline

for BMP implementation comparisons. These assumptions are outlined in the following sections.

Irrigation Practices. Several assumptions were made regarding irrigation methods for different types of irrigated crops. It was assumed that furrow irrigation with blocked ends is the most commonly used method of irrigating cotton, grain sorghum, corn and sugarcane crops in the study area. Flood irrigation or level border irrigation is the most prevalent method of irrigating citrus. A six-inch irrigation volume was assumed to be standard for furrow irrigation systems and a five-inch volume was assumed for flood irrigation. The number of applications per year varied based on the annual rainfall conditions and were defined for wet, dry and normal rainfall years. (See Table 9.)

Crop Rotations. As stated earlier, it was assumed that 85 percent of the cotton produced in the area was rotated with grain sorghum and 15 percent was rotated with corn. These percentages were assumed for both irrigated and dryland cotton production. A two-year crop rotation was assumed for cotton with cotton being produced the first year and grain sorghum or corn the next, then alternating every year. Thus, for the 24-year simulation period, cotton production was simulated for 12 years, and either grain sorghum or corn for the alternate 12 years.

For sugarcane, a six year crop rotation was assumed. It was assumed that sugarcane would be planted the first year, followed by three years of ratoon cane. Cotton would be cultivated during the fifth and sixth years of the rotation, after which sugarcane would be planted again. Based on this crop rotation, 4 full rotations were simulated during the 24-year period. The modeling results represent simulations of 16 years of sugarcane production and 8 years of cotton production.

For citrus production, it was assumed that the trees were planted during the first year and began producing in the third year of a 24-year simulation period.

Residue Management. In defining the current (baseline) conditions, it was assumed that crop residues from corn and grain sorghum crops were shredded and disked into the soil shortly after harvest. This practice was assumed to apply only to the corn and grain sorghum crops. Since mandatory plow down dates are set annually as a measure to control overwintering boll weevils, this practice is not applicable to the cotton rotation. Residue management is also not applicable to sugarcane production due to the method used to harvest sugarcane which involves burning of fields prior to harvesting of the cane.

Fertilization. It was assumed that baseline crop fertilization occurred as a single fertilizer application before or during planting with the amount based on anticipated yields and crop utilization without regard to soil nutrient levels. It was further assumed that fertilizer application rates would remain relatively constant from year to year. Annual fertilization rates assumed for baseline conditions are listed in Table 7.

Table 7. Current Fertilization Practices

Crop	Management / Crop Stage	Yield Goal per Hectare (Acre)	Nitrogen N kg/ha (lb/ac)	Phosphorus P ₂ O ₅ kg/ha (lb/ac)	Potassium K ₂ O kg/ha (lb/ac)
Cotton	Irrigated	1401 kg (2.5 bales)	140 (125)	90 (80)	0
	Dryland	1121 kg (2.0 bales)	112 (100)	90 (80)	0
Grain Sorghum	Irrigated	6727 kg 6000 lbs	135 (120)	90 (80)	0
	Dryland	5605 kg(5000 lbs.)	112 (100)	67 (60)	0
Corn	Irrigated	122 hl (140 bu)	168 (150)	90 (80)	0
	Dryland	65 hl (75 bu)	84 (75)	67 (60)	0
Sugarcane	Plant Cane	123,318 kg (55 tons)	90 (80)	49 (44)	0
	Ratoon Cane	112,108 kg (50 tons)	202 (180)	0	0
Citrus	See recommended rates for each year of growth in Table 8.				

hl=hectoliter

Irrigation Land Leveling/Precision Land Forming. Based on discussions with local project participants during Technical Advisory Committee meetings, it was estimated that approximately 80 percent of the farmed soils in the study area have been leveled. This assumption was applied to both irrigated and dryland cotton in rotation with either grain sorghum or corn. It was also assumed that 80 percent of the sugarcane acreage had implemented irrigation land leveling. For citrus production under flood irrigation management, it was assumed that 100 percent of the acreage had been leveled prior to establishment of the orchard.

Integrated Pest Management (IPM). As integrated pest management (IPM) practices have been promoted through educational programs of TAEX and other entities, it was necessary to determine the extent to which area producers were currently utilizing these practices. It was assumed that IPM was already being utilized in dryland agriculture because the profit margin is much narrower under dryland production requiring the farmer to pay particular attention to pesticide applications (Norman, 1997). Likewise, the practice of IPM has been quite common in citrus production for many years (Sauls, 1997). Therefore, the environmental benefits of IPM implementation on these areas have already been realized.

IPM implementation to sugarcane grown in the area is also not likely to yield much benefit. According to Norman Rozeff, agriculturist employed by the Rio Grande Valley Sugar Growers, Inc., insecticides are rarely applied to sugarcane grown in the Valley (Rozeff, 1997). Of the cropping systems evaluated, only irrigated cotton in rotation with either grain sorghum or corn is likely to show an environmental benefit from implementation of this BMP.

A survey of Texas cotton producers, conducted by Smith *et al.* (1996), compiled information on pesticide usage in the cotton industry. Survey results noted that the tactic ranked as the most important aspect of IPM is the practice of "scouting" acreage for the presence of insects, weeds, and disease. Survey results indicated that 99 percent of the cotton acreage in the Lower Rio Grande Valley (LRGV) was scouted, suggesting that some level of IPM was employed on almost all cotton acreage. Scouting was performed by farmers (34%), by dealers of farm supplies and/or chemicals (11%), and by consultants and

specialists (50%) in the LRGV. Theory holds that pesticide application decisions are based on an economic threshold (ET), i.e., the point at which crops need treatment before pest populations cause economic crop loss, and scouting helps to determine the ET.

To determine the degree of IPM implementation by the area's cotton producers, participants in the Arroyo Colorado project evaluated the survey results as to which entity had performed the scouting. Although the survey results reported apply to the four county region comprising the LRGV, it was assumed these percentages are also representative of cotton production within the Arroyo Colorado Study Area and as such characterize the baseline conditions. The following percentages were assumed to represent baseline conditions for the irrigated cotton acreage in the Arroyo Colorado study area.

- Fully Implemented IPM Program 50%
- Mid-level IPM Program 45%
- Low-level IPM Program 5%

3.5 BMPs Evaluated

Through the project's technical advisory committee, BMPs suitable for crops grown in the study area were selected for evaluation. Six BMPs were selected for evaluation; however, some of the BMPs were not applicable to a particular crop or soil type. Assumptions regarding the BMPs selected and how each of the BMPs would be represented in the modeling analyses are discussed in the following sections.

BMP #1 - Improved Nutrient Management

The first BMP evaluated was improved nutrient management. The primary difference between this BMP and the baseline condition is that fertilization rates would be based on soil test results with annual rates split into two applications rather than a single application. Annual fertilizer applications were based on expected yields and residual soil nutrient levels. Annual applications of nitrogen fertilizer to cotton, grain sorghum and corn crops were split, with one-half of the annual rate being applied during preplant or at planting and other one-half side-dressed approximately 30 days after planting. All of the phosphorus fertilizer requirement was applied in a single pre-plant application.

For flood-irrigated citrus, two-thirds of the annual nitrogen fertilizer requirement was applied in February and the remaining one-third was applied in May. For citrus groves utilizing microspray irrigation, it was assumed that liquid fertilizer was injected once per month, at the end of an irrigation application, with the annual fertilizer requirement reduced by 20 percent of that utilized by flood irrigated citrus.

Split nutrient applications are not recommended for sugarcane (Rozeff, 1997), however, soil testing would prove beneficial to sugarcane production. In simulating this BMP for sugarcane, fertilizer applications consisted of a single application with rates dependent on the stage of growth or ratoon cycle. The recommended fertilization rates used to simulated this BMP are listed in Table 8.

Table 8. Recommended Fertilization Rates Under BMP #1 - Improved Nutrient Management

Crop	Management/ Crop Stage	Average Crop Yield/Hectare (Acre)	Nitrogen N kg/ha (lb/ac)	Phosphorus P ₂ O ₅ kg/ha (lb/ac) (P=P ₂ O ₅ x 0.44)	Potassium K ₂ O ¹ kg/ha (lb/ac)
Cotton	Irrigated	841 kg (750 lb. lint, 1.5 bales)	67 (60)	67 (60)	0
	Dryland	561 kg (500 lb. lint, 1.0 bales)	45 (40)	45 (40)	0
Grain Sorghum	Irrigated	5605 kg (5000 lb.)	112 (100)	67 (60)	0
	Dryland	4484 kg (4000 lb.)	90 (80)	45 (40)	0
Corn	Irrigated	65 hl (75 bu)	84 (75)	67 (60)	0
	Dryland	37 hl (42 bu)	47 (42)	67 (60)	0
Sugarcane	Plant Cane	67,265 kg (30 tons)	25 (22)	83 (74)	0
	1st Ratoon Cane	67,265 kg (30 tons)	112 (100)	0	0
	2nd Ratoon Cane	67,265 kg (30 tons)	157 (140)	0	0
	3rd Ratoon Cane	67,265 kg (30 tons)	168 (150)	0	0
Citrus	1 yr.	-	39 (35)	0	0
	2 yr.	-	56 (50)	0	0
	3 yr.	4,484-6,726 kg (2-3 tons)	84 (75)	0	0
	4 yr.	11,211-13,453 kg (5-6 tons)	112 (100)	0	0
	5 yr.	15,695-20,179 kg (7-9 tons)	118 (105)	0	0
	6 yr.	22,422-31,390 kg (10-14 tons)	123 (110)	0	0
	7 yr.	29,148-40,359 kg (13-18 tons)	129 (115)	0	0
	8 yr.	33,632-44,843 kg (15-20 tons)	140 (125)	0	0
	9 yr.	38,117-49,327 kg (17-22 tons)	157 (140)	0	0
10+ yr.	40,359-51,570 kg (18-23 tons)	168 (150)	0	0	

¹ Area soils are generally high in potassium, Potash is not applied
Rates should be reduced as appropriate based on soil test results

BMP #2 - Improved Residue Management

Residue management is appropriate only for grain sorghum and corn crops. In simulating this BMP, it was assumed that crop residues left after harvesting of grain sorghum and corn crops were shredded and maintained on the surface of the field until seedbed preparation. The residue was plowed under and disked into the soil in December prior to bedding in preparation for cotton planting in the spring.

BMP #3 - Improved Irrigation Water Management

It was assumed that improved irrigation water management, which consists of furrow irrigation, would result in the same number of irrigation applications with a reduction in irrigation volume from 152.4 mm (6 in.) per application to 101.6 mm (4 in.) per application (Fipps, 1997b). The number and volume of irrigations assumed for each crop are listed in Table 9.

Table 9. Number and Volume of Irrigation Applications for Irrigation BMPs (BMP#3 and BMP #4)

Crop	BMP	Wet Year		Normal Year		Dry Year	
		Number	Volume (mm)	Number	Volume (mm)	Number	Volume (mm)
Cotton	Baseline Condition/Furrow Irrigation	2	152.4	4	152.4	6	152.4
	Improved Irrigation Water Management	2	101.6	4	101.6	6	101.6
	Improved Irrigation Technology	2	50.8	5	50.8	8	50.8
Grain Sorghum / Corn	Baseline Condition/Furrow Irrigation	0	-	2	152.4	3	152.4
	Improved Irrigation Water Management	0	-	2	101.6	3	101.6
	Improved Irrigation Technology	0	-	3	50.8	4	50.8
Sugarcane	Baseline Condition/Furrow Irrigation	4	152.4	8	152.4	10	152.4
	Improved Irrigation Water Management	3	101.6	7	101.6	9	101.6
Citrus	Baseline Condition/Flood Irrigation	4	127.0	5	127.0	6	127.0
	Improved Irrigation Technology	Variable, weekly applications based on evapotranspiration					

BMP #4 - Improved Irrigation Technology

Improved irrigation technology includes surge flow irrigation of cotton, grain sorghum, and corn and microjet spray irrigation of citrus. Surge flow technology has not proven successful for sugarcane due to the large amounts of plant debris that accumulates in the cane furrows (Fipps, 1997b). The number and volume of irrigations assumed for each crop are also listed in Table 9.

The irrigation strategy used by microspray irrigators of citrus is usually determined by the estimated evapotranspiration rates for the LRGV area (Sauls, 1997). Timed weekly applications are made to citrus groves, provided no rainfall has occurred in the previous week. If rainfall occurs, citrus producers forego the scheduled weekly application until the following week. Based on information provided by Extension specialists the following weekly irrigation application rates were calculated as denoted in Table 10. The weekly applications were based on an assumed flow rate of 61 liters (16 gallons) per hour per tree for the microjet spray nozzles and an assumed tree spacing of approximately 59 trees per hectare (145 trees per acre).

Table 10. Microspray Irrigation Schedule for Citrus

Month	Weekly Irrigation Timing	Weekly Irrigation Application
February and March	8 hr/wk	17.3 mm
April and May	9 hr/wk	19.6 mm
June	10 hr/week	21.6 mm
July	11 hr/week	23.9 mm
August	12 hr/week	26.2 mm
October and November	11 hr/wk	23.9 mm

BMP #5 - Irrigation Land Leveling/Precision Land Forming

Since partial implementation of this BMP has already been realized in the study area, this BMP was evaluated based on an increase in the percentage of leveled cropland in the study area from 80 percent to 95 percent.

BMP #6 - Integrated Pest Management

This BMP, similar to land leveling practices, is in partial implementation in the study area. Based on baseline characterizations of IPM implementation, this BMP was evaluated through an increase in the cotton acreage under full implementation of IPM practices from 50 percent to 95 percent with 5 percent of the acreage remaining under a low-level IPM program.

Increased implementation of IPM from a mid-level to an almost fully implemented program on irrigated cotton acreage in rotation with either grain sorghum or corn, impacted roughly 58 percent of the study area on a bi-annual basis. Based on the crop management assumptions outlined for the baseline conditions, the modeled level of influence was limited to a reduction in the number of insecticide applications from 10 to 8 per year for the cotton rotation under normal rainfall conditions. Over the 24-year simulation period, this impacted 12 years, eliminating a total of 24 pesticide applications during this period.

This assessment, while addressing the benefits of increased implementation of IPM practices, has a very small impact on the total application of pesticides because the baseline condition already has a relatively high level of IPM implementation. During a normal year, this represents a 0.56 kg/ha (11%) reduction in pesticides applied to irrigated cotton from 4.96 kg/ha under a mid-level implementation to 4.40 kg/ha under the fully implemented program.

4.0 MODEL SELECTION AND TESTING

4.1 Model Selection

Three models were initially considered for evaluation of BMP effectiveness implemented throughout the Arroyo Colorado Project study area including DRAINMOD/CREAMS, EPIC-WT and the most recent version of EPIC, version 5300. The DRAINMOD/CREAMS model consists of DRAINMOD (version 4.6) linked with the CREAMS model and was developed by Parsons and Skaggs (1988) at North Carolina State University. The Erosion Productivity Impact Calculator - Water Table, EPIC-WT model, was developed by researchers at Louisiana State University (Sabbagh, *et al.*, 1991). The EPIC-WT model combines the EPIC model (version 3657) with a drainage model which utilizes the same approach as the DRAINMOD model. The Environmental Policy Integrated Climate, EPIC model (version 5300) is the most recent version of the field-scale model developed by the USDA-ARS at the Grassland, Soil and Water Research Laboratory, collocated with the Blackland Research Center in Temple, Texas (Mitchell *et al.*, undated).

Although the DRAINMOD/CREAMS and EPIC-WT models incorporate a more sophisticated drainage model and are capable of simulating the movement of nutrients and pesticides within the soil profile, the method used by these models to calculate tile flow rates is limited to flow resulting from high water table encroachment into the drain tiles. In the study area, however, flow in drain tiles can result from irrigation or rainfall events. Based on the application of Hooghoudt's steady state equation in DRAINMOD, the tile flow rate is set to zero when the water table is below the drainage depth even if sufficient precipitation or irrigation is applied to cause outflow through the tile drains. Deficiencies associated with the use of Hooghoudt's equation to predict subsurface tile flow (when water table depths are below the drainage depth) have been noted by several researchers (Sanoja, *et al.*, 1988; Kanwar, 1981; Rogers, 1985). This problem was observed during preliminary evaluation of the models based on test datasets generated for the Arroyo Project Area and was confirmed through conversations with model developers at Louisiana State University and North Carolina State University.

An additional drawback to these models is the limitation associated with crop growth, nutrient and pesticide components of the older versions of the USDA-ARS CREAMS and EPIC models. Modification and enhancement of the original CREAMS and GLEAMS models in the evolution of the current EPIC model and its multi-field version APEX have increased the level of sophistication of these models. Continual testing, development and refinement of these models by ARS researchers at the Grassland, Soil and Water Research Laboratory have led to increased capabilities and improved accuracy compared to earlier versions. Enhancements of the EPIC/APEX models since the release of CREAMS and EPIC (version 3657) include an improved crop growth model, upgrade of the pesticide model components, the addition of ammonia volatilization subroutines, new erosion equations and the addition of TR-55 peak rate estimator.

Given the limitations of the DRAINMOD/CREAMS and EPIC-WT models and the fact that BMPs selected for evaluation relate to management and conservation practices rather than the structural design of tile drainage system (e.g., tile spacing, placement, depth, etc.), it seems appropriate to base model selection on the level of sophistication of the crop growth/management components of the model rather than the drainage components. EPIC (version 5300) while utilizing simplified drainage calculations, has been extensively tested and validated in many areas of the nation. Performance testing of EPIC's crop growth components as well as the hydrology, nutrient and pesticide subroutines have indicated that EPIC performs well even with limited calibration. For these reasons, EPIC5300 was selected for use in evaluating the effects of BMP implementation within the Arroyo Colorado study area.

4.2 Model Calibration/Sensitivity Analysis

Model calibration was performed through comparisons of model predictions to measured data collected at the irrigated and dryland demonstration sites. Available crop management data (tillage and harvest dates, fertilization, irrigation, and pesticide applications) for activities during the study period were obtained from NRCS and Agro-Synergetics, Inc. All available weather and water level data for the demonstration sites were also obtained from NRCS. Based on acquired information, input datasets for the EPIC model were

generated to characterize grain sorghum and cotton production during the 1996 and 1997 growing seasons. EPIC datasets for the demonstration sites are included in Appendix D. Daily weather data and hourly water level data utilized for model calibration are included in Appendices E and F, respectively.

Water level data collected by NRCS was converted to flow based on the following equations supplied by NRCS:

$$D = \frac{d - 4.11''}{12}$$

$$Q = 0.1015\sqrt{D}$$

where

D = depth of water in the drain in feet,

d = the water level recorded by datalogger in inches, and

Q = drain flow in cfs.

The hourly drain flow calculated was converted to metric units (m^3/s) and accumulated on a daily basis for comparison to daily drain flow predicted by the EPIC model.

Illustrated in Figure 10 is a comparison of subsurface drain flow predicted by EPIC for the irrigated demonstration site to that measured during the two irrigation events for which flow data were available.

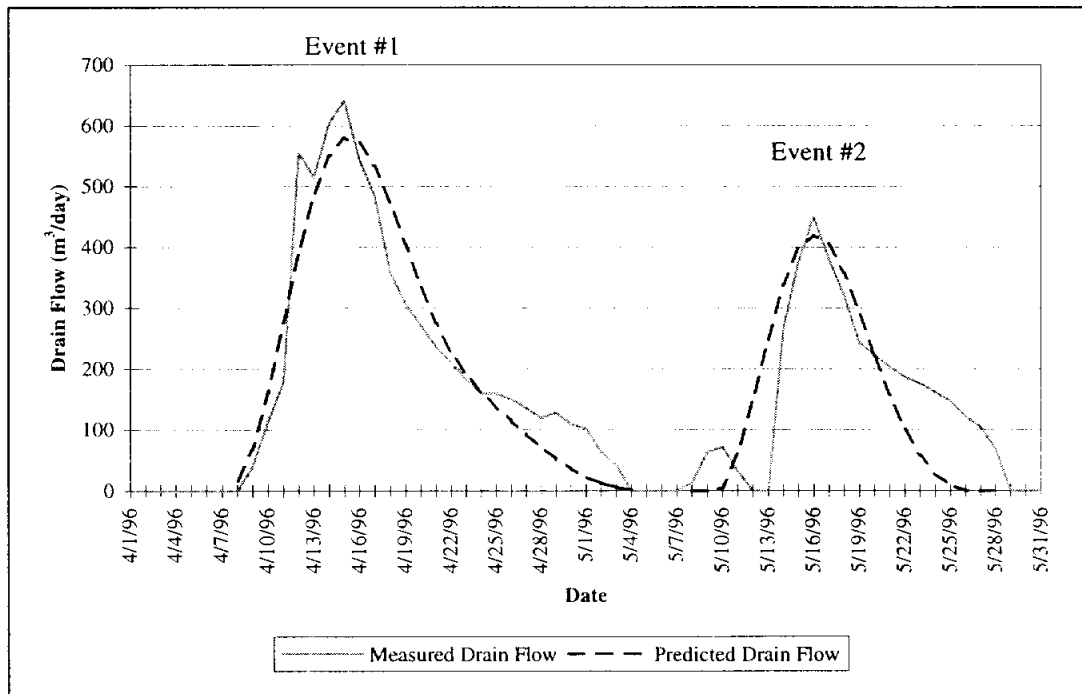


Figure 10. Comparison of Predicted to Measured Subsurface Drain Flow at the Irrigated Demonstration Site

The results indicate good correspondence between the subsurface drain flow predicted by the calibrated EPIC model and the measured data observed for two irrigation events at the irrigated control site. Comparisons of drained volume and soluble nitrogen loads for each event also yielded good correspondence as indicated in Table 11. For event number one, EPIC predicted a drain volume of 6,251 cubic meters compared to 6,412 cubic meters which was computed based on water level measurements in the drain. The soluble nitrogen load predicted by EPIC for the event was 97 kilograms compared to 98 kilograms computed from the flow and constituent concentration data.

For event number two, close agreement between the predicted and measured drain volume was observed. EPIC predicted a drain volume of 3,247 cubic meters which compares well with the computed drain volume of 3,611 cubic meters. The soluble nitrogen load predicted by EPIC for event number 2 was slightly greater (53 kilograms) than the 44 kilograms calculated based on the monitoring data.

Table 11. Comparison of Predicted to Measured Subsurface Data for the Irrigated Demonstration Site

	Measured	Predicted
Event # 1		
4/8/1996 12:02:00 AM - 5/4/1996 11:02:00 PM		
Drain Volume (cubic meters)	6,412	6,251
Mass of Soluble N (kg)	98	97
Event # 2		
5/8/1996 12:02:00 AM - 5/28/1996 11:02:00 PM		
Drain Volume (cubic meters)	3,611	3,247
Mass of Soluble N (kg)	44	53

Since accompanying flow data were not available for sampling events three through seven at either the BMP or control sections of the irrigated demonstration site, model testing for these events was limited to comparisons of soluble nitrogen concentrations predicted by the EPIC model to measured concentrations of soluble nitrogen. For both the BMP and control sites, the predicted and measured soluble nitrogen concentrations in the drain flow were plotted over time (Figures 11 and 12).

Comparisons were made for two time periods. Figures 11 a) and 12 a) examine a two-month period from April 1, 1996 through May 31, 1996 for the grain sorghum rotation. Measured data represent concentrations observed in subsurface drainage following two irrigation events. Geometric mean daily concentrations were computed from sample concentrations for comparison to daily predicted values. Figures 11 b) and 12 b) depict a three-month period from January 1, 1997 through March 31, 1997. This timeframe depicts measured and predicted soluble nitrogen concentrations for the 1997 pre-plant period for the cotton rotation. This period primarily encompasses irrigation and fertilizer applications prior to planting of the cotton crop on March 20, 1997 with measured data representing subsurface drain concentrations during a single pre-plant irrigation event. As can be seen in Figures 11 and 12, concentrations of

soluble nitrogen predicted by the EPIC model generally are within the range of values observed in the monitoring data.

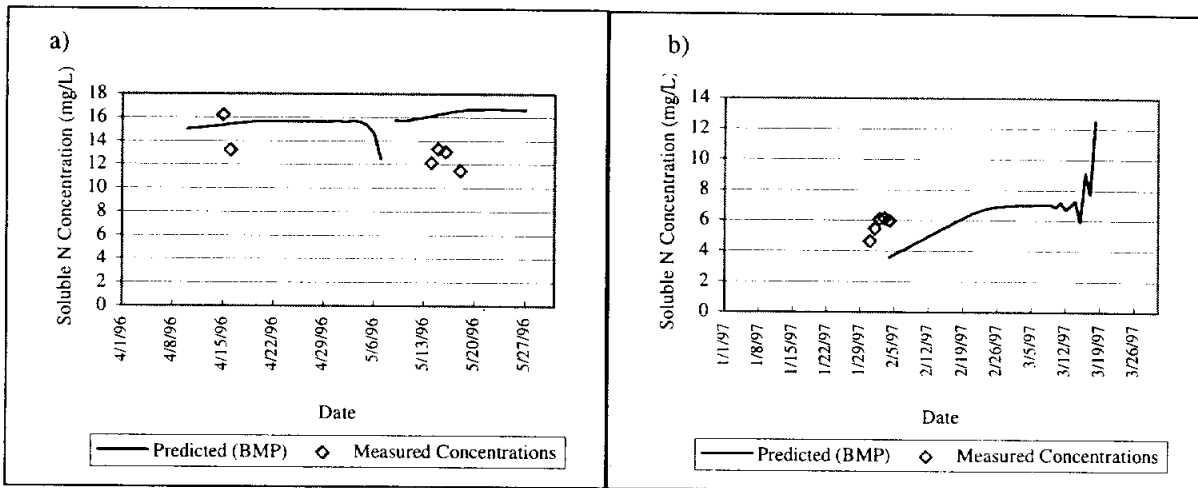


Figure 11. Soluble Nitrogen Concentrations Predicted for Subsurface Drain Flow, Irrigated BMP Site
a) 4/1/96 - 5/31/96 b) 1/1/97 - 3/31/97

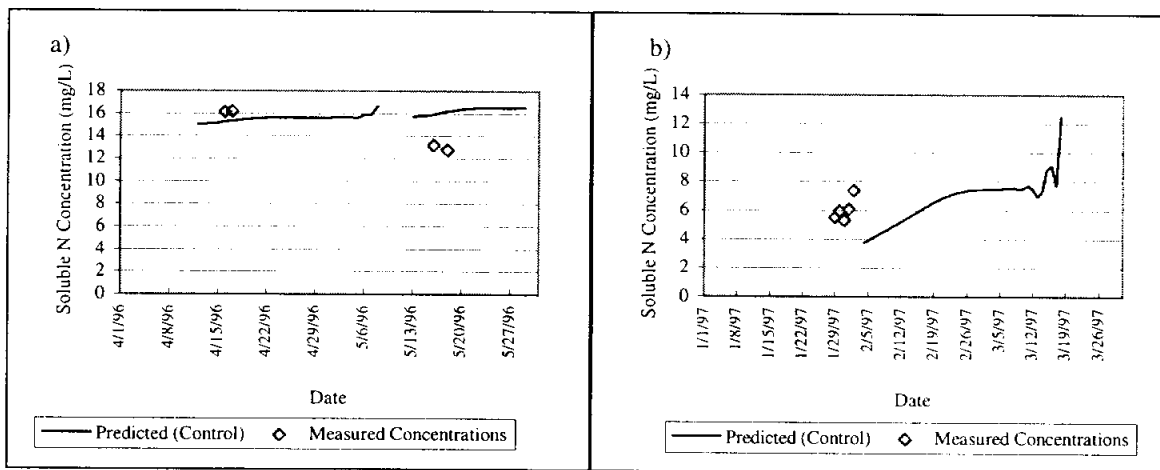


Figure 12. Soluble Nitrogen Concentrations Predicted for Subsurface Drain Flow, Irrigated Control Site
a) 4/1/96 - 5/31/96 b) 1/1/97 - 3/31/97

The limited amount of water level data available for the demonstration sites precluded an exhaustive calibration of the EPIC model. Calibration was performed for the irrigated demonstration site based on data collected during the first two irrigation events for which accompanying flow data was available.

Without accompanying flow data for the runoff events monitored at the dryland site, attempts to calibrate the controlling input variables to more closely correlate

predicted concentrations with observed values was not possible. A cursory comparison of predicted concentrations to those observed at the demonstration sites was performed. The model output including predicted flow, concentrations and crop yields were inspected for reasonableness based on "best professional judgment." If the predicted results appeared to be reasonable, i.e., displaying an acceptable range of values, no further adjustments were made. If input adjustments were deemed necessary, initial soil moisture or runoff curve numbers were modified to predict flow (runoff or subsurface drainage) that corresponded more closely with the timing of observed flow events.

Due to a lack of site specific rainfall data for the dryland site beyond February 1997, comparisons of predicted to measured concentrations for the dryland demonstration sites were conducted for a shorter period, extending from April 1, 1996 through March 31, 1997. As a check of model fidelity, predicted and measured concentrations were compared. For several important water quality parameters, geometric mean concentrations computed based on measured and predicted data for corresponding time periods are listed in Table 12. Measured data from runoff events one through three were used for comparisons. The results indicated that the mean concentrations predicted by EPIC were comparable to those computed from observed data. With the exception of organic and total nitrogen, the predicted concentrations were slightly higher than those observed. Predicted organic and total nitrogen concentrations were slightly lower than measured values. Overall, the concentrations predicted by EPIC for these comparisons were considered to be within acceptable ranges and, given the limited calibration that was possible, provided reasonable estimates of nutrient and sediment concentrations in surface runoff from the dryland demonstration site.

Table 12. Measured and Predicted Geometric Mean Concentrations in Surface Runoff from the Dryland Demonstration Site

Constituent (units)	BMP Site		Control Site	
	Measured	Predicted	Measured	Predicted
Soluble N in Surface Runoff (mg/L)	0.220	0.567	0.243	0.580
Organic N in Surface Runoff (mg/L)	1.865	1.008	1.928	1.606
Total N in Surface Runoff (mg/L)	2.156	1.585	2.225	2.198
Soluble P in Surface Runoff (mg/L)	0.349	0.511	0.316	0.549
Organic P in Surface Runoff (mg/L)	0.860	0.917	0.727	1.413
Total P in Surface Runoff (mg/L)	1.357	1.764	1.243	1.986
Sediment Concentration in Surface Runoff (mg/L)	488	522	586	735

A sensitivity analysis was also completed for key input parameters to the EPIC model using the datasets developed for the demonstration sites. The sensitivity of model output to the runoff curve number (EPIC variable CN2), initial nitrate concentration in the soil (EPIC variable WNO3), and the time required for the drainage system to reduce plant stress (EPIC variable DRT) was determined. These key calibration parameters were selected based on a sensitivity analysis performed on an earlier release of EPIC5300 (Chung and Gu, 1997) and discussions with model developers at the Blackland Research Center. Results of the sensitivity analysis, included in Appendix G, aided in the calibration of EPIC

for the two events monitored at the irrigated control site. The values for DRT used in the model application were determined through the model calibration process. A DRT value of 3.5 days yielded the best correspondence with measured drain flow for calibration events number one and two.

As noted by Chung and Gu (1997), calibration of initial nitrate nitrogen concentration (WNO3) in the soil improves model predictions for the first year of the simulation but has little effect on subsequent years. Measured soil nitrogen levels were used for model calibration based on soil samples collected at the demonstration sites. In applying the EPIC model for long-term simulations of the study areas, initial soil nutrient levels were estimated based on program defaults.

While minor adjustments in the runoff curve number (CN2), within the published range for the soil and crop category, were made for calibration of the EPIC model to specific conditions at the BMP demonstration sites, no attempts were made to adjust the selected curve numbers used in model applications. Curve numbers used in application runs were selected from standard tables published by the NRCS (USDA-SCS, 1972, 1986). NRCS project participants provided assistance in selection of runoff curve numbers based on their knowledge of local soil and crop conditions.

5.0 EVALUATION OF BMP IMPLEMENTATION

Through the project's technical advisory committee, BMPs suitable for crops grown in the study area were selected for evaluation. Evaluation of the environmental impacts of BMP implementation for the study area was performed based on a modeling analysis. The methodology used for these evaluations are documented in the following sections.

Input datasets characterizing crop production areas within the Arroyo Colorado study area were developed with the assistance of extension specialists at the TAMU Research and Extension Center in Weslaco, who provided information on pesticide use in Cameron County including typical timing and application rates for the crops of interest. Representative crop management schedules developed for the modeling analyses are included in Appendix H. Assumptions relating to BMP implementation within the watershed were also defined and are included in Appendix I. Pesticides which were identified in the representative crop management schedules included 10 herbicides, 13 insecticides and 2 defoliant. The specific pesticides considered in the modeling analysis of BMPs are listed in Table 13.

Table 13 . List of Pesticides Considered in the Modeling Analysis

	Common Name	Trade Name		Common Name	Trade Name
HERBICIDES:	* Atrazine	Aatrex	INSECTICIDES:	Benomyl	Benlate
	Dicamba Soluble Salt	Banvel		Dicrotophos	Bidrin
	Ametryn	Evik		* Azinphos-methyl	Guthion
	Bromacil	Hyvar X		Cyhalothrin	Karate
	Simazine	Princep		Dicofol	Kelthane
	Pendimethalin	Prowl		Copper hydroxide	Kocide
	* Trifluralin	Treflan		Chlorpyrifos	Lorsban
	Glyphosate amine	Roundup		Acephate	Orthene
	Oryzalin	Surflan		* Permethrin	Pounce
DEFOLIANTS:	Norflurazon	Evital/Solicam	Aldicarb	Temik	
	Tribufos	DEF	Fenbutatin oxide	Vendex	
	Thidiazuron	Dropp	Oxamyl	Vydate	
			Petroleum Oil Spray		

* Monitored at Demonstration Fields

Model simulations were performed for each of the crop/soil/BMP combinations. Average annual loads of nutrients and pesticides were calculated for the study area based on the modeling results. In calculating load reductions for the study area, individual pesticide loads were summed representing a total pesticide load. Percent reductions of surface, subsurface and total constituent losses were estimated for each of the six BMPs evaluated. Also evaluated was the condition in which all of the applicable BMPs were implemented within the study area. Percent change for the study area was calculated as:

$$\frac{L(ABI) - L(BC)}{L(BC)} \times 100$$

Where:

$L(ABI)$ = Total constituent load after BMP implementation, and

$L(BC)$ = Total constituent load at baseline condition.

Results of BMP evaluations (Table 14) indicated significant reductions in nutrient and pesticide loads from implementation within the study area. Percent reductions in total nitrogen loads exceeding 30 percent were estimated for improved nutrient management, improved irrigation water management and improved irrigation technology. Improved nutrient management also had the greatest impact on total phosphorus loads with an estimated 15 percent reduction attributed to this BMP. With respect to pesticide and sediment losses from cropland areas, the two BMPs dealing with irrigation practices (improved irrigation water management and improved irrigation technology) showed the greatest potential for reducing contributions from the study area. Based on the modeling analysis, BMP number 2, improved residue management, displayed only minor reductions in nutrient loads but effected an estimated 18 percent reduction in sediment loss due to water erosion. Improved nutrient management resulted in an estimated 34 percent reduction in total nitrogen losses and an estimated 15 percent reduction in total phosphorus; however, it showed no change in pesticide contributions.

Table 14. Percent Change¹ Associated with BMP Implementation in the Arroyo Colorado Study Area

BMP	Nitrogen Losses			Phosphorus Losses	Pesticide Losses			Sediment Loss Due to Water Erosion
	Surface	Subsurface	Total	Total	Surface	Subsurface	Total	
BMP# 1 - Improved Nutrient Management	-5	-40	-34	-15	0	0	0	0
BMP# 2 - Improved Residue Management	-4	0	0	-2	-13	0	-8	-18
BMP# 3 - Improved Irrigation Water Management	-2	-36	-30	-4	-28	-33	-30	-30
BMP# 4 - Improved Irrigation Technology	4	-56	-45	-5	-31	-22	-28	-43
BMP# 5 - Increase in Irrigation Land Leveling/Precision Land Forming to 95%	-9	2	0	-5	-8	1	-5	-21
BMP# 6 - Increase in IPM Implementation to 95%	0	0	0	0	-1	0	-1	0
Implementation of all applicable BMPs	-21	-76	-64	-27	-78	-28	-62	-62

¹Negative values represent a percent decrease in the constituent, whereas a positive value represents a percent increase.

Although BMPs number 5 and 6, dealing with land leveling practices and integrated pest management (IPM) practices, both displayed rather minor reductions in constituent loads, it should be kept in mind that these practices are largely implemented under the baseline condition, and this evaluation merely dealt with increasing the implementation in each case to 95 percent. It cannot and should not be concluded that these BMPs are not successful in reducing nonpoint pollution, but rather that much of the environmental benefits associated with these BMPs has already been realized. It would appear that educational and planning efforts by TAEX, NRCS, TSSWCB and other organizations in promoting integrated pest management and land leveling practices have been largely successful in effecting implementation among area producers.

Relatively low pesticide reductions were predicted for BMP number 6, i.e., increased IPM implementation, because a high level of IPM implementation is already occurring. However, the actual environmental benefits associated with these practices may be demonstrated by the differences in surface and subsurface pesticide losses predicted for a single field under the low and full implementation schemes. The average annual pesticide loss predicted for surface runoff from a cotton-grain sorghum rotation on a soil representative of Group 2 decreased from 5.9 g/ha under a low-level IPM program to 4.4 g/ha under the full implemented IPM program. Similarly, the subsurface pesticide losses decreased from 3.4 g/ha to 0.01 g/ha.

The evaluation considering implementation of all applicable BMPs to cropland within the study area displayed percent reductions ranging from 21 percent to 78 percent. Percent reductions estimated for total nitrogen, pesticide and sediment losses exceeded 60 percent for all BMPs combined.

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APPENDIX A

General Soil Categories Defined for the Arroyo Colorado Project

General Soil Category ¹	Soil Intake Curve ² (Inches/hour)	Slope Range (%)	Average Slope (%)	Soil Mapping Unit
1	< 0.06	0 - 1	0.50	BE - Benito clay
		0 - 1	0.50	GR - Grulla clay
		0 - 1	0.50	HA - Harlingen clay
		0 - 1	0.50	HC - Harlingen clay, saline
		0 - 1	0.50	MEA - Mercedes clay, 0 to 1 percent slope
		1 - 3	2.00	MEB - Mercedes clay, 1 to 3 percent slope
		1 - 5	3.00	MGC - Mercedes clay, loamy substratum, 1 to 5 percent slope
		0 - 1	0.50	OR - Orelia clay loam, clayey subsoil variant
		2	0.3	0 - 1
0 - 1	0.50			MA - Matamoros silty clay
0 - 1	0.50			MC - Matamoros-Rio Grande complex
0 - 1	0.50			OM - Olmito silty clay
0 - 1	0.50			RE - Raymondville clay loam
0 - 1	0.50			RG - Raymondville clay loam, saline
0 - 1	0.50			RO - Rio clay loam
3	0.5			0 - 1
		0 - 1	0.50	CC - Camargo silty clay loam
		0 - 1	0.50	LAA - Laredo silty clay loam, 0 to 1 percent slopes
		0 - 3	2.00	LAB - Laredo silty clay loam, 1 to 3 percent slopes
		0 - 1	0.50	LC - Laredo silty clay loam, saline
		0 - 1	0.50	LD - Laredo-Olmito complex
		0 - 1	0.50	LEA - Laredo-Reynosa complex, 0 to 1 percent slopes
		1 - 3	2.00	LEB - Laredo-Reynosa complex, 1 to 3 percent slopes
		4	0.5	0 - 1
1 - 3	2.00			HGB - Hidalgo fine sandy loam, 1 to 3 percent slopes
0.2 - 0.3	0.25			HO - Hidalgo sandy clay loam
0.3 - 0.5	0.40			LY - Lyford sandy clay loam
0.1 - 0.2	0.15			RA - Racombes sandy clay loam
5	0.5	0 - 1	0.50	WAA - Willacy fine sandy loam, 0 to 1 percent slopes
		1 - 3	2.00	WAB - Willacy fine sandy loam, 1 to 3 percent slopes
6	1.0	0 - 1	0.50	RR - Rio Grande silt loam
		1 - 3	2.00	RT - Rio Grande silty clay loam
		0 - 1	0.50	RZ - Rio Grande-Zalla complex
7 (Not Farmed)	> 1.0 non-typical > 1.0	0 - 12	6.00	GA - Galveston fine sand, hummocky
		0 - 1	0.50	TC - Tiocano clay
		0 - 1	0.50	ZA - Zalla loamy fine sand

¹ Basis for soil groupings: Soil intake curve, water holding capacity, and crop suitability.

² Lower Rio Grande Plain Irrigation Guide, USDA-NRCS (June 1983).

DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 1 (without subsurface drains)

Execution Mode : EPIC
 SOIL NAME : HARLINGEN
 Horizons : 3
 Execution Date : 7-07-1997
 Execution Time : 19:36:35

*** INPUTS ***

State : TX
 S5 Number : TX0412
 Soil Survey Area : 061
 Map Unit Symbol : HA
 Map Unit Kind : Consociation
 Component Number : 1
 Component Percentage : 100.00000
 Number of Components : 1
 Hydrological Group : D
 Soil Surface Texture : C
 Slope % : .00 - 1.00

SALB	.02	.11	.18	
Z	.01	.28	.89	1.80
BD	1.12	1.12	1.15	1.23
U	.34	.34	.42	.40
FC	.48	.48	.50	.48
SAN	17.19	17.19	9.61	11.11
SIL	27.81	27.81	22.39	25.89
PH	8.15	8.15	8.15	8.15
CBN	1.16	1.16	.39	.13
CEC	49.93	49.93	56.38	51.06
ROK	.00	.00	.00	.00
BDD	1.71	1.71	1.90	1.90
SC	.20	.20	.04	.06

Definition of soil variables:

SALB Soil albedo
 Z Depth from the surface to the bottom of the soil layer (m)
 BD Bulk density of the soil layer (t/m³)
 U Wilting point, 1500 kPa (m/m)
 FC Field capacity, 33 kPa (m/m)
 SAN Sand content (%)
 SIL Silt content (%)
 PH Soil pH
 CBN Organic carbon(%)
 CEC Cation exchange capacity (cmo/kg)
 ROK Coarse fragment content (% vol)
 BDD Bulk density, oven dry (t/m³)
 SC Saturated conductivity (mm/hr)

DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 1 (with subsurface drains)

Execution Mode : EPIC
 SOIL NAME : MERCEDES
 Horizons : 3
 Execution Date : 7-07-1997
 Execution Time : 19:43:01

*** INPUTS ***

State : TX
 S5 Number : TX0477
 Soil Survey Area : 061
 Map Unit Symbol : MEA
 Map Unit Kind : Consociation
 Component Number : 1
 Component Percentage : 100.00000
 Number of Components : 1
 Hydrological Group : D
 Soil Surface Texture : C

Slope % : .00- 1.00

SALB	.02	.11	.18	
Z	.01	.46	1.19	1.88
BD	1.18	1.18	1.32	1.37
U	.30	.30	.33	.31
FC	.44	.44	.43	.41
SAN	22.23	22.23	18.14	22.23
SIL	27.77	27.77	29.36	27.77
PH	8.15	8.15	8.45	8.45
CBN	1.16	1.16	.39	.13
CEC	45.93	45.93	43.98	40.66
ROK	6.27	6.27	6.38	6.68
BDD	1.68	1.68	1.83	1.84
SC	.38	.38	.17	.23

Definition of soil variables:

SALB Soil albedo
 Z Depth from the surface to the bottom of the soil layer (m)
 BD Bulk density of the soil layer (t/m³)
 U Wilting point, 1500 kPa (m/m)
 FC Field capacity, 33 kPa (m/m)
 SAN Sand content (%)
 SIL Silt content (%)
 PH Soil pH
 CBN Organic carbon(%)
 CEC Cation exchange capacity (cmo/kg)
 ROK Coarse fragment content (% vol)
 BDD Bulk density, oven dry (t/m³)
 SC Saturated conductivity (mm/hr)

DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 2

Execution Mode : EPIC
 SOIL NAME : RAYMONDVILLE
 Horizons : 3
 Execution Date : 7-07-1997
 Execution Time : 19:37:54

*** INPUTS ***

State : TX
 S5 Number : TX0169
 Soil Survey Area : 061
 Map Unit Symbol : RE
 Map Unit Kind : Consociation
 Component Number : 1
 Component Percentage : 100.00000
 Number of Components : 1
 Hydrological Group : D
 Soil Surface Texture : CL
 Slope % : .00- 1.00

SALB	.02	.11	.18	
Z	.01	.36	.94	1.98
BD	1.34	1.34	1.49	1.51
U	.23	.23	.25	.25
FC	.41	.41	.41	.39
SAN	30.44	30.44	29.23	29.23
SIL	32.56	32.56	31.27	31.27
PH	8.15	8.15	8.15	8.15
CBN	1.16	1.16	.39	.13
CEC	24.43	24.43	21.73	20.41
ROK	.00	.00	1.29	3.97
BDD	1.57	1.57	1.72	1.74
SC	2.81	2.81	1.28	1.15

Definition of soil variables:

SALB Soil albedo
 Z Depth from the surface to the bottom of the soil layer (m)
 BD Bulk density of the soil layer (t/m³)
 U Wilting point, 1500 kPa (m/m)
 FC Field capacity, 33 kPa (m/m)
 SAN Sand content (%)
 SIL Silt content (%)
 PH Soil pH
 CBN Organic carbon(%)
 CEC Cation exchange capacity (cmo/kg)
 ROK Coarse fragment content (% vol)
 BDD Bulk density, oven dry (t/m³)
 SC Saturated conductivity (mm/hr)

DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 2

Execution Mode : EPIC
 SOIL NAME : OLMITO
 Horizons : 2
 Execution Date : 7-07-1997
 Execution Time : 19:43:40

*** INPUTS ***

State : TX
 S5 Number : TX0518
 Soil Survey Area : 061
 Map Unit Symbol : OM
 Map Unit Kind : Consociation
 Component Number : 1
 Component Percentage : 100.00000
 Number of Components : 1
 Hydrological Group : D
 Soil Surface Texture : SIC
 Slope % : .00 - 1.00

SALB	.02	.11	
Z	.01	.86	1.60
BD	1.27	1.27	1.35
U	.32	.32	.30
FC	.48	.48	.44
SAN	5.52	5.52	7.37
SIL	46.98	46.98	47.63
PH	8.15	8.15	8.15
CBN	1.16	1.16	.39
CEC	43.93	43.93	37.98
ROK	.00	.00	2.89
BDD	1.70	1.70	1.75
SC	.15	.15	.14

Definition of soil variables:

SALB Soil albedo
 Z Depth from the surface to the bottom of the soil layer (m)
 BD Bulk density of the soil layer (t/m³)
 U Wilting point, 1500 kPa (m/m)
 FC Field capacity, 33 kPa (m/m)
 SAN Sand content (%)
 SIL Silt content (%)
 PH Soil pH
 CBN Organic carbon(%)
 CEC Cation exchange capacity (cmo/kg)
 ROK Coarse fragment content (% vol)
 BDD Bulk density, oven dry (t/m³)
 SC Saturated conductivity (mm/hr)

DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 3

Execution Mode : EPIC
SOIL NAME : LAREDO
Horizons : 2
Execution Date : 7-07-1997
Execution Time : 19:38:46

*** INPUTS ***

State : TX
S5 Number : TX0446
Soil Survey Area : 061
Map Unit Symbol : LAA
Map Unit Kind : Consociation
Component Number : 1
Component Percentage : 100.00000
Number of Components : 1
Hydrological Group : B
Soil Surface Texture : SICL
Slope % : .00 - 1.00

SALB	.02	.13	
Z	.01	.46	1.83
BD	1.30	1.30	1.46
U	.15	.15	.18
FC	.37	.37	.39
SAN	7.16	7.16	6.82
SIL	65.34	65.34	61.68
PH	8.15	8.15	8.15
CBN	1.16	1.16	.29
CEC	10.06	10.06	6.21
ROK	.00	.00	1.34
BDD	1.36	1.36	1.52
SC	1.36	1.36	.92

Definition of soil variables:

SALB Soil albedo
Z Depth from the surface to the bottom of the soil layer (m)
BD Bulk density of the soil layer (t/m³)
U Wilting point, 1500 kPa (m/m)
FC Field capacity, 33 kPa (m/m)
SAN Sand content (%)
SIL Silt content (%)
PH Soil pH
CBN Organic carbon(%)
CEC Cation exchange capacity (cmo/kg)
ROK Coarse fragment content (% vol)
BDD Bulk density, oven dry (t/m³)
SC Saturated conductivity (mm/hr)

DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 4

Execution Mode : EPIC
 SOIL NAME : HIDALGO
 Horizons : 3
 Execution Date : 7-07-1997
 Execution Time : 19:39:44

*** INPUTS ***

State : TX
 S5 Number : TX0226
 Soil Survey Area : 061
 Map Unit Symbol : HO
 Map Unit Kind : Consociation
 Component Number : 1
 Component Percentage : 100.00000
 Number of Components : 1
 Hydrological Group : B
 Soil Surface Texture : SCL
 Slope % : .00- 1.00
 SALB .02 .11 .18
 Z .01 .43 .71 2.03
 BD 1.43 1.43 1.58 1.60
 U .17 .17 .19 .19
 FC .31 .31 .31 .31
 SAN 56.98 56.98 55.46 53.94
 SIL 18.02 18.02 17.54 17.06
 PH 8.15 8.15 8.15 8.15
 CBN 1.16 1.16 .39 .13
 CEC 18.43 18.43 15.48 15.16
 ROK 1.43 1.43 1.27 5.36
 BDD 1.57 1.57 1.72 1.75
 SC 11.76 11.76 5.93 4.57

Definition of soil variables:

SALB Soil albedo
 Z Depth from the surface to the bottom of the soil layer (m)
 BD Bulk density of the soil layer (t/m³)
 U Wilting point, 1500 kPa (m/m)
 FC Field capacity, 33 kPa (m/m)
 SAN Sand content (%)
 SIL Silt content (%)
 PH Soil pH
 CBN Organic carbon(%)
 CEC Cation exchange capacity (cmo/kg)
 ROK Coarse fragment content (% vol)
 BDD Bulk density, oven dry (t/m³)
 SC Saturated conductivity (mm/hr)

DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 5

Execution Mode : EPIC
 SOIL NAME : WILLACY
 Horizons : 2
 Execution Date : 7-07-1997
 Execution Time : 19:40:38

*** INPUTS ***

State : TX
 S5 Number : TX0156
 Soil Survey Area : 061
 Map Unit Symbol : WAA
 Map Unit Kind : Consociation
 Component Number : 1
 Component Percentage : 100.00000
 Number of Components : 1
 Hydrological Group : B
 Soil Surface Texture : FSL
 Slope % : .00 - 1.00

Variable	Value 1	Value 2	Value 3
SALB	.02	.11	
Z	.01	.36	1.88
BD	1.46	1.46	1.58
U	.11	.11	.17
FC	.24	.24	.30
SAN	65.33	65.33	56.60
SIL	19.67	19.67	17.90
PH	7.20	7.20	7.50
CBN	1.16	1.16	.39
CEC	13.43	13.43	14.73
ROK	.00	.00	2.89
BDD	1.54	1.54	1.71
SC	36.93	36.93	6.59

Definition of soil variables:

SALB Soil albedo
 Z Depth from the surface to the bottom of the soil layer (m)
 BD Bulk density of the soil layer (t/m³)
 U Wilting point, 1500 kPa (m/m)
 FC Field capacity, 33 kPa (m/m)
 SAN Sand content (%)
 SIL Silt content (%)
 PH Soil pH
 CBN Organic carbon(%)
 CEC Cation exchange capacity (cmo/kg)
 ROK Coarse fragment content (% vol)
 BDD Bulk density, oven dry (t/m³)
 SC Saturated conductivity (mm/hr)

DOMINANT SOIL/REPRESENTATIVE OF SOIL GROUP 6

Execution Mode : EPIC
 SOIL NAME : RIO GRANDE
 Horizons : 2
 Execution Date : 7-07-1997
 Execution Time : 19:41:32

*** INPUTS ***

State : TX
 S5 Number : TX0542
 Soil Survey Area : 061
 Map Unit Symbol : RR
 Map Unit Kind : Consociation
 Component Number : 1
 Component Percentage : 100.00000
 Number of Components : 1
 Hydrological Group : B
 Soil Surface Texture : SIL
 Slope % : .00 - 1.00

SALB	.10	.10	
Z	.01	.18	1.60
BD	1.43	1.43	1.52
U	.07	.07	.08
FC	.27	.27	.28
SAN	20.98	20.98	20.75
SIL	68.02	68.02	67.25
PH	8.15	8.15	8.15
CBN	.44	.44	.44
CEC	3.87	3.87	4.02
ROK	.00	.00	.00
BDD	1.46	1.46	1.55
SC	5.76	5.76	3.94

Definition of soil variables:

SALB Soil albedo
 Z Depth from the surface to the bottom of the soil layer (m)
 BD Bulk density of the soil layer (t/m³)
 U Wilting point, 1500 kPa (m/m)
 FC Field capacity, 33 kPa (m/m)
 SAN Sand content (%)
 SIL Silt content (%)
 PH Soil pH
 CBN Organic carbon(%)
 CEC Cation exchange capacity (cmo/kg)
 ROK Coarse fragment content (% vol)
 BDD Bulk density, oven dry (t/m³)
 SC Saturated conductivity (mm/hr)

MUIR Soil Data for Cameron County

State	Survey Area	Map Unit	Soil Group	Series Name	ID #	Slope _{min}	Slope _{max}	Average Slope	Surface Texture	Acreeage	Average Depth to Water Table	Hydrologic Soil Group	Natural Drainage Condition	Hydric Soil	Non-irrigated Capability Class	Irrigated Capability Class
TX	61	BE	1	BENITO	TX0236	0	1	0.5	C	25730	154380	D	P	Y	6S	4W
TX	61	GR	1	GRULLA	TX0396	0	1	0.5	C	1530	9180	D	SP	Y	4W	4W
TX	61	HA	1	HARLINGEN	TX0412	0	1	0.5	C	49730	298380	D	MW	N	3S	3S
TX	61	HC	1	HARLINGEN	TX0413	0	1	0.5	C	4110	24660	D	MW	N	4S	4S
TX	61	MEA	1	MERCEDES	TX0477	0	1	0.5	C	16950	101700	D	MW	N	3S	3S
TX	61	MEB	1	MERCEDES	TX0477	1	3	2.0	C	1780	10680	D	MW	N	3E	3E
TX	61	MGC	1	MERCEDES	TX0780	1	5	3.0	C	2240	13440	D	MW	N	4E	4E
TX	61	OR	1	ORELIA VARIANT	TX0781	0	1	0.5	CL	1100	6600	D	SP	Y	4S	4S
								0.58		103170	6.00					
TX	61	CE	2	CAMERON	TX0232	0	1	0.5	SIC	1840	10120	D	MW	N	2S	2S
TX	61	MA	2	MATAMOROS	TX0379	0	1	0.5	SIC	6090	36540	C	MW	N	2S	2S
TX	61	MC	2	MATAMOROS	TX0379	0	1	0.5	SIL	864	5184	C	MW	N	2S	2S
TX	61	MC	2	RIO GRANDE	TX0542	0	1	0.5	SIL	766	4596	B	W	N	3C	1
TX	61	OM	2	OLMITO	TX0518	0	1	0.5	SIC	29940	179640	D	MW	N	2S	2S
TX	61	RE	2	RAYMONDVILLE	TX0169	0	1	0.5	CL	49540	297240	D	MW	N	2S	2S
TX	61	RG	2	RAYMONDVILLE	TX0170	0	1	0.5	CL	700	2450	D	MW	N	4S	4S
TX	61	RO	2	RIO	TX0043	0	1	0.5	CL	1240	7440	D	SP	Y	3W	3W
								0.50		90980	5.97					
TX	61	CA	3	CAMERGO	TX0281	0	1	0.5	SIL	2240	13440	B	W	N	3C	1
TX	61	CC	3	CAMARGO	TX0281	0	1	0.5	SICL	600	3600	B	W	N	3C	1
TX	61	LAA	3	LAREDO	TX0446	0	1	0.5	SICL	64420	386520	B	W	N	2C	1
TX	61	LAB	3	LAREDO	TX0446	1	3	2.0	SICL	2470	14820	B	W	N	2E	2E
TX	61	LC	3	LAREDO	TX0447	0	1	0.5	SICL	12410	46537.5	B	MW	N	4S	3S
TX	61	LD	3	LAREDO	TX0446	0	1	0.5	SICL	2982	17892	B	W	N	2C	1
TX	61	LD	3	OLMITO	TX0518	0	1	0.5	SIC	1828	10968	D	MW	N	2S	2S
TX	61	LEA	3	LAREDO	TX0446	0	1	0.5	SICL	1862	11172	B	W	N	2C	1
TX	61	LEA	3	REYNOSA	TX0541	0	1	0.5	SIL	1348	8088	B	W	N	3C	1
TX	61	LEB	3	LAREDO	TX0446	1	3	2.0	SICL	253	1518	B	W	N	2E	2E
TX	61	LEB	3	REYNOSA	TX0541	1	3	2.0	SIL	207	1242	B	W	N	3C	1
								0.55		90620	5.69					
TX	61	HGA	4	HIDALGO	TX0226	0	1	0.5	FSL	1330	7980	B	W	N	2C	1
TX	61	HGB	4	HIDALGO	TX0226	1	3	2.0	FSL	570	3420	B	W	N	2E	2E
TX	61	HO	4	HIDALGO	TX0226	0.2	0.3	0.25	SCL	22100	132600	B	W	N	2C	1
TX	61	LY	4	LYFORD	TX0473	0.3	0.5	0.4	SCL	10950	43800	C	MW	N	2W	2W
TX	61	RA	4	RACOMBES	TX0105	0.1	0.2	0.15	SCL	19610	93147.5	B	MW	N	2W	2W
								0.27		54560	5.15					
TX	61	WAA	5	WILLACY	TX0156	0	1	0.5	FSL	28570	171420	B	W	N	2C	1
TX	61	WAB	5	WILLACY	TX0156	1	3	2.0	FSL	3200	19200	B	W	N	2E	2E
								0.65		31770	6.00					
TX	61	RR	6	RIO GRANDE	TX0542	0	1	0.5	SIL	9440	56640	B	W	N	3C	1
TX	61	RT	6	RIO GRANDE	TX0542	1	3	2.0	SICL	1580	9480	B	W	N	3E	2E
TX	61	RZ	6	RIO GRANDE	TX0542	0	1	0.5	VFSL	253	1518	B	W	N	3C	1
TX	61	RZ	6	ZALLA	TX0580	0	1	0.5	LFS	207	1242	A	SE	N	4W	4W
								0.71		11480	6.00					
TX	61	GA	7	GALVESTON	TX0221	0	12	6.0	FS	2730	12285	A	SE	N	7E	
TX	61	TC	7	TIOCANO	TX0564	0	1	0.5	C	3630	21780	D	SP	Y	6W	
TX	61	ZA	7	ZALLA	TX0580	0	1	0.5	LFS	1650	9900	A	SE	N	4W	4W
								2.37		8010	5.49					

Data Description:

Survey Area - A three-digit number which uniquely identifies a survey area and is usually the county FIPS code.

Map Unit - The symbol used on the soil map to identify the soil type.

Soil Group - The soil grouping determined for this project based on soil intake curve, water holding capacity, and crop suitability.

Series Name - The name of the soil series or component of a soil complex.

ID Number - The Soil Interpretations Record (SOI-5) identification number.

Slope min - The minimum value for the range of slope of a soil component. Units = percent

Slope max - The maximum value for the range of slope of a soil component. Units = percent

Average Slope - Calculated from minimum and maximum slopes for the map unit. $(\text{Slope}_{\text{min}} + \text{Slope}_{\text{max}}) / 2$ Units = percent

Surface Texture - Code for the USDA texture for the surface layer or horizon.

C - Clay

CL - Clay loam

SIC - Silty clay

SIL - Silty loam

SICL - Silty clay loam

FSL - Fine sandy loam

SCL - Sandy clay loam

VFSL - Very fine sandy loam

LFS - Loamy fine sand

FS - Fine sand

Acreeage - Acreeage of the soil component of the map unit in Cameron County. Units = acres

Average Depth to Water Table - Calculated from the minimum and maximum value for the range in depth to the seasonally high water table
(Depth_{min} + Depth_{max})/2. Units = feet

Hydrologic Soil Group - The hydrologic soil group for the soil.

Natural Drainage Condition Code - Code describing the natural drainage condition of the soil referring to the frequency and duration of periods when the soil is free of saturation.

P	poorly drained
SP	somewhat poorly drained
MW	moderately well drained
W	well drained
SE	somewhat excessively drained

Hydric Soil - The symbol Y (yes) or N (no) identifying hydric soils.

Non-Irrigated Capability Class and Subclass Rating - A rating of the soil for non-irrigated agricultural use. The number indicates progressively greater limitations and narrower choices for use.

Irrigated Capability Class and Subclass Rating - A rating of the soil for irrigated agricultural use. The number indicates progressively greater limitations and narrower choices for use.

A detailed description of capability classes is available in the Cameron County Soil Survey (USDA-SCS, 1977).

APPENDIX B

Land Use in the Arroyo Colorado Study Area

Cropping System	Soil Group	Dominant Soil/ Representative of Soil Grouping	Hydrologic Soil Group	Runoff Curve #	Subsurface Drainage	Irrigation Land Leveling (Precision Land Forming)	Acreage (Ac)	Acreage (Ha)
Irrigated Cotton-Grain Sorghum			(85% of cotton rotated with Grain Sorghum)				44,599	18,049
	1	Mercedes Clay (MEA)	D	89	No	80%	11,945	4,834
	1	Mercedes Clay (MEA)	D	89	Yes	80%	10,434	4,223
	2	Raymondville Clay Loam (RE)	D	89	Yes	80%	7,766	3,143
	3	Laredo Silty Clay Loam (LAA)	B	78	Yes	80%	3,078	1,246
	4	Hidalgo Sandy Clay Loam (HO)	B	78	Yes	80%	8,656	3,503
	5	Willacy Fine Sandy Loam (WAA)	B	78	Yes	80%	2,128	861
	6	Rio Grande Silt Loam (RR)	B	78	Yes	80%	592	239
Irrigated Cotton-Corn			(15% of cotton rotated with Corn)				7,870	3,185
	1	Harlingen Clay (HA)	D	89	No	80%	2,108	853
	1	Mercedes Clay (MEA)	D	89	Yes	80%	1,841	745
	2	Raymondville Clay Loam (RE)	D	89	Yes	80%	1,370	555
	3	Laredo Silty Clay Loam (LAA)	B	78	Yes	80%	543	220
	4	Hidalgo Sandy Clay Loam (HO)	B	78	Yes	80%	1,528	618
	5	Willacy Fine Sandy Loam (WAA)	B	78	Yes	80%	376	152
	6	Rio Grande Silt Loam (RR)	B	78	Yes	80%	104	42
Dryland Cotton-Grain Sorghum			(85% of cotton rotated with Grain Sorghum)				628	254
	1	Mercedes Clay (MEA)	D	89	No	80%	598	242
	4	Hidalgo Sandy Clay Loam (HO)	B	78	No	80%	30	12
Dryland Cotton-Corn			(15% of cotton rotated with Corn)				111	45
	1	Mercedes Clay (MEA)	D	89	No	80%	106	43
	4	Hidalgo Sandy Clay Loam (HO)	B	78	No	80%	5	2
Irrigated Sugar Cane							7,658	3,099
	1	Harlingen Clay (HA)	D	82	No	80%	1,407	569
	1	Mercedes Clay (MEA)	D	82	Yes	80%	419	170
	2	Olmite Silty Clay (OM)	D	82	Yes	80%	1,909	773
	3	Laredo Silty Clay Loam (LAA)	B	65	Yes	80%	3,304	1,337
	4	Hidalgo Sandy Clay Loam (HO)	B	65	Yes	80%	524	212
	5	Willacy Fine Sandy Loam (WAA)	B	65	Yes	80%	28	11
	6	Rio Grande Silt Loam (RR)	B	65	Yes	80%	67	27
Irrigated Citrus							1,984	803
	1	Mercedes Clay (MEA)	D	83	No	100%	14	6
	2	Raymondville Clay Loam (RE)	D	83	No	100%	158	64
	3	Laredo Silty Clay Loam (LAA)	B	66	No	100%	45	18
	4	Hidalgo Sandy Clay Loam (HO)	B	66	No	100%	1,357	549
	5	Willacy Fine Sandy Loam (WAA)	B	66	No	100%	410	166
Non-Row Crop Agriculture/Perennial Vegetation							17,566	7,109
	1	Harlingen Clay (HA)					5,368	2,172
	2	Raymondville Clay Loam (RE)					3,959	1,602
	3	Laredo Silty Clay Loam (LAA)					1,984	803
	4	Hidalgo Sandy Clay Loam (HO)					3,051	1,235
	5	Willacy Fine Sandy Loam (WAA)					258	104
	6	Rio Grande Silt Loam (RR)					949	384
	7	Tiicano Clay (TC) - <i>not typically farmed</i>					1,997	808
Non-Agricultural Areas							9,700	3,926
Water/Pits							3,462	1,401
Urban Areas							6,238	2,525
TOTAL							90,116	36,470

APPENDIX C

Monthly Climatic Summaries for Harlingen

Monthly Temperature Data for Harlingen

YEAR	MO.	MIN T (C)	MAX T (C)	YEAR	MO.	MIN T (C)	MAX T (C)	YEAR	MO.	MIN T (C)	MAX T (C)	YEAR	MO.	MIN T (C)	MAX T (C)
1954	1	1	31	1955	1	0	30	1956	1	1	30	1957	1	0	32
	2	3	36		2	-2	31		2	1	32		2	8	34
	3	3	39		3	3	34		3	3	37		3	6	33
	4	12	37		4	13	41		4	13	36		4	11	35
	5	10	38		5	18	38		5	14	36		5	15	37
	6	20	37		6	19	38		6	19	41		6	19	37
	7	21	42		7	21	37		7	21	39		7	22	40
	8	21	40		8	20	38		8	19	41		8	21	39
	9	18	37		9	20	34		9	17	38		9	16	39
	10	9	35		10	9	34		10	12	37		10	7	36
	11	4	31		11	5	32		11	1	34		11	2	32
	12	2	31		12	2	31		12	4	31		12	-2	28
1958	1	2	27	1959	1	-1	28	1960	1	1	31	1961	1	1	27
	2	1	31		2	3	32		2	-1	32		2	1	30
	3	4	32		3	4	32		3	2	32		3	9	36
	4	11	37		4	11	35		4	7	33		4	7	37
	5	16	35		5	18	37		5	11	37		5	12	36
	6	21	38		6	19	36		6	20	38		6	20	37
	7	22	38		7	21	39		7	23	40		7	21	38
	8	17	40		8	23	40		8	22	39		8	19	38
	9	20	38		9	17	39		9	14	35		9	17	38
	10	10	34		10	10	37		10	11	36		10	9	34
	11	4	31		11	0	33		11	6	31		11	7	33
	12	-2	28		12	2	28		12	2	28		12	2	31
1962	1	-10	29	1963	1	-6	32	1964	1	-2	28	1965	1	1	31
	2	3	35		2	-1	37		2	2	27		2	0	30
	3	1	31		3	3	33		3	4	35		3	1	31
	4	4	36		4	14	38		4	10	38		4	12	37
	5	16	35		5	17	34		5	16	37		5	13	34
	6	21	38		6	20	38		6	16	36		6	20	37
	7	20	38		7	16	37		7	22	38		7	20	38
	8	21	41		8	21	39		8	22	38		8	20	37
	9	16	37		9	16	36		9	18	37		9	17	38
	10	10	37		10	14	32		10	7	34		10	8	32
	11	5	32		11	3	32		11	5	33		11	9	34
	12	2	29		12	-3	26		12	-1	32		12	4	27

YEAR	MO.	MIN T (C)	MAX T (C)	YEAR	MO.	MIN T (C)	MAX T (C)	YEAR	MO.	MIN T (C)	MAX T (C)	YEAR	MO.	MIN T (C)	MAX T (C)
1966	1	-1	27	1967	1	-2	29	1968	1	-1	27	1969	1	-2	31
	2	0	27		2	-1	30		2	-1	29		2	6	30
	3	0	33		3	6	33		3	1	30		3	3	33
	4	9	34		4	14	35		4	8	33		4	12	35
	5	16	34		5	14	37		5	14	34		5	15	35
	6	14	36		6	17	38		6	19	36		6	16	38
	7	18	36		7	19	37		7	21	37		7	21	38
	8	21	38		8	16	38		8	21	38		8	21	39
	9	16	38		9	12	34		9	15	36		9	17	36
	10	9	36		10	9	32		10	10	36		10	11	34
	11	1	32		11	6	31		11	3	33		11	-2	34
	12	-3	29		12	1	30		12	1	33		12	3	28
1970	1	-3	27	1971	1	-1	34	1972	1	1	32	1973	1	-4	27
	2	1	27		2	-1	33		2	1	31		2	-3	30
	3	2	33		3	1	38		3	6	38		3	7	32
	4	7	35		4	6	35		4	8	36		4	6	36
	5	9	33		5	13	36		5	16	33		5	14	40
	6	14	35		6	20	34		6	19	36		6	18	36
	7	20	36		7	21	36		7	20	35		7	21	37
	8	18	38		8	20	37		8	21	37		8	21	38
	9	14	38		9	16	38		9	21	37		9	18	36
	10	7	34		10	13	33		10	11	34		10	14	34
	11	-1	31		11	8	32		11	4	34		11	0	0
	12	6	31		12	4	29		12	1	32		12	-4	30
1974	1	1	29	1975	1	-4	29	1976	1	-2	28	1977	1	-2	27
	2	0	30		2	2	31		2	1	29		2	2	28
	3	6	37		3	7	34		3	6	32		3	4	31
	4	7	37		4	9	34		4	9	30		4	8	34
	5	19	41		5	17	34		5	8	32		5	18	35
	6	15	37		6	14	34		6	17	35		6	19	35
	7	21	37		7	21	34		7	20	33		7	20	37
	8	21	38		8	21	35		8	19	35		8	21	37
	9	15	37		9	12	33		9	18	36		9	19	38
	10	9	32		10	11	32		10	7	32		10	9	36
	11	2	30		11	3	31		11	-1	28		11	6	33
	12	3	29		12	2	28		12	1	27		12	0	33

Monthly Rainfall Data for Harlingen

YEAR	MO.	Monthly Rain		YEAR	MO.	Monthly Rain		YEAR	MO.	Monthly Rain		YEAR	MO.	Monthly Rain	
		(mm)	(in.)			(mm)	(in.)			(mm)	(in.)			(mm)	(in.)
1954	1	8.1	0.32	1955	1	19.1	0.75	1956	1	0.3	0.01	1957	1	4.4	0.17
	2	0.3	0.01		2	7.1	0.28		2	29.7	1.17		2	61.6	2.43
	3	9.7	0.38		3	0.8	0.03		3	5.9	0.23		3	66.5	2.62
	4	106.2	4.18		4	9.1	0.36		4	61.9	2.44		4	110.3	4.34
	5	11.9	0.47		5	24.6	0.97		5	6.6	0.26		5	59.0	2.32
	6	61.7	2.43		6	0.0	0.00		6	50.3	1.98		6	169.5	6.67
	7	4.6	0.18		7	144.9	5.70		7	16.3	0.64		7	1.8	0.07
	8	86.7	3.41		8	51.1	2.01		8	7.6	0.30		8	8.6	0.34
	9	30.8	1.21		9	312.6	12.31		9	42.3	1.67		9	11.1	0.44
	10	172.1	6.78		10	68.7	2.70		10	39.4	1.55		10	7.8	0.31
	11	35.1	1.38		11	47.0	1.85		11	8.2	0.32		11	75.1	2.96
	12	2.3	0.09		12	6.4	0.25		12	1.8	0.07		12	8.5	0.33
1958	1	130.1	5.12	1959	1	39.1	1.54	1960	1	5.6	0.22	1961	1	35.2	1.39
	2	181.1	7.13		2	60.8	2.39		2	25.6	1.01		2	6.5	0.26
	3	18.9	0.74		3	8.1	0.32		3	27.2	1.07		3	0.0	0.00
	4	2.1	0.08		4	44.8	1.76		4	58.0	2.28		4	63.3	2.49
	5	64.2	2.53		5	136.6	5.38		5	34.0	1.34		5	10.7	0.42
	6	59.5	2.34		6	113.3	4.46		6	44.7	1.76		6	45.6	1.80
	7	36.9	1.45		7	16.3	0.64		7	10.6	0.42		7	68.3	2.69
	8	0.0	0.00		8	29.1	1.15		8	159.4	6.28		8	115.0	4.53
	9	204.5	8.05		9	2.3	0.09		9	189.1	7.44		9	210.9	8.30
	10	272.8	10.74		10	135.4	5.33		10	91.0	3.58		10	22.9	0.90
	11	44.0	1.73		11	69.4	2.73		11	29.0	1.14		11	40.9	1.61
	12	42.2	1.66		12	8.6	0.34		12	72.1	2.84		12	18.0	0.71
1962	1	8.6	0.34	1963	1	5.0	0.20	1964	1	4.4	0.17	1965	1	8.2	0.32
	2	3.3	0.13		2	11.2	0.44		2	38.4	1.51		2	68.5	2.70
	3	33.0	1.30		3	1.3	0.05		3	2.1	0.08		3	17.2	0.68
	4	21.6	0.85		4	9.9	0.39		4	19.1	0.75		4	7.9	0.31
	5	17.6	0.69		5	154.2	6.07		5	67.2	2.65		5	28.2	1.11
	6	75.7	2.98		6	47.7	1.88		6	75.2	2.96		6	23.6	0.93
	7	0.0	0.00		7	48.7	1.92		7	10.7	0.42		7	5.1	0.20
	8	22.4	0.88		8	69.9	2.75		8	6.9	0.27		8	70.7	2.78
	9	58.0	2.28		9	109.0	4.29		9	70.2	2.76		9	73.6	2.90
	10	34.3	1.35		10	95.3	3.75		10	12.2	0.48		10	29.5	1.16
	11	49.5	1.95		11	109.6	4.31		11	16.5	0.65		11	95.6	3.76
	12	41.7	1.64		12	64.8	2.55		12	42.8	1.69		12	108.3	4.26

YEAR	MO.	Monthly Rain		YEAR	MO.	Monthly Rain		YEAR	MO.	Monthly Rain		YEAR	MO.	Monthly Rain	
		(mm)	(in.)			(mm)	(in.)			(mm)	(in.)			(mm)	(in.)
1966	1	89.6	3.53	1967	1	36.3	1.43	1968	1	94.0	3.70	1969	1	9.9	0.39
	2	23.6	0.93		2	26.2	1.03		2	39.8	1.57		2	53.1	2.09
	3	20.4	0.80		3	28.6	1.13		3	24.1	0.95		3	21.3	0.84
	4	89.3	3.52		4	2.0	0.08		4	19.6	0.77		4	3.3	0.13
	5	203.1	8.00		5	47.7	1.88		5	122.7	4.83		5	103.1	4.06
	6	130.9	5.15		6	21.9	0.86		6	63.3	2.49		6	15.8	0.62
	7	37.6	1.48		7	14.2	0.56		7	69.7	2.74		7	4.8	0.19
	8	76.2	3.00		8	143.6	5.65		8	68.9	2.71		8	94.8	3.73
	9	65.0	2.56		9	364.8	14.36		9	177.3	6.98		9	148.4	5.84
	10	106.4	4.19		10	133.1	5.24		10	47.6	1.87		10	11.2	0.44
	11	2.3	0.09		11	85.3	3.36		11	12.5	0.49		11	46.8	1.84
	12	8.9	0.35		12	92.7	3.65		12	24.1	0.95		12	7.9	0.31
1970	1	97.1	3.82	1971	1	2.8	0.11	1972	1	10.1	0.40	1973	1	115.8	4.56
	2	22.1	0.87		2	30.8	1.21		2	23.4	0.92		2	185.0	7.28
	3	18.3	0.72		3	0.3	0.01		3	80.5	3.17		3	7.9	0.31
	4	40.7	1.60		4	23.6	0.93		4	26.4	1.04		4	18.1	0.71
	5	111.7	4.40		5	9.9	0.39		5	66.4	2.61		5	11.4	0.45
	6	97.8	3.85		6	59.2	2.33		6	120.2	4.73		6	191.1	7.52
	7	49.8	1.96		7	49.8	1.96		7	72.3	2.85		7	41.8	1.65
	8	33.6	1.32		8	65.1	2.56		8	14.7	0.58		8	227.6	8.96
	9	199.2	7.84		9	303.7	11.96		9	114.1	4.49		9	122.7	4.83
	10	141.2	5.56		10	29.1	1.15		10	13.0	0.51		10	111.8	4.40
	11	8.1	0.32		11	6.1	0.24		11	32.3	1.27		11	42.7	1.68
	12	7.8	0.31		12	35.3	1.39		12	9.3	0.37		12	4.4	0.17
1974	1	30.7	1.21	1975	1	39.5	1.56	1976	1	15.6	0.61	1977	1	45.3	1.78
	2	0.5	0.02		2	14.7	0.58		2	0.0	0.00		2	41.8	1.65
	3	6.1	0.24		3	3.1	0.12		3	20.6	0.81		3	4.5	0.18
	4	25.9	1.02		4	0.0	0.00		4	263.7	10.38		4	85.2	3.35
	5	27.9	1.10		5	50.3	1.98		5	53.9	2.12		5	31.5	1.24
	6	48.8	1.92		6	57.7	2.27		6	94.6	3.72		6	184.7	7.27
	7	31.6	1.24		7	219.6	8.65		7	178.6	7.03		7	47.8	1.88
	8	106.9	4.21		8	112.8	4.44		8	141.0	5.55		8	10.8	0.43
	9	265.7	10.46		9	218.6	8.61		9	83.6	3.29		9	70.6	2.78
	10	94.3	3.71		10	26.4	1.04		10	161.5	6.36		10	55.9	2.20
	11	10.8	0.43		11	7.0	0.28		11	95.2	3.75		11	55.7	2.19
	12	23.1	0.91		12	40.9	1.61		12	43.3	1.70		12	9.2	0.36

3 Management Information-Irrigation Fertilizer/Tillage Schedule (One line for each operation and one section for each year of rotation)

MON	DAY	COID	CRPRGRZ	STAT	PHU	CND	WSF	QVOL	HPP	PNMX	HUSC
			FN	FAP	LA	RPD					
			PST	PCF	PAR						
1	26	80									
1	27	80									
2	1	72		91.44							
2	27	71	67	175.00							
3	1	19									
3	1	2	3	2000.00							
4	1	71	67	105.00							
4	8	72		91.44							
5	1	19									
5	7	72		91.44							
7	7	7	51								
7	7	7	51								
8	1	41									
8	1	16									
8	5	15									
8	6	80									
8	7	72		152.40							
1	15	16									
1	17	15									
1	19	80									
1	23	72		91.44							
3	18	71	67	210.00							
3	1	2	5	2000.00							
4	20	7									
4	04	19									
4	08	72		91.44							
5	06	19									
5	10	72		91.44							
6	10	19									
6	14	72		91.44							
6	20	71	67	140.00							
9	1	11	96	1.00	17						
9	15	51									
9	16	41									
9	17	57									
9	18	15									
11	15	21									
12	15	21									

Month of the operation
Day of the operation
Operation/Tillage code number
Crop identification number OR Clearing
Years necessary to mature or year until harvest (For trees only)
Potential Heat Units
Runoff curve number after this operation
Plant water stress factor
Fraction of original plant population
Maximum annual nitrogen fertilizer applied to a crop
Time of this operation as a fraction of the growing season or of the year if no crop's growing, using 0 C as the base temperature
Fertilizer ID number applied
Fertilizer application rate (Kg/ha or lbs/ac)
Depth of fertilizer placement (mm)
Irrigation volume (mm)
Runoff VOL/CT of irrigation water applied
Pesticide ID number
Pest control factor (fraction)
Pesticide application rate (Kg/ha or lbs/ac of active ingredient)

IC5300 DATA ASSEMBLY FORM

IC5300 Parameter Number	Description	Value	Units	IC5300 Parameter Number	Description	Value	Units	IC5300 Parameter Number	Description	Value	Units				
1	Arroyo Colorado Project - Irrigated Demonstration Site 12.4178e97			196	OBM(X1-12)			196	OBM(X1-12)						
1	cont. Gran Sulphur Cotton, Olinde silty clay (Contd Site) 96.97			197	OBM(N1-12)			197	OBM(N1-12)						
1	Wc1 9 TX BROWNSVILLE.w1 9 TX BROWNSVILLE.w			198	SDTM(X1-12)			198	SDTM(X1-12)						
1	Number of years of simulation	2		199	SDTM(N1-12)			199	SDTM(N1-12)						
1	Start year - Year	1996		200	RMDM(1-12)			200	RMDM(1-12)						
1	Month	1													
1	Day	1													
1	Runout interval	1													
1	Output Print Code	6													
1	Weather code	12													
1	Number of times generator cycles	0													
1	Day weather generator steps per minute same weather	0													
1	Leq/Year considered	0													
1	Powerful expansion method code	4													
1	Curve number estimator (1 - 0.95) (0.95)	1													
1	Graph Display (0 - 1) (0)	1													
1	Output conversion code	0													
1	Peak water volume code	0													
1	Static soil code	0													
1	Automatic head unit scheduling	0													
1	Number of cows	0													
1	Non saving CS - CS2 used for all downs	0													
1	Remoff (Q) estimation methodology	0													
1	Postcode (Output in Mass and/or Con.	0													
1	Watershed drainage area (ha)	8.69													
1	Runoff curve number	0													
1	Channel Length (km)	40													
1	Average channel slope (m/m)	0.0075													
1	Channel roughness factor (Manning's N)	0.250													
1	Surface roughness Factor (Manning's N)	1.900													
1	Peak runoff rate rainfall energy adjustment factor	1.0													
1	Latitude of watershed (degrees)	26.10													
1	Longitude of watershed (degrees)	105.2													
1	Average elevation of watershed (m)	8													
1	Water content of snow on ground at start of simulation (mm)	0													
1	Average concentration of nitrogen in rainfall (g m ³) [PPM]	501													
1	Number of years of cultivation before simulation starts (Yr)	8													
1	CO2 concentration in atmosphere [PPM]	330.0													
1	NO3 concentration in irrigation water [PPM]	1													
1	(SALT) salt concentration in irrigation water [PPM]	960.0													
1	(CHD Channel) depth (m)	1.52													
1	Drainage Area of a watershed feeding a Lagoon (ha)	0.00													
1	Normal Lagoon Volume (mm)	0.00													
1	Maximum Lagoon Volume (mm)	0.00													
1	Lagoon input from wash water (m ³ /day)	0.00													
1	Slope length (m)	402.3													
1	Slope steepness (m/m)	0.0075													
1	Erosion control practice	1.00													
1	Water erosion equation	3.00													
1	Parameter estimates for MS/SL erosion equation														
1	Number of days of max monthly 0.5 hour rainfall record	8.0													
1	Co-efficient for wet/dry weather probability	0													
1	Parameter used to modify exponential distribution	0													
1		100.0													
1		100.0													
1	Average monthly maximum air temperature (°C)	20.60		22.60	25.80	29.10	31.40	33.60	34.80	35.10	32.80	29.70	24.70	22.00	OBM(X1-12)
1	Average monthly minimum air temperature (°C)	9.30		10.80	14.10	18.00	21.00	22.80	21.30	23.20	21.80	17.90	13.30	10.60	OBM(N1-12)
1	Monthly standard deviation maximum air temperature (°C)	6.70		6.10	5.30	3.90	2.80	2.30	2.20	2.50	3.80	6.50	6.20	5.80	SDTM(X1-12)
1	Monthly standard deviation minimum air temperature (°C)	6.00		5.70	5.30	4.20	3.00	2.10	1.40	1.40	2.40	4.00	5.70	5.80	SDTM(N1-12)
1	Monthly precipitation (mm)	35.2		41.6	22.5	48.3	68.7	73.6	41.1	71.5	129.7	67.9	39.1	32.7	RMDM(1-12)

141	Monthly standard deviation of daily precipitation (mm)	7.9	16.0	8.5	27.2	19.5	16.2	12.6	17.4	21.0	14.9	10.7	8.5	RST3(-12)
151	Monthly skew coefficient for daily precipitation	4.58	7.54	3.45	6.07	3.36	2.41	4.54	3.64	3.10	2.74	2.70	4.08	RST3(+12)
161	Monthly probability of wet day after dry day	1.71	1.45	1.07	1.03	1.17	1.30	1.17	1.38	2.21	1.48	1.42	1.51	PRW1(-12)
171	Monthly probability of wet day after wet day	.508	.586	.385	.400	.364	.498	.417	.483	.541	.437	.440	.490	PRW3(-12)
181	Average number of days of rain per month	8.00	6.40	4.50	4.40	5.70	6.20	5.20	6.50	9.70	6.40	6.10	7.10	DAYPR(-12)
191	Monthly maximum (0.5 hour-rainfall for period of record (TP24) (mm))	8.4	18.3	3.3	40.9	25.7	36.1	25.7	44.5	31.5	58.2	21.1	20.8	W0(-12)
201	Monthly average daily solar radiation (MJ/m ² or by)	296	341	403	456	564	610	626	568	475	411	296	263	OBSLU(-12)
211	Monthly average relative humidity (fraction)	.76	.75	.72	.72	.74	.73	.72	.71	.73	.73	.76	.75	RH(-12)
221	Field length (km)										.40			FL
222	Field width (km)										.20			FW
223	Clockwise angle of field from north (deg)										355.00			ANG
224	Shading dead crop residue (t/ha)										.00			STD
231	Power of modified exponential distribution of wind speed										.30			UXP
232	Climate factor										350			DXM
241	Average monthly wind velocity (m/s)	5.24	5.51	5.97	6.27	5.92	5.45	5.13	4.64	4.24	4.33	4.82	4.85	UAVM(-12)
251	N wind during each month (%)	9.0	9.0	6.0	4.0	2.0	1.0	0	2.0	3.0	7.0	8.0	9.0	DIR1(-12)
261	NE wind during each month (%)	4.0	4.0	4.0	3.0	2.0	1.0	1.0	4.0	4.0	4.0	4.0	3.0	DIR2(-12)
271	E wind during each month (%)	3.0	5.0	5.0	4.0	3.0	2.0	1.0	3.0	8.0	7.0	4.0	3.0	DIR3(-12)
281	ESE wind during each month (%)	2.0	4.0	5.0	4.0	4.0	3.0	1.0	4.0	7.0	5.0	3.0	3.0	DIR4(-12)
291	E wind during each month (%)	3.0	5.0	7.0	8.0	7.0	7.0	5.0	8.0	9.0	8.0	4.0	3.0	DIR5(-12)
301	ESE wind during each month (%)	5.0	7.0	10.0	13.0	16.0	16.0	12.0	14.0	13.0	6.0	5.0	5.0	DIR6(-12)
311	SE wind during each month (%)	13.0	15.0	19.0	26.0	34.0	36.0	35.0	29.0	16.0	17.0	12.0	11.0	DIR7(-12)
321	SSE wind during each month (%)	17.0	17.0	20.0	22.0	20.0	22.0	31.0	23.0	11.0	11.0	15.0	14.0	DIR8(-12)
331	S wind during each month (%)	10.0	9.0	9.0	7.0	5.0	6.0	11.0	10.0	6.0	5.0	10.0	12.0	DIR9(-12)
341	SSW wind during each month (%)	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	DIR10(-12)
351	SW wind during each month (%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	DIR11(-12)
361	WSW wind during each month (%)	1.0	1.0	1.0	1.0	0	0	0	1.0	1.0	1.0	1.0	1.0	DIR12(-12)
371	W wind during each month (%)	1.0	1.0	1.0	1.0	1.0	0	0	1.0	1.0	1.0	2.0	2.0	DIR13(-12)
381	WSW wind during each month (%)	3.0	2.0	1.0	1.0	1.0	1.0	0	1.0	1.0	3.0	3.0	3.0	DIR14(-12)
391	SW wind during each month (%)	10.0	8.0	4.0	2.0	2.0	1.0	0	2.0	8.0	8.0	11.0	11.0	DIR15(-12)
401	NSW wind during each month (%)	15.0	10.0	6.0	3.0	2.0	1.0	0	7.0	9.0	13.0	15.0	15.0	DIR16(-12)
411	Soil alkali										.02			SALB
412	Maximum number of soil layers										.00			SALB
413	Minimum thickness of maximum layer (m)										.00			SALB
414	Initial layer splitting thickness (cm)													SALB
415	Minimum soil profile thickness (cm)													SALB
416	Initial soil water content fraction of field capacity													SALB
417	Minimum depth to water table (m)													SALB
418	Maximum depth to water table (m)													SALB
419	Internal depth to water table (m)													SALB
4110	Soil weathering code													SALB
4111	Time for sub-surface flow (travel time/d)	.010	.860	1.600	6.27	5.92	5.45	5.13	4.64	4.24	4.33	4.82	4.85	UAVM(-12)
421	Depth from the surface to the bottom of the soil layer (m)	1.270	1.270	1.350	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	BD1(-10)
431	Bulk density of the soil layer (t/m ³)	1.270	1.270	1.350	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	BD1(-10)
441	Willing Point (1500 kPa) (t/m ³)	.480	.480	.480	.480	.480	.480	.480	.480	.480	.480	.480	.480	U(-10)
451	Field capacity (1500 kPa) (t/m ³)	.480	.480	.480	.480	.480	.480	.480	.480	.480	.480	.480	.480	FCC(-10)
461	Sand content (%)	5.5	5.5	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	SANR(-10)
471	Silt content (%)	47.0	47.0	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	SILT(-10)
481	Organic N concentration (g/l) [PPM]	8.47	8.47	5.96	8.47	8.47	8.47	8.47	8.47	8.47	8.47	8.47	8.47	WNO(-10)
491	Soil pH	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	PH(-10)
501	Sum of bases (centMol/g)													SM0B(-10)
511	Organic carbon (%)	.51	.42											CBRN(-10)
521	Cation exchange capacity (centMol/kg)													CACE(-10)
531	Coarse Fragment content (%) soil													CEC(-10)
541	Initial Nitrate concentration (g/l) [PPM]	5	5	5	5	5	5	5	5	5	5	5	5	ROK(-10)
551	Labile P concentration (g/l) [PPM]	6	6	6	6	6	6	6	6	6	6	6	6	WNOX(-10)
561	Crop residue (t/ha)													OK(-10)
571	Bulk density (oven dry) (t/m ³)	1.70	1.70	1.75										RSD(-10)
581	Phosphorus sorption ratio													BDD(-10)
591	Saturated conductivity (mm/h)													PSR(-10)
601	Fraction of storage interacting with NO ₃ leaching	.15	.15	.14										SC(-10)
611	Organic P concentration (g/l) [PPM]	0	0	0										STPR(-10)
621	Crop rotation duration (yr)	140	140											WR(-10)
631	Rigid or variable tillage													NRO
632	Irrigation code													NIRR
633														JRR

6.3 Management Information-Irrigation Fertilizer/Tillage Schedule
 One line for each operation and one section for each year of rotation

MOON	DAY	COD	CRPGGRZ	MAAT	PHU	CND	WSF	FAP	FDP	LA	PAR	QVOL	IRI	FIA	LM	FPD	IDR	IDFT	BIR	EFT	VIMX	ARMN	ARMX	BFT	ENP	PMX	DRT	EDSF
1	26	15																										
2	1	27	80	91.44																								
3	1	17	15	16																								
4	1	19	80	91.44																								
5	1	23	72	67	350.00																							
6	1	19	72	67	350.00																							
7	1	19	72	67	350.00																							
8	1	19	72	67	350.00																							
9	1	19	72	67	350.00																							
10	1	19	72	67	350.00																							
11	1	19	72	67	350.00																							
12	1	19	72	67	350.00																							

Minimum application interval for automatic irrigation (di)
 Minimum fertilizer application interval for automatic fertilizer (di)
 Irrigation code
 Fertilizer code
 Automatic fertilizer or fertigation fertilizer file
 Water stress factor to trigger automatic irrigation
 Irrigation runoff ratio
 Maximum annual irrigation volume allowed for each crop (mm)
 Maximum annual irrigation volume automatic irrigation (mm)
 Maximum single application volume automatic irrigation (mm)
 Maximum single application volume automatic irrigation (mm)
 N stress factor to trigger automatic fertilizer
 Amount of fertilizer (kg/ha) per automatically scheduled application
 Maximum annual N fertilizer application for a crop (kg/ha)
 Time required for drainage system to reduce stress (di)
 Fraction of furrow dikes volume available for storage

MOON	DAY	COD	CRPGGRZ	MAAT	PHU	CND	WSF	FAP	FDP	LA	PAR	QVOL
1	26	15										
2	1	27	80	91.44								
3	1	17	15	16								
4	1	19	80	91.44								
5	1	23	72	67	350.00							
6	1	19	72	67	350.00							
7	1	19	72	67	350.00							
8	1	19	72	67	350.00							
9	1	19	72	67	350.00							
10	1	19	72	67	350.00							
11	1	19	72	67	350.00							
12	1	19	72	67	350.00							

MOON = Month of the operation
 DAY = Day of the operation
 COD = Operation/Tillage code number
 CRPGGRZ = Crop identification number OR Grazing
 MAAT = Years necessary to mature or year until harvest (For trees only)
 PHU = Potential Heat Units
 CND = Rainoff curve number after this operation
 WSP = Plant water stress factor
 FAP = Fraction of original plant population
 FDP = Maximum annual nitrogen fertilizer applied to a crop
 LA = Time of this operation as a fraction of the growing season or of the year if no crop is growing using ITC as the base temperature
 PAR = Fertilizer ID number applied
 QVOL = Fertilizer application rate (kg/ha-% moisture)
 IRI = Depth of fertilizer placement (mm)
 FIA = Irrigation volume (mm)
 LM = Rainoff (VOL/VOL) of irrigation water applied
 FPD = Residue ID number
 IDR = Pest control factor (fraction)
 IDFT = Pest control factor (fraction)
 BIR = Pesticide application rate (kg/ha or lbs/ac of active ingredient)
 EFT = Pesticide application rate (kg/ha or lbs/ac of active ingredient)
 VIMX = Pesticide application rate (kg/ha or lbs/ac of active ingredient)
 ARMN = Pesticide application rate (kg/ha or lbs/ac of active ingredient)
 ARMX = Pesticide application rate (kg/ha or lbs/ac of active ingredient)
 BFT = Pesticide application rate (kg/ha or lbs/ac of active ingredient)
 ENP = Pesticide application rate (kg/ha or lbs/ac of active ingredient)
 PMX = Pesticide application rate (kg/ha or lbs/ac of active ingredient)
 DRT = Pesticide application rate (kg/ha or lbs/ac of active ingredient)
 EDSF = Pesticide application rate (kg/ha or lbs/ac of active ingredient)

EPIC5300 DATA ASSEMBLY FORM

Line #	Description	Value	Unit	Code	Code
1.1	Arroyo Colorado Project - Dryland Demonstration Site 12-28-29oct97				
2.1	border - Gran Sorphism/Colom, Hidalgo Silty Clay Loam (BMP Site) 96-97				
3.1	Wca. 9 TX BROWNSVILLEW4, 9 TX BROWNSVILLE W				
4.1	Number of years of simulation	2			
4.2	Starting date - Year	1996			
4.3	Month	1			
4.4	Day	1			
4.5	Printout interval	1			
4.6	Output print code	0			
4.7	Weather code	6			
4.8	Number of times generator cycles	12			
4.9	Day weather generator stops generating same weather	0			
4.10	Leap Year considered	0			
4.11	Potential evaporation method code	0			
4.12	Curve number estimator (0=soilabatic, 20=grid)	4			
4.13	Graph Display (0=off, 1=on)	1			
4.14	Output conversion code	0			
4.15	Peak rate estimate code	0			
4.16	Static soil code	0			
4.17	Automatic heat unit scheduling	0			
4.18	Number of cows	0			
4.19	Non-varying C _{N2} -C _{N2} used for all farms	0			
4.20	Rumoff (Q) estimation methodology	0			
4.21	Pesticide Output in Mass and/or Cmc	0			
5.1	Watershed drainage area (ha)	0			
5.2	Rumoff curve number	0			
5.3	Channel Length (Km)	6.07			
5.4	Average channel slope (m/m)	72.0			
5.5	Channel roughness factor (Manning's N)	35			
5.6	Surface roughness factor (Manning's N)	0.0075			
5.7	Peak runoff rate rainfall-energy adjustment factor	0.990			
5.8	Latitude of watershed (degrees)	1.0			
5.9	Average elevation of watershed (m)	26.27			
5.10	Water content of snow on ground at start of simulation (mm)	0			
6.1	Average concentration of nitrogen in rainfall (g m ³) [PPM]	8			
6.2	Number of years of cultivation before simulation starts (yr.)	0			
6.3	CO ₂ concentration in atmosphere [PPM]	330.0			
6.4	NO ₃ concentration in irrigation water [PPM]	1			
6.5	CSALT salt concentration in irrigation water [PPM]	9640.0			
6.6	CHD (Channel) depth (m)	1.52			
6.7	Drainage Area of a watershed feeding a Lagoon (ha)	0.08			
6.8	Normal Lagoon Volume (mm)	0.00			
6.9	Maximum Lagoon Volume (mm)	0.00			
6.10	Lagoon input from wash water (in /ac/wday)	348.4			
7.1	Slope length (m)	0.0075			
7.2	Slope steepness (m/m)	1.08			
7.3	Erosion control practice	3.00			
7.4	Water erosion equation				
7.5	Parameter estimates for MUSLE erosion equation				
8.3	Number of years of max monthly 0.5 hour rainfall record	8.0			YWI
8.4	Coefficient used to establish wet-dry probability	0			ETA
8.5	Parameter used to modify exp rain distribution	0			EXPK
9.1	Average monthly maximum air temperature (°C)	20.60			OBAX(1-12)
10.1	Average monthly minimum air temperature (°C)	9.30			OBAM(1-12)
11.1	Monthly standard deviation maximum air temperature (°C)	6.70			SDTMMX(1-12)
12.1	Monthly standard deviation minimum air temperature (°C)	6.80			SDTMNI(1-12)
13.1	Average monthly precipitation (mm)	35.2			RM0(1-12)

141	Monthly standard deviation of daily precipitation (mm)	7.9	16.0	8.5	27.2	19.5	16.2	12.6	17.4	21.0	14.9	10.7	8.5	RSTZ(-12)
141	Monthly skew coefficient for daily precipitation	4.58	7.54	3.45	6.07	3.36	2.41	4.54	3.64	3.10	2.74	2.70	4.08	RSTZ(-12)
151	Monthly probability of wet day after dry day	1.71	1.45	1.07	1.03	1.32	1.40	1.17	1.38	2.21	1.48	1.42	1.51	PRM(-12)
161	Monthly probability of wet day after wet day	.508	.506	.365	.400	.364	.498	.417	.483	.541	.457	.440	.490	PRW(-12)
171	Average number of days of rain per month	8.00	6.40	4.50	4.40	5.30	6.20	5.20	6.50	9.70	6.40	6.10	7.10	DAYM(-12)
181	Monthly maximum 0.5-hour-rainfall for period of record (TP<24) (mm)	8.4	18.3	3.3	40.9	25.7	36.1	25.7	44.5	31.5	58.2	21.1	20.8	WM(-12)
201	Monthly average daily solar radiation (MJ/m ² or ft ²)	296	341	403	456	564	610	626	588	475	411	296	263	OBSL(-12)
211	Monthly average relative humidity (fraction)	76	75	72	72	74	73	72	71	73	73	76	75	RH(-12)
221	Field length (km)										35			FL
222	Clockwise angle of field from north (deg)										17			FW
223	Shading dead crop residue (t/ha)										355.00			ANG
234	Power of modified exponential distribution of wind speed										.00			STD
231	Climate factor										.30			UXP
232											380			DIAM
241	Average monthly wind velocity (m/s)	5.24	5.51	5.97	6.27	5.92	5.45	5.13	4.64	4.24	4.33	4.82	4.85	UAVM(-12)
241	N wind during each month (%)	9.0	9.0	6.0	4.0	2.0	1.0	0	2.0	5.0	7.0	8.0	9.0	DIR1(-12)
241	NE wind during each month (%)	4.0	4.0	4.0	3.0	1.0	1.0	1.0	1.0	4.0	4.0	4.0	3.0	DIR2(-12)
261	ENE wind during each month (%)	3.0	5.0	5.0	4.0	3.0	2.0	1.0	3.0	8.0	7.0	4.0	4.0	DIR3(-12)
271	E wind during each month (%)	3.0	4.0	5.0	4.0	4.0	4.0	3.0	3.0	7.0	5.0	3.0	3.0	DIR4(-12)
281	ESE wind during each month (%)	2.0	4.0	5.0	4.0	4.0	4.0	3.0	5.0	8.0	8.0	4.0	4.0	DIR5(-12)
291	ESE wind during each month (%)	3.0	5.0	7.0	8.0	7.0	7.0	5.0	8.0	9.0	8.0	6.0	5.0	DIR6(-12)
301	SE wind during each month (%)	5.0	7.0	10.0	13.0	16.0	16.0	12.0	14.0	13.0	11.0	6.0	11.0	DIR7(-12)
311	SE wind during each month (%)	13.0	15.0	19.0	26.0	34.0	36.0	35.0	29.0	16.0	17.0	12.0	11.0	DIR8(-12)
321	SSE wind during each month (%)	17.0	17.0	20.0	22.0	20.0	22.0	31.0	23.0	11.0	11.0	15.0	14.0	DIR9(-12)
331	SSE wind during each month (%)	10.0	9.0	9.0	7.0	5.0	6.0	6.0	6.0	6.0	5.0	10.0	12.0	DIR10(-12)
341	SSW wind during each month (%)	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	DIR11(-12)
341	SW wind during each month (%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	DIR12(-12)
361	WSW wind during each month (%)	1.0	1.0	1.0	1.0	0	0	0	0	1.0	1.0	1.0	1.0	DIR13(-12)
371	W wind during each month (%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	DIR14(-12)
381	WSW wind during each month (%)	3.0	2.0	1.0	1.0	1.0	1.0	0	0	1.0	2.0	3.0	3.0	DIR14(-12)
391	NW wind during each month (%)	10.0	8.0	4.0	2.0	2.0	2.0	1.0	1.0	8.0	8.0	11.0	11.0	DIR15(-12)
401	NNW wind during each month (%)	15.0	10.0	6.0	3.0	2.0	2.0	0	2.0	7.0	9.0	13.0	15.0	DIR16(-12)
411	Soil albedo										.02			SALB
412	Maximum number of soil layers										.00			TSLA
413	Minimum thickness of maximum layer (m)										.00			ZOT
414	Initial layer splitting thickness (cm)										50			ZFC
415	Minimum soil profile thickness (cm)										1.60			WTM
416	Initial soil water content fraction of field capacity										4.57			WTM
417	Minimum depth to water table (m)										4.27			WTBL
418	Maximum depth to water table (m)										0			XHDS
419	Initial depth to water table (m)										0			RFTT
4110	Soil weathering scale										0			RFTT
4111	Time for soil surface flow gravel tunnel													ZL(-10)
421	Depth from the surface to the bottom of the soil layer (m)	0.0	4.30	7.0	2.030									BIX(-10)
431	Bulk density of the soil layer (t/m ³)	1.40	1.430	1.580	1.600									LIC(-10)
441	Wilting point (1500 kPa) (mm)	1.70	1.70	1.90	1.90									LIC(-10)
451	Field capacity (18kPa) (mm)	3.0	3.0	3.0	3.0									LIC(-10)
461	Sand content (%)	57.0	57.0	55.5	54.9									SANM(-10)
471	Silt content (%)	18.0	18.0	17.5	17.1									SILT(-10)
481	Organic N concentration (g/t) [PPM]	8.2	8.2	8.2	8.2									WSNL(-10)
491	Soil pH													PH(-10)
501	Sum of bases (cmol/kg)	63	42	42	42									SMBI(-10)
511	Organic carbon (%)													CBNI(-10)
521	Calcium carbonate (g/t)													CACI(-10)
531	Cation exchange capacity (cmol/kg)	1.4	1.4	1.3	5.4									CCECI(-10)
541	Cation exchange capacity (% vol)	1	9	9	7									WNOKI(-10)
551	Initial Nitrate concentration (g/t) [PPM]	160	191											ON(-10)
561	Labile P concentration (g/t) [PPM]													KSIX(-10)
571	Crop residue (t/ha)													BODI(-10)
581	Bulk density (oven dry) (t/m ³)	1.57	1.57	1.72	1.75									PSPI(-10)
591	Phosphorus sorption rate													SC(-10)
601	Saturated conductivity (mm/hr)	11.76	11.76	5.93	4.57									STTR(-10)
611	Fraction of storage increasing with NO ₃ leaching	0	0	0	0									WPI(-10)
621	Organic P concentration (g/t) [PPM]	98	149	85										NKO
631	Crop rotation duration (yr)													NIR
632	Regid or variable irrigation													IRK
633	Irrigation code													

FIG5300 DATA ASSEMBLY FORM

Line	Description	Value	Unit	Code	Code
1.1	Arroyo Colorado Project - Drip-Irrigation Demonstration Site (L-5) 29c-07				
1.1	County - Grant Sarghoun County, Hidalgo, Siba, Clay, Leona, (Control Site) 96-97				
1.1	Well 9 - TX BROWN SVLLEW 9 TX BROWN SVLLEW				
4.1	Number of Years of Simulation	2			TITLE(1)
4.2	Starting Date - Year	1996			TITLE(2)
4.3	Month	1			TITLE(3)
4.4	Day	1			NBYR
4.5	Printout interval	0			IVR
4.6	Output print code	6			IMO
1.7	Weather code	12			IDA
1.8	Number of times per year cycles	0			NIPD
1.9	Day weather generator steps/generating sun weather	0			IPD
1.10	Leap year sun period	0			NGN
1.11	Regional evaporation method code	0			IGN
1.12	Curve number estimation for subbasin - at graph	0			IGSD
1.13	Graph Display (0=off, 1=on)	0			LPYR
1.14	Output conversion code	4			IEL
1.15	Peak rate estimate code	0			ICSN
1.16	Static soil code	1			ICRAF
1.17	Automatic heat unit scheduling	1			ICODF
1.18	Number of cows	0			ITYP
1.19	Non-carrying CN - CN2 used for all storms	0			ISTA
1.20	Humid (H) estimation methodology	0			IHDJ
1.21	Residue Output in Stress and/or Croc	0			NGOW
1.22	Watershed drainage area (ha)	0			NVCN
5.1	Curve number	0			INHL
5.2	Channel Length (km)	6.07			MASP
5.3	Average channel slope (m/m)	70.0			WSA
5.4	Channel roughness factor/managing %N	35			CN2
5.5	Channel roughness factor/managing %N	.0013			CHL
5.6	Surface roughness factor/managing %N	.0980			CHS
5.7	Peak runoff rate rainfall energy adjustment factor	.0980			CHN
5.8	Latitude of watershed (degrees)	0			SN
5.9	Longitude of watershed (degrees)	26.27			APM
6.0	Average elevation of watershed (m)	7.0			YLT
6.1	Water content of soil on ground at start of simulation (mm)	0			ELEV
6.2	Average concentration of nitrogen in rainfall (g/m) (PPM)	8			SNO
6.3	Number of years of cultivation before simulation starts (Y)	50.0			RCN
6.4	CO2 concentration in atmosphere (PPM)	330.0			RTN
6.5	NO3 concentration in irrigation water (PPM)	1			CO2
6.6	CSALT concentration in irrigation water (PPM)	960.0			CSALT
6.7	CHY Channel depth (m)	1.52			CHD
6.8	Drainage Area of a watershed feeding a Lagoon (ha)	.000			DALG
6.9	Normal Lagoon Volume (mm)	.000			VILGM
6.10	Maximum Lagoon Volume (mm)	.000			COWM
7.1	Lagoon input from each water (m flow/ha/yr)	348.4			SL
7.2	Slope length (m)	.0013			S
7.3	Slope steepness (m/m)	1.00			PEC
7.4	Erosion control practice	3			DRV
7.5	Water erosion equation				BUS(1)
7.6	Parameter estimates for AHSI erosion equation				BUS(2)
8.1	Number of years of max monthly 0-5 hour rainfall record	8.0			BUS(3)
8.2	Coefficient used to establish wet-dry probabilities	.0			BUS(4)
8.3	Parameter used to modify exp rain distribution	.0			YWF
8.4		100.0			BTA
8.5		100.0			EXPK

Line	Description	Value	Unit	Code	Code
9.1	Average monthly maximum air temperature (°C)	20.60			OBMX(1-12)
10.1	Average monthly minimum air temperature (°C)	9.30			OBMNI(1-12)
11.1	Monthly standard deviation maximum air temperature (°C)	6.70			SDTMX(1-12)
12.1	Monthly standard deviation minimum air temperature (°C)	6.00			SDTMNI(1-12)
13.1	Average monthly precipitation (mm)	35.2			RRMO(1-12)
14.1	Monthly standard deviation of daily precipitation (mm)	7.9			RSTD(1-12)
15.1	Monthly skew coefficient for daily precipitation	1.58			RSTI(1-12)

161	Monthly probability of wet day after dry day	171	145	107	103	132	130	117	188	221	148	142	151	PRW(1-12)
171	Monthly probability of wet day after wet day	508	506	365	400	364	498	417	483	541	437	440	490	PRW2(1-12)
181	Average number of days of rain per month	8.00	6.40	4.50	4.40	5.30	6.20	5.30	6.50	9.70	6.40	6.10	7.10	DAVW(1-12)
191	Monthly maximum 0.5 hour rainfall for period of record (1924)(mm)	8.4	18.3	3.3	40.9	25.7	36.1	25.7	44.5	31.5	58.2	21.1	20.8	W(1-12)
201	Monthly average daily solar radiation (MJ/m ² or ly)	296	341	303	456	564	610	626	568	475	411	296	263	OBSL(1-12)
211	Monthly average relative humidity (fraction)	76	75	72	72	74	73	72	71	73	73	76	75	RH(1-12)
221	Field length (km)													FL
222	Field width (km)													FW
223	Checkbase angle of field from north (deg)													ANG
224	Standing dead crop residue (t/ha)													STD
231	Power of modified exponential distribution of wind speed													CXP
232	Climate factor													D/AM
241	Average monthly wind velocity (m/s)	5.24	5.51	5.97	6.27	5.92	5.45	5.13	4.64	4.24	4.33	4.82	4.85	UAVM(1-12)
251	N wind during each month (%)	9.0	9.0	6.0	4.0	2.0	1.0	0	2.0	5.0	7.0	8.0	9.0	DIR1(1-12)
261	NNE wind during each month (%)	4.0	4.0	4.0	3.0	2.0	1.0	1.0	1.0	4.0	4.0	4.0	3.0	DIR2(1-12)
271	NW wind during each month (%)	5.0	5.0	5.0	4.0	3.0	2.0	1.0	3.0	8.0	7.0	4.0	3.0	DIR3(1-12)
281	ENE wind during each month (%)	2.0	4.0	5.0	4.0	4.0	3.0	2.0	1.0	7.0	5.0	3.0	3.0	DIR4(1-12)
291	E wind during each month (%)	3.0	5.0	7.0	8.0	7.0	7.0	5.0	8.0	9.0	8.0	4.0	3.0	DIR5(1-12)
301	ESE wind during each month (%)	5.0	7.0	10.0	13.0	16.0	16.0	12.0	14.0	13.0	11.0	6.0	5.0	DIR6(1-12)
311	SE wind during each month (%)	13.0	15.0	19.0	26.0	34.0	36.0	35.0	29.0	16.0	17.0	11.0	14.0	DIR7(1-12)
321	SSE wind during each month (%)	17.0	17.0	20.0	22.0	20.0	22.0	31.0	21.0	11.0	11.0	13.0	15.0	DIR8(1-12)
331	S wind during each month (%)	10.0	9.0	9.0	7.0	5.0	6.0	11.0	10.0	6.0	5.0	10.0	12.0	DIR9(1-12)
341	SSW wind during each month (%)	2.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	3.0	DIR10(1-12)
351	SW wind during each month (%)	1.0	1.0	1.0	1.0	0	0	0	1.0	1.0	1.0	2.0	2.0	DIR11(1-12)
361	WSW wind during each month (%)	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	1.0	2.0	2.0	DIR12(1-12)
371	W wind during each month (%)	1.0	1.0	1.0	1.0	1.0	1.0	0	1.0	1.0	1.0	2.0	3.0	DIR13(1-12)
381	WNW wind during each month (%)	3.0	2.0	1.0	1.0	1.0	1.0	0	1.0	2.0	2.0	3.0	3.0	DIR14(1-12)
391	NW wind during each month (%)	10.0	8.0	4.0	2.0	2.0	1.0	0	2.0	8.0	8.0	11.0	11.0	DIR15(1-12)
401	NNW wind during each month (%)	15.0	10.0	6.0	3.0	2.0	1.0	0	2.0	7.0	9.0	13.0	15.0	DIR16(1-12)
411	Soil albedo													SALB
412	Maximum number of soil layers													TSLA
413	Minimum thickness of bottom layer (cm)													ZOT
414	Initial layer splitting thickness (cm)													ZTK
415	Minimum soil profile thickness (cm)													ZFC
416	Minimum soil water content fraction of field capacity													FWC
417	Minimum depth to water table (m)													WTRN
418	Maximum depth to water table (m)													WTRX
419	Initial depth to water table (m)													WTBL
4110	Soil weathering code													XIDS
4111	Time for sub-surface flow travel time(d)													REFTT
421	Depth from the surface to the bottom of the soil layer (m)	0.00	0.66	0.90	1.30	1.980								Z1(10)
431	Bulk density of the soil layer (t/m ³)	1.340	1.340	1.490	1.510									BDM1-10)
441	Wilting point (3000 KPa) (m/m)	2.00	2.00	2.50	2.50									LQ1-10)
451	Field capacity (3000 KPa) (m/m)	4.10	4.10	4.10	3.90									FC1-10)
461	Sand content (%)	30.4	30.4	29.2	29.2									SSAN1-10)
471	Silt content (%)	32.6	32.6	31.3	31.3									SILC1-10)
481	Organic N concentration (g/t) (PPM)	501	506	501	422									WN1-10)
491	Soil pH	8.2	8.2	8.2	8.2									PH1-10)
501	Sum of bases (cmol/kg)	0.68	0.39	0.30	0.32									SNBR1-10)
511	Organic carbon (%)													CHNC1-10)
521	Cation exchange capacity (cmol/kg)													CAC1-10)
531	Cation exchange capacity (cmol/kg)													CEC1-10)
541	Cation exchange content (% vol)													ROK1-10)
551	Initial Nitrate concentration (g/t) (PPM)	211	200	14	12									WNO1-10)
561	Labile P concentration (g/t) (PPM)	1.57	1.57	1.72	1.74									O1-10)
571	Crop residue (t/ha)													RS1X1-10)
581	Bank density (oven dry) (t/m ³)													BDD1-10)
591	Phosphorus sorption ratio													ESP1-10)
601	Saturated conductivity (cm/hr)	2.81	2.81	1.28	1.15									SC1-10)
611	Fraction of storage interacting with NO3 leaching													STRK1-10)
621	Organic P concentration (g/t) (PPM)													WPL-10)
631	Crop rotation duration (yr)													NRO
632	Rigid or variable irrigation													NRR
633	Irrigation code													IRR
634	Minimum application interval for automatic irrigation (d)													IRI
635	Minimum fertilizer application interval for automatic fertilizer (d)													IJA

APPENDIX G

Results of EPIC Sensitivity Analysis

PIC Variable DRT, Days Required for Drainage to Reduce Plant Stress

HHI Hyd	PICQ	Q	SSF mm	PRK mm	QDRN mm	IRCA mm	ET mm	YDN kg/ha	YNO3 kg/ha	SSFN kg/ha	PRKN kg/ha	DRNN kg/ha	FN03 kg/ha	FNH3 kg/ha	YP kg/ha	YAP kg/ha	PRKP kg/ha	MOSS t/ha	YW t/ha	UN03 kg/ha	UPP kg/ha	DN kg/ha	GRSG t/ha	COTP t/ha
0.2	762 80	193 85	327 11	1 10	223 39	320 04	740 33	13 96	3 88	27 25	0 12	25 61	28 32	84 00	3 38	0 03	0 00	15 50	5 52	381 93	62 31	16 90	5 51	2 33
0.5	762 80	193 86	225 29	2 72	222 04	320 04	740 47	13 96	3 88	27 03	0 30	25 47	28 32	84 00	3 38	0 03	0 01	15 51	5 52	381 97	62 29	16 91	5 51	2 33
1	762 80	193 90	222 21	5 38	219 63	320 04	740 79	13 95	3 88	26 66	0 59	25 25	28 32	84 00	3 38	0 03	0 01	15 51	5 50	381 74	62 25	16 92	5 51	2 33
1.5	762 80	193 92	219 27	8 00	217 44	320 04	741 05	13 97	3 88	26 31	0 86	25 01	28 32	84 00	3 38	0 03	0 02	15 52	5 52	381 62	62 22	16 94	5 50	2 33
2	762 80	193 94	216 53	10 55	215 04	320 04	741 18	14 00	3 88	25 98	1 27	24 77	28 32	84 00	3 39	0 03	0 03	15 52	5 58	381 47	62 17	16 95	5 50	2 33
2.5	762 80	193 96	213 91	13 05	212 67	320 04	741 22	14 09	3 88	25 67	1 57	24 54	28 32	84 00	3 41	0 03	0 03	15 52	5 72	381 28	62 13	16 96	5 50	2 33
3	762 80	193 97	211 40	15 48	210 33	320 04	741 22	14 20	3 88	25 37	1 86	24 31	28 32	84 00	3 44	0 03	0 04	15 53	5 89	381 10	62 08	16 97	5 49	2 32
3.5	762 80	193 99	208 97	17 87	208 03	320 04	741 17	14 27	3 88	25 08	2 14	24 09	28 32	84 00	3 46	0 03	0 05	15 53	5 99	380 90	62 04	16 98	5 49	2 32
4	762 80	194 00	206 51	20 28	205 78	320 04	741 11	14 32	3 88	24 79	2 42	23 87	28 32	84 00	3 47	0 03	0 05	15 53	6 07	380 69	61 99	16 99	5 49	2 32
4.5	762 80	194 01	204 32	22 48	203 57	320 04	741 02	14 31	3 88	24 52	2 70	23 55	28 32	84 00	3 47	0 03	0 06	15 54	6 05	380 48	61 94	17 01	5 48	2 32
5	762 80	194 02	202 08	24 71	201 40	320 04	740 91	14 30	3 88	24 25	2 97	23 43	28 32	84 00	3 46	0 03	0 06	15 54	6 04	380 25	61 89	17 02	5 48	2 32
5.5	762 80	194 04	199 90	26 89	199 27	320 04	740 80	14 30	3 88	23 99	3 23	23 22	28 32	84 00	3 46	0 03	0 07	15 54	6 03	380 03	61 84	17 03	5 48	2 32
6	762 80	194 05	197 77	29 03	197 19	320 04	740 68	14 29	3 88	23 73	3 48	23 01	28 32	84 00	3 46	0 03	0 08	15 55	6 02	379 80	61 79	17 05	5 47	2 31
6.5	762 80	194 06	195 63	31 13	195 15	320 04	740 56	14 29	3 88	23 48	3 74	22 81	28 32	84 00	3 45	0 03	0 08	15 55	6 01	379 58	61 74	17 06	5 47	2 31
7	762 80	194 07	193 56	33 18	193 15	320 04	740 43	14 28	3 88	23 24	3 98	22 61	28 32	84 00	3 46	0 03	0 09	15 55	6 01	379 35	61 69	17 07	5 47	2 31
7.5	762 80	194 08	191 67	35 19	191 19	320 04	740 29	14 28	3 88	23 00	4 22	22 41	28 32	84 00	3 46	0 03	0 09	15 55	6 01	379 14	61 64	17 09	5 46	2 31
8	762 80	194 09	189 72	37 16	189 28	320 04	740 16	14 29	3 88	22 77	4 46	22 21	28 32	84 00	3 46	0 03	0 10	15 56	6 00	378 91	61 60	17 10	5 46	2 31
8.5	762 80	194 10	187 81	39 09	187 39	320 04	740 02	14 29	3 88	22 54	4 69	22 02	28 32	84 00	3 46	0 03	0 10	15 56	6 00	378 70	61 55	17 11	5 46	2 30
9	762 80	194 11	185 94	40 98	185 55	320 04	739 89	14 30	3 88	22 31	4 92	21 83	28 32	84 00	3 46	0 03	0 11	15 56	6 00	378 47	61 50	17 12	5 45	2 30

Description of Variables:
 CN2: Runoff curve number, antecedent moisture condition 2
 COTP: Crop yield for picker cotton (t/ha)
 DN: N loss by denitrification (kg/ha)
 DRNN: Mineral N loss in subsurface drain flow (kg/ha)
 DRT: Drain time, days required for drainage to reduce plant stress (days)
 ETP: Evapotranspiration (mm)
 FNH3: Fertilizer N applied in the form NH3-N (kg/ha)
 FNO3: Fertilizer N applied in the form NO3-N (kg/ha)
 GRSG: Crop yield for grain sorghum (t/ha)
 IRCA: Irrigation water applied (mm)
 MOSS: Soil loss from water erosion using a modified MUSLE option for small watersheds
 PRK: Precipitation (mm)
 PRKN: Mineral N loss in percolate (kg/ha)
 PRKP: Percolation of P below the root zone (kg/ha)
 Q: Runoff (mm)
 QDRN: Subsurface drain flow (mm)
 SSFN: Lateral subsurface flow (mm)
 SSFN: Mineral N loss in subsurface flow (kg/ha)
 UN03: N uptake by the crop (kg/ha)
 UPP: Initial nitrate concentration in the soil (ppm)
 YAP: Soluble P loss in runoff (kg/ha)
 YDN: NO3 loss in surface runoff (kg/ha)
 YNO3: Organic N loss with sediment (kg/ha)
 YW: P loss with sediment (kg/ha)
 YW: Soil loss from wind erosion (t/ha)

EPIC Variable DRT, Days Required for Drainage to Reduce Plant Stress % Change

DRT	PRCP	Q	SSF	PRK	GDPM	HGA	ET	YON	YNO3	SSM	PRM	DRM	FN03	FMB3	YP	YAP	PRP	MUSS	YW	UN03	UPP	DN	GRSG	COTP
-94%	0.0%	-0.1%	8.7%	-93.9%	7.4%	0.0%	-0.1%	-2.2%	-0.1%	8.7%	-94.4%	6.3%	0.0%	0.0%	-2.2%	-0.1%	-93.8%	-0.2%	-7.9%	0.3%	0.4%	-0.5%	0.4%	0.3%
-86%	0.0%	-0.1%	7.8%	-84.8%	6.7%	0.0%	-0.1%	-2.2%	-0.1%	7.8%	-86.0%	5.7%	0.0%	0.0%	-2.2%	-0.1%	-84.8%	-0.2%	-7.9%	0.3%	0.4%	-0.4%	0.4%	0.3%
-71%	0.0%	0.0%	6.3%	-69.8%	5.7%	0.0%	-0.1%	-2.2%	0.0%	6.3%	-72.9%	4.8%	0.0%	0.0%	-2.2%	0.0%	-69.9%	-0.1%	-8.2%	0.2%	0.4%	-0.3%	0.3%	0.2%
-57%	0.0%	0.0%	4.9%	-55.2%	4.5%	0.0%	0.0%	-2.1%	0.0%	4.9%	-55.2%	3.8%	0.0%	0.0%	0.0%	0.0%	-55.1%	-0.1%	-7.9%	0.2%	0.3%	-0.2%	0.2%	0.2%
-43%	0.0%	0.0%	3.6%	-40.9%	3.4%	0.0%	0.0%	-1.8%	0.0%	3.6%	-40.9%	2.8%	0.0%	0.0%	-1.9%	0.0%	-41.0%	-0.1%	-6.9%	0.1%	0.2%	-0.2%	0.2%	0.2%
-29%	0.0%	0.0%	2.4%	-27.0%	2.2%	0.0%	0.0%	-1.2%	0.0%	2.4%	-27.0%	1.9%	0.0%	0.0%	-1.2%	0.0%	-26.9%	0.0%	-4.6%	0.1%	0.1%	-0.1%	0.1%	0.1%
-14%	0.0%	0.0%	1.2%	-13.3%	1.1%	0.0%	0.0%	-0.4%	0.0%	1.2%	-13.3%	0.9%	0.0%	0.0%	-0.5%	0.0%	-13.5%	0.0%	-1.7%	0.1%	0.1%	0.0%	0.1%	0.1%
0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
14%	0.0%	0.0%	-1.1%	13.0%	-1.1%	0.0%	0.0%	0.4%	0.0%	-1.1%	13.0%	-0.9%	0.0%	0.0%	0.4%	0.0%	13.0%	0.0%	1.4%	-0.1%	-0.1%	0.1%	-0.1%	-0.1%
29%	0.0%	0.0%	-2.2%	26.8%	-2.1%	0.0%	0.0%	0.3%	0.0%	-2.2%	26.8%	-1.8%	0.0%	0.0%	0.3%	0.0%	25.6%	0.0%	1.0%	-0.1%	-0.2%	0.2%	-0.1%	-0.1%
43%	0.0%	0.0%	-3.3%	38.3%	-3.2%	0.0%	0.0%	0.2%	0.0%	-3.3%	38.3%	-2.7%	0.0%	0.0%	0.2%	0.0%	38.2%	0.1%	0.8%	-0.2%	-0.2%	0.3%	-0.2%	-0.2%
57%	0.0%	0.0%	-4.5%	50.5%	-4.2%	0.0%	0.0%	0.2%	0.0%	-4.3%	50.5%	-3.6%	0.0%	0.0%	0.2%	0.0%	50.4%	0.1%	0.6%	-0.2%	-0.3%	0.3%	-0.2%	-0.3%
71%	0.0%	0.0%	-5.4%	62.5%	-5.2%	0.0%	0.0%	0.2%	0.0%	-5.4%	62.5%	-4.5%	0.0%	0.0%	0.2%	0.0%	62.4%	0.1%	0.5%	-0.3%	-0.4%	0.4%	-0.3%	-0.4%
86%	0.0%	0.0%	-6.4%	74.2%	-6.2%	0.0%	0.0%	0.2%	0.0%	-6.4%	74.2%	-5.3%	0.0%	0.0%	0.1%	0.0%	74.1%	0.1%	0.4%	-0.3%	-0.5%	0.5%	-0.4%	-0.4%
100%	0.0%	0.0%	-7.3%	85.7%	-7.2%	0.0%	0.0%	0.2%	0.0%	-7.3%	85.7%	-6.2%	0.0%	0.0%	0.1%	0.0%	85.5%	0.1%	0.3%	-0.4%	-0.6%	0.6%	-0.4%	-0.5%
114%	0.0%	0.0%	-8.3%	96.9%	-8.1%	0.0%	0.0%	0.2%	0.0%	-8.3%	96.9%	-7.0%	0.0%	0.0%	0.1%	0.0%	96.8%	0.2%	0.2%	-0.5%	-0.6%	0.6%	-0.5%	-0.6%
129%	0.0%	0.1%	-9.2%	108.0%	-9.0%	0.0%	0.0%	0.1%	0.2%	-9.2%	108.0%	-7.8%	0.0%	0.0%	0.1%	0.1%	107.7%	0.2%	0.2%	-0.5%	-0.7%	0.7%	-0.5%	-0.7%
143%	0.0%	0.1%	-10.1%	118.8%	-9.9%	0.0%	0.0%	0.2%	0.1%	-10.1%	118.8%	-8.6%	0.0%	0.0%	0.1%	0.1%	118.6%	0.2%	0.2%	-0.6%	-0.8%	0.8%	-0.6%	-0.8%
157%	0.0%	0.1%	-11.0%	129.3%	-10.8%	0.0%	0.0%	0.2%	0.1%	-11.0%	129.3%	-9.4%	0.0%	0.0%	0.1%	0.1%	129.1%	0.2%	0.2%	-0.6%	-0.9%	0.8%	-0.6%	-0.8%

PIC Variable WNO3, Initial Nitrate Concentration (ppm) In Soil Layers 1 - 3

WNO3 Layer	Q mm	SSF mm	PMK mm	QDRN mm	INGA mm	ET mm	YON kg/ha	YNO3 kg/ha	SSFN kg/ha	PRKN kg/ha	DRNN kg/ha	FINO3 kg/ha	FRH3 kg/ha	YP kg/ha	YAP kg/ha	PRKP kg/ha	MUSS t/ha	YW t/ha	UNO3 kg/ha	UPP kg/ha	DN t/ha	GRSG t/ha	COTP t/ha
1	762.80	193.98	208.96	17.87	208.02	320.04	741.13	12.98	3.88	1.43	16.65	28.32	84.00	3.24	0.03	0.05	14.88	5.79	350.60	61.69	13.57	5.39	2.32
2	762.80	193.98	208.96	17.87	208.02	320.04	741.13	13.07	3.88	1.61	19.12	28.32	84.00	3.32	0.03	0.05	14.88	5.87	350.60	61.69	13.57	5.39	2.32
3	762.80	193.98	208.96	17.87	208.02	320.04	741.13	13.68	3.88	1.81	21.52	28.32	84.00	3.41	0.03	0.05	15.30	5.95	365.61	61.91	15.21	5.45	2.32
4	762.80	193.99	208.97	17.87	208.03	320.04	741.17	14.05	3.88	2.09	24.09	28.32	84.00	3.46	0.03	0.05	15.53	5.99	380.90	62.04	16.98	5.49	2.32
5	762.80	193.99	208.97	17.87	208.03	320.04	741.21	14.27	3.88	2.14	24.09	28.32	84.00	3.46	0.03	0.05	15.61	6.01	391.65	62.10	18.75	5.51	2.32
6	762.80	193.99	208.94	17.86	208.01	320.04	741.21	14.38	3.88	2.16	26.65	28.32	84.00	3.48	0.03	0.05	15.62	6.02	399.19	62.13	20.51	5.52	2.32
7	762.80	193.98	208.75	17.85	207.81	320.04	741.43	14.44	3.88	2.22	29.14	28.32	84.00	3.48	0.04	0.05	15.82	6.02	407.08	62.56	22.31	5.53	2.32
8	762.80	193.97	208.63	17.84	207.69	320.04	741.56	14.50	3.88	2.28	31.77	28.32	84.00	3.49	0.04	0.05	15.63	6.02	407.08	62.56	22.31	5.53	2.32
9	762.80	193.97	208.58	17.83	207.64	320.04	741.62	14.57	3.88	2.32	34.51	28.32	84.00	3.50	0.04	0.05	15.66	6.03	415.13	62.94	24.13	5.53	2.32
10	762.80	193.97	208.57	17.83	207.63	320.04	741.63	14.66	3.88	2.31	37.19	28.32	84.00	3.51	0.04	0.05	15.69	6.04	423.19	63.05	26.02	5.53	2.32
11	762.80	193.97	208.57	17.83	207.63	320.04	741.64	14.74	3.88	2.31	39.87	28.32	84.00	3.52	0.04	0.05	15.73	6.04	431.24	63.05	27.89	5.53	2.32
12	762.80	193.97	208.57	17.83	207.63	320.04	741.64	14.81	3.88	2.32	42.56	28.32	84.00	3.53	0.04	0.05	15.75	6.05	439.30	63.05	29.76	5.53	2.32
13	762.80	193.97	208.57	17.83	207.63	320.04	741.64	14.88	3.88	2.32	45.25	28.32	84.00	3.53	0.04	0.05	15.78	6.05	447.36	63.05	31.63	5.53	2.32
14	762.80	193.97	208.57	17.83	207.63	320.04	741.64	14.90	3.88	2.32	48.00	28.32	84.00	3.53	0.04	0.05	15.78	6.05	449.48	63.05	33.51	5.53	2.32
15	762.80	193.97	208.57	17.83	207.63	320.04	741.64	14.90	3.88	2.32	50.32	28.32	84.00	3.53	0.04	0.05	15.78	6.05	449.48	63.05	35.39	5.53	2.32
16	762.80	193.97	208.57	17.83	207.63	320.04	741.64	14.90	3.88	2.32	52.17	28.32	84.00	3.53	0.04	0.05	15.78	6.05	449.48	63.05	37.26	5.53	2.32
17	762.80	193.97	208.57	17.83	207.63	320.04	741.64	14.90	3.88	2.32	54.00	28.32	84.00	3.53	0.04	0.05	15.78	6.05	449.48	63.05	39.13	5.53	2.32
18	762.80	193.97	208.57	17.83	207.63	320.04	741.64	14.90	3.88	2.32	55.88	28.32	84.00	3.53	0.04	0.05	15.78	6.05	449.48	63.05	41.00	5.53	2.32
19	762.80	193.97	208.57	17.83	207.63	320.04	741.64	14.90	3.88	2.32	57.76	28.32	84.00	3.53	0.04	0.05	15.78	6.05	449.48	63.05	42.87	5.53	2.32

- Description of Variables:
- CN2 Runoff curve number, antecedent moisture condition 2
 - COTP Crop yield for pucker cotton (t/ha)
 - DN N loss by denitrification (kg/ha)
 - DRNN Mineral N loss in subsurface drain flow (kg/ha)
 - DPRT Drain time, days required for drainage to reduce plant stress (days)
 - ET Evapotranspiration (mm)
 - FNH3 Fertilizer N applied in the form NH₃-N (kg/ha)
 - FN03 Fertilizer N applied in the form NO₃-N (kg/ha)
 - GRSG Crop yield for grain sorghum (t/ha)
 - IRGA Irrigation water applied (mm)
 - MUSS Soil loss from water erosion using a modified MUSLE option for small watersheds.
 - PRCP Precipitation (mm)
 - PRK Precipitation below the root zone (mm)
 - PRKN Mineral N loss in percolate (kg/ha)
 - PRKP Percolation of P below the root zone (kg/ha)
 - Q Runoff (mm)
 - QDRN Subsurface drain flow (mm)
 - SSF Lateral subsurface flow (mm)
 - SSFN Mineral N loss in subsurface flow (kg/ha)
 - SSN N uptake by the crop (kg/ha)
 - UPP P uptake by the crop (kg/ha)
 - WNO3 Initial nitrate concentration in the soil (ppm)
 - YAP Soluble P loss in runoff (kg/ha)
 - YNO3 NO₃ loss in surface runoff (kg/ha)
 - YON Organic N loss with sediment (kg/ha)
 - YP P loss with sediment (kg/ha)
 - YW Soil loss from wind erosion (t/ha)

EPIC Variable WNO3, Initial Nitrate Concentration (ppm) in Soil Layers 1 - 3
% Change

WNO3	PRCP	Q	SF5	PKK	QDN	IRGA	ET	YON	WNO3	SFN	PRN	DRN	FNO3	FH3	YP	YAP	PRP	MUS	YW	UND3	UPP	DN	GRS3	COTP
-88%	0.0%	0.0%	0.2%	0.2%	0.2%	0.0%	-0.1%	-10.5%	-33.3%	-53.9%	-53.9%	-53.9%	0.0%	0.0%	-10.1%	-16.5%	0.2%	-10.1%	-5.5%	20.9%	-3.4%	-52.4%	-8.1%	0.0%
-75%	0.0%	0.0%	0.2%	0.2%	0.2%	0.0%	-0.1%	-7.8%	-33.3%	-46.6%	-47.0%	0.0%	0.0%	7.1%	-11.0%	0.2%	-7.1%	-3.9%	-17.4%	-2.1%	-45.9%	-4.5%	0.0%	
-53%	0.0%	0.0%	0.2%	0.2%	0.2%	0.0%	-0.1%	-5.7%	-33.3%	-39.9%	-39.8%	0.0%	0.0%	4.9%	-5.5%	0.2%	-4.8%	-2.6%	-13.9%	-1.4%	-39.1%	-2.5%	0.0%	
-50%	0.0%	0.0%	0.2%	0.2%	0.2%	0.0%	-0.1%	-3.1%	-33.3%	-33.2%	-32.2%	0.0%	0.0%	-2.4%	-5.5%	0.2%	-2.1%	-1.3%	-10.2%	-1.0%	-31.8%	-1.3%	0.0%	
-38%	0.0%	0.0%	0.2%	0.2%	0.2%	0.0%	-0.1%	-1.6%	-33.3%	-19.9%	-24.2%	0.0%	0.0%	-1.0%	-5.5%	0.2%	-0.6%	-0.5%	-6.4%	-0.8%	-23.9%	-0.7%	0.0%	
-25%	0.0%	0.0%	0.2%	0.2%	0.2%	0.0%	0.0%	-0.9%	-33.3%	-13.2%	-13.2%	0.0%	0.0%	0.0%	-0.5%	0.2%	-0.1%	-0.3%	-3.8%	-0.7%	-15.9%	-0.3%	0.0%	
-13%	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	-0.4%	-33.3%	-6.6%	-6.6%	0.0%	0.0%	-0.3%	0.0%	0.0%	-0.1%	-0.1%	-1.9%	-0.7%	8.1%	0.0%	0.0%	
0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
13%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	13.3%	13.3%	8.6%	0.0%	0.0%	0.3%	5.5%	0.2%	0.2%	0.1%	2.0%	0.6%	8.2%	0.0%	0.0%	
25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	20.0%	20.0%	17.1%	0.0%	0.0%	0.6%	5.5%	0.2%	0.4%	0.2%	4.0%	0.8%	16.6%	0.0%	0.0%	
38%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.6%	26.6%	26.6%	25.5%	0.0%	0.0%	0.8%	5.5%	0.2%	0.6%	0.3%	5.9%	0.8%	25.0%	0.0%	0.0%	
50%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%	40.0%	33.3%	34.0%	0.0%	0.0%	1.0%	5.5%	0.2%	0.8%	0.4%	7.9%	0.8%	33.4%	0.0%	0.0%	
63%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	46.6%	46.6%	42.4%	0.0%	0.0%	1.1%	5.5%	0.2%	0.9%	0.5%	9.9%	0.8%	41.8%	0.0%	0.0%	
75%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	60.0%	60.0%	58.4%	0.0%	0.0%	1.1%	5.5%	0.2%	1.0%	0.5%	10.4%	0.8%	47.4%	0.0%	0.0%	
88%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	79.9%	79.9%	77.1%	0.0%	0.0%	1.2%	5.5%	0.2%	1.0%	0.5%	10.4%	0.8%	52.0%	0.0%	0.0%	
100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	99.9%	99.9%	95.7%	0.0%	0.0%	1.2%	5.5%	0.2%	1.0%	0.5%	10.4%	0.8%	56.7%	0.0%	0.0%	
113%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	119.9%	119.9%	114.3%	0.0%	0.0%	1.2%	5.5%	0.2%	1.0%	0.5%	10.4%	0.8%	61.3%	0.0%	0.0%	
125%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	139.9%	139.9%	133.0%	0.0%	0.0%	1.2%	5.5%	0.2%	1.0%	0.5%	10.4%	0.8%	65.9%	0.0%	0.0%	
138%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.7%	153.5%	153.5%	151.6%	0.0%	0.0%	1.2%	5.5%	0.2%	1.0%	0.5%	10.4%	0.8%	70.5%	0.0%	0.0%	

EPIC Variable CN2, Runoff Curve Number - Antecedent Moisture Condition 2

CN2	PRCP	Q	SSF	PRK	QDRN	IRGA	ET	YON	YNO3	SSRN	PRKN	DRNN	FN03	FNH3	YP	YAP	PRKP	MUSS	YW	UNCS	UPP	DN	GRSG	COTP
	mm	mm	mm	mm	mm	mm	mm	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
74	762.80	131.41	244.51	20.90	243.36	320.04	759.59	10.16	1.31	29.34	2.51	30.09	28.32	84.00	2.43	0.02	0.05	9.83	5.05	371.75	60.75	17.18	5.49	2.21
75	762.80	129.90	246.58	21.08	245.40	320.04	759.03	10.16	1.29	29.59	2.53	30.42	28.32	84.00	2.42	0.02	0.06	9.86	5.05	371.96	60.78	17.14	5.49	2.22
76	762.80	131.34	244.65	20.91	243.49	320.04	758.86	10.19	1.31	29.36	2.51	30.14	28.32	84.00	2.45	0.02	0.06	10.06	5.06	372.21	60.81	17.17	5.49	2.22
77	762.80	133.79	242.65	20.76	241.71	320.04	759.51	10.32	1.34	29.14	2.49	29.88	28.32	84.00	2.49	0.02	0.05	10.27	5.07	372.41	60.84	17.18	5.49	2.22
78	762.80	136.27	241.20	20.62	240.07	320.04	757.98	10.45	1.36	28.94	2.47	29.64	28.32	84.00	2.52	0.02	0.05	10.48	5.06	372.61	60.87	17.20	5.49	2.22
79	762.80	140.21	239.27	20.45	238.16	320.04	756.30	10.72	1.40	28.71	2.45	29.35	28.32	84.00	2.59	0.03	0.05	10.84	5.07	372.82	60.90	17.23	5.49	2.23
80	762.80	142.78	237.78	20.33	236.68	320.04	755.52	10.87	1.43	28.53	2.44	29.13	28.32	84.00	2.62	0.03	0.05	11.06	5.08	373.04	60.93	17.24	5.49	2.23
81	762.80	145.07	236.62	20.23	235.52	320.04	754.68	10.98	1.45	28.39	2.43	28.97	28.32	84.00	2.65	0.03	0.05	11.26	5.08	373.28	60.97	17.25	5.49	2.23
82	762.80	147.22	235.32	20.12	234.23	320.04	754.13	11.10	1.47	28.24	2.41	28.78	28.32	84.00	2.68	0.03	0.05	11.44	5.09	373.52	61.00	17.25	5.49	2.23
83	762.80	149.14	234.17	20.02	233.10	320.04	753.30	11.15	1.49	28.10	2.40	28.63	28.32	84.00	2.69	0.03	0.05	11.59	5.02	373.33	60.98	17.26	5.49	2.23
84	762.80	151.00	233.09	19.93	232.02	320.04	752.30	11.20	1.51	27.97	2.39	28.49	28.32	84.00	2.70	0.03	0.05	11.74	4.94	372.89	60.91	17.27	5.49	2.23
85	762.80	152.84	232.29	19.86	231.23	320.04	751.20	11.25	1.53	27.87	2.38	28.39	28.32	84.00	2.72	0.03	0.05	11.89	4.90	372.70	60.88	17.27	5.49	2.22
86	762.80	166.19	213.89	18.29	212.93	320.04	743.47	13.65	3.72	25.67	2.19	24.73	28.32	84.00	3.90	0.03	0.05	14.81	5.67	380.57	62.00	17.18	5.49	2.32
87	762.80	168.78	212.10	18.13	211.15	320.04	742.83	13.85	3.78	25.45	2.18	24.46	28.32	84.00	3.95	0.03	0.05	15.05	5.75	380.61	62.00	17.18	5.49	2.32
88	762.80	191.36	210.36	17.99	209.42	320.04	742.17	14.00	3.83	25.24	2.16	24.31	28.32	84.00	3.99	0.03	0.05	15.29	5.79	380.73	62.01	16.98	5.49	2.32
89	762.80	193.99	209.97	17.87	208.03	320.04	741.17	14.27	3.88	25.08	2.14	24.09	28.32	84.00	3.46	0.03	0.05	15.53	5.99	380.90	62.04	16.98	5.49	2.32
90	762.80	196.60	207.56	17.75	206.63	320.04	740.19	14.07	3.93	24.91	2.13	23.87	28.32	84.00	3.41	0.03	0.05	15.77	5.45	381.13	62.07	16.98	5.49	2.32
91	762.80	199.20	205.93	17.61	205.01	320.04	739.43	14.08	3.98	24.71	2.11	23.63	28.32	84.00	3.41	0.03	0.05	16.02	5.24	381.26	62.09	16.96	5.49	2.33
92	762.80	201.61	204.40	17.48	203.49	320.04	738.74	14.17	6.05	24.53	2.10	23.40	28.32	84.00	3.43	0.03	0.05	16.25	5.18	381.40	62.11	16.96	5.49	2.33

Description of Variables:
 CN2 Runoff curve number, antecedent moisture condition 2
 COTP Crop yield for picker cotton (t/ha)
 DN N loss by denitrification (kg/ha)
 DRNN Mineral N loss in subsurface drain flow (kg/ha)
 DRT Drain time, days required for drainage to reduce plant stress (days)
 ET Evapotranspiration (mm)
 FNH3 Fertilizer N applied in the form NH₄-N (kg/ha)
 FN03 Fertilizer N applied in the form NO₃-N (kg/ha)
 GRSG Crop yield for grain sorghum (t/ha)
 IRGA Irrigation water applied (mm)
 MUSSE Soil loss from water erosion using a modified MUSLE option for small watersheds
 PRCP Precipitation (mm)
 PRK Percolation below the root zone (mm)
 PRKN Mineral N loss in percolate (kg/ha)
 PRKP Percolation of P below the root zone (kg/ha)
 Q Runoff (mm)
 QDRN Subsurface drain flow (mm)
 SSF Lateral subsurface flow (mm)
 SSFN Mineral N loss in subsurface flow (kg/ha)
 UNO3 N uptake by the crop (kg/ha)
 UP P uptake by the crop (kg/ha)
 WNO3 Initial nitrate concentration in the soil (ppm)
 YAP Soluble P loss in runoff (kg/ha)
 YNO1 NO₃ loss in surface runoff (kg/ha)
 YON Organic N loss with sediment (kg/ha)
 YP P loss with sediment (kg/ha)
 YW Soil loss from wind erosion (t/ha)

EPIC Variable CN2, Runoff Curve Number - Antecedent Moisture Condition 2
% Change

CN2	PRCP	Q	SSF	PKK	QDRN	IRGA	ET	YON	YON3	SSFN	PKRN	DRNN	FN03	FNH3	VP	VAP	PRPP	MUSS	YW	UM03	UPP	DN	GRSG	COIP
-3%	0.0%	-9.4%	3.3%	3.3%	0.0%	0.5%	8.1%	-9.4%	3.3%	3.3%	3.9%	0.0%	0.0%	-8.3%	-9.4%	3.4%	-12.7%	-0.6%	-0.4%	-0.3%	-0.3%	0.0%	-0.9%	
-7%	0.0%	-11.1%	4.2%	4.2%	0.0%	0.6%	-8.4%	-11.1%	4.2%	4.2%	5.0%	0.0%	0.0%	-8.7%	-11.1%	4.3%	-12.4%	-0.5%	-0.3%	-0.3%	-0.6%	0.0%	-0.7%	
-6%	0.0%	-9.5%	3.4%	3.4%	0.0%	0.6%	-7.2%	-9.5%	3.4%	3.4%	4.1%	0.0%	0.0%	-7.4%	-9.5%	3.6%	-10.6%	-0.3%	-0.3%	-0.3%	-0.5%	0.0%	-0.6%	
-5%	0.0%	-7.8%	2.6%	2.6%	0.0%	0.5%	-6.0%	-7.8%	2.6%	2.6%	3.2%	0.0%	0.0%	-6.2%	-7.8%	2.8%	-8.8%	-0.2%	-0.2%	-0.2%	-0.4%	0.0%	-0.5%	
-4%	0.0%	-6.1%	1.9%	1.9%	0.0%	0.4%	-4.9%	-6.1%	1.9%	1.9%	2.3%	0.0%	0.0%	-5.0%	-6.1%	2.1%	-6.9%	-0.3%	-0.2%	-0.2%	-0.3%	0.0%	-0.4%	
-2%	0.0%	-3.4%	1.1%	1.1%	0.0%	0.2%	-2.4%	-3.4%	1.1%	1.1%	1.3%	0.0%	0.0%	-2.4%	-3.4%	1.1%	-3.7%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	-0.3%	
-1%	0.0%	-1.6%	0.5%	0.5%	0.0%	0.1%	-1.1%	-1.6%	0.5%	0.5%	0.6%	0.0%	0.0%	-1.1%	-1.6%	0.6%	-1.7%	0.1%	0.1%	0.1%	0.1%	0.0%	-0.1%	
0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
1%	0.0%	1.5%	-0.6%	-0.5%	0.0%	-0.1%	1.1%	1.5%	-0.6%	-0.5%	-0.6%	0.0%	0.0%	1.1%	1.5%	-0.6%	1.6%	0.2%	0.1%	0.1%	0.0%	0.0%	0.1%	
2%	0.0%	2.8%	-1.0%	-1.0%	0.0%	-0.2%	1.5%	2.8%	-1.0%	-1.0%	-1.2%	0.0%	0.0%	1.6%	2.8%	-0.9%	3.0%	-1.2%	0.2%	0.1%	0.0%	0.0%	0.1%	
4%	0.0%	4.1%	-1.5%	-1.5%	0.0%	-0.3%	1.9%	4.1%	-1.5%	-1.5%	-1.6%	0.0%	0.0%	2.0%	4.1%	-1.5%	4.3%	-1.5%	0.2%	0.1%	0.1%	0.0%	-0.2%	
5%	0.0%	5.4%	-1.8%	-1.8%	0.0%	-0.5%	2.5%	5.4%	-1.8%	-1.8%	-2.0%	0.0%	0.0%	2.6%	5.4%	-1.9%	5.6%	-3.6%	-0.2%	-0.1%	0.1%	0.0%	-0.3%	
6%	0.0%	28.3%	-9.6%	-9.6%	0.0%	-1.5%	24.3%	28.3%	-9.6%	-9.6%	-14.6%	0.0%	0.0%	24.7%	21.2%	-9.8%	31.5%	11.6%	2.0%	1.7%	-0.4%	0.0%	3.9%	
7%	0.0%	30.1%	-10.4%	-10.4%	0.0%	-1.6%	26.1%	30.1%	-10.4%	-10.4%	-15.5%	0.0%	0.0%	26.5%	22.9%	-10.5%	33.7%	13.3%	2.0%	1.7%	-0.4%	0.0%	3.9%	
9%	0.0%	31.5%	-11.1%	-11.1%	0.0%	-1.7%	27.5%	31.5%	-11.1%	-11.1%	-16.1%	0.0%	0.0%	27.9%	24.6%	-11.3%	35.9%	13.9%	2.0%	1.7%	-1.5%	0.0%	4.0%	
10%	0.0%	33.7%	-11.7%	-11.7%	0.0%	-1.8%	29.9%	33.7%	-11.7%	-11.7%	-16.8%	0.0%	0.0%	30.4%	26.3%	-11.9%	38.0%	18.0%	2.0%	1.8%	-1.6%	0.0%	4.1%	
11%	0.0%	35.5%	-12.3%	-12.3%	0.0%	-1.9%	28.1%	35.5%	-12.3%	-12.3%	-17.6%	0.0%	0.0%	28.5%	28.0%	-12.6%	40.1%	7.3%	2.1%	1.8%	-1.5%	0.0%	4.1%	
12%	0.0%	37.3%	-13.0%	-13.0%	0.0%	-2.0%	28.2%	37.3%	-13.0%	-13.0%	-18.4%	0.0%	0.0%	28.7%	29.7%	-13.2%	42.3%	3.2%	2.1%	1.8%	-1.6%	0.0%	4.2%	
14%	0.0%	39.0%	-13.6%	-13.6%	0.0%	-2.1%	29.0%	39.0%	-13.6%	-13.6%	-19.2%	0.0%	0.0%	29.5%	31.3%	-13.9%	44.4%	2.0%	2.2%	1.9%	-1.7%	0.0%	4.3%	

Dryland Cotton - Baseline BMP, Current Conditions

Bdry Year N=Normal Year W=Wet Year	Month	Day	Operation	EPRC Tillage #	Irrigation Volume		EPRC Pesticide #	Pesticide Trade Name (Common Name)	Pesticide Application Rates (Active Ingredient)		N Application Rates		P Application Rates (as P) P-O ₅ = 2.27P	
					mm	in			kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac
D,N,W	1	10	Apply fertilizer (dry, surface applied)	10										
D,N,W	2	10	Cultivate	19										
D,N,W	2	15	Plant picker cotton with row planter. Potential Heat Units for crop = 2900	2										
D,N,W	2	15	Apply preemergent herbicide; soil incorporated (top 2")	6		255	TriBan (Trihalin)	1.68	1.50					
D,N,W	3	15	Cultivate	19										
D,N,W	4	20	Apply insecticide to control cotton fleahoppers	19		43	Budin (Dicrotophos)	0.22	0.20					
D,N,W	5	20	Cultivate	19										
N,W	6	1	Apply insecticide to control overwintering/fescusion cotton boll weevils	11		122	Guthion (Azinphos-methyl)	0.28	0.25					
D,N,W	6	20	Apply dual purpose (prethroid) insecticide to control both weevils and worms	11		122	Guthion (Azinphos-methyl)	0.28	0.25					
D,N,W	7	5	Apply dual purpose (prethroid) insecticide to control both weevils and worms	11		130	Karate (Chlorfenvinphos)	0.03	0.03					
D,N,W	8	5	Apply defoliant (29% use Dropp/ 71% use DFE)	11		96	Dropps (Thidiazuron)	0.17	0.15					
D,N,W	8	5	Apply defoliant (29% use Dropp/ 71% use DFE)	11		83	DEF (Trihalos or Phosphorothioic)	1.23	1.10					
D,N,W	8	30	Harvest - picker cotton	11										
D,N,W	8	30	Kill cotton crop	41										
D,N,W	8	25	Shedding	57										
D,N,W	9	1	Pruning	24										
D,N,W	9	1	Sweep Chisel	32										
D,N,W	9	9	Discing-offset	33										
D,N,W	9	15	Discing-offset	33										
D,N,W	9	30	Discing-offset	33										
D,N,W	12	15	Bedding	15										

† Changes in Pesticide applications due to rainfall conditions
 ‡ Under normal rainfall conditions, dropped with an (N), four insecticide applications are generally sufficient to control cotton pests
 § One preemergent herbicide application for weed control at planting
 ¶ During dry years, dropped with a (D), one less Guthion application may be sufficient

Urrrow Irrigated Grain Sorghum - Baseline BMP, Current Conditions

Day Year: Normal Year
 Crop Year: 2000
 Grain Sorghum - EPIC Crop # in (USDA/CROP DAT = X, PIU=2000)

Month	Day	Operation	EPIC Tillage #	Irrigation Volume		EPIC Pesticide #	Pesticide Trade Name (Common Name)	Pesticide Application Rates (Active Ingredient)		N Application Rates		P Application Rates (as P)	
				mm	in			kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac
1	10	Apply fertilizer (dry, surface applied)	10										
1	15	Cultivate	19							135	120	29.6	26
2	10	Border Ditching, forming block ends in preparation for furrow irrigation	80										
2	10	Cultivate	19										
2	15	Plant grain sorghum with row planter; Potential heat units for crop = 2700	2			235	Treflan (trifluralin)	0.78	0.70				
3	15	Apply post emergence herbicide, incorporated (cut-grass)	6										
3	15	Cultivate	19										
3	15	Border Ditching, forming block ends in preparation for furrow irrigation	80										
3	16	Furrow Irrigation	72	152	6								
4	14	Cultivate	19										
4	14	Border Ditching, forming block ends in preparation for furrow irrigation	80										
4	15	Furrow Irrigation	72	152	6								
5	14	Border Ditching, forming block ends in preparation for furrow irrigation	80										
5	15	Furrow Irrigation	72	152	6								
7	20	Harvest - grain sorghum	51										
9	10	Kill sorghum crop	41										
9	10	Steeding	57										
9	15	Sweep - field	32										
9	20	Discing - offset	33										
10	15	Discing - offset	33										
11	15	Discing - offset	33										
12	15	Bedding	15										

Notes: In the table applications of irrigation due to rainfall conditions for normal rainfall conditions.
 Grain sorghum crops in the area typically do not receive insecticide applications.
 The pre-emergent herbicide application at planting.
 Two irrigations of known with 5/4" each supply 12" of irrigation water at 7/4 efficiency = 8" of water supplied to crop.
 Irrigation not required.

Three irrigations of known with 1/3" of each supply 18" of irrigation water at 7/4 efficiency = 12" of water supplied to crop.

Dryland Grain Sorghum - Baseline BMP, Current Conditions

D=Dry Year N=Normal Year W=Wet Year	Month	Day	Operation	Epic Tillage #	Irrigation Volume		Epic Pesticide #	Pesticide Trade Name (Common Name)	Pesticide Application Rates (Active Ingredient)		N Application Rates		P Application Rates (as P) P ₂ O ₅ = 2.27P	
					mm	in			kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac
D.N.W	1	15	Apply fertilizer (dry - surface applied)	10										
D.N.W	2	10	Cultivate	19										
D.N.W	2	15	Plant grain sorghum with row planter. Potential Heat Units for crop = 2000	2										
D.N.W	3	15	Cultivate	19										
D.N.W	5	15	Cultivate	19										
D.N.W	7	20	Harvest - grain sorghum	19										
D.N.W	9	10	Kill sorghum crop	41										
D.N.W	9	10	Shedding	57										
D.N.W	9	15	Plowing	24										
D.N.W	9	16	Sweep-chisel	32										
D.N.W	9	20	Discing-offset	33										
D.N.W	10	15	Discing-offset	33										
D.N.W	11	15	Hoading	15										

Changes in management due to rainfall conditions.

Under normal rainfall conditions.
 Grain sorghum crops in the area typically do not receive insecticide applications.
 No herbicide or insecticide applications under normal conditions.

Irrigation Irrigated Corn - Baseline BMP, Current Conditions

Day Year	Month	Day	Operation	EPIC Tillage #	Irrigation Volume mm	EPIC Pesticide #	Pesticide Trade Name (Common Name)	Pesticide Application Rates (Active Ingredient) kg/ha	N Application Rates kg/ha	P Application Rates (P) P-20 = 2.27P kg/ha
NW	1	15	Apply fertilizer (dry, surface applied)	10						
NW	2	10	Cultivate	19					168	150
NW	2	10	Harrow: Discharge, forming block ends for furrow irrigation	80						24.7
NW	2	15	Plant corn with row planter. Potential Heat Units for crop = 1950	2				0.78		
NW	2	15	Apply preemergent herbicide, surface applied	6		255	Proval (Pendimethalin)	0.70		
NW	3	10	Cultivate	19						
NW	3	15	Harrow: Discharge, forming block ends for furrow irrigation	80						
NW	4	15	Furrow Irrigation	72	152	6				
NW	4	15	Cultivate	19						
NW	4	15	Harrow: Discharge, forming block ends for furrow irrigation	80						
NW	4	15	Furrow Irrigation	72	152	6				
NW	5	15	Harrow: Discharge, forming block ends for furrow irrigation	80						
NW	5	15	Furrow Irrigation	72	152	6				
NW	6	15	Furrow Irrigation	72	152	6				
NW	9	10	Harvest Corn	51						
NW	9	10	Kill corn crop	41						
NW	9	10	Shedding	57						
NW	9	15	Sweep-chisel	32						
NW	9	20	Discharge-offset	33						
NW	10	15	Discharge-offset	33						
NW	11	15	Discharge-offset	33						
NW	12	15	Bedding	15						

Two irrigations, due to rainfall conditions.

Two irrigations of 6" each supply 12" of irrigation water at 2% efficiency = 8" of water supplied to crop

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Dryland Corn - Baseline BMP, Current Conditions

Year	Month	Day	Operation	EPRC Tillage #	Irrigation Volume	EPRC Pesticide #	Pesticide Trade Name (Common Name)	Pesticide Application Rates (Active Ingredient)		N Application Rates		P Application Rates (as P)	
								kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac
Dry	1	15	Apply fertilizer (dry, surface applied)	10						84.07	75		
Normal	2	10	Cultivate	19									
Normal	3	15	Plant corn with row planter. Potential Heat Units for crop = 1950	2									
Normal	4	10	Cultivate	19									
Normal	6	10	Cultivate	19									
Normal	9	20	Harvest - Corn	51									
Normal	9	10	Kill corn crop	41									
Normal	9	10	Steeding	57									
Normal	9	15	Plowing	24									
Normal	9	16	Sweep-schisel	32									
Normal	9	20	Discing-offset	33									
Normal	10	15	Discing-offset	33									
Normal	11	15	Bedding	15									

Assumed the same management for wet, normal and dry years

Irrigation Frigated Sugarcanne (Plant Cane) - Baseline BMP, Current Conditions

Day year	Month	Day	Operation	EPIC Tillage #	Irrigation Volume	EPIC Pesticide #	Pesticide Trade Name (Common Name)	Pesticide Application Rates (Active Ingredient)	N Application Rates	P Application Rates (as P)
Month	Day	Operation			mm			kg/ha	kg/ha	kg/ha
N.W.	9	seed disking or sheathing or previous crop		57						
N.W.	9	Flowing or deep subsoil ripping		14						
N.W.	9	Surface disking		33						
N.W.	9	Land plowing (later leveling)								
N.W.	9	drawing of plant furrows		15					89.6	
N.W.	9	fertilizer application (fertilizer #1)		10					80	
N.W.	9	fertilizer application (fertilizer #2)		2						49.28
N.W.	9	planting/seed covering (4 GrowJacks)		11		3	Aarex (Atrazine)	2.24		
N.W.	9	herbicide application (pre-emergence)		11		194	Prowl (Pendimethalin)	3.31		
N.W.	9	herbicide application (pre-emergence)		80						
N.W.	9	build borders		72	152.4					
N.W.	9	furrow irrigation		72	6					
N.W.	10	knock down borders		72	152.4					
N.W.	10	furrow irrigation (dry years only)		77						
N.W.	11	knock down borders		19						
N.W.	11	cultivate and reshape cane rows		19						
N.W.	12	cultivate and reshape cane rows		19						
N.W.	1	cultivate interrows		11						
N.W.	2	herbicide application (post-emergence)		11		3	Aarex (Atrazine)	2.24		
N.W.	2	herbicide application (post-emergence)		11		194	Prowl (Pendimethalin)	2.31		
N.W.	2	herbicide application (post-emergence)		80						
N.W.	3	rebuild borders		72	152.4					
N.W.	4	herbicide application (post-emergence)		11						
N.W.	5	spot spray or aerial application of herbicides		32				0.56	0.50	
N.W.	5	spot spray or aerial application of herbicides		11				2.24	2.00	
N.W.	5	spot spray or aerial application of herbicides		11				1.792	1.60	
N.W.	5	herbicide application (dry years only)		72	152.4					
N.W.	5	herbicide application (dry years only)		72	6					
N.W.	6	furrow irrigation		72	152.4					
N.W.	7	knock down and rebuild weedy borders		80						
N.W.	7	furrow irrigation		72	152.4					
N.W.	7	furrow irrigation		72	6					
N.W.	8	furrow irrigation		72	152.4					
N.W.	8	furrow irrigation		72	6					
N.W.	9	furrow irrigation		72	152.4					
N.W.	9	knock down borders (pre-harvest preparation)		77						
N.W.	9	knock down borders (pre-harvest preparation)		25						
N.W.	1	burn & harvest		53						

Irrigation Frigate for the furrow left condition.
 Operational rainfall conditions: allowed with N3.
 Eight irrigations of 67 cm in supply, 47% of irrigation water at 27% efficiency = 38% of water supplied to crop.
 Total irrigation of 67 cm in supply, 27% of irrigation water at 27% efficiency = 16% of water supplied to crop.
 Total irrigation of 67 cm in supply, 27% of irrigation water at 27% efficiency = 16% of water supplied to crop.
 Eight irrigations of 67 cm in supply, 47% of irrigation water at 27% efficiency = 38% of water supplied to crop.
 Total irrigation of 67 cm in supply, 47% of irrigation water at 27% efficiency = 38% of water supplied to crop.

Herbicide Applications (3 applications/year)
 Fall pre-emergence applications (9/16) of Aarex (Atrazine) & Prowl (Pendimethalin)
 Winter post-emergence applications (2/10) of the same two herbicides
 Spring spot sprays (5/10) for misers

Furrow Irrigated Sugarcane (Plant Cane) - BMP #1, Nutrient Management

D=Dry year N=Normal year W=Wet year	Month	Day	Operation	EPC Tillage #	Irrigation Volume		EPC Pesticide #	Pesticide Trade Name (Common Name)	Pesticide Application Rates (Active Ingredient)		N Application Rates		P Application Rates (as P) P ₂ O ₅ = 2.27P	
					mm	in			kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac
D,N,W	9	1	weed disking or shedding of previous crop	57										
D,N,W	9	3	plowing or deep subsoil tillage	34										
D,N,W	9	4	surface disking	33										
D,N,W	9	5	land leveling (laser leveling)											
D,N,W	9	13	harrow of plant furrows	15										
D,N,W	9	14	fertilizer application I (372-01200 Insecticide)	10								24.64	22	82.88
D,N,W	9	15	planting/seed covering (4.6 tons/acre)	2			3	Atrax (Atrazine)	2.34	2.00				74
D,N,W	9	16	herbicide application (pre-emergence)	11			194	Proval (Pendimethalin)	2.31	2.06				
D,N,W	9	17	build borders	80										
D,N,W	9	18	furrow irrigation	72	152.4	6								
D,N,W	10	18	furrow irrigation (dry years only)	72	152.4	6								
D,N,W	11	20	knock down borders	77										
D,N,W	11	21	cultivate and reshape cane rows	19										
D,N,W	12	21	cultivate and reshape cane rows	19										
D,N,W	1	25	salvage internodes	19										
D,N,W	2	10	herbicide application (post-emergence)	11			3	Atrax (Atrazine)	2.34	2.00				
D,N,W	2	10	herbicide application (post-emergence)	11			194	Proval (Pendimethalin)	2.31	2.06				
D,N,W	4	13	rebuild borders	80										
D,N,W	4	15	furrow irrigation	72	152.4	6								
D,N,W	5	10	spot spray or aerial application of herbicides	11			32	Banvel (Dicamba Soluble Salt)	0.86	0.50				
D,N,W	5	10	spot spray or aerial application of herbicides	11			264	Roundup (Glyphosate Amine)	2.34	2.00				
D,N,W	5	10	spot spray or aerial application of herbicides	72	152.4	6	109	Evik (Ametryn)	1.79	1.60				
D,N,W	6	22	furrow irrigation (dry years only)	72	152.4	6								
D,N	6	15	furrow irrigation	72	152.4	6								
D,N	7	1	knock down and rebuild weedy borders	80										
D,N,W	7	14	furrow irrigation	72	152.4	6								
D,N,W	7	15	furrow irrigation	72	152.4	6								
D,N,W	8	1	furrow irrigation	72	152.4	6								
D,N,W	8	1	furrow irrigation	72	152.4	6								
D,N,W	8	15	furrow irrigation	72	152.4	6								
D,N	9	1	knock down borders (pre-harvest preparation)	77										
D,N,W	1	3	knock down borders (pre-harvest preparation)	77										
D,N,W	1	4	harrow furrows (pre-harvest preparation)	25										
D,N,W	1	5	burn & harvest	53										

Changes in irrigation due to rainfall conditions
 Under normal rainfall conditions (denoted with N),
 Eight irrigations of 6" each supply 42" of irrigation water at 2/3 efficiency = 28" of water supplied to crop
 During wet years (denoted with W),
 Four irrigations of 6" each supply 24" of irrigation water at 2/3 efficiency = 16" of water supplied to crop
 During dry years (denoted with D),
 Two irrigations of 6" each supply 12" of irrigation water at 2/3 efficiency = 8" of water supplied to crop

Herbicide Applications 13 applications/year
 Fall pre-emergence applications (9/16) of
 Atrax (Atrazine) & Proval (Pendimethalin)
 Winter post-emergence applications (2/10)
 of the same two herbicides
 Spring spot sprays (5/10) for mites

Furrow Irrigated Sugarcane (Ratoon Cane) - BMP #1, Nutrient Management

D-Day year N-Season year W-M-R-L-N-S-R	Month	Date	Operation	EPIC Tillage #	Irrigation Volume		EPIC Pesticide #	Pesticide Trade Name (Common Name)	Pesticide Application Rates (Active Ingredients)		N Application Rates		P Application Rates (as P)	
					mm	in			kg/ha	lb/ac	kg/ha	lb/ac	kg/ha	lb/ac
D,N,W	1	13	furrow gang harrow	25										
D,N,W	1	14	subsoil	34										
D,N,W	1	15	fertilizer (liquid N-32, insecticide)	13										
D,N,W	1	15	cultivation - reshape	19										
D,N,W	1	20	herbicide application (sprayer)	11		3	Aatex (Atrazine)	2.24	2.00					
D,N,W	1	20	herbicide application (sprayer)	11		194	Provi (Pendimethalin)	2.31	2.06					
D,N,W	1	21	bonder banding	80										
D,N,W	1	24	furrow irrigation	72		6								
D	1	3	furrow irrigation	72		6								
D,N,W	4	12	knock down borders	77										
D,N,W	4	12	cultivate weeds	19										
D,N,W	4	13	herbicide application (sprayer)	11		3	Aatex (Atrazine)	2.24	2.00					
D,N,W	4	13	herbicide application (sprayer)	11		194	Provi (Pendimethalin)	2.31	2.06					
D,N,W	4	14	rebuild borders	80										
D,N,W	4	15	furrow irrigation	72		6								
D	5	1	furrow irrigation	72		6								
D,N,W	5	20	spot spray or aerial application of herbicides	11		32	Bavel (Diamber Soluble Salt)	0.56	0.50					
D,N,W	5	20	spot spray or aerial application of herbicides	11		204	Roundup (Glyphosate Amine)	2.24	2.00					
D,N,W	5	22	spot spray or aerial application of herbicides	11		109	Evik (Ameryn)	1.792	1.60					
D,N	5	22	furrow irrigation	72		6								
D,N	6	15	furrow irrigation	72		6								
D,N,W	7	1	furrow irrigation	72		6								
D,N,W	7	14	rebuild borders	80										
D,N	7	15	furrow irrigation	72		6								
D,N	8	1	furrow irrigation	72		6								
D,N	8	15	knock down borders (pre-harvest preparation)	72		6								
D,N,W	12	3	furrow furrows (pre-harvest preparation)	77										
D,N,W	12	3	burn & harvest	25										
D,N,W	1	6	burn & harvest	53										

** Fertilizer application rate depends on ratoon cycle

Under normal rainfall conditions (denoted with N),
 Eight irrigations of 6" each supply 42" of irrigation water at 2/3 efficiency = 28" of water supplied to crop
 During wet years (denoted with W),
 Four irrigations of 6" each supply 24" of irrigation water at 2/3 efficiency = 16" of water supplied to crop
 During dry years (denoted with D),
 Ten irrigations of 6" each supply 60" of irrigation water at 2/3 efficiency = 40" of water supplied to crop
 Three herbicide applications (1/20, 4/1, and 5/20)

1st Year Ratoon Cane
 100 lbs/ac N (112.09 kg/ha)
 2nd Year Ratoon Cane
 140 lbs/ac N (156.93 kg/ha)
 3rd - 5th Year Ratoon Cane
 150 lbs/ac N (168.14 kg/ha)

Flood Irrigated Citrus (Level Border Irrigation) - Baseline BMP, Current Conditions

D3-D5 year N=Normal year W=Water year	Month	Days	Operation	EPIC Tillage #	Irrigation Volume in	EPIC Pesticide #	Pesticide Trade Name (Common Name)	Pesticide Application Rates (Active Ingredient) kg/ha	N Application Rates kg/ha	P Application Rates (as P) P-05 = 2.27P kg/ha
D1N.W	11	15	Flood Irrigation	72	137					
D1N.W	2	10	Border Ditching, forming border in preparation for flood irrigation	82						
D1N.W	2	15	Fertilizer application (Anhydrous Sulfur, 21.6% N, 86%)	10						
D1N.W	2	20	Flood Irrigation	72	137					
D1N.W	3	15	Apply selective herbicide (preemergent)	11		192	Princip (Suzarone)	1.53	1.15	
D1N.W	3	15	Apply selective herbicide (preemergent)	11		126	Hivar X (Bromacil)	3.14	2.80	
D1N.W	3	15	Apply contact herbicide	11		204	Roundup (Glyphosate isopropyl amine salt)	1.79	1.60	
D1N.W	4	20	Flood Irrigation	72	127					
D1N.W	4	1	Apply Pesticide: sprayer	11		236	Tenik (Ailicarb)	5.54	4.95	
D1N.W	4	15	Flood Irrigation	72	127					
D1N.W	6	15	Apply contact herbicide	11		204	Roundup (Glyphosate isopropyl amine salt)	0.28	0.25	
D1N.W	6	20	Flood Irrigation	72	127					
D1N.W	7	20	Flood Irrigation	72	127					
D1N.W	8	15	Apply sedgeicide	11		145	Loxaban (Chlorpyrifos)	2.24	2.00	
D1N.W	8	15	Apply fungicide	11		39	Benlate (Benomyl)	1.79	1.60	
D1N.W	8	15	Apply fungicide: sprayer	11		131	Kelthane (Difenoconazole)	2.24	2.00	
D1N.W	8	15	Apply selective herbicide (preemergent)	11		192	Princip (Suzarone)	3.53	3.15	
D1N.W	8	15	Apply selective herbicide (preemergent)	11		126	Hivar X (Bromacil)	3.14	2.80	
D1N.W	8	15	Apply contact herbicide	11		204	Roundup (Glyphosate isopropyl amine salt)	1.79	1.60	
D1N.W	10	5	Harvest - Ring Pick	50						

* Fertilizer Application Rates depend on tree age

Tree Age	Fertilizer Application Rates		Nitrogen Rates	
	One Appl kg/ha	Split Appl kg/ha	kg/ha	kg/ha
1 yr	186.7	134.4	62.2	35
2 yr	266.7	177.8	88.9	50
3 yr	400.0	266.7	133.3	75
4 yr	533.3	355.6	177.8	100
5 yr	566.7	391.1	195.6	110
6 yr	566.7	391.1	195.6	110
7 yr	613.3	408.9	204.4	115
8 yr	666.7	444.4	222.2	125
9 yr	766.7	497.8	248.9	140
10+ yr	800.0	533.3	266.7	150

4 Bursts of pre-irrigation or irrigation after the rainfall condition
 Under normal rainfall conditions, five irrigations (Determined with 8) of 5" each supply 25" of irrigation water at 95% efficiency = 24" of water supplied to crop
 During wet years, four irrigations (Determined with 10) of 5" each supply 20" of irrigation water at 95% efficiency = 19" of water supplied to crop
 During dry years, six irrigations (Determined with 13) of 5" each supply 30" of irrigation water at 95% efficiency = 29" of water supplied to crop
 Herbicide Applications (3 Applications/year)
 Spring application (3/15) of 2 selective herbicides and a contact post-emergent herbicide
 Treat again in early summer (6/15) and again in late summer (8/15)
 Schedule/Amount of Insecticide Applications under Tenik Program (3 applications/yr)
 Simple application of Tenik in spring (4/1) at 30 lb/acre
 Late Summer (8/15) application of insecticide (Kelthane), sedgeicide (Loxaban) and fungicide (Benlate)

APPENDIX I

Assumptions Used in Modeling Analysis

1. Non-row crop areas consisting of perennial vegetation including native pastures and rangeland (native grasses, trees and shrubs) do not utilize subsurface drains or land leveling.
2. Dryland cropping systems (cotton rotated with either grain sorghum or corn) do not utilize subsurface drainage systems.
3. Most of the irrigated cropland acreage (cotton in rotation with either grain sorghum or corn, sugarcane rotated with cotton) have subsurface drains installed except for the very heavy clays such as Grulla clay and Harlingen clay.

Based on assumptions 1, 2 and 3, it was calculated that 44,667 acres, approximately 72 percent of the irrigated cropland in the study area have subsurface drainage systems installed.

4. All of the irrigated citrus acreage (regardless of soil type) has been leveled.
5. Approximately 80 percent of the cropland in the study area, has had irrigation land leveling [or precision land forming of dryland areas] implemented as a management practice for improved distribution of irrigation and rain water.
6. The land slopes assumed for areas which have been leveled.
Citrus - 0 % slope (used 0.0001)
All other cropland areas - $(0.075'/100') = 0.075\%$ slope (used 0.00075)
7. The natural slopes for cropland areas which have not been leveled were assumed to be:
Soil Group 1 = 0.58 %
Soil Group 2 = 0.50 %
Soil Group 3 = 0.55 %
Soil Group 4 = 0.27 %
Soil Group 5 = 0.65 %
Soil Group 6 = 0.71 %

These are based on area weighted slopes calculated for the study area using slopes designated in the Cameron County Soil Survey. In some instances, the specified slopes were adjusted based on the professional judgment of local NRCS personnel.
8. Vegetable crops were not considered in the modeling analysis. Only 25,090 acres of vegetable crops were grown in Cameron County in 1989 (TWDB, 1991), comprising less than 10% of the cropland acreage countywide. Vegetable crops are not prevalent in the Arroyo Colorado study area due to the soil types occurring in the area.
9. Approximately 10-15% of the cotton in the study area is rotated with corn. The majority (85-90%) of the cotton is rotated with grain sorghum. Assumption: 15% of the cotton rotated with corn and 85% rotated with grain sorghum.
10. The majority (>90%) of the cotton grown in the area (both dryland and irrigated) is picker cotton. Less than 10% of the cotton is stripper cotton. For the modeling analysis, it was assumed that all of the cotton grown in the study area was picker cotton.

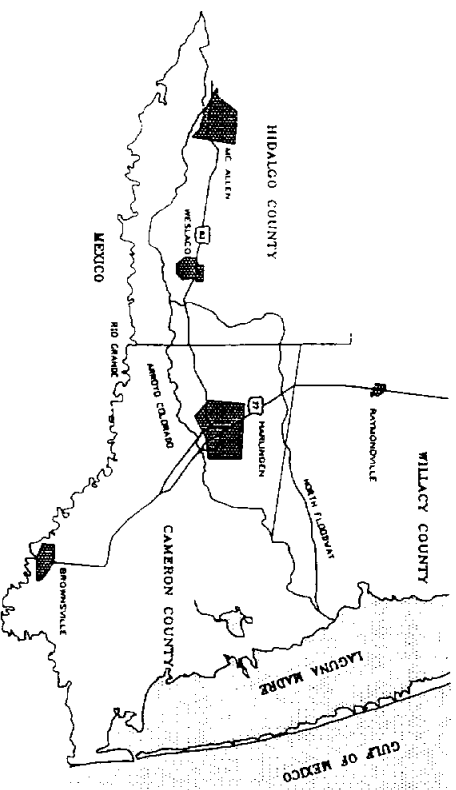
APPENDIX G

Registration Lists and Materials Prepared for Seminars and Workshops

PLANKERS

- Arrie Bausch
Student Technician, Agricultural Engineering Department, Texas Agricultural Extension Service, College Station
- Tim Guy Fipps
Associate Professor and Extension Agricultural Engineer, Texas Agricultural Extension Service, College Station
- Alan Flowers
Senior Research Associate, Texas Institute for Applied Environmental Research, Stephenville
- Greg Gonzales
Conservationist, Natural Resources Conservation Service, San Benito
- Jan Moore
Cameron County Extension Agent, San Benito Agricultural Engineer, Natural Resources Conservation Service, San Benito
- Ann Pardee
USEPA Project Manager - Region 6, U.S. Environmental Protection Agency, Dallas
- Bryan Shaw
Assistant Professor and Extension Agricultural Engineer, Texas Agricultural Extension Service, College Station
- David W. Smith
Extension Associate, Texas Agricultural Extension Service, College Station
- Stormy Sparks
Associate Professor and Extension Entomologist, Texas Agricultural Extension Service, Weslaco
- Kevin Sprounts
Texas State Soil and Water Conservation Board, Temple

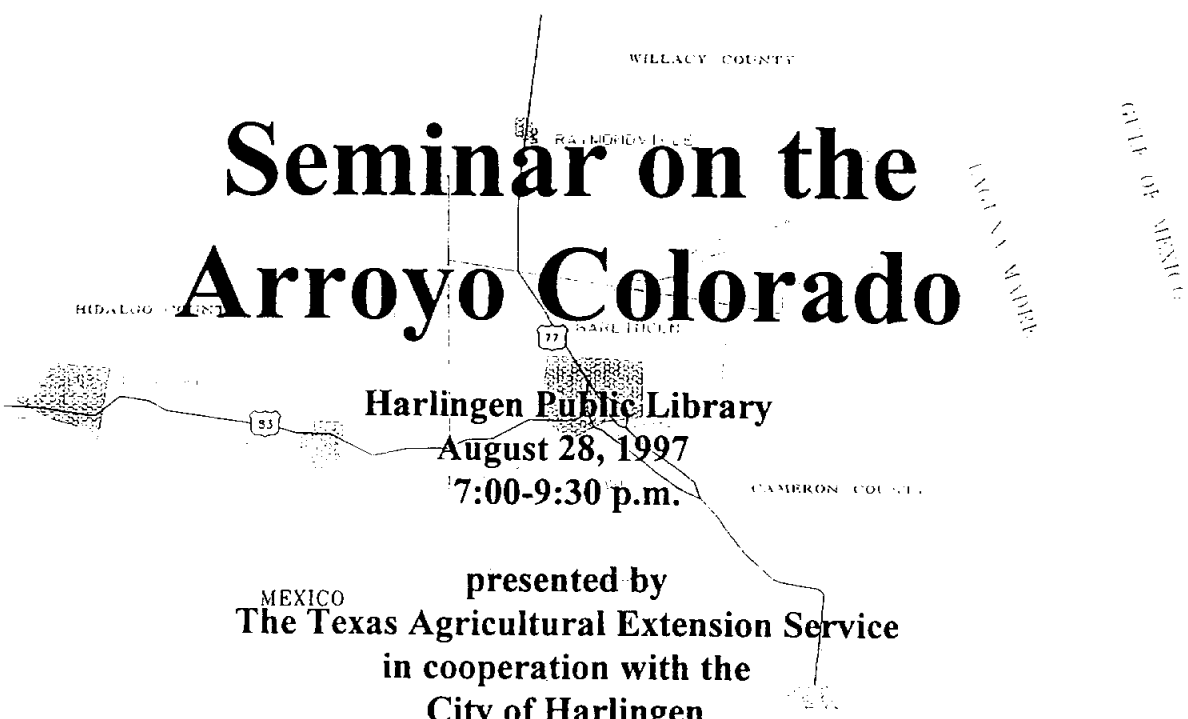
Seminar on the Arroyo Colorado



Harlingen Public Library
August 28, 1997
7:00-9:30 p.m.

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The Texas Agricultural Extension Service
in cooperation with the
City of Harlingen

This seminar is funded through a grant from the United States Environmental Protection Agency through the Texas Natural Resource Conservation Commission



Seminar on the Arroyo Colorado

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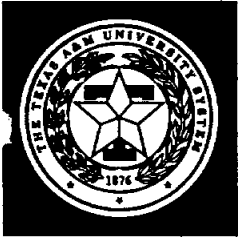
Description

The Seminar will present the results of the multi-agency project: *Non-point Source Pollution Prevention in the Arroyo Colorado Watershed*. The project was funded by the U.S. Environmental Protection Agency (EPA) through the Texas Natural Resource Conservation Commission (TNRCC) and the Texas State Soil and Water Conservation Board (TSSWCB). Cooperating agencies included the Natural Resources Conservation Service (NRCS), the Southmost Soil and Water Conservation District, the Texas Institute for Applied Environmental Research (TIAER), and the Texas Agricultural Extension Service (TAEX).

Program

- | | |
|-----------|--|
| 7:00 p.m. | Welcome, Project Overview
T. Lockamy, G. Fipps, B. Spoonts, L. Pardee (invited) |
| 7:30 | The Arroyo Colorado Water Quality Data Base - What do we know?
C. Bausch, G. Fipps |
| 8:00 | Demonstration Sites and Results
T. Gonzales, A. Moore |
| 8:30 | Best Management Practices - Modeling and Projected Benefits
J. Flowers |
| 9:00 | Educational Program Outcomes
G. Fipps, D. Smith, S. Sparks, B. Shaw |
| 9:30 | Adjourn |

This seminar is funded through a grant from the United States Environmental Protection Agency through the Texas Natural Resource Conservation Commission.



Texas Agricultural Extension Service

The Texas A&M University System

August 13, 1997

RECEIVED

SEP 18 1997

TEXAS STATE SOIL AND
WATER CONSERVATION BOARD

RE: Local Advisory Committee - Arroyo Colorado Project

Dear

Several years ago, you were asked by the then Texas Water Commission (now the Texas Natural Resource Conservation Commission) and the Texas State Soil and Water Conservation Board (TSSWCB) to serve on the Local Advisory Committee for the Section 319 Project: *Non-point Source Prevention in the Arroyo Colorado Watershed*. You may be aware that this project officially ends on August 31, 1997.

The Texas Agricultural Extension Service invites you to participate in a **Seminar on the Arroyo Colorado** to be held on August 28, 7:00 p.m. to 9:30 p.m. at the Harlingen City Library (see enclosed flyer). For the Seminar, we have asked representatives from all participating agencies to provide a brief overview of their roles in the project and the results of their efforts.

Please join us for this informative program.

Sincerely,

Guy Fipps
Associate Professor *and*
Extension Agricultural Engineer

enclosure

Seminar on the Arroyo Colorado

Harlingen Public Library

August 28, 1997

7:00 pm - 9:30 pm

Name	Company	Address	City	Zip Code	Phone Number
Jack P. Oliver	Valley Foreman Club	RT 1 Box 320	Del Rio	78586	399-3867
Trodon Dix	Valley Foreman Club	1113 E. Folk	Del Rio	78550	428-4742
John Norman	Tr. As. Ext. Serv.	2401 E. Highway 83	Del Rio	78196	968-5581
Tony Gonzales	USDA NRCS	2315 W. Exas 83	San Benito	78586	399-2522
Alan Miner		2350 E. Exas 103	San Benito	78586	399-2522
Alvin		1010 E. Exas	Del Rio	76501	254-2522
Alvin		PO BOX 171	San Benito	78196	636-1411
LEN PARTEE	ENR	1445 RUSS DALLAS TX 202			214 665 8086
Kelvin Moore	TNRCC		Austin	76753	512 2392272
Bo Sports	TSUBIB	311 N 5th St Del Rio	Del Rio	76801	254 773 2255
David		1500 E. Exas	Harlingen	78550	956 421-5841
David		1500 E. Exas	Harlingen	78550	956 430-6266
David		1500 E. Exas	Harlingen	78550	956 430-6266
David		1500 E. Exas	Harlingen	78550	956 430-6266
David		1500 E. Exas	Harlingen	78550	956 430-6266
David		1500 E. Exas	Harlingen	78550	956 430-6266

Cameron County Field Crops Committee

Sented by: Cameron County Crops Committee

Committed to the future of agriculture.

Operating Sponsors:

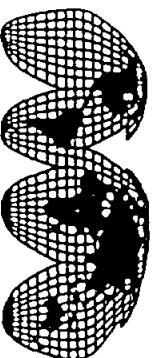
Cameron County Extension Office
Natural Resource Conservation Service
Southern Regional Sustainable Agricultural
Research and Education Program
Southmost Soil & Water Conservation District
Texas Agricultural Extension Service
USDA-Agricultural Research Service
U.S.E.P.A. - Arroyo Colorado Project

2nd Annual

**No-Till Field Day &
Farm Show**

**Rangerville Coop Gin
April 30, 1997
9:00 a.m. - Noon
Lunch Provided**

3 CEU's and Door Prizes



Committed to the future of agriculture.



Texas Agricultural Extension Service

The Texas A&M University System



2nd Annual
No - Till Field Day
Rangerville Coop Gin
April 30, 1997
9:00 - Noon



Presented By: CAMERON COUNTY FIELD CROP
COMMITTEE

FEATURING:

PLANTING EQUIPMENT FOR CONSERVATION TILLAGE
COULTERS, RESIDUE FINGERS, RIDGE RUNNER

CATOLACCUS AND CONTROL OF THE BOLL WEEVIL

CROP CULTIVATION IN HIGH RESIDUE CONDITIONS

FERTILIZER PLACEMENT FOR CONSERVATION TILLAGE

HOODED SPRAYERS FOR CONSERVATION TILLAGE

OTHER CONSERVATION TILLAGE EQUIPMENT

STALK PULLER

FERTILIZER APPLICATORS

SHREDDER

CULTIVATORS

PLANTERS

CHEMICAL PRECISION APPLICATORS AND SAFETY CONCERNS

IMPROVING FERTILIZER EFFICIENCY THROUGH BEST
MANAGEMENT PRACTICES

EQUIPMENT DISPLAY & FIELD DEMONSTRATION

TECHNICAL ASSISTANCE PROVIDED BY:

TEXAS AGRICULTURAL EXTENSION SERVICE

NATURAL RESOURCE CONSERVATION SERVICE

USDA- AGRICULTURAL RESEARCH SERVICE

LUNCH PROVIDED

2 CEU'S AVAILABLE

40	Kenneth Buford	464-04-2378	2514 S. 4 th Rd.	Edinburg, Tx	78539
41	Eloy Corona	463-29-1196	P.O. Box 531090	Harlingen, Tx	78553
42	Eduardo Mendez	466-83-1605	1826 W. Jefferson	Harlingen, Tx	78550
43	Ruben Vento	449-06-6613	Rt. 1, Box 53	La Feria, Tx	78559
44	Steve Frazier	122963	2313 N. Parkwood	Harlingen, Tx	78550
45	H.J. Garrett	526-10-3910	Rt. 3 Box 171	Harlingen, Tx	78550
46	Joel Saldivar	210884	Rt. 2 Box 376	Lyford, Tx	78569
47	Bailey H. Duntap, Jr.	185392	P.O. Box 458	La Feria, Tx	78559
48	Ed Gage	122533	P.O. Box 63447	Pipe Creek, Tx	
49	Noe G. Garza	133566	2514 S. 4 th Rd. Sec 2	Edinburg, Tx	78539
50	Terry W. Mize	127069	7502 Dreyfuss	Amarillo, Tx	
51	Charles Stichler	212487	Box 1849	Uvalde, Tx	78802
52	Juan Leija	126713	413 N. Kenyon Rd.	Edinburg, Tx	78539
53	Juan M. Pena	133598	P.O. Box 195	Raymondville, Tx	78580
54	Norman Ruzoff	030-26-3340	P.O. Drawer A	Santa Rosa, Tx	78593
55	William Good	P99-64436	775 E. Hudson Rd.	San Benito, Tx	78586
56	Peter Bachman	185646	Rt.2, Box 112A	Alamo, Tx	78516
57	Ramon Reza	133604	P.O. Box 519	Sebastian, Tx	
58	Tony Prado	P-99-64842	Rt. 1 Box 100-C	Santa Rosa, Tx	78593
59	Dan Jaeger	471-62-1866	Rt. 1, Box 221	Primera, Tx	
60	Larry Allen	134502	1616 Ave. M	Hondo, Tx	78861
61	Jack N. Sutter	455-28-9989	4104 Old Port Isabel Rd.	Brownsville, Tx	78521
62	Joe Lane	467-18-5860	Rt. 3, Box 429	Harlingen, Tx	78550
63	James L. Cantrell	453-46-5396	RR8 Box 58	San Benito, Tx	78586
64	Fred G. Karle	121668	Rt.2, Box 2232	McAllen, Tx	78504
65	James Smart	167778	2082 E. 18th	Wheaco, Tx	78596

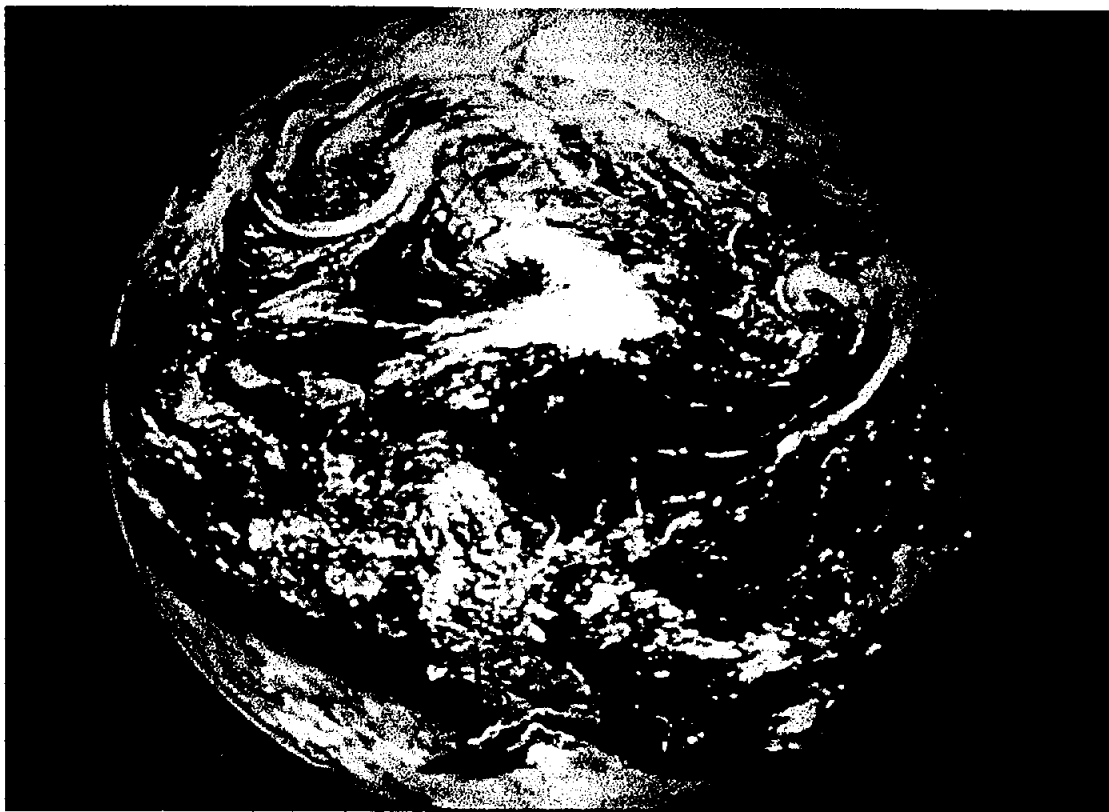
92	Jaime Luna	204757	Rt. 1 Box 198-E	La Perla, Tx	78539
93	Jesus Vasquez	1193413	P.O. Box 5109	Brownsville, Tx	78523
94	Miguel Burtamante	198099	Rt. 2, Box 55	Mercedes, Tx	78570
95	Mike Black	461-64-3610	Box 366	Agua Dulce, Tx	
96	S. T. Minor	456-62-7192		San Benito, Tx	78586
97	Michael Yeary	194516	P.O. Box 278	Progreso, Tx	78579
98	Craig Bookout	187692	Rt. 1 Box 43-B	Santa Rosa, Tx	78593
99	Heath Harris	461-61-3219	185 Laketown S.	San Benito, Tx	78586
100	Don Sugarek	463-74-5629	Rt. 1, Box 237	Beeville, Tx	
101	Andy Scott	122475	Rt. 1 Box 324	Monte Alto, Tx	78538
102	Victor H. Valladarez	207617	Rt. 1, Box 521	Westaco, Tx	78596
103	Don Vogel	454-78-5022	Rt. 2, Box 184	Mercedes, Tx	78570
104	Jim E. Brockington	223904	616 Silva Dr.	Westaco, Tx	78596
105	Oscar Longoria, Jr.	134683	1811 N. Alamo Rd.	Edinburg, Tx	78539
106	Gary Mack	133743	905 Travis	Hartlingen, Tx	78550
107	Blaine M. Morrow	457-92-2630	P.O. Box 4797	McAllen, Tx	78502
108	David L. Schertz	322-3808610	1342 Butler Churn Dr.	Herriden, VA	

21	Joe A. Fernandez		P.O. Box 533576	Hartingen	78553
22	Les Waldrop		P.O. Box 718	Portland, Tx	78374
23	Justin Hester		P.O. Box 658	Temple, Tx	76502
24	Abel Epp		P.O. Box 4652	McAllen, Tx	78504
25	Joe Bradford		USDA-ARS	Weslaco, Tx	78596
26	Susan Gray		USDA-ARS	Weslaco, Tx	78596
27	Steve Roach		Rt. 2, Box 155B	Alamo, Tx	78516
28	Lee Bauer		Rt.5, Box 195	Hartingen, Tx	78550
29	Jason Johnson		2401 E. Hwy 83	Weslaco, Tx	78596
30	Troy Myers		4110 N. 77#7178	Hartingen, Tx	78552
31	Bubba King		RR7 Box 213Y	Edinberg, Tx	
32	Shannon Linderath		301 Hesters Crossing, Sk. 130	RoundRock, Tx	78681
33	Dan Crummett		408 S. Main Ste 3	Salliswater, OK	74074
34	Mark Seipel		P.O. Box 158	Colchester, IL	
35	Tony Gonzales		2315 W. Expy 83	San Benito, Tx	78586
36	Donald Makus		USDA-ARS	Weslaco, Tx	78596
37	David W. Smith		306 E. Agen Dept.	College Station	77843-2121
38	Sam Migece		Rt. 1 Box 381	San Benito	78586
39	Ricardo Gonzalez		5250 Coffee Port	Brownsville	78520
40	Doug Sharer		143 Woodland Trl	Belton, Tx	76513
41	Jorge Rosas		105 Villafraanca St.	Brownsville,	78521
42	Guy Thomas			Canyon Lake	
43	M. Dailey		614 So. 16th	Hartingen, Tx	78550

22	Lucio Mercado G.		Carr. M. Aleman KM 15.5	Apodaca	N.L., Mexico
23	G. Jimenez			Monterrey	
24	J. Enrique Rodarte S.		3 ERA Cerrada de Medfida	Sinaloa	Mexico
25	Jorge Lugo		Rio Hymaya #128-C pre.	Culiacan, Sin.	Mexico
26	Mario M. Silva		Campo Exp. Rio Bravo	Apdo. Postal 1F2	
27	Fernando Gonzalez G.			Matamoros	Tamps
28	Abel Duran		Costa Azul	Matamoros	Tamps
29	Jaime Villarreal		A. Obregon #3	Matamoros	Tamps
30	Francisco de la Garza		Calle 8 #170	Matamoros	Tamps
31	Angel Sanchez		Laguna Madre	Matamoros	Tamps
32	Teodoro Cantu		Morelos 312	Rio Bravo	Tamps
33	Pablo Flores Morales			Matamoros	Tamps
34	Fernando Gomez Gomez		Francisco I. Madero #907	Rio Bravo	Tamps
35	Luis Lovanca		Carr. Miguel Aleman	N.L. Mexico	Tamps
36	Jorge Luis Martinez S.		Fisicos #140 Col. Tercero	Monterrey	N.L., Mexico
37	Miguel Ibarra		San Lorenzo	Guadalupe	N.L., Mexico
38	Jorge Gonzalez P.			Monterrey	N.L., Mexico
39	Navolato Sin				Mexico
40	Rafael Dominguez Obeso			Sinaloa	Mexico
41	Jacobo Gaxiola Lugo		Lago de Ipacara 3114	Sinaloa	Mexico
42	Guillermo Gastelón		Juan Escutia #440	Col. Chapulte Pec	Mexico
43	Palszugas Arned		Monjes Ciriales 504		Mexico

Help Yourself, Help the Environment

Today, you are learning about the benefits of no-till and reduced tillage for improving crop yields, reducing costs and maintaining soil productivity. However, there are other benefits - like helping our environment. Conservation tillage helps reduce runoff from agricultural land. Such runoff can carry with it sediment, nutrients and certain crop protection chemicals. By adopting a program including conservation tillage, and proper water and nutrient management, you will be doing your part to help protect the water quality in the Valley.



The Arroyo Colorado

The Arroyo Colorado and its tributary, the North Floodway is the principle drainage outlet for the Valley. The water quality of the Arroyo is a major concern, particularly due to its potential impact on wildlife and the Laguna Madre. Elevated levels of nitrate, phosphorous, sulfate, chloride and fecal coliform have been detected. Urban and agricultural runoff, municipal wastewater, septic tanks, and industrial discharges are all suspected of contributing to the problem.

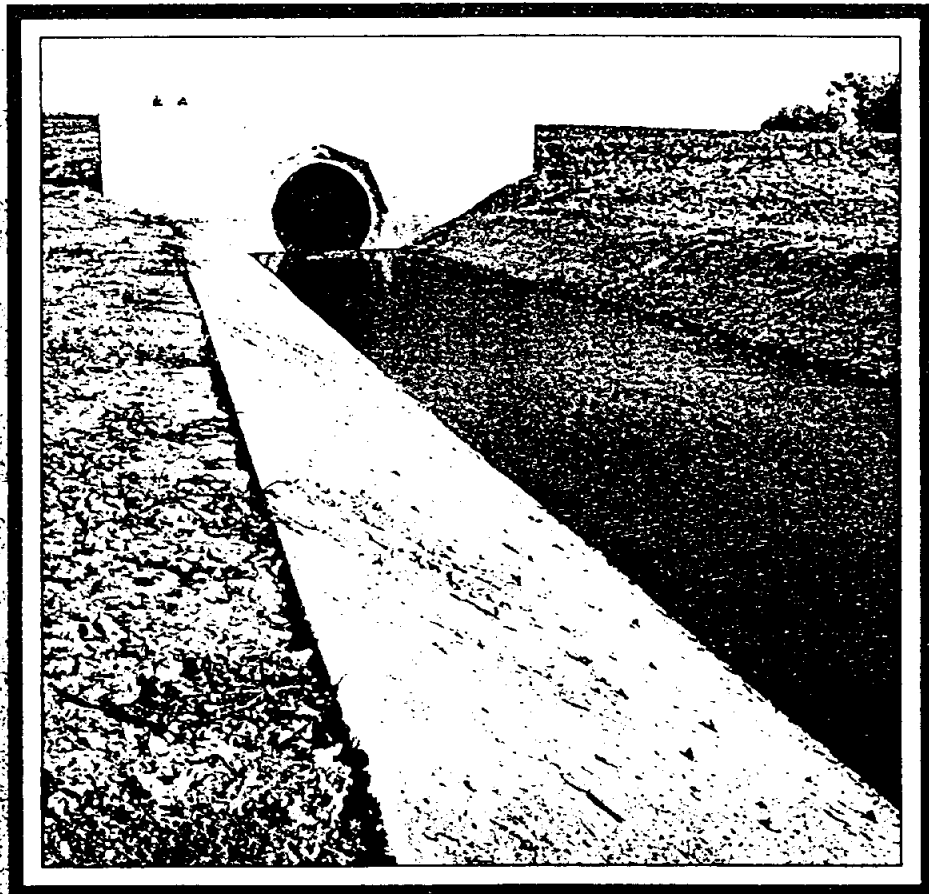
ASCE

The First International Conference on
WATER RESOURCES ENGINEERING

and International
GROUNDWATER MANAGEMENT
Symposium

WATERSHED MANAGEMENT
Symposium

TEXAS WATER '95



Hyatt Regency, San Antonio
San Antonio, Texas • August 14-18, 1995

AMERICAN SOCIETY OF CIVIL ENGINEERS

TEXAS WATER '95 SESSIONS CONTINUED

Buffalo Bayou Erosion Control And Bank Stabilization Study: DAVID PARKHILL, Brown&Root, Inc., Houston, TX and GREG DICIOCCIO, Harris County Flood Control District, Houston, TX,

Application Of The Unit Hydrograph Method To The Hill Country Region Of South-Central Texas: KELLY J. KAATZ and DAVID A. DICKERSON, HDR Engineering, Inc., Austin, TX

SESSION T 7*Nueces***TEXAS WATER PLANNING**

Moderator: JOHN GROUNDS, Albert Halff & Associates, Inc., Houston, TX

Development of Reservoir Operating Rule to Meet Bay And Estuary Needs: STEPHEN DENSMORE, Texas Water Development Board, Austin, TX

Urban Hydrology Information For Stormwater Management Planning in Texas: MARSHALL E. JENNINGS, U.S. Geological Survey, Austin, TX and WILLIAM H. ESPEY, JR., RMI, Inc., Austin, TX

Lower Colorado River Authority Water Management Plan: QUENTIN MARTIN, Lower Colorado River Authority, Austin, TX
Lower Colorado River Authority Clean Rivers Act Program: KEN MANNING, Lower Colorado River Authority, Austin, TX

SESSION T 8*Frio***TEXAS WATER RESOURCES II**

Moderator: SHERYL FRANKLIN, Brazos River Authority, Waco, TX

City of Austin Water and Wastewater Utility – Use Of Reclaimed Water At The New Austin Airport Location: REBECCA COBOS, City of Austin, Austin, TX

Flood Forecasting In The Lower Colorado River Basin – A Cooperative Effort Between LCRA and National Weather Service: RANDY RIEMAN, Lower Colorado River Authority, Austin, TX and DAVID REED, National Weather Service, Slidell, LA

Use Of Labyrinth Weir Dam For Flood Control And Improved Operation And Maintenance At Elemendorf Lake, San Antonio, Texas: DORIAN FRENCH, Brown&Root, Inc., San Antonio, TX and STEVE RAMSEY, San Antonio River Authority, San Antonio, TX

Hydrogeologic Investigations By The U.S. Geological Survey In The Edwards Aquifer Region: REBECCA LAMBERT, U.S. Geological Survey, San Antonio, TX

SESSION T 9*Blanco***TEXAS HYDROLOGY I**

Moderator: QUENTIN MARTIN, Lower Colorado River Authority, Austin, TX

LCRA Hydrologic Studies Related To Dam Safety Of Highland Lakes: RICK FRITHIOF, Lower Colorado River Authority, Austin, TX

Modeling Surface Runoff To Playa Lakes: DAVID THOMPSON and KEN RAINWATER, Texas Tech University, Lubbock, TX and ALAN J. REED, Parkhill, Smith, and Cooper, Inc., Lubbock, TX

Reservoir Management Using Conditional Probability Analysis: ALFREDO RODRIGUEZ and STEPHEN DENSMORE, Texas Water Development Board, Austin, TX

Modeling Irrigation Districts With IRDDSS – A Tool For Conservation And Planning: D.M. ENDALE and GUY FIPPS, Texas A&M University, College Station, TX

THURSDAY, AUGUST 17, 1995

8:30am - 10:00am

CONCURRENT SESSIONS**SESSION T 10***Nueces***TRANS-TEXAS WATER PLAN I**

Moderator: STEVEN J. RAABE, San Antonio River Authority, San Antonio, TX

Overview And State of Texas Perspective on The Trans-Texas Water Program: MIKE PERSONETT, Texas Water Development Board, Austin, TX

The Trans-Texas Water Program – South-Central Study Area: JAMES DODSON, City of Corpus Christi, Texas and HERB GRUBB and DAVID C. WHEELOCK, HDR Engineering, Inc., Austin, TX

The Trans-Texas Water Program – West-Central Study Area: STEVEN J. RAABE, San Antonio River Authority, San Antonio, TX and DAVID C. WHEELOCK, HDR Engineering, Inc., Austin, TX

Potential Introduction of Aquatic Organisms From Interbasin Water Transfers in Southeast, South-Central and West-Central Texas: JOSEPH KASBEY AND ROSS RASMUSSEN, Geo-Marine, Inc., Plano, TX

SESSION T 11*Frio***TEXAS RIVER-QUALITY**

Moderator: CINDY LOEFFLER, Texas Parks&Wildlife Department, Austin, TX

Contributions of the U.S. Geological Survey's National Water-Quality Assessment Program in Assessing The Quality of Water in Texas' Streams and Aquifers: LARRY F.LAND and MARSHALL E. JENNINGS, U.S. Geological Survey, Austin, TX

The TMDL Process: A Partnership To Achieve Texas' Water Quality Goals: TROY C. HILL and R. BRAD JENNINGS, U.S. Environmental Protection Agency VI, Dallas, TX

Is The Arroyo Colorado In Texas Polluted?: GUY FIPPS and DAVID W. SMITH, Texas A&M University, College Station, TX

Streamflow Data Collection and Water-Quality Monitoring By The U.S. Geological Survey In Texas: FRANK C. WELLS, U.S. Geological Survey, Austin, TX

SESSION T 12*Blanco***TEXAS HYDROLOGY II**

Moderator: JACK FURLONG, HDR Engineering, Inc., Dallas, TX

Freshwater Inflows To Corpus Christi Bay National Estuary Program Study Area: J.GREG MOSIER, WILLIAM ASQUITH and MARSHALL E. JENNINGS, U.S. Geological Survey, San Antonio and Austin, TX

Intersection Of The Houston Ship Channel and Gulf Intracoastal Waterway, A Marine Simulator Navigation Study: DENNIS W. WEBB, U.S.Army, Waterways Experiment Station, Vicksburg, MS

Potential Of Improved Irrigation Technologies For Reducing Irrigation Water Use: GUY FIPPS and R.M.SEYMOUR, Texas A&M University, College Station, TX

The Lower Rio Grande Irrigation Conference

Registration Form

Name _____
Company _____
City/Time Phone _____
Address _____
City _____ State _____ Zip _____

EASE REGISTER

_____ Persons at \$15 per person

Must be received by December 8, 1995. After
December 8, registration fee will be \$20.

Total Enclosed (\$) _____

MAKE CHECKS PAYABLE TO:

Irrigation Conference

RETURN TO THE:

**Cameron County Extension Office,
Hidalgo County Extension Office, or
Starr County Extension Office**

MAIL TO:

**Ms. Pamela Baker
Agricultural Engineering Department
Texas A&M University
College Station, TX 77843-2117**

Speakers

Joe Barrera, Manager, Brownsville Irrigation and Drainage District
Dr. Guy Fipps, Associate Professor and Extension Agricultural
Engineer, Texas A&M University, College Station
Gordon Hill, Manager, Bayview Irrigation District
John Hinojosa, Rio Grande River Water Master, TNRCC, McAllen
Glenn Jarvis, Attorney, McAllen
Alan Moore, Engineer, Natural Resources Conservation Service, San
Benito
Leon New, Professor and Extension Agricultural Engineer, Texas
A&M Center, Armarillo
Ray Prewett, General Manager, Texas Citrus Mutual
Jack Rabe, Manager, Donna Irrigation District
Dr. Julian Sauls, Professor and Extension Horticulturist, Texas A&M
Center, Weslaco
David Smith, Extension Associate-Landscape Irrigation, Texas A&M
University, College Station
Dr. Charles Stichler, Professor and Extension Agronomist, Texas
A&M Center, Uvalde
Dr. Merritt Taylor, Extension Economist, Texas A&M Center,
Weslaco
Bill Thompson, Manager, United Irrigation District, Mission
Don Thompson, President, TNT Associates, Garland
John Walker, Waterman Industries, Lubbock
Dr. Bob Wiedenfeld, Associate Professor - Soil Science, Texas A&M
Center, Weslaco

Conference Hotels

Reservations must be made by December 5, 1995 (mention the
"Irrigation Conference" when making reservations). Free shuttle
service to the civic center will be provided by both hotels.

The Doubletree Club-Casa de Palmas - 101 N. Main, McAllen,
(800) 274-1102; (210) 631-1101; \$49.95 single and \$55 double.

The Fairway Resort - 2105 S. Tenth Street, McAllen
(800) 432-4792; (210) 682-2445; \$50 for a single or double.
The Fairway can accommodate trailers and other large vehicles.

For More Information

Contact:

Brad Cowan
Hidalgo County Extension Agent, Edinburg
(210) 383-1026

or

Dr. Guy Fipps
Associate Professor and Extension Agricultural Engineer,
Texas A&M University, College Station
(409) 845-7454

THE LOWER RIO GRANDE IRRIGATION CONFERENCE

December 12, 1995
McAllen Civic Center

Presented By the

Texas Agricultural Extension Service
LRGV Irrigation District Managers'
Association

Sponsored by the

Texas Water Development Board
Texas Agricultural Irrigation
Association
Southmost Soil and Water
Conservation District



Texas Agricultural Extension Service

The Texas A&M University System

ATTENDANCE RECORD

RIO GRANDE VALLEY IRRIGATION CONFERENCE	DECEMBER 12, 1995
Activity or Event	Date

Please sign in for our records

Name	Address	City	Zip	Phone
1 MIKE PERSONETT	TUDB PO. BOX 13231	AUSTIN	78711	512/463-906
2 DALE MURDEN	PO FARM	EDROUSE	78538	262-4387
3 Kenneth Hood	113 Westgate	Westlaco	78596	968-1752
4 Carmel Cuenca	400 EAST 18 ST LOT 640	WESLACO	78596	462-4194
5 Bob BOECKER	P.O. Box 328 ALAMO, TX.		78516	781-526
6 ERNIE P. GARCIA	308A TEXAS BLVD	WESTLACO	78596	968-3174
7 Bill Thompson	216 country club	MISSION		
8 BILL PADEN	P.O. Box 1291	HIDALGO	78557	843-2591
9 NEWT DIER	#1 Box 1164 PHARR	PHARR	78577	843-806
10 JIM PAKE	ATE ³⁰ BOX 1242 MISSION	MISSION	78572	581-8786
11 JAIME SANCHEZ	1404 SON HORRERO	BROWN	78521	5427825
12 ALVARO RIVERA	Turbide y 9	MAT.		
13 JUAN M. MINANA	BOX 1772	BROWNS	78520	549 0329
14 A. St. White	P.O. Box 237	Mercedes	78599	565-2411
15 ROSE RAMIREZ	P.O. Box 1001	ROMA	78567	487 2582
16 ENRIQUE PEREZ	500 N. BRIDGEMAN TRAIL	RGC		
17 Linda Fernandez	TURCE PO Box 13087	AUSTIN	78711	512-257-5016
18 Dewain Ritchie	United Irrigation P.O. Box 867	MISSION	78572	585-8818
19 BOB OLIVIERO	PO Box 994	MISSION	78572	585-1661
20 George Carpenter	#7 Box 37-B	MALLA	78504	383-5780



Texas Agricultural Extension Service

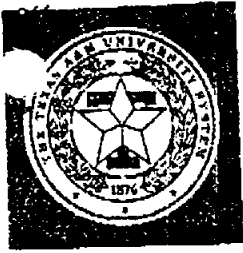
The Texas A&M University System

ATTENDANCE RECORD

RIO GRANDE VALLEY IRRIGATION CONFERENCE	DECEMBER 12, 1995
Activity or Event	Date

Please sign in for our records

	Name	Address	City	Zip	Phone
1	Juan Leija	913 N. Canyon Rd	Edinburg	78539	383-3686 ✓
2	Harry Sullivan	6116 Old Winter Garden Rd	Orlando	32835	407 893-5535 ✓
3	BILL TEHAN	1609 WALNUT AVE.	McALLEN	78501	(210) 682-5822 PA
4	Sary A. Williams	Box 657	Los Fresnos	78566	(210) 293-9232
5	Albert M. Kotz	RT 3 Box 161-17	Edinburg	78539	210-942-3111
6	Jimmy Pawlik	P.O. Box 4467	McAllen	78502	210-696-5035
7	Carlos H. H.	P. O. Box 326	Hidalgo	78557	(817) 211-1111
8	Paul Lopez	P.O. Box 1705	Hon.	78551	423-1270
9	Honny Williams	P.O. Box 361	Harlingen	78551	423-4412
10	Ed Tracy	1600 Ridge Rd	Alamo	78416	781-1552
11	Chuck Sellman	901 Business Park Dr., Ste 300	Mission	78572	584-1881
12	Charles Hutchins	Box 494 Castroville	Castroville	78009	538-9712
13	CLAIRE BROWN	Box 7158 4110 No Hwy 77	HARLINGEN	78552	428-9285
14	RAY PENROD	4110 N. Hwy 77 # 7272	HARLINGEN	78552	425-2014
15	Arturo Vasquez	Rt. 2 Box 523-A	Westaco	78596	968-6028
16	Jesus Avalo	2415 E Hwy 83	Westaco	78596	968-5585
17	ERNEST GARCIA	206 6th	Mercedes	78570	514-2000
18	Rafael Sjafla	206 6th	Mercedes	78570	514-2000
19	Euer Cortes	Jaxta 24	Go. Diaz Ordez	88400	8-24-04
20					



Texas Agricultural Extension Service

The Texas A&M University System

ATTENDANCE RECORD

RIO GRANDE VALLEY IRRIGATION CONFERENCE

DECEMBER 12, 1995

Activity or Event

Date

Please sign in for our records

Name	Address	City	Zip	Phone
Mario H. Daza	626 E 6th	Mercedes	78572	514-2000
Bob H. Egan	1415 Box 7012-15 Mission			
Jim Williams	PO Box 2345	McAllen	78504	631-3311
John Lightner	3225 Cobblestone Dr.	Harlingen	78550	421-2159
Joe L. Harris	229 Tompkinsville Dr	Mission	78572	585-2347
GENARO LINO	1914 West Adrian	Harlingen	78552	423-2086
Ed Pierson	10 N. Garfield	Eugene	97440	
BETH MERCIER	PO Box 4157	MONTEALTO	78538	262-1012
Walt Pat Cobb	PO Box 337	Shallowater	79363	806 744-2071
Margaret Johnson	PO Box 1043	Missin	78572	585-4761
John Johnson	P.O. Box 1043	Mission	78572	585-4761
Don Parker	PO Box 246-A	HARLINGEN	78552	412-8568



Texas Agricultural Extension Service
 The Texas A&M University System

ATTENDANCE RECORD

RIO GRANDE VALLEY IRRIGATION CONFERENCE	DECEMBER 12, 1995
Activity or Event	Date

Please sign in for our records

Name	Address	City	Zip	Phone
<i>Juan Leja</i>	<i>413 N. Canyon Rd</i>	<i>Edinburg</i>	<i>78539</i>	<i>383-3686</i> <small>607</small>



Rio Grande Valley Cotton Production & Physiology Workshop

Hoblitzelle Auditorium
Texas Agricultural Research & Extension Center - Weslaco
October 25, 1995
7:30 a.m.

Registration Fee: \$5.00 at the door

- | | |
|-------------------|--|
| 7:30 - 8:00 a.m. | <u>Registration</u> (\$5.00 at the door) |
| 8:00 - 12:00 | <u>Water Situation Update</u> - John Hinojosa
<u>Water Quality Issues</u> - Dr. Guy Fipps, Extension Irrigation Specialist
<u>Managing for Earliness</u> - Dr. Charles Stichler, Extension Agronomist
<u>Cotton Insect ID & Thresholds</u> - John Norman, Extension Cotton Entomologist
<u>Stalk Destruction Update</u> - Jimmy Day, Texas Department of Agriculture
<u>New Chemistries</u> - Dr. Stormy Sparks, Extension Entomologist
<u>Budgeting the Cotton Crop</u> - Dr. Merritt Taylor, Extension Economist
<u>Market Outlook</u> - Dr. Carl Anderson, Extension Economist |
| 12:00 - 1:00 p.m. | Lunch (on your own) |
| | ***** <u>Optional Afternoon Session</u> ***** |
| 1:00 | <u>Disaster Program Update</u> - Marcos Garza, Consolidated Farm Services Agency
<u>Cotton Physiology Workshop</u> - Dr. Charles Stichler, Extension Agronomist |

Sponsored by:

Texas Agricultural Extension Service
Cameron County Row Crops Committee
Hidalgo County Row Crops Committee
Willacy County Row Crops Committee

This program is worth three (3) hours of CEU's for commercial, non-commercial, and private applicators.
For more information contact: Terry Lockamy - Cameron County (399-4412); Brad Cowan - Hidalgo County (383-1026); or Luis Saldaña -Willacy County (689-2412)

7757

Extension programs serve people of all ages regardless of socioeconomic level, race, color, sex, religion, disability or national origin.



Texas Agricultural Extension Service

The Texas A&M University System

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ATTENDANCE RECORD

ACTIVITY Cotton Production Mtg DATE 10-25-95
 PLEASE SIGN IN FOR OUR RECORDS.

NAME	ADDRESS	CITY	ZIP	PHONE
Thomas Casuso	R.R. 1-Box-134A	LA FERIA	78559	797-2310
Antonio R. L. he	RT. 1 BOX 347A	Edinburg	78539	381-0330
Michael Fike	RT. 1 BOX 348A	Edinburg	78539	383-647
Frank Machac Jr.	1140X 1958	MISSION	78572	580-1603
FRANK MACHAC JR.	2504 CAUTERBURY	MISSION	78572	580-1603
Jerry Bradford	1203 W. 6th	Weston	78596	968-92
Clay Lacher	90 E S Tex	Westaco	78596	968-79
Alex Keller	RT 20 Box 816	Mission	78572	580-4342
D. E. Fagala	RT 2 Box 152B	SAN JUAN	78589	783-5741
BOB REKTORIK	RT Box 409	WESTLACO	78596	968-3702
Jim Gamble	RT. 1 Box 173	La Feria	78559	797-2008
Don Moskal	RT 1 Box 211	Santa Rosa	78593	636-1621
Frank Krupala	RT 2 Box 803	Raymondville	78580	689-6803
Eric Alexander	2102 Nth 7th #20	Harlingen	78550	415-2980
Kurt F. Clay	RT 1 Bx 39-K	La Feria	78559	797-2310
Merritt J. Taylor	2401 E Hwy 83 Bldg 201	Westaco	78596	969-4817
LARRY W. KOESTER	2401 E Hwy 83 Bldg 201	Westaco	78596	969-4817
Foel Garza	2401 E Hwy 83 Bldg 203	Westaco	78596	969-485
Richard Plata	RT 5 Box 550	SAN BENITO	78586	399-0210
JUAN KEIJA (TAES)	413 N. Kenyon Rd	Edinburg Tx	78539	383-3681
Robert Lopez	PO Box 111	Del Rio Tx	78840	718-2897
Gary Williams	P.O. Box 657	West Fresno	78566	233-523
Josue S. Perez	TAES	Westaco	78596	968-558
Noe L. Hernandez	RT 1 Box 115A	Pharr	78577	783-8662
Celestino Aguirre	RV Box 124	Pharr	78577	787-3177



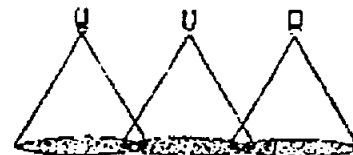
Texas Agricultural Extension Service

The Texas A&M University System

Hidalgo County Extension Office P.O. Box 600 Edinburg, TX 78540 210/383-1026

260

COTTON PRE-PLANT MEETING and SPRAYER CALIBRATION CLINIC



1996
Wednesday, January 17, 1995

Hoblitzelle Auditorium, A&M Research & Extension Center, Weslaco

3 TDA Recertification Credits to Be Offered for Private, Commercial and Non-Commercial Licenseholders

8:00- 8:30 Registration (\$10.00 per person)

8:30- Noon Program

----- SPEAKERS AND TOPICS -----

Update on Section 18's for Cotton in 1996

Terry Mitchell, Program Specialist- Texas Department of Agriculture, Austin

Moisture Management Strategies for the 1996 Crop

Kater Hake, Extension Agronomist, Lubbock

Calibration of Sprayers

Dr. Bryan Shaw, Extension Ag Engineering Specialist, College Station

Review of Cotton Variety Trials Conducted During the 1995 Crop

Brad Cowan, County Extension Agent- Agriculture, Edinburg

Drift Minimization Practices

Dr. Bryan Shaw, Extension Ag Engineering Specialist, College Station

Resistance Management, New Chemistries for Cotton

Dr. Stormy Sparks, Extension Entomologist, Weslaco

Farm Program Update

Wayne Labar, Executive Director, Cotton & Grain Producers Association

I look forward to seeing you on the 17th.

Sincerely,

Brad Cowan

County Extension Agent- Agriculture, Hidalgo County

TEXAS DEPARTMENT OF AGRICULTURE
 P.O. BOX 12847, AUSTIN, TEXAS, 78711
RECERTIFICATION ATTENDANCE FORM

Please furnish an affidavit with recertification requirements, the name below, and have defoliated through in the address listed above. Attendees must receive a certificate upon course completion as a receipt of attendance.
 SPONSOR (Name and Address)

COURSE # 2404	COUNTY CODE# Required for access 6666	COURSE DATE JANUARY 17, 1996
NUMBER OF APPROVED CONTINUING EDUCATION CREDITS		DEPT. ADMINISTRATION
LAWS AND REGULATIONS		INTEGRATED PESTICIDE
GENERAL		

NAME (Last, First, Middle Initial as appears on the form)	LICENSE #	THIS INFORMATION MUST BE TYPED			CITY, STATE	ZIP
		SSN #	ADDRESS			
C. PRUKOP, JR	186096		RT 8 BOX 160		MISSION, TX	78572
L. SALDANA	142596		975 W GEN AVE		RAYMONDVILLE, TX	78580
E. HERMANDEZ		460-90-7298	2415 E. BUS. HWY 83		MESLACO, TX	78596
J. PEREZ		449-66-1299	RT 2 BOX 117		MERCEDES, TX	78570
E. CASTANEDA	136096		108 BRUCE		MERCEDES, TX	78570
C. BAUER		456-62-7048	P O BOX 1908		LA FERIA, TX	78559
J. L. WILLIAMS	122693		P O BOX 149		LOS FRESNOS, TX	78566
C. EUBANKS		455-90-1029	P O BOX 343		SANTA ROSA, TX	78593
D. MCDANIEL		464-96-8830	1900 CITRUS		MESLACO, TX	78596
N. LYNN		457-60-6046	RT 1 BOX 13A		ALAMO, TX	78516
L. BECK		480-74-2523	P O BOX 720425		MCALLEN, TX	78504
M. YEARY		463-29-3783	P O BOX 278		PROGRESO, TX	78579
L. JONES		449-27-7400	BOX 1560		MISSION, TX	78572
D. SHATLEY		571-88-2947	BOX 40		LOCKNEY, TX	79241
B. COWAN	124558		P O BOX 600		EDINBURG, TX	78540
P. ARNMANTROUT		369-14-9890	RT 1 BOX 98K		ALAMO, TX	78516
D. G. WARREN	122867		2401 E HWY 83		MESLACO, TX	78596
D. PETERS			RT 4 BOX 835		SAN BENITO, TX	78586
W. HARRISON		461-40-1683	1202 ELM		MISSION, TX	78572

as

1996 NO-TILL FIELD DEMONSTRATION

CAMERON COUNTY FIELD CROPS COMMITTEE

at WILBUR-ELLIS, RIO HONDO -(follow signs)

REGISTRATION: 8:30 A.M.

25 Multi-Wave

JUNE 12, 1996
2 CEU CREDITS

REGISTRATION: 8:30 A.M.
LUNCH PROVIDED

FEATURING:

Demonstrations of No-Till Planters & Cultivators

John Deere

Yetter

Buffalo

Dawn

Groft

Martin

Cultivating to create a Water Furrow
Water Conservation Displays
Boll Weevil Parasite Display - *Catolaccus grandis*



TECHNICAL ASSISTANCE:

USDA-ARS, NRCS, TAEX-TAES & BARBEE NEUHAUS

SPECIAL GUESTS:

TAMAULIPAS GROWERS ASSOCIATION

The following sponsors made this day possible:

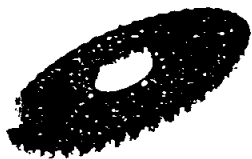
Texas State Bank
PCA
San Benito Bank & Trust
First National Bank
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First Valley Bank
Brownsville Nat'l Bank

Harlingen Irrigation District #1
San Benito Irrigation District #2
La Feria Irrigation District #3
Valco
Southmost Soil & Water
Conservation District

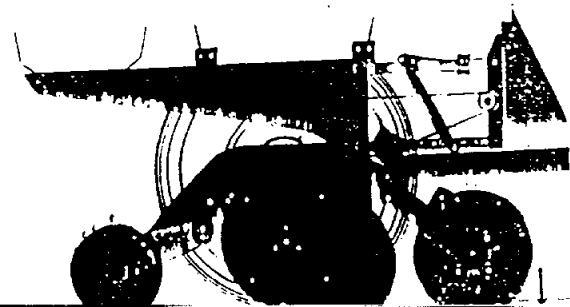
ASOCIACION AGRICOLA DE MATAMOROS
WILBUR-ELLIS



3 Shallow Wave



Ripple



Bubble

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mailed
2-14-97*
UNITED STATES
DEPARTMENT OF
AGRICULTURE

NATURAL RESOURCES
CONSERVATION
SERVICE

2315 W EXPWY 83
SAN BENITO, TEXAS 78586
PHONE: (210) 399-2522

To: Justin Hester
TSSWCB Project Officer
Texas State Soil and Water Conservation Board
P.O. Box 658
Temple, Texas 76501

Date: February 13, 1997

Subject: NPS Prevention in Arroyo Colorado Watershed
NRCS Quarterly Report-September thru November 1996

TASK 4.0 Annual Education Workshop Conducted

The Extension Service in cooperation with NRCS, SWCD and Cameron County Crops Committee sponsored a conservation field day at the Gearge Labar farm in Rio Hondo. Alan Moore, Ag Engineer, NRCS, San Benito spoke about and demonstrated the monitoring equipment and sampling procedures at the demonstration site. Tony Gonzales, DC, NRCS spoke on BMP's including rotation cropping system, conservation tillage, precision land forming, nutrient management and pest management. Jim Childers, Agronomist, NRCS also spoke on conservation tillage and BMP's as applicable to dryland farming. Planting in heavy standing residue was demonstrated. About 100 producers attended. The field day was held on October 23, 1996 (agenda attached).

Other NRCS activities during this quarter included:

1. Visited with producers Wayne Halbert and George Labar about managing crop residues, fertilizer application and irrigation water management.
2. Coordinated sample collection and equipment maintenance with Agro-Synergetics, John Lightner.
3. Ordered new set of bottles for sample collecting.
4. Ordered new data loggers for all sites.
5. Assisted SWCD with clerical duties relating to the project.

Sincerely,

Antolin Gonzales

Antolin Gonzales
District Conservationist

Cameron County Field Crops Committee

Presented by: Cameron County Crops Committee

Committed to the future of agriculture.

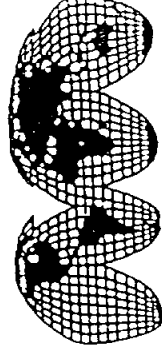
Cooperating Sponsors:

Cameron County Extension Office
Natural Resource Conservation Service
Southern Regional Sustainable Agricultural
Research and Education Program
Southmost Soil & Water Conservation District
Texas Agricultural Extension Service
USDA-Agricultural Research Service
U.S.E.P.A. - Arroyo Colorado Project

2nd Annual

**No-Till Field Day &
Farm Show
Rangerville Coop Gin
April 30, 1997
9:00 a.m. - Noon
Lunch Provided**

3 CEU's and Door Prizes



Committed to the future of agriculture.

Conservation Tillage Field Day
 October 23, 1996
 Registration and coffee 8:00 a.m.
 Tour starts at 8:30
 George Labar Farm Headquarters
 (FM 1420, across from Camp Perry on West side of Road)

Managing Soil Moisture:

- Estimating available moisture
- Estimating crop usage rate
- Impacts on decision making

Best Management Practices:

- reduce Nitrogen losses
- reduce moisture losses
- reduce land preparation costs
- reduce non point source pollution potential
- Water Quality Issues
- Senate Bill 503 - requirements and incentives



Equipment Demonstration & Displays:

- Planting in heavy residue
- Fertilizer applications in residue
- Residue managers for planting, cultivating, and off season weed control
- Herbicide application

Hosted by:

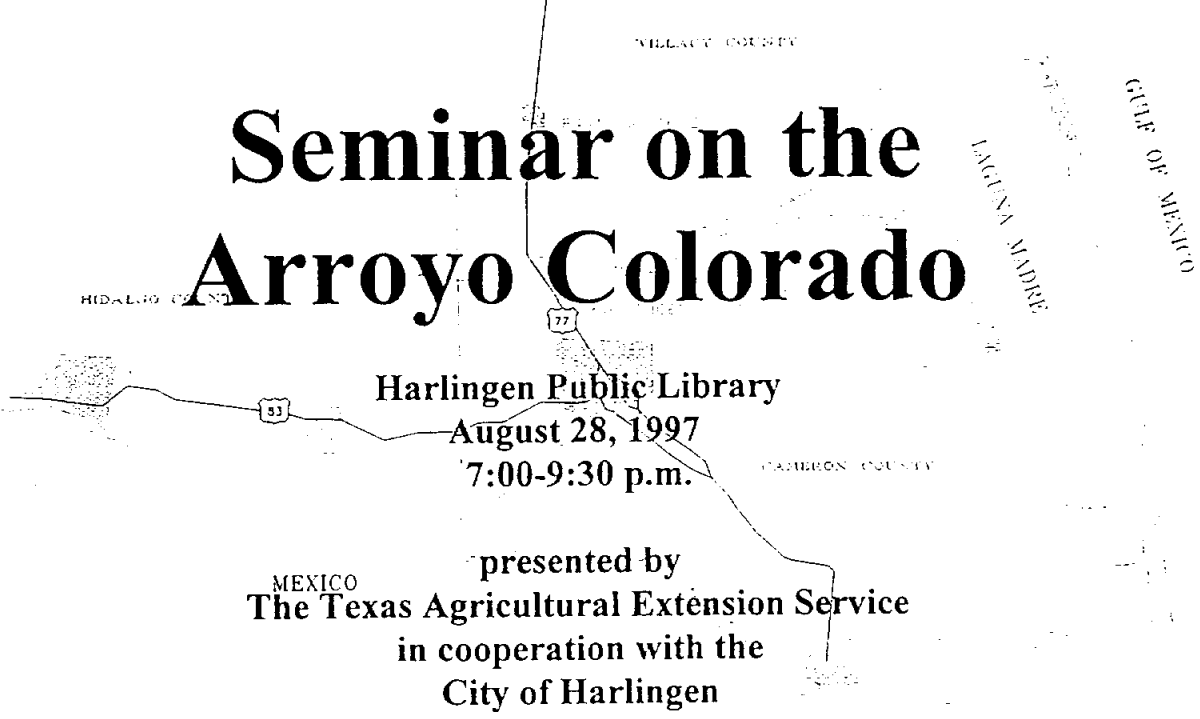
Cameron County Field Crops Committee
 Southmost Soil & Water Conservation District
 Texas Agricultural Extension Service
 Natural Resource Conservation Service
 USDA-Agr. Research Service

Equipment provided by:

Barbee-Neulhaus Implement Co

Sponsored by:

Monsanto
 Southmost Soil & Water Conservation District
 Asociacion Agricola De Matamoros
 Brownsville National Bank
 San Benito Irrigation Dist. #2
 First National Bank - San Benito
 First Valley Bank
 Harlingen Irrigation Dist. #1
 La Feria Irrigation Dist. #3
 Production Credit Association
 San Benito Bank & Trust
 Southmost Soil & Water Conservation District
 Texas State Bank-
 Valley Co-Op Oil Mill



Seminar on the Arroyo Colorado

Harlingen Public Library

August 28, 1997

7:00-9:30 p.m.

presented by
The Texas Agricultural Extension Service
in cooperation with the
City of Harlingen

Description

The Seminar will present the results of the multi-agency project: *Non-point Source Pollution Prevention in the Arroyo Colorado Watershed*. The project was funded by the U.S. Environmental Protection Agency (EPA) through the Texas Natural Resource Conservation Commission (TNRCC) and the Texas State Soil and Water Conservation Board (TSSWCB). Cooperating agencies included the Natural Resources Conservation Service (NRCS), the Southmost Soil and Water Conservation District, the Texas Institute for Applied Environmental Research (TIAER), and the Texas Agricultural Extension Service (TAEX).

Program

- | | |
|-----------|--|
| 7:00 p.m. | Welcome, Project Overview
T. Lockamy, G. Fipps, B. Spoons, L. Pardee (invited) |
| 7:30 | The Arroyo Colorado Water Quality Data Base - What do we know?
C. Bausch, G. Fipps |
| 8:00 | Demonstration Sites and Results
T. Gonzales, A. Moore |
| 8:30 | Best Management Practices - Modeling and Projected Benefits
J. Flowers |
| 9:00 | Educational Program Outcomes
G. Fipps, D. Smith, S. Sparks, B. Shaw |
| 9:30 | Adjourn |

This seminar is funded through a grant from the United States Environmental Protection Agency through the Texas Natural Resource Conservation Commission.

On-Farm 8/15/95

Comey Jack	TWDB	512-463-7983
Jeff Walker	TWDB	512 463-7940
DAROLD ARDATHNOT	BUREAU OF RECLAMATION	652-247-7776
OSVALDO Longoria Jr.	NRCS	210- 689-2542
ROEL E. TREVINO	NRCS	210-383-3002
Paul DeArman	NRCS	512-239-4729
BRAD Cowan	Texas Agricultural Extension Service	383-1026
Alan Moore	NRCS	210-399-2527
BAILEY H. DUNLAP JR	53 WED #319	1210 797 2541
WAYNE HALBERT	HARLINGEN IRRIGATION	210 423 7015
Terry Lockamy	Tx Ag. Ext. Service - Cameron Co.	210 399 4412
Lenny Duberstein	U.S. BOR. - Billings MT	406-247-7707
Tony Gonzales	USDA, NRCS	210-399-2522
Alberto Ramirez	TSSWCB - Edinburg	210 - 381 - 6614
Doyle & Warren	TAEY	210 968 5581
John M. Swatten	Ag Eng Dept. College Station TX TX Ag Ext. Serv. Service, TX A & M Univ.	409/845-7451
JAMES KOWIS	TNRCC / Austin	(512) 239-4706
LINDA FERNANDEZ	TNRCC / Austin	512-239-5016
Guy F. P. S	Ag Eng, TAMU / TAEY	409 845-7454
Bill Thompson	United Irrigation	210 585-4818
DARIUSZ SWIETLIK	TEXAS A&M - Kingsville Citrus Center	210-968-
MIKE PERSONETT	TWDB	512/463-8061