### A Landowner's Manual Managing Agricultural Irrigation Drainage Water:

### A guide for developing Integrated On-Farm Drainage Management systems

Developed for the
State Water Resources Control Board
by the
Westside Resource Conservation District
in conjunction with the
Center for Irrigation Technology,
California State University, Fresno

"Funding for this project has been provided in part by the U.S. Environmental Protection Agency (USEPA) pursuant to Assistance Agreement No. C998998901-0 and any amendments thereto which has been awarded to the State Water Resources Control Board (SWRCB) for the implementation of California's Nonpoint Source Pollution Control Program. The contents of this document do not necessarily reflect the views and policies of the USEPA or the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendation for use."

### **Table of Contents**

Chapter 1: General Information	
Introduction	
This manual	
History	1-2
Chapter 2: Salt Management Using IFDM	
Introduction	
Land Retirement	
Drainage Water Reuse	
What is an IFDM System and How Does It Work?	
Components of an IFDM System	
Solar Evaporator	
Site Evaluation & Considerations	
Climatology	
Groundwater	
Regional Groundwater Flow	
Soil	
Farm Area	
Subsurface Drainage System	
Water Management & Monitoring	
Crop and Tree Areas	
System Operation & Maintenance	
Future Investigations	2-14
Chapter 3: Monitoring, Recordkeeping and Reporting	
Introduction	
Data Quality	
Monitoring and Reporting Program	
Reporting Requirements	
<b>Chapter 4: The Impact of Geology and Soils in Salt Management</b>	
Introduction	
Soils of the Westside – geography and geology	4-1
Chapter 5: Drainage Water Characteristics	
Introduction	
Units of measurement	
Characteristics of agriculture drainage waters	5-1
Chapter 6: Plant Selection for IFDM	
Introduction	
Considerations for Proper Plant Selection	
Field crops and vegetables	
Salt-tolerant forages	
Halophytes	
Trees	
Conclusion	6-13

Chapter 7: Drainage Water and its Effect on Wildlife Resources	
Introduction	7-1
Laws that address wildlife issues	
Constituents of concern	
Water quality objectives	7-4
Biological sampling	
Chapter 8: IFDM Economics	
Introduction	8-1
Cost Breakdown	8-1
Funding Sources	8-2
Chapter 9: Laws and Regulations	
Introduction	9-1
Questions That Should be Answered Before Proceeding with the Project	
Regulatory Requirements	
Environmental Evaluation Resources	
Answers to the Most Common Questions Concerning the Solar Evaporator Regulation	s9-7
References	R-1
Appendix	A-1
Glossary	Glossary-1

### **List of Tables**

Cnapter 2:	
Table 1: An example of monthly weather data available from CIMIS	Page 2-6
Table 2: Estimated size of the solar evaporator	
Table 3: Water applied to solar evaporator (time required per day @ 250 gpm/acre)	Page 2-12
Chapter 5:	
Table 1: Conversion factors for drainage waters in the San Joaquin Valley	Page 5-3
Table 2: Irrigation guideline limits for various constituents and	
water quality targets for wildlife	Page 5-4
Table 3: Composition of drainage water used to irrigate salt-tolerant	
forages and halophytes in drainage water reuse projects on the	
Westside of the San Joaquin Valley	Page 5-5
Chapter 6:	
Table 1: Drainage water constituents having potential impacts on	
plants, soil structure, migratory waterfowl and wildlife, ruminant	
animals, and groundwater or surface water	Page 6-1
Table 2: Comparison of salinity tolerance and profit potential for	
various plants in an IFDM system	Page 6-2
Table 3: Soil salinity threshold (ECe)	Page 6-3
Table 4: Example of Maas Hoffman salinity tolerance coefficients and	
slopes for field crops and vegetables (Maas & Grattan, 1999)	Page 6-4
Table 5: The maximum percent of saline water (4 to 10 dS/m) that can	
be mixed with non-saline irrigation water (0.8dS/m) to achieve a	
yield potential of 100% and 80% for selected crops that vary in salt	
tolerance. Estimates assume a leaching fraction of 25% (Dinar and Letey)	Page 6-5
Table 6: Comparison of salt tolerant forages	
Table 7: Forage quality for Jose Tall Wheatgrass growing at Red Rock Ranch	Page 6-8
Table 8: Comparison of halophytes	Page 6-9
Chapter 7:	
Table 1: Water quality objectives for the protection of wildlife	Page 7-4
Chapter 8:	
Table 1: The estimated costs of installing, operating, and maintaining	
the solar evaporator and the estimated annual costs of land used	
for the evaporator, salt tolerant crops, forages and halophytes	Page 8-2

## **List of Figures**

Chapter 2:	
Figure 1: Multiple stage sequential water reuse	Page 2-2
Figure 2: AndrewsAg IFDM. Sequential re-use, three stages (1035 acres)	Page 2-2
Figure 3: Red Rock Ranch IFDM. Sequential re-use, four stages (640 acres)	_
Figure 4: Solar evaporator and water catchment basin	_
Figure 5: Solar evaporator with salt concentrator and water catchment basins	Page 2-11
Figure 6: Evaporation rates throughout the year	Page 2-12
Chapter 3:	O
Figure 1: EM-38 survey equipment	Page 3-7
Figure 2: Salinity map created from EM-38 survey data	O
(values represented in this map are ECe (dS/m)	Page 3-7
Chapter 5:	O
Figure 1: Salt accumulation in the San Joaquin Valley totals about	
11 semi-trailers an hour at 25 tons per truck.	Page 5-2
Chapter 7:	O
Figure 1: Bio-accumulation of selenium flow-chart for wildlife	Page 7-3

#### **Dedication**

This drainage management manual is dedicated to the memory of Frank Menezes, who passed away in 2001.

Frank was a valuable asset to the San Joaquin Valley's Westside agricultural community, focusing on salinity and drainage management – in particular, development of the Integrated On-Farm Drainage Management system.

Frank's technical knowledge, practical understanding of farmers' and ranchers' needs, and warm and engaging manner made him one of the Westside's most respected and beloved individuals. Because of his tireless efforts in helping develop and implement IFDM systems on Red Rock Ranch and at other sites, this publication is dedicated to Frank Menezes.

#### A Landowner's Manual

## Managing Agricultural Irrigation Drainage Water A guide for developing Integrated On-Farm Drainage Management systems

Edited by Tim Jacobsen and Lisa Basinal

# Chapter 1 GENERAL INFORMATION Liz Hudson<sup>1</sup>

<sup>1</sup>Hudson•Orth Communications, <u>hudsonfarms@aol.com</u>

#### Chapter 2 SALT MANAGEMENT USING IFDM

Tim Jacobsen<sup>1</sup>, Lisa Basinal<sup>1</sup>, Nettie R. Drake<sup>2</sup>, Vashek Cervinka, Ph.D.<sup>3</sup>, Kathleen Buchnoff<sup>4</sup>, and Morris A. "Red" Martin<sup>3</sup>

<sup>1</sup> Center for Irrigation Technology (CIT), California State University, Fresno,

tjacobse@csufresno.edu

<sup>2</sup>B&N Enterprises

<sup>3</sup>Westside Resource Conservation District

<sup>4</sup> Integrated Drainage Management Section of Agricultural Drainage Program, Department of Water Resources

# Chapter 3 MONITORING, RECORDKEEPING AND REPORTING

Kathleen Buchnoff<sup>1</sup>, Julie Vance<sup>2</sup>, and Lisa Basinal<sup>3</sup>

<sup>1</sup> Integrated Drainage Management Section of Agricultural Drainage Program, Department of Water Resources, <a href="mailto:kbuchnof@water.ca.gov">kbuchnof@water.ca.gov</a>

<sup>2</sup> Environmental Science, Department of Water Resources

<sup>3</sup> Center for Irrigation Technology (CIT), California State University, Fresno

# Chapter 4 THE IMPACT OF GEOLOGY AND SOILS IN SALT MANAGEMENT Tim Jacobsen<sup>1</sup>

<sup>1</sup> Center for Irrigation Technology (CIT), California State University, Fresno, tjacobse@csufresno.edu

# Chapter 5 DRAINAGE WATER CHARACTERISTICS

Sharon Benes<sup>1</sup>, Tim Jacobsen<sup>2</sup>, and Lisa Basinal<sup>2</sup>

<sup>1</sup>Dept. of Plant Science & Center for Irrigation Technology (CIT), California State University, Fresno, <u>sbenes@csufresno.edu</u> <sup>2</sup>Center for Irrigation Technology (CIT), California State University, Fresno

## Chapter 6 PLANT SELECTION FOR IFDM

Sharon Benes<sup>1</sup>, Steve Grattan<sup>2</sup>, Clarence Finch<sup>3</sup>, Lisa Basinal<sup>1</sup>

<sup>1</sup>Dept. of Plant Science & Center for Irrigation Technology (CIT), California State University, Fresno, sbenes@csufresno.edu,

<sup>2</sup>Dept. of Land, Air and Water Resources, University of California, Davis <sup>3</sup>USDA Natural Resources Conservation Center (NRCS), Fresno, CA, (retired)

# Chapter 7 DRAINAGE WATER AND ITS EFFECT ON WILDLIFE RESOURCES Lisa Basinal<sup>1</sup> and Andrew G. Gordus, Ph.D.<sup>2</sup>

<sup>1</sup>Center for Irrigation Technology (CIT), California State University, Fresno, <u>Ibasinal@csufresno.edu</u> <sup>2</sup>California Department of Fish and Game

### Chapter 8 IFDM ECONOMICS

Tim Jacobsen<sup>1</sup> and Nettie R. Drake<sup>2</sup>

<sup>1</sup> Center for Irrigation Technology (CIT), California State University, Fresno, <u>tjacobse@csufresno.edu</u> <sup>2</sup> B&N Enterprises

### Chapter 9 LAWS AND REGULATIONS

Gerald Hatler<sup>1</sup>, Wayne Verrill<sup>2</sup>, Mike Tietze, C.HG, C.E.G.<sup>3</sup>

<sup>1</sup> Environmental Science, Department of Water Resources, <u>ghatler@water.ca.gov</u>
<sup>2</sup> Environmental Science, State Water Resources Control Board
<sup>3</sup> Hydrogeology, MFG, Inc.

### Acknowledgements

This manual would not be possible were it not for the help, support and guidance of the following people and their affiliations:

#### **Center for Irrigation Technology**

Tim Jacobsen Lisa Basinal Marilyn Creel

#### California State University, Fresno

Sharon Benes Florence Cassel-Sharmasarkar Derek Dormedy Dave Goorahoo

#### California Department of Water Resources

Kathleen Buchnoff Vashek Cervinka Jose Faria Gerald Hatler Charyce Taylor Julie Vance John Shelton Manucher Alemi Ray Hoagland Holly Jo Ferrin Tony Lam Donald Woodson Charles Blalock

#### MFG, Inc.

Mike Tietze Nettie Drake, B&N Enterprises Bill Bazlen

#### **Westside Resource Conservation District**

Morris "Red" Martin Sarge Green

### U.S. Department of Agriculture-Natural Resources Conservation Service

Clarence Finch (retired) Kerry Arroues Dave Krietemeyer Raul Ramirez USDA

#### **Hudson•Orth Communications**

Liz Hudson Shelley Orth

### U.S.Department of Agriculture-Agriculture Research Station

Jim Ayers Catherine Grieve James Poss

### California Department of Food and Agriculture

Matt Reeve

#### California Department of Fish and Game

Andy Gordus

#### University of California, Davis

Steve Grattan Bryan Jenkins Kenneth Tanji (retired)

#### University of California, Riverside

John Letey

Although many people contributed to the production of this drainage manual, two people must be recognized for their longtime commitment to the development of Integrated On-Farm Drainage Management systems.

Since 1985, Dr. Vashek Cervinka, of the Department of Water Resources, and Morris A. "Red" Martin, of the Westside Resources Conservation District, have been major forces in the development of agroforestry and on-farm drainage reuse to help manage salinity and shallow groundwater levels. Their early efforts and institutional knowledge of salinity and drainage on Westside soils — much of it documented in this manual — provides farmers with a viable option to ensure continued production of high quality food and fiber crops.

### Acknowledgements

Red Rock Ranch

John Diener

**State Water Resources Control Board** 

Wayne Verrill Khoban Kochai

Central Valley Regional Water Quality

Control Board

Anthony Toto Lonnie Wass

AndrewsAg, Inc.

Michael Andrews

U.S. Bureau of Reclamation

Mike Delamore

**Westlands Water District** 

Jerry Robb

**Broadview Water District** 

David Cone

**Provost and Pritchard** 

Eric Abrahamsen

**Boyle Engineering** 

Ken Swanson

**Tulare Lake Drainage District** 

Doug Davis

The authors of Chapter 6 wish to acknowledge the hard work of Cynthia Eroh and James Bartram who conducted fieldwork that provided information for this chapter. Also, the authors express appreciation to Dr. Vashek Cervinka, Clarence Finch, and the late-Frank Menezes, who were involved in the initial plant selection for drainage water reuse projects. Gratitude also is extended to the funding agencies, California State University (CSU) Agricultural Research Initiative (ARI) and the Proposition 204 Agricultural Drainage Reuse Program administered by the California Department of Water Resources. Earlier support was provided by a grant from the USDA National Research InitiativeWater Resources Assessment and Protection program.