Enhanced Agricultural Irrigation Efficiency Program

City of Temecula and Portions of the City of Murrieta and Southwest Riverside County, CA

FINAL PROJECT REPORT

U.S. Department of Interior, Bureau of Reclamation
Agreement Number R12AP35350

Rancho California Water District

42135 Winchester Rd.
P.O. Box 9017
Temecula, CA 92589-9017

December 31, 2014

1. Recipient Information

Rancho California Water District
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2. Final Funding Information

	Project Expenditures
Non-Federal Entities	
1. Rancho California Water District	$195,678.08
Non-Federal Subtotal	$195,678.08
Other Federal Entities	$0
Bureau of Reclamation	$174,191.71
Total Project Funding	$369,814.02

3. Project Summary

The Enhanced Agricultural Irrigation Efficiency Program (Enhanced AIEP/Program) expanded the scope of assistance made available to local farmers through Rancho California Water District's (RCWD/District) Existing Agricultural Irrigation Efficiency Program (Existing AIEP), which provides financial assistance to farmers within the District's service area for increasing the hydraulic efficiency of their irrigation systems through replacement of irrigation system components such as pipelines, sprinklers, and pressure regulation devices. Through installation of weather stations and soil moisture sensors at select avocado farms within the District's service area, the Enhanced AIEP provided farmers with easily accessible and valuable data that allowed them to make more informed irrigation scheduling decisions, resulting in further irrigation efficiency improvements.

Four weather stations were installed at strategic locations within the District's avocado growing region to represent the area's diverse microclimates. The stations produced evapotranspiration (ETo) data that was more relevant to the participating farmers' growing operations and allowed them to more accurately estimate crop water requirements. Twenty four soil moisture sensors were installed at 24 different growing operations and provided the farmers with volumetric soil moisture data, which allowed them to monitor actual crop water usage. Both types of data were made available to them on the World Wide Web, and they were accessed on office computers, tablets, and smart phones. Together, these data allowed participating farmers to further increase irrigation scheduling efficiencies through more accurate irrigation scheduling.

For implementing the Enhanced AIEP, the Bay Delta Restoration Program funding was used to pay for the following activities: 1) pre-screening and identifying project sites prior to installation; 2) developing weather station/radio relay infrastructure and local ETo data availability; 3) installing soil moisture capacitance probe technologies; 4) demonstrating the technologies and providing training on how to use them; and 5) monitoring post-installation water consumption; and 6) reporting to Reclamation.

4. Final Project Description

RCWD implemented the Enhanced AIEP as part of its long-term goal of water supply reliability and efficient water management. The Program functioned as an expansion to the District's Existing AIEP, which was implemented starting in 2010 with the goal of helping to sustain regional agriculture by reducing agricultural water requirements through irrigation system retrofits that resulted in increased distribution uniformity. The Existing AIEP included six major program components:

1. Developing water budgets for 1,724 agricultural operations utilizing GIS and infrared data.
2. Comparing water budgets to consumption histories for 1,724 agricultural operations, and targeting 100 of them (~1,000 acres) that demonstrate the greatest need for water use efficiency improvements.
3. Auditing the irrigation systems at the targeted sites to evaluate each one in terms of irrigation system efficiency, i.e. distribution uniformity.
4. Providing financial incentives to owners of the targeted sites for irrigation system retrofits (upgrades) to improve irrigation system efficiency. RCWD pays for 50% of approved equipment costs for irrigation system retrofits that result in improved distribution uniformity.
5. Auditing the irrigation systems following implementation of the system retrofits to quantify resulting improvements in distribution uniformity.
6. Quantification of water supply benefits in terms of improved irrigation system efficiency resulting from the irrigation system retrofits.

While the Existing AIEP provided financial incentives for installation of irrigation equipment (i.e. piping, valves, pressure regulators, and pressure compensating sprinklers) that improved on-farm water use efficiency through distribution uniformity improvements, the Existing AIEP did not incentivize equipment that helped growers schedule irrigation events more accurately and according to the needs of the crop. Thus, one of the goals of the proposed Enhanced AIEP was to broaden the focus of the Existing AIEP to include financial incentives not only for improving irrigation system distribution uniformity, but also for the implementation of remote sensing devices that would enhance on-farm irrigation by providing growers with essential data that would allow them to schedule irrigation events more accurately.

The types of data made available to growers through implementation of the Enhanced AIEP included volumetric soil moisture data and ETo data. Volumetric soil moisture data was obtained through the installation of a capacitance probe at each of the 24 properties that were selected for participation. These probes were connected to wireless telemetry equipment, which communicated the data to a website that was

accessed by participating growers through any device with an internet connection. In addition to the installation of the 24 capacitance probes, four weather stations were installed at four of the 24 participating sites. These weather stations produced ETo data, which were also connected to wireless telemetry equipment and made available to the participating growers on the same website.

Within RCWD's service area, the value of these remote sensing devices in improving water management and producing water savings had been demonstrated through efforts conducted by the Temecula Valley Winegrowers Association, which helped local vineyard owners to build a small network of devices similar to those described above. Analysis of water consumption among four sites utilizing the devices indicated a decrease in consumption of 29% annually when compared to the year prior to installation. The intent of the Enhanced AIEP was to build a similar network of equipment within the avocado growing region of the District's service area and achieve similar water savings for these growers.

The goals of the Enhanced AIEP were to:

1. Target avocado growing operations, which represent a significant portion of the District's water demand, for implementation of the aforementioned remote sensing devices.
2. Pre-qualify customers within the targeted group and select them for participation based on potential for water savings and willingness to participate.
3. Provide training to participants on the proper use of the remote sensing devices.

Following is a task-by-task description of work that was performed by RCWD for implementation of the Enhanced AIEP:

Task 1: Pre-screen and Identify Project Sites

Sub-task 1.1: Develop site-specific water budgets.
RCWD staff developed site specific annual water budgets for every avocado growing operation within RCWD's service area. Annual water budgets for these operations were developed using GIS analysis to ascertain crop types and irrigated acreage measurements. Irrigated acreage data was then combined with historical weather data from California Irrigation Management Information System (CIMIS) station #62 and avocado water requirement data to estimate site water requirements.

The site water requirements were compared against site water consumption histories to verify potential for water savings at each site. Sites with consumption histories that exceeded their water budgets were deemed to have the highest potential to reduce water use. These sites were targeted for irrigation system audits.

Sub-task 1.2: Perform irrigation system audits at 100 avocado grove sites and select 24 for technology implementation.

One hundred avocado growing operations were audited for irrigation system efficiency (i.e. distribution uniformity). The audits were conducted according to standards developed by California Polytechnic State University, San Luis Obispo's Department of Agricultural Engineering. Sites were considered for Enhanced AIEP participation based on adequate condition of the irrigation system, and the growers' acceptance

and willingness to utilize the remote sensing devices for irrigation scheduling. Twenty-four sites were ultimately chosen for participation.

Task 2: Develop Weather Station/Radio Relay Infrastructure and Local ETo Data Availability

Sub-task 2.1: Install weather stations.

A total of four weather stations and associated radio relay equipment were installed at strategic locations, which represented four distinct microclimates within RCWD's avocado growing region; one weather station per microclimate zone.

Sub-task 2.2: Coordinate communication of data from weather stations to World Wide Web.

The weather stations are powered by small solar panels and were equipped with temperature sensors, pyranometers, relative humidity sensors, and wind speed/direction sensors. Data collected by the stations was sent via a network of radio relays to a computer server in Madera, CA where the company Crop Production Services, Inc. used software to run the data through the Penman-Monteith equation for calculating ETo on a daily basis. The ETo data was then made available to growers on a webpage.

Sub-task 2.3: Develop webpage and coordinate customer data access.

Crop Production Services, Inc. provided a webpage where the ETo data was available for the benefit of participating growers. Program participants were provided with passwords for accessing the localized ETo data.

Task 3: Install Capacitance Probe Technology

Sub-task 3.1: Install capacitance probes.

One capacitance probe was installed at each of the 24 participating sites. Each probe was installed at a location that best represented the entire growing operation. These capacitance probes generated site-specific volumetric soil moisture data that was made available for the individual grower on a website.

Sub-task 3.2: Coordinate communication of data from probes to World Wide Web.

The capacitance probes detected soil moisture through continuous monitoring of the dielectric properties of soil. The data was communicated to the web every 15 minutes via the same network of radio relays installed as part of the weather station infrastructure development phase. A computer server received the data and used software to translate it into a volumetric soil moisture percentage that was useful in determining irrigation event run times.

Sub-task 3.3: Develop webpage and coordinate customer data access.

Data produced by the newly installed capacitance probes were published on the same webpage as the ETo data for subtask 2.3 and made accessible to the individual site owner/manager.

Task 4: Demonstrate Technology and Provide Training

Sub-task 4.1: Provide training to 24 program participating property owners/managers.

Following installation of the remote sensing devices, RCWD worked with Crop Production Services, Inc. to provide one-on-one training to the 24 participating grove owners/managers.

Sub-task 4.2: Conduct a growers' workshop.

RCWD staff conducted a grower's workshop on how to use ETo data effectively for irrigation scheduling. The workshop also provided information on the remote sensing devices and the benefits of their use.

Sub-task 4.3: Distribute training manual called "Using CIMIS Data to Estimate Orchard Water Use".

RCWD purchased and distributed "Using CIMIS Data to Estimate Orchard Water Use," a manual created by The Mission Resource Conservation District, to local growers as a means of providing training on how to use ETo data for scheduling irrigation events.

Sub-task 4.4: Produce newsletter(s).

Information regarding the Enhanced AIEP was made available to the public through an RCWD newsletter article.

Task 5: Monitor Post Installation Consumption.

Sub-task 5.1: Monitor water consumption.

Water consumption at each of the 24 participating sites was monitored over a 12-month period using monthly billing data.

Sub-task 5.2: Compare pre- and post-installation water consumption.

Water consumption for the 12 months following equipment installation was compared to the consumption data during the 12 months prior to equipment installation. Post-installation consumption for each site was weather-normalized based on ETo data for the two time periods.

Task 6 Report to Reclamation

Sub-task 6.1: Prepare quarterly or semi-annual progress report.

Progress reports were submitted to Reclamation as specified within the Reclamation Assistance Agreement.

Sub-task 6.2: Prepare Final Report.

This Final Report documenting project findings was prepared and submitted to Reclamation following conclusion of the Program.

5. Amount of Water Conserved, Marketed or Better Managed

A. RCWD Total Water Supply (average annual available in AF/Y)

Average annual supply over 10-15 years is approximately 75,000 AF/Y. However, the recent drought conditions, specifically in the past three years, have limited supply. The average annual supply in the past 3 years is approximately 66,300 AF/Y. Total RCWD water supply includes imported treated, groundwater, and recycled water.

B. Amount and Calculation of Water Conserved, Marketed or Better Managed as a Result of the Enhanced AIEP

a. Calculation Information/Data

For estimating water savings resulting from implementation of the Enhanced AIEP, water consumption data, as reported through RCWD's automated metering infrastructure, was collected for the 24 properties where the technology was directly installed and for 224 additional properties affected by the installation of remote sensing technologies. The 224 additional properties affected by the installation of the technologies include those that were owned/managed by the same owners/managers of the 24 properties where the technology was directly installed. These properties are included in the analysis because the irrigation strategies implemented at these sites were influenced by the data produced by the installed technologies.

Consumption data for each of the sites included in the analysis was collected for the 12-month periods both preceding and following installation of the technologies. Consumption for the post-installation time period was adjusted according to differences in weather and crop canopy conditions between the time periods. Differences in weather conditions were quantified in terms of pre- and post-installation ETo data while differences in crop canopy were estimated for each property through visual assessment of GIS aerial imagery from time periods both preceding and following installation of the technologies. The following formula was used to estimate water savings for each of the properties.

$$WS = WC_{pre} - [WC_{post} - (WC_{post} \times \%ET_{chg}) - (WC_{post} \times \%CP_{chg})]$$

where,

WS	= Water Savings
WC_{pre}	= Pre-Installation Water Consumption
WC_{post}	= Post-Installation Water Consumption
$\%ET_{chg}$	= % Change Evapotranspiration
$\%CP_{chg}$	= % Change Canopy

b. Reliability of Information/Data

The data relied upon for the water savings calculation includes water consumption, ETo, and GIS aerial imagery data. All of the data used for the calculation are considered extremely accurate and reliable. It should be

noted, however, that while it is crucial to include in the water savings calculation a variable capturing pre- and post-installation canopy differences due to the vigorous growth habit of the avocado crop, the drastic pruning practices employed by some avocado growers, and the planting of additional crop, which can cause extreme effects on crop water requirements, this variable can be difficult to correlate to water consumption data since the timing of such events does not always occur in conjunction with the generation of the aerial photography and the point in time the equipment was installed. In other words, challenges in quantifying crop canopy changes include making considerations for the differences between the time aerial photos were taken, the time the equipment was installed, and the time pruning or additional crop planting practices were implemented. Therefore, for this water savings analysis, experience-based estimates were used in conjunction with GIS aerial imagery to ascertain crop canopy changes during pre- and post-installation time periods.

c. Supporting Data Attached

Following is a summary of estimated Water Savings resulting from the Enhanced AIEP:

Site Group	Pre-Installation Water Consumption (AF)	Adjusted Post-Installation Water Consumption* (AF)	Estimated Water Savings (AFY)
24 Device Properties	1,396	1,266	130
224 Affected Properties	6,047	5,832	215
		TOTAL	345

*Post-installation consumption was adjusted to reflect differences in both weather and crop canopy conditions between pre- and post-installation time periods.

C. Use of Conserved Water

Water conserved was not pumped from its sources to the properties participating in the Enhanced AIEP. The sources include the California Bay Delta, the Colorado River, and the District's local aquifer. For each acre foot of water conserved, approximately one-third would have originated in the local aquifer, and two-thirds would have been imported. Of that import water, about two-thirds would have originated in the Colorado River watershed, and the remainder in the Bay Delta.

D. Future Tracking of Project Benefits

RCWD has no plans to track the Project benefits in the future beyond the current Project benefits identified; however, should Reclamation request that an analysis of water savings be conducted in the future, RCWD would provide the analysis.

6. Amount of Renewable Energy Added

The Enhanced AIEP does not have a renewable energy component.

7. Project Collaboration, Stakeholder Involvement or Formation of Partnerships

The Project included the development of water budgets for avocado growing operations and the auditing of irrigation systems. These activities were paid for, in part, by California's Department of Water Resources.

8. Other Pertinent Issues Regarding the Enhanced AIEP

None.

9. Feedback to Reclamation Regarding the Bay Delta Restoration Program: CALFED Water Use Efficiency Grants

None.

10. Attachments – Provided upon request

- Map Depicting Project Sites

Since the Project is District-wide at multiple locations, it is not feasible to provide maps, drawings, or photos of each specific site. The Final Project Costs are shown in the next section. All items listed as follows will be provided upon Reclamation's request.

- Summary of Water Budgets & Consumption for Agricultural Operations
- Summary of Irrigation System Audit Results
- Photo of Webpage Listing Installation Sites
- Workshop Attendees List
- Invitation Letter for Technology Training Sessions
- Training Manual
- Newsletter Article

11. Final Project Costs

Budget Item Description	Computation								Recipient Funding	Reclamation Funding	Total Cost
	FY11/12		FY12/13		FY13/14		FY14/15				
	$/Unit And Unit	Quantity	$/Unit And Unit	Quantity	$/Unit And Unit	Quantity	$/Unit And Unit	Quantity			
Salaries And Wages											
Justin Haessly, Conservation/Water Use Efficiency Analyst	$ 37.44	98	$ 39.8700	49	$ 42.36	34	$ 45.54	224	$ 13,104.68	$ 4,159.20	$ 17,263.88
Peter Knepp, Intern			$ 49.10	2					$ 83.47	$ 24.55	$ 98.20
Liviu Rosu, GIS Coordinator	$ 45.96	10							$ 390.63	$ 114.89	$ 459.56
Salaries and Wages Subtotal									$ 13,578.78	$ 4,298.64	$ 17,821.64
Fringe Benefits	72.91%		77.71%		72.91%		77.71%				
Justin Haessly, Conservation/Water Use Efficiency Analyst	$ 2,675.16		$ 1,518.17		$ 1,050.12		$ 7,927.07		$ 13,170.51		$ 13,170.51
Peter Knepp, Intern			$ 76.31						$ 76.31		$ 76.31
Liviu Rosu, GIS Coordinator	$ 335.07								$ 335.07		$ 335.07
Fringe Benefits Subtotal									$ 13,581.89	$ -	$ 13,581.89
Equipment											
Capacitance Probes & Weather Station									$ 3,228.14	$ 115,646.06	$ 118,874.20
Equipment Subtotal									$ 3,228.14	$ 115,646.06	$ 118,874.20
Supplies/Materials											
Outreach/Demonstration Materials	$5,000	1							$ 452.55	$ 150.85	$ 603.40
Supplies/Materials Subtotal									$ 452.55	$ 150.85	$ 603.40
Contractual/Construction											
GIS Imagery	$ 68,023.91	1							$ 51,017.93	$ 17,005.98	$ 68,023.91
Data Service/Maintenance Fee									$ 2,408.20	$ 13,441.80	$ 15,850.00
GIS Consultant									$ 33,755.84	$ 11,251.95	$ 45,007.78
Irrigation Auditing Contractor									$ 37,189.31	$ 12,396.44	$ 49,585.74
Contractual/Construction Subtotal									$ 124,371.27	$ 54,096.16	$ 178,467.43
Total Direct Costs									$ 155,212.63	$ 174,191.71	$ 329,348.56
FY1112 Indirect Costs: 207.23% of Salaries and Wages	$ 8,555.86								$ 8,555.86		$ 8,555.86
FY1213 Indirect Costs: 236.07% of Salaries and Wages			$ 4,843.76						$ 4,843.76		$ 4,843.76
FY1314 Indirect Costs: 207.23% of Salaries and Wages					$ 2,984.73				$ 2,984.73		$ 2,984.73
FY1415 Indirect Costs: 236.07% of Salaries and Wages							$ 24,081.11		$ 24,081.11		$ 24,081.11
Total Direct Costs									$ 40,465.46	$ -	$ 40,465.46
Total Project Costs									**$ 195,678.08**	**$ 174,191.71**	**$ 369,814.02**