



Good Irrigation Water Management Practices

December 7, 2016



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Spencer Cooper, Almond Board of California
(Moderator)

Larry Schwankl, UCCE Irrigation Specialist
Emeritus

Spencer Cooper, Almond Board of California

Terry Prichard, UCCE Water Management
Specialist Emeritus

Spencer Cooper, Almond Board of California





**Spencer Cooper,
Almond Board of California**



Water Management and Efficiency

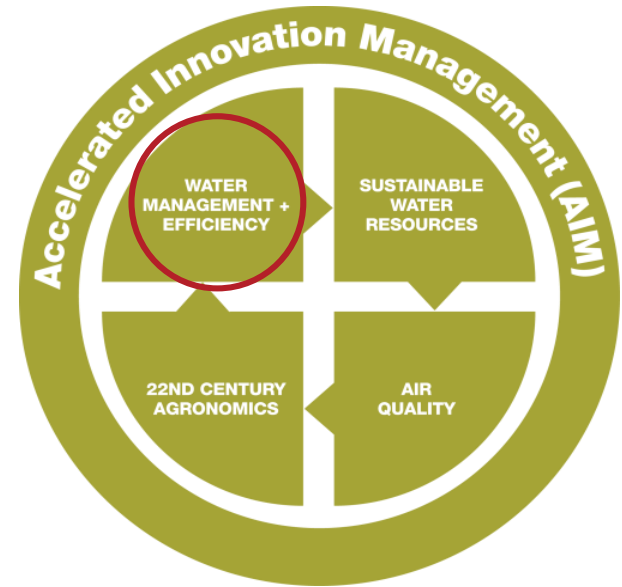
Almond Irrigation Improvement Continuum



Water Management and Efficiency

Almond Irrigation Improvement Continuum

- Water Management and Efficiency
 - One of four key components of the Accelerated Innovation Management (AIM) program adopted by Almond Board of California's (ABC) Board of Directors.
 - California experts noted there were a range of tools growers could be implementing without wholly new technologies.
 - Focuses on accelerating almond grower adoption of research based, commercially available, and increasingly water efficient irrigation management and scheduling tools.
 - An Almond Irrigation Improvement Continuum has been developed to describe the steps of this transition.



Almond Irrigation Improvement Continuum

- Three proficiency levels
 - **Level 1.0** (minimum) outlines research-based irrigation management practices that are within reach for all California Almond growers. (Room 310 – 311)
 - **Level 2.0** (intermediate) and **level 3.0** (advanced) advance practices to more sophisticated levels that attain even more “crop per drop.”
 - Comprehensive program of irrigation management and scheduling practices in five key areas
 - Assessing irrigation system performance and efficiency regularly
 - Estimating orchard water requirements based on evapotranspiration
 - Determining the water applied
 - Evaluating soil moisture
 - Evaluating plant water status
- Guidance on how to effectively integrate the practices at each level

Almond Irrigation Improvement Continuum

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Almond Irrigation Improvement Continuum Outreach

- The Almond Board's objective is to assist all almond growers in meeting level 1.0 proficiency
- Beyond this, to work with growers to progress along the continuum to levels 2.0 and 3.0 proficiency
- This will be done in partnership with the many trusted and respected technical experts and resources available to California Almonds
 - University of California Cooperative Extension
 - USDA NRCS, RCD's
 - CSU Fresno, Cal Poly SLO, CSU CHICO, Modesto Junior College
 - CDFA SWEEP Program
 - Private companies and services, irrigation districts, and others
- Adoption will be assessed via the Almond Sustainability Program and Basic Irrigation Assessment
- Ebook version of Irrigation Continuum 1.0 is available online at <http://www.almonds.com/irrigation>
- One Pagers

Larry Schwankl, UCCE Irrigation Specialist Emeritus



Almond Irrigation Improvement Continuum

- Step-by-step approach to provide almond growers with the irrigation water management information to improve their irrigation practices.
 - Provide the information in one, easy-to-access, location – the ABC website.
 - Start easy and then build on that.

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Big Picture – What do you need to manage irrigation water?

- Know how much water you need to apply and when.
- Know your irrigation system so you can determine how long (and often) you need to operate your system.
- Tools to check to see how you are doing.

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All Level 1.0 information is now available as pdf documents.

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Irrigation Calculator

Almond Conference 2016

Introduction

- Historical Et One Pager
- Sure Harvest Irrigation Calculator

ET Reference Chart

IRRIGATION SCHEDULING USING EVAPOTRANSPIRATION (ET)

Understanding the changing demand of almond trees based on water use by evapotranspiration, or ET, is a first step toward optimum irrigation scheduling. ET scheduling accounts for the loss of water through soil surface evaporation and transpiration through openings in the leaves. In almonds, ET will change throughout the year according to weather (e.g., heat and humidity impact evaporation) and time of year or crop stage (e.g., lower leaf surface in early season equals lower transpiration).

$$\text{Crop Water Use (ETc)} = \text{Reference Evaporation (ETo)} \times \text{Crop Coefficient (Kc)}$$

ETc (almond water use) in inches of water can be time-framed to the day, week, month, or season in order to assess the orchard's water requirements for irrigation scheduling purposes.

ETo (reference ET) information is available from a variety of sources, but most well-known is the California Department of Water Resources' CIMIS network of nearly 100 California weather stations that provide daily reference evapotranspiration values (www.cimis.water.ca.gov).

Thirty-year average evapotranspiration reference rates (ETo)¹ and almond (ETc)² for several CIMIS zones within almond-producing areas of California (adapted from UC ANR Pub. 8515)

Kc ^{3,4,5,6,7}	Zone 12 ⁴		Zone 14 ⁵		Zone 15 ⁶		Zone 16 ⁷		
	ETo	ETc	ETo	ETc	ETo	ETc	ETo	ETc	
Jan	0.4	1.24	0.5	1.55	0.62	1.24	0.5	1.55	0.62
Feb	0.41	1.06	0.81	2.24	0.92	2.24	0.92	2.52	1.04
Mar	0.62	3.41	2.11	3.72	2.3	3.72	2.3	4.03	2.49
Apr	0.8	5.1	4.09	5.1	4.09	5.7	4.57	5.7	4.57
May	0.94	6.82	6.44	6.82	6.44	7.44	7.02	7.75	7.31
Jun	1.05	7.8	8.2	7.8	8.2	8.1	8.51	8.7	9.14
Jul	1.11	8.06	8.93	8.68	9.61	8.68	9.61	9.3	10.3
Aug	1.11	7.13	7.9	7.75	8.59	7.75	8.59	8.37	9.28
Sep	1.06	5.4	5.73	5.7	6.05	5.7	6.05	6.3	6.68
Oct	0.92	3.72	3.41	4.03	3.69	4.03	3.69	4.34	3.97
Nov	0.69	1.8	1.23	2.1	1.44	2.1	1.44	2.4	1.84
Dec	0.43	0.93	0.4	1.55	0.66	1.24	0.53	1.55	0.66
Totals (in)									
Yearly			49.75		52.61		53.73		57.70

¹ Normal year evapotranspiration of unstressed grass (reference crop, ETo) 30-year CIMIS average for the respective zone.

² Evapotranspiration rates for almonds were calculated by multiplying ETo by the crop coefficient (Kc).

³ Almond crop coefficients (UC ANR Pub. 8515).

⁴ Zone 12 ETo rates from Chico, Fresno, Madera, Merced, Modesto, and Visalia.

⁵ Zone 14 ETo rates from Newman, Red Bluff, and Woodland.

⁶ Zone 15 ETo rates from Bakersfield, Los Banos and westside San Joaquin Valley.

⁷ Zone 16 ETo rates from Coalinga and Hanford.





Growing Safe Product

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HELLO, GROWERS

Haven't signed up for [The Almond Conference](#) yet? Don't wait! Save time, save yourself from standing in line and save a seat at the table by going online to [register](#) and to reserve your meal tickets for The Almond Conference, Dec. 6-8, at the Sacramento Convention Center. If you wait to register in Sacramento, you'll be taking a chance that all meal events will be sold out. Online registration closes at noon, Wednesday, Nov. 30.

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ALMOND ALMANAC

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IN THE ORCHARD

PESTS

IRRIGATION
MANAGEMENT

NUTRIENTS

ALMOND
HARVEST

POLLINATION

ORCHARD
DEVELOPMENT

GRANTS FOR
GROWERS

IRRIGATION
IMPROVEMENT
CONTINUUM

WATER SUPPLY

WATER QUALITY

IRRIGATION IMPROVEMENT CONTINUUM



Limited water supplies — with or without the California drought — are a reality. Almond Board of California has invested heavily in the area of water irrigation strategies and technologies that conserve water while optimizing almond production and tree health, as well as in ways to protect ground-and surface-water from potential runoff or leaching of grower inputs.

One of these investments is the [Almond Irrigation Improvement Continuum](#); a comprehensive manual of irrigation management and scheduling practices. Recognizing that growers may be operating at different stages of irrigation efficiency, the Continuum provides information at three proficiency levels (1.0, 2.0 and 3.0), each covering the following concepts and how to execute and effectively integrate them:

- Measuring irrigation system performance and efficiency
- Estimating orchard water requirements based on evapotranspiration
- Determining the water applied
- Evaluating soil moisture
- Evaluating plant water status

The Irrigation Continuum was developed in partnership with the many trusted and respected technical experts and resources available, such as University of California Division of Agriculture and Natural Resources Cooperative Extension.

1.0

The [Continuum Level 1.0](#) outlines irrigation management practices that are within reach for all California Almond growers. It is available as a [downloadable PDF](#) and coming soon is an EPUB to read on an iBook or other digital reader app.

In addition to the manual, there are one page summary documents from sections within the manual.



2.0 and 3.0

While the above tools are available now, development of the Continuum continues with respected irrigation experts to build out levels 2.0 and 3.0.

The Continuum Level 2.0 consists of more intermediate level practices and Level 3.0 address practices at more sophisticated levels to attain even more "crop per drop." As Level 2.0 and 3.0 manuals are developed, they will be published on this web page.

Why is Irrigation Improvement a Priority?

In 2015, Almond Board of California's (ABC) Board of Directors adopted Water Management and Efficiency as one of four key components of the [Accelerated Innovation Management \(AIM\)](#) program. ABC has long been a research-based organization and will continue to support traditional research and sustainability initiatives, but is now placing greater emphasis on the innovative almond farming practices that will be required to meet the future needs of the California almond industry, as well as the consumer, the community and the planet.

The Water Management and Efficiency initiative focuses on accelerating almond grower transition and adoption of research based, commercially available, and increasingly water efficient irrigation management and scheduling tools.

Irrigation Calculator

The [Irrigation Calculator](#) supports the practices in the Irrigation Continuum and generates irrigation run time schedules that advise the amount and timing of irrigations based on local evapotranspiration and information about your individual orchard and irrigation system. Linked to your nearest CIMIS station, this tool automatically integrates current weather information, allowing you to better calculate your orchard's irrigation water requirement. The tool can be accessed on the [California Almond Sustainability Program website](#) and is referenced throughout Almond Irrigation Continuum 1.0.

The scheduling tool stores data by orchard block, making updates easy as information changes. It's also completely private — information is not shared with anyone. Data entered into the Irrigation Calculator can be saved and updated as necessary. All almond growers can use the Calculator to create irrigation schedules, but must be participants in the [California Almond Sustainability Program](#) for the data storage aspect, which saves the need to reenter all the data when making revisions during the growing season. Data can be printed or displayed as a PDF file, or exported into a database.

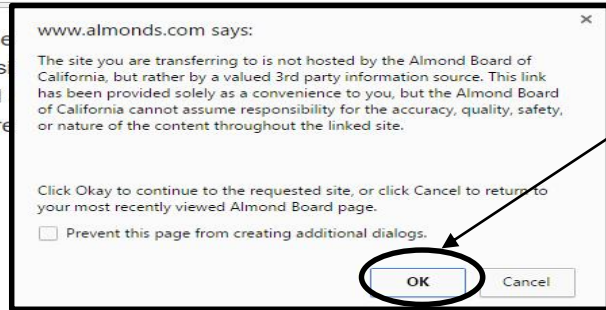
Hullsplit Strategic Deficit Irrigation

Almond trees can tolerate moderate drought stress from the completion of kernel fill to 90% hullsplit without risk of crop loss or long-term yield effects. Moderate water stress at this time provides three additional benefits: 1) lower potential for [hull rot](#); 2) a more uniform [hullsplit](#), leading to an earlier harvest, when crop damage from rainfall is less likely; and 3) an earlier harvest, all of which can help minimize crop exposure to late-season navel orangeworm flights and potential aflatoxin contamination.

Additional Resources

- [California Agriculture: Regulated deficit irrigation reduces water use of almonds without affecting yield](#)
- [UC ANR Publication: Using the pressure Chamber for Irrigation Management in Almonds](#)

- Determining When to Be
- Irrigation Scheduling Us
- Almond Salinity Hazard
- What to Consider Before



2.0 and 3.0

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California Almonds - Get Almond Irrigation Management Techniques

Home

Monday, November 14, 2016

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About Almond Nitrogen Budgeting
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CASP Home Page

California Almonds - Get x Home x

https://www.sustainablealmondgrowing.org/Home/tabid/71/Default.aspx

California Almonds Sustainability Program

Home Events Assessments N Calculator Irrigation Calculator

Monday, November 14, 2016

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Quick Links

- Manage Spencer cooper's Profile
- Assessments**
 - Goto Assessments
 - Clone Assessments
- Tools**
 - Add an Orchard
 - View N Budgets
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 - View Irrigation Schedules
 - Add Irrigation Schedule
- Education Content**
 - Search Education Content
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 - Getting Started Guide
 - N-Budget Guide
 - Mapping Guide
 - Irrigation Calculation Guide

News

NEW Irrigation Calculator

CASP irrigation Calculator automates CIMIS data downloads to calculate weekly run times to meet Etc.

Week	Entered Run Hrs	Run Hrs to Meet ETC
5/27 - 5/27	20	21.7
5/28 - 5/14	20	21.7
5/15 - 5/21	20	21.7
5/22 - 5/28	20	21.7

To see how, open the tool or check out the irrigation calculator user [guide](#)

Nitrogen Budgeting and ILRP

Create ILRP: Part D - Farm Map & ILRP: Nitrogen Management Plan

NITROGEN MANAGEMENT PLAN									
Field ID	Field Name	Field Area (Acres)	Field Type	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
1	Field 1	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
2	Field 2	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
3	Field 3	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
4	Field 4	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
5	Field 5	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
6	Field 6	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
7	Field 7	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
8	Field 8	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
9	Field 9	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes
10	Field 10	10	Field	Field Use	Field Status	Field Owner	Field Manager	Field Contact	Field Notes

[LINK](#) to My Maps help [LINK](#) to N Budget help

Upcoming Events

No Events found

CASP Home Page

https://www.sustainablealmondgrowing.org/Home/tabid/71/Default.aspx



Home Events Assessments N Calculator Irrigation Calculator

Add Irrigation Schedule
View Irrigation Schedules

Quick Links

- Manage Spencer cooper's Profile
- Assessments**
 - Goto Assessments
 - Clone Assessments
- Tools**
 - Add an Orchard
 - View N Budgets
 - Add N Budget
 - Goto Maps
 - View Irrigation Schedules
 - Add Irrigation Schedule
- Education Content**
 - Search Education Content
- Help**
 - Getting Started Guide
 - N-Budget Guide
 - Mapping Guide
 - Irrigation Calculation Guide

News

NEW Irrigation Calculator

CASP irrigation Calculator automates CIMIS data downloads to calculate weekly run times to meet Etc.

Week	Entered Run Hrs	Run Hrs to Meet ETC
5/1 - 5/7	20	21.7
5/8 - 5/14	20	21.7
5/15 - 5/21	21.7	21.7

To see how, open the tool or check out the irrigation calculator user [guide](#)

Nitrogen Budgeting and ILRP

Create ILRP: Part D - Farm Map & ILRP: Nitrogen Management Plan

[LINK to My Maps help](#) [LINK to N Budget help](#)

Welcome back **Spencer cooper** (v1.8.1) [Provide Feedback](#) | [Need Help?](#) | [Logout](#)

Upcoming Events

No Events found



Irrigation Scheduler

The screenshot shows a web browser window with the URL https://www.sustainablealmondgrowing.org/IrrigationCalculator/AddIrrigationSchedule/tabid/211/ctl/Edit/mid/663/IrrigationModelRun_ID/-1/Default.aspx. The page features a header with the California Almonds logo and navigation links: Home, Events, Assessments, N Calculator, and Irrigation Calculator. The main content area is titled "Irrigation Schedule" and includes a "Provide Feedback | Irrigation Calculation Help" link. It contains two numbered steps: Step 1, "Crop Year", with a dropdown menu set to "2016"; and Step 2, "Organization", "Enterprise", and "Orchard" fields, with values "Almond Board", "Almond Board", and "Test" respectively. Below these fields is a text instruction: "Verify the orchard for which you want to create a schedule. Click the 'Create Schedule' button." Two buttons are visible: "Select Crop Year" and "Create Schedule". The "Create Schedule" button is circled in red, and a black arrow points to it from the right. The footer contains the copyright notice: "Copyright © 2011-2016, SureHarvest. All Rights Reserved. Website Technology by JVF Consulting."

California Almonds - Get x Add Irrigation Schedule x

https://www.sustainablealmondgrowing.org/IrrigationCalculator/AddIrrigationSchedule/tabid/211/ctl/Edit/mid/663/IrrigationModelRun_ID/-1/Default.aspx

Home Events Assessments N Calculator Irrigation Calculator

Monday, November 14, 2016

Welcome back **Spencer cooper1** (v1.8.1) Provide Feedback | Need Help? | Logout

Irrigation Schedule

Provide Feedback | Irrigation Calculation Help

1 Crop Year: 2016

2 Organization: Almond Board
Enterprise: Almond Board
Orchard: Test

Verify the orchard for which you want to create a schedule. Click the "Create Schedule" button.

< Select Crop Year **Create Schedule** >

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Weather Setup

Irrigation Calculation Work Flow

Crop Year: 2016 Orchard: Test Organization: Almond Board Business: Almond Board

- Weather Setup
- Orchard Setup
- Irrigation Setup
- Weekly Run Times
- Weekly Measured Rainfall
- Weekly Measured Soil Moisture
- Weekly Observed Tree Stress

Save Close Next > Tab

Use Station associated with ZIP

* Orchard ZIP code: 95361 Confirm

* CIMIS Station: Oakdale (194)

* Source of ETo data: Spatial CIMIS CIMIS Station

* denotes required for calculations

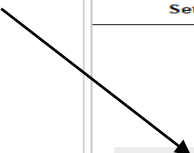
Reports

- Show Details (PDF)
- Download Details (CSV File)
- Show Summary (PDF)
- Download Summary (CSV File)

Calculations

Update Weather Data Refresh Calculations

Week	Entered Run Hrs	Run Hrs to Meet ETC	Run Hrs to Fill ASM	Calc % ASM Depleted	Entered % ASM Depleted	Obs Tree Status
1/3 - 1/9						
1/10 - 1/16						
1/17 - 1/23						
1/24 - 1/30						
1/31 - 2/6						
2/7 - 2/13						
2/14 - 2/20						
2/21 - 2/27						
2/28 - 3/5						
3/6 - 3/12						
3/13 - 3/19						
3/20 - 3/26						
3/27 - 4/2						
4/3 - 4/9						
4/10 - 4/16						
4/17 - 4/23						



Weekly Run Times

Weather Setup |
 Orchard Setup |
 Irrigation Setup |
 Weekly Run Times |
 Weekly Measured Rainfall |
 Weekly Measured Soil Moisture

Weekly Observed Tree Stress

< Previous Tab |
 Save |
 Close |
 Next > Tab |
 Delete

Enter the irrigation system run time in hours for each week.

Week	Run time (hours)
1/3 - 1/9	
1/10 - 1/16	
1/17 - 1/23	
1/24 - 1/30	
1/31 - 2/6	
2/7 - 2/13	
2/14 - 2/20	
2/21 - 2/27	
2/28 - 3/5	
3/6 - 3/12	
3/13 - 3/19	
3/20 - 3/26	
3/27 - 4/2	
4/3 - 4/9	18
4/10 - 4/16	18
4/17 - 4/23	18
4/24 - 4/30	24
5/1 - 5/7	24
5/8 - 5/14	18
5/15 - 5/21	36
5/22 - 5/28	42
5/29 - 6/4	32
6/5 - 6/11	42
6/12 - 6/18	36

Reports

3/13 - 3/19

3/20 - 3/26

3/27 - 4/2

Calculati

4/3 - 4/9

4/10 - 4/16

4/17 - 4/23

4/24 - 4/30

5/1 - 5/7

5/8 - 5/14

5/15 - 5/21

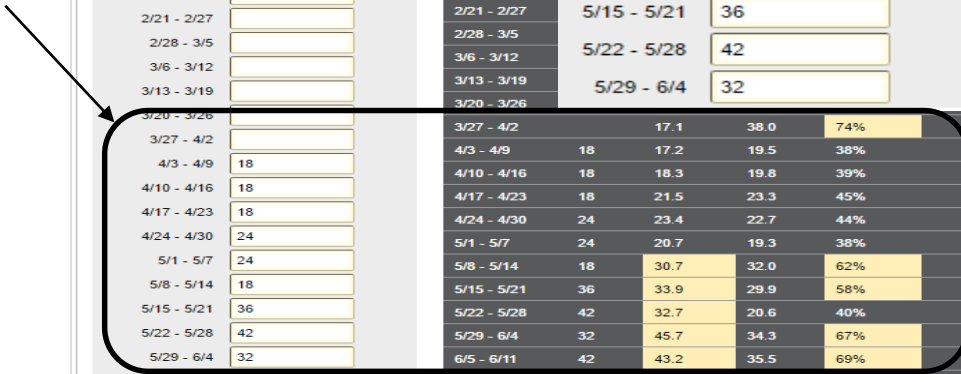
5/22 - 5/28

3/13 - 3/19

3/20 - 3/26

Week	Run time (hours)	Weekly Measured Rainfall	Weekly Measured Soil Moisture	Weekly Observed Tree Stress
3/13 - 3/19		10.3	8.8	17%
3/20 - 3/26		12.2	21.0	41%
3/27 - 4/2		17.1	38.0	74%
4/3 - 4/9	18	17.2	19.5	38%
4/10 - 4/16	18	18.3	19.8	39%
4/17 - 4/23	18	21.5	23.3	45%
4/24 - 4/30	24	23.4	22.7	44%
5/1 - 5/7	24	20.7	19.3	38%
5/8 - 5/14	18	30.7	32.0	62%
5/15 - 5/21	36	33.9	29.9	58%
5/22 - 5/28	42	32.7	20.6	40%
5/29 - 6/4	32	45.7	34.3	67%
6/5 - 6/11	42	43.2	35.5	69%
6/12 - 6/18	36	39.6	39.1	76%
6/19 - 6/25	36	48.8	52.0	100%

3/13 - 3/19		10.3	8.8	17%
3/20 - 3/26		12.2	21.0	41%
3/27 - 4/2		17.1	38.0	74%
4/3 - 4/9	18	17.2	19.5	38%
4/10 - 4/16	18	18.3	19.8	39%
4/17 - 4/23	18	21.5	23.3	45%
4/24 - 4/30	24	23.4	22.7	44%
5/1 - 5/7	24	20.7	19.3	38%
5/8 - 5/14	18	30.7	32.0	62%
5/15 - 5/21	36	33.9	29.9	58%
5/22 - 5/28	42	32.7	20.6	40%
5/29 - 6/4	32	45.7	34.3	67%
6/5 - 6/11	42	43.2	35.5	69%



Weekly Measured Rainfall

← → ↻ https://www.sustainablealmondgrowing.org/IrrigationCalculator/AddIrrigationSchedule/tabid/211/ctl/Edit/mid/663/IrrigationModelRun_ID/99/Default.aspx

Provide Feedback | Irrigation Calculation Help

Irrigation Calculation Work Flow

Crop Year: 2016 Orchard: Test Organization: Almond Board Business: Almond Board

Weather Setup | Orchard Setup | Irrigation Setup | **Weekly Run Times** | Weekly Measured Rainfall | Weekly Measured Soil Moisture | Weekly Observed Tree Stress

Save Close Next > Tab < Previous Tab

Reports

Show Summary (PDF) Download Summary (CSV File)

Enter the measured rainfall in inches.

Week	Rain	Week	Measured Rainfall (inches)
1/3 - 1/9	0.25	1/3 - 1/9	0.25
1/10 - 1/16		1/10 - 1/16	
1/17 - 1/23		1/17 - 1/23	
1/24 - 1/30	1	1/24 - 1/30	1
1/31 - 2/6	0.12	1/31 - 2/6	0.12
2/7 - 2/13	0.5	2/7 - 2/13	0.5
2/14 - 2/20		2/14 - 2/20	
2/21 - 2/27	1.25	2/21 - 2/27	1.25
2/28 - 3/5		2/28 - 3/5	
3/6 - 3/12	0.75	3/6 - 3/12	0.75
3/13 - 3/19		3/13 - 3/19	
3/20 - 3/26	0.5	3/20 - 3/26	0.5
3/27 - 4/2			
4/3 - 4/9			
4/10 - 4/16			
4/17 - 4/23			
4/24 - 4/30			
5/1 - 5/7			
5/8 - 5/14			
5/15 - 5/21			
5/22 - 5/28			
5/29 - 6/4			

Calculations						
Week	Entered Run Hrs	Run Hrs to Meet Etc	Run Hrs to Fill ASM	Calc % ASM Depleted	Entered % ASM Depleted	Obs Tree Status
1/3 - 1/9	1.6	0.0	0.0	0%		
1/10 - 1/16	2.6	2.6	5%			
1/17 - 1/23	2.1	0.0	0%			
1/24 - 1/30	2.7	0.0	0%			
1/31 - 2/6	3.9	1.3	3%			
2/7 - 2/13	5.3	0.0	0%			
2/14 - 2/20	4.9	4.9	10%			
2/21 - 2/27	6.2	0.0	0%			
2/28 - 3/5	8.1	0.0	0%			
3/6 - 3/12	6.2	0.0	0%			
3/13 - 3/19	10.3	0.9	2%			
3/20 - 3/26	12.2	2.4	5%			
3/27 - 4/2	17.1	19.5	38%			
5/8 - 5/14	18	30.7	13.5	26%		
5/15 - 5/21	36	33.9	11.3	22%		
5/22 - 5/28	42	32.7	2.0	4%		
5/29 - 6/4	32	45.7	15.7	31%		
6/5 - 6/11	42	43.2	17.0	33%		

Weekly Measured Soil Moisture

Provide Feedback | Irrigation Calculation Help

Irrigation Calculation Work Flow

Crop Year: 2016 Orchard: Test Organization: Almond Board Business: Almond Board

[Weather Setup](#) >
 [Orchard Setup](#)
[Irrigation Setup](#)
[Weekly Run Times](#)
[Weekly Measured Rainfall](#)
[Weekly Measured Soil Moisture](#)
[Weekly Observed Tree Stress](#)

[< Previous Tab](#)
[Save](#)
[Close](#)
[Delete](#)
[Next > Tab](#)

Enter the measured available soil moisture (ASM) depleted (%).

Week	(%) ASM Depleted
1/3 - 1/9	<input type="text"/>
1/10 - 1/16	<input type="text"/>
1/17 - 1/23	<input type="text"/>
1/24 - 1/30	<input type="text"/>
1/31 - 2/6	<input type="text"/>
2/7 - 2/13	<input type="text"/>
2/14 - 2/20	<input type="text"/>
2/21 - 2/27	<input type="text"/>
2/28 - 3/5	<input type="text"/>
3/6 - 3/12	<input type="text"/>
3/13 - 3/19	<input type="text"/>
3/20 - 3/26	<input type="text"/>
3/27 - 4/2	<input type="text" value="25"/>
4/3 - 4/9	<input type="text"/>
4/10 - 4/16	<input type="text"/>

Reports

[Show Details \(PDF\)](#) [Download Details \(CSV File\)](#)
[Show Summary \(PDF\)](#) [Download Summary \(CSV File\)](#)

Calculations

[Update Weather Data](#) [Refresh Calculations](#)

Week	Entered Run Hrs	Run Hrs to Meet Etc	Run Hrs to Fill ASM	Calc % ASM Depleted	Entered % ASM Depleted	Obs Tree Status
1/3 - 1/9		1.6	0.0	0%		
1/10 - 1/16		2.6	2.6	5%		
1/17 - 1/23		2.1	0.0	0%		
1/24 - 1/30		2.7	0.0	0%		
1/31 - 2/6		3.9	1.3	3%		
2/7 - 2/13		5.3	0.0	0%		
2/14 - 2/20		4.9	4.9	10%		
2/21 - 2/27		6.2	0.0	0%		
2/28 - 3/5		8.1	0.0	0%		
3/6 - 3/12		6.2	0.0	0%		
3/13 - 3/19		10.3	0.9	2%		
3/20 - 3/26		12.2	2.4	5%		
3/27 - 4/2		17.1	19.5	38%	25%	
4/3 - 4/9	18	17.2	0.0	0%		
4/10 - 4/16	18	18.3	0.3	1%		

Weekly Observed Tree Stress

Irrigation Calculation Work Flow

Crop Year: 2016 Orchard: Test Organization: Almond Board Business: Almond Board

[Weather Setup](#) > [Orchard Setup](#) [Irrigation Setup](#) **[Weekly Run Times](#)** [Weekly Measured Rainfall](#) [Weekly Measured Soil Moisture](#) [Weekly Observed Tree Stress](#)

[Save](#) [Close](#) [Delete](#) [< Previous Tab](#)

Enter observed tree water stress. ?

Week	Observed Stress
1/3 - 1/9	
1/10 - 1/16	
1/17 - 1/23	
1/24 - 1/30	
1/31 - 2/6	
2/7 - 2/13	
2/14 - 2/20	
2/21 - 2/27	
2/28 - 3/5	
3/6 - 3/12	
3/13 - 3/19	
3/20 - 3/26	
3/27 - 4/2	Minimal
4/3 - 4/9	
4/10 - 4/16	
4/17 - 4/23	

Reports

[Show Details \(PDF\)](#) [Download Details \(CSV File\)](#)
[Show Summary \(PDF\)](#) [Download Summary \(CSV File\)](#)

Calculations ?

[Update Weather Data](#) [Refresh Calculations](#)

Week	Entered Run Hrs	Run Hrs to Meet Etc	Run Hrs to Fill ASM	Calc % ASM Depleted	Entered % ASM Depleted	Obs Tree Status
1/3 - 1/9		1.6	0.0	0%		
1/10 - 1/16		2.6	2.6	5%		
1/17 - 1/23		2.1	0.0	0%		
1/24 - 1/30		2.7	0.0	0%		
1/31 - 2/6		3.9	1.3	3%		
2/7 - 2/13		5.3	0.0	0%		
2/14 - 2/20		4.9	4.9	10%		
2/21 - 2/27		6.2	0.0	0%		
2/28 - 3/5		8.1	0.0	0%		
3/6 - 3/12		6.2	0.0	0%		
3/13 - 3/19		10.3	0.9	2%		
3/20 - 3/26		12.2	2.4	5%		
3/27 - 4/2		17.1	19.5	38%	25%	
4/3 - 4/9	18	17.2	0.0	0%		
4/10 - 4/16	18	18.3	0.3	1%		
4/17 - 4/23	18	21.5	3.8	7%		

Irrigation Schedule Details

Orchard/Org/Business: Test Schedule Year: 2016

Schedule Details

Year	2016
Organization	Almond Board
Enterprise	Almond Board
Orchard	Test

Orchard Details

Year Planted	2000
Orchard Status	Mature
**Orchard Canopy Cover at Midday	85%
<u>K_r</u> Factor	100%
Planted Acres	100
**Row / Tree Spacing	21 x 18 feet
Trees per Acre	115.2
**Soil Texture	Medium- Loams, silt loams, sandy clays, silty clays, clays
Water Holding Capacity	2 inches/foot
Available Water Holding Capacity	1 inches/foot
Soil Notes	
**Effective Rooting Depth	3 feet
Available Soil Moisture for Orchard	3 inches
Available Soil Moisture in Wetted Area	2.4 inches
Available Soil Moisture (ASM) Depletion Alert (%)	50%

Weather Data Setup Details

Orchard ZIP Code	95361
**CIMIS Station	Oakdale
CIMIS Station ID	194
CIMIS Station Location (<u>Lat Long</u>)	37.727194 - 120.850860
Reference CIMIS Zone	Zone 12
**Source for Actual (Real Time) <u>ET_o</u>	CIMIS Station

Irrigation System Setup Details

Week to Start Accumulating <u>ET_c</u>	1/3 - 1/9
Typical Run Time	24 hours
Irrigation System Notes	
**System Type	Micro-sprinkler
**Emitters/ <u>Microsprinklers</u> per Tree	1 emitters/tree
**Average Gallons per Hour (GPH) Rate per Emitter/ <u>Microsprinkler</u>	13 gallons/hour
**Subsurface Wetted Volume	80%
**Distribution Uniformity (DU)	85%
Emitters per Acre	115.2 emitters
Inches per Hour Unadjusted for DU	0.05515 <u>inches/hr</u>
Inches per Hour (Effective)	0.04 <u>inches/hr</u>

** Denotes item required for calculations, if blank please review and insert.

This recommendation is not intended to be used as the sole source of information for making irrigation decisions. Local environmental conditions can have a profound effect on irrigation demands. The Almond Board of California, the University of California, and the California State University are not responsible for the accuracy of this model.

Irrigation Schedule Details

Irrigation Schedule Details

Orchard/Org/Business: Test Schedule Year: 2016

Week	Typical ETo (in.)	This Yr ETo (in.)	Kc	ETc (in.)	Accum ETc (in.)	CIMIS Precip (in.)	Entered Precip (in.)	Effective Precip (in.)	Run Hrs to Meet ETc	Entered Run Hrs	Inches Supplied	Run Hrs to Fill ASM	Inches to Fill ASM	Calc % ASM Depleted	Entered % ASM Depleted	Obs Tree Stress
1/3 - 1/9	0.28	0.19	0.4	0.08	0.08	1.52	0.25	0.25	1.6		0.25		-0.17	0		
1/10 - 1/16	0.28	0.3	0.4	0.12	0.2	0.22			2.6			2.6	0.12	5		
1/17 - 1/23	0.28	0.24	0.4	0.1	0.3	2.55		1.64	2.1		1.64		-1.42	0		
1/24 - 1/30	0.28	0.32	0.4	0.13	0.43	0.23	1	1	2.7		1		-0.87	0		
1/31 - 2/6	0.47	0.44	0.41	0.18	0.61	0.25	0.12	0.12	3.9		0.12	1.3	0.06	3		
2/7 - 2/13	0.47	0.6	0.41	0.25	0.86		0.5	0.5	5.3		0.5		-0.19	0		
2/14 - 2/20	0.47	0.56	0.41	0.23	1.09	0.5			4.9			4.9	0.23	10		
2/21 - 2/27	0.47	0.71	0.41	0.29	1.38		1.25	1.25	6.2		1.25		-0.73	0		
2/28 - 3/5	0.77	0.61	0.62	0.38	1.76	0.99		0.39	8.1		0.39		-0.01	0		
3/6 - 3/12	0.77	0.47	0.62	0.29	2.05	1.73	0.75	0.75	6.2		0.75		-0.46	0		
3/13 - 3/19	0.77	0.78	0.62	0.48	2.53	1.05		0.44	10.3		0.44	0.9	0.04	2		
3/20 - 3/26	0.77	0.92	0.62	0.57	3.1	0.06	0.5	0.5	12.2		0.5	2.4	0.11	5		
3/27 - 4/2	1.19	1	0.8	0.8	3.9	0.01			17.1			19.5	0.91	38	25	Minimal
4/3 - 4/9	1.19	1.01	0.8	0.81	4.71	1.54		0.83	17.2	18	1.82		-0.27	0		
4/10 - 4/16	1.19	1.07	0.8	0.86	5.57	0.16			18.3	18	0.99	0.3	0.01	1		
4/17 - 4/23	1.19	1.26	0.8	1.01	6.58	0.01			21.5	18	0.99	3.8	0.18	7		
4/24 - 4/30	1.19	1.37	0.8	1.1	7.68	0.04			23.4	24	1.32	3.1	0.15	6		
5/1 - 5/7	1.54	1.03	0.94	0.97	8.65	0.23			20.7	24	1.32		-0.01	0		

Irrigation Schedule

Irrigation Schedule	
Criteria	
Year	2016
Organization	Almond Board
Enterprise	Almond Board
Orchard	Test
Weather Setup	
Orchard ZIP Code	95361
CIMIS Station	Oakdale
Source for current year ETo data	CIMIS Station
Orchard Setup	
Year Orchard Planted	2000
Planted Acres	100
Row / Tree Spacing	21 x 18 feet
Soil Texture	Medium - Loams, silt loams, sandy clays, silty clays, clays (2.0)
Soil Notes	
Effective Rooting Depth (feet)	3
Orchard Maturity	Mature
Available Soil Moisture (ASM) Depletion Alert (%)	50
Irrigation Setup	
Week to Start Accumulating ETC	1/3 - 1/9
Number of Sets	2
Typical Run Time Hours	24
Irrigation System Notes	
System Type	Micro-sprinkler
Emitters/Microsprinklers per Tree	1
Average Gallons per Hour (GPH) Rate per Emitter/Microsprinkler	13
Subsurface Wetted Volume (%)	80
Distribution Uniformity (%)	85

Calculations					
Week	Entered Run Hours	Run Hrs to Meet ETC	Run Hrs to Fill ASM	Calc % ASM Depleted	Entered % ASM Depleted
1/3 - 1/9		1.6		0%	
1/10 - 1/16		2.6	2.6	5%	
1/17 - 1/23		2.1		0%	
1/24 - 1/30		2.7		0%	
1/31 - 2/6		3.9	1.3	3%	
2/7 - 2/13		5.3		0%	
2/14 - 2/20		4.9	4.9	10%	
2/21 - 2/27		6.2		0%	
2/28 - 3/5		8.1		0%	
3/6 - 3/12		6.2		0%	
3/13 - 3/19		10.3	0.9	2%	
3/20 - 3/26		12.2	2.4	5%	
3/27 - 4/2		17.1	19.5	38%	25%
4/3 - 4/9	18	17.2		0%	
4/10 - 4/16	18	18.3	0.3	1%	
4/17 - 4/23	18	21.5	3.8	7%	
4/24 - 4/30	24	23.4	3.1	6%	
5/1 - 5/7	24	20.7		0%	
5/8 - 5/14	18	30.7	12.7	25%	
5/15 - 5/21	36	33.9	10.6	21%	
5/22 - 5/28	42	32.7	1.3	2%	
5/29 - 6/4	32	45.7	14.9	29%	
6/5 - 6/11	42	43.2	16.2	32%	
6/12 - 6/18	36	39.6	19.8	39%	
6/19 - 6/25	36	48.8	32.6	64%	
6/26 - 7/2	48	52.6	37.2	73%	
7/3 - 7/9	48	46.7	35.9	70%	
7/10 - 7/16	48	45.8	36.6	72%	
7/17 - 7/23	48	49.3	37.9	74%	
7/24 - 7/30	48	51.9	41.7	82%	
7/31 - 8/6	48	44.5	38.3	75%	
8/7 - 8/13	36	43.6	45.8	89%	
8/14 - 8/20	42	44.3	45.1	94%	
8/21 - 8/27	36	37.9	50	98%	
8/28 - 9/3	24	36.6	62.6	100%	
9/4 - 9/10	0	34.4	85.6	100%	
9/11 - 9/17	48	30.5	33.7	66%	
9/18 - 9/24	36	30.3	28	55%	
9/25 - 10/1	24	26.1	30.1	59%	
10/2 - 10/8		19.2	38.7	76%	
10/9 - 10/15		17.5	50.8	99%	
10/16 - 10/22		14.7	65.5	100%	
10/23 - 10/29		10	18.5	36%	
10/30 - 11/5		8.2	24.7	48%	
11/6 - 11/12		7.8	32.5	63%	
11/13 - 11/19		6.2	33.3	65%	
11/20 - 11/26		6.2	28.8	56%	
11/27 - 12/3		1.9	4.1	8%	
12/4 - 12/10		1.9	6	12%	
12/11 - 12/17		1.9		0%	
12/18 - 12/24		1.9		0%	
12/25 - 12/31		1.9		0%	

This recommendation is not intended to be used as the sole source of information for making irrigation decisions. Local environmental conditions can have a profound effect on irrigation demands. The Almond Board of California, the University of California, and the California State University are not responsible for the accuracy of this model.

A close-up photograph of several green almonds on a branch, with vibrant green leaves. The almonds are in various stages of growth, some appearing more rounded and others more elongated. The background is softly blurred, showing more of the tree and a hint of a person in the distance.

**Terry Prichard,
UCCE Water Management
Specialist Emeritus**

Introducing One Page Irrigation Management Topics

When to Begin Irrigating Almonds

Almond Salinity Hazard & Leaching Requirements

Terry Prichard

Water Management Specialist, Emeritus



DETERMINING WHEN TO BEGIN IRRIGATING ALMONDS USING ET, SOIL WATER HOLDING CAPACITY, AND EFFECTIVE RAINFALL

Knowing when to begin almond irrigation and how much to apply requires knowledge of crop water use, the level of moisture stored in the root zone, and the effectiveness of spring rainfall.

Factors that determine the root zone available-water reservoir are:

- Root zone depth
- Soil water holding capacity (largely determined by soil texture)
- Estimate of the effective rainfall

Plant-available water holding capacities of various textured soils

Soil Texture	Plant-Available Water Holding Capacity (in. of water per ft. of soil)
Very coarse sands	0.40 – 0.75
Coarse sands, fine sands, loamy sands	0.75 – 1.25
Sandy loams, fine sandy loams	1.25 – 1.75
Very fine sandy loams, loams, silt loams	1.60 – 2.30
Clay loams, silty clay loams, sandy clay loams	1.75 – 2.60
Sandy clays, silty clays, clays	1.60 – 2.60

Source: Adapted from: Sohwanik, L.J. and T. L. Pritchard. 2009. University of California Drought Management website. <http://UCManageDrought.ucdavis.edu>

Example: A sandy loam with a 4-foot root zone:
1.5 inches per foot x 4 feet = 6 inches available water capacity

Estimating the effective rainfall to fill the root zone

A study by the California Department of Water Resources conducted over a four-year period developed relationships for determining effective rainfall in California. Monthly rainfall is factored by the evaporative effect using bare soil. The table below indicates the effective rainfall for each inch of rainfall.

Rainfall (inches)	Effective Rainfall (inches)		
	Oct	Nov-Feb	Mar-April
1	0.6	0.4	-0.2
2	1.2	1.3	0.6
3	1.8	2.3	1.4
4	2.5	3.2	2.3
5	3.1	4.2	3.1
6	3.8	5.1	4.0



Factors in determining the root zone available water reservoir

- Root zone depth
- Soil water holding capacity
(largely determined by soil texture)

Plant-Available Water Holding Capacity

Soil Texture	Plant-Available Water Holding Capacity (in. of water per ft. of soil)
Very coarse sands	0.40 – 0.75
Coarse sands, fine sands, loamy sands	0.75 – 1.25
Sandy loams, fine sandy loams	1.25 – 1.75
Very fine sandy loams, loams, silt loams	1.50 – 2.30
Clay loams, silty clay loams, sandy clay loams	1.75 – 2.50
Sandy clays, silty clays, clays	1.60 – 2.50

Root zone plant-available water Example:

Sandy loam with a
4 foot root zone:

Sandy Loam = 1.25 – 1.75 in water per foot soil

1.5 inches per foot x 4 ft =

6.0 inches of plant-available water = root zone water capacity

Effective Rainfall

Rainfall that enters the soil and is stored for tree use

Rainfall - evaporation

Rainfall (inches)	Effective Rainfall (inches)		
	Oct	Nov-Feb	Mar-April
1	0.6	0.4	-0.2
2	1.2	1.3	0.6
3	1.8	2.3	1.4
4	2.5	3.2	2.3
5	3.1	4.2	3.1
6	3.8	5.1	4.0

Estimate Effective Rainfall

November through February

Merced average rainfall by month

	Rainfall (inches)	Effective Rainfall (inches)
Oct	0.8	0.5
Nov	1.3	0.7
Dec	2.1	1.4
Jan	2.6	1.9
Feb	2.4	1.7
Total	9.2	6.2

The effective rainfall exceeds the root zone capacity, so the reservoir would be 6 inches of available water

Effective Rainfall, March and April

Rainfall that enters the soil and is stored for tree use

Rainfall - evaporation

Rainfall (in)	Effective Rainfall (in)
1	-0.2
2	0.6
3	1.4
4	2.3
5	3.1

When and how much to Irrigate?

Estimated Orchard Water Requirement – effective rainfall – Available moisture

Month	Orchard Water Requirement (in)	Effective Rainfall (in)	Stored Moisture * (in)	Irrigation Application (in)
March	2.1	2.5	0	0
April	4.1	1.5	1.0	1.6
May	6.4	0.0	1.0	5.4
June	8.2	0.0	1.0	7.2
July	8.9	0.0	0.0	8.9

* Use 50% of moisture stored in the root zone or 3.0 inches

Almond Salinity Hazard & Leaching Requirements

Almond salt hazard
Measuring salts
How much leaching is necessary
Leaching considerations



ALMOND SALINITY HAZARD AND LEACHING REQUIREMENTS

- All irrigation water contain salts
- Concentration and composition varies by water source
- Over time without leaching salts can build up reducing production

Salt Accumulation Hazard in Orchards

- Excess total salinity creates an osmotic stress, which reduces crop production
- A toxic effect of specific salts such as sodium, chloride, and boron.
- Decreased water infiltration rates due to increased sodium salts.

Measuring Total Salts

- Soil
 - Salinity of the saturated soil extract
- Water
 - Salinity of the water
- Units
 - Electrical Conductivity (EC)
 - dS/m or mmho/cm

Estimate the amount of leaching needed

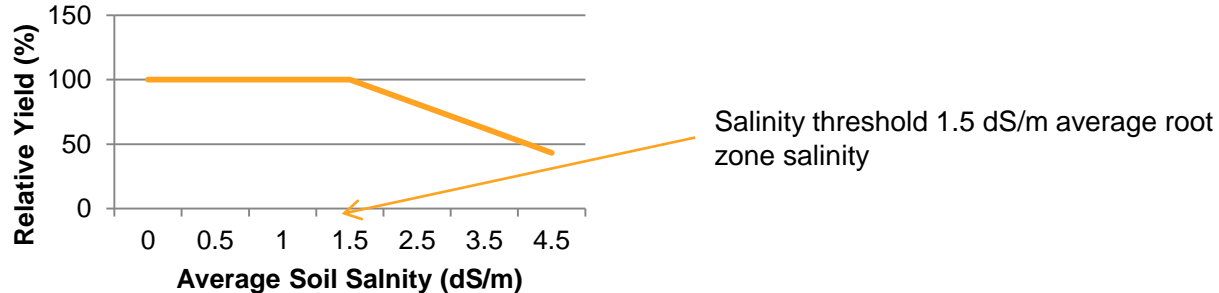
Leaching Fraction

The amount of water that passes through the root zone as a percent of the crop water use (leaching fraction)

- Estimated from water salinity to maintain salts below the salinity threshold

When to Leach

- Measured root zone soil salinity average and compare to salinity threshold



Salt Leaching Considerations

- When is leaching needed
- When to leach
- The role of rainfall in leaching
- How to leverage winter rainfall for more leaching
- Partial coverage irrigation system leaching tips

Introducing One Page Irrigation Management Topics

Irrigation Scheduling Using ET

When to Begin Irrigating Almonds

Almond Salinity Hazard & Leaching Requirements

What to Consider Before Investing in Irrigation Technology





Future of the Continuum

Almond Irrigation Improvement Continuum

Almond Irrigation Improvement Continuum

Use the proficiency levels and guidance below to adopt good irrigation water management (IWM) practices for almonds. Each level of the Almond Irrigation Improvement Continuum will provide the tools necessary to obtain measurements needed to best schedule and manage almond irrigation.

Measurement	1.0 Minimum	2.0 Intermediate	3.0 Advanced
Orchard Water Requirements	Estimate orchard water requirements using "normal year" regional ETc to estimate irrigation demand on a monthly time step.	Estimate orchard water requirements using "normal year" regional ETc – adjusting for current weather and cover crop use on a bi-weekly time step.	Estimate orchard water requirements using "normal year" regional ETc to plan irrigations then use real time ETc data to correct the schedule on a weekly time step.
Irrigation System Performance	Evaluate irrigation system for pressure variation and average application rate at least once every 3 years. Correct any diagnosed system performance problems.	Assess distribution uniformity and average application rate by measuring water volume at least every 3 years. Correct any diagnosed system performance problems.	Assess distribution uniformity and average application rate by measuring water volume at least every 2 years. Correct any diagnosed system performance problems.
Applied Water	Use application rate and duration of irrigation to determine water applied.	Use water meters to determine flow rate and water applied.	Use water meters to determine applied water and compare to crop water use (ETc, evapotranspiration) to determine irrigation efficiency.
Soil Moisture	Evaluate soil moisture based upon feel and appearance by augering to at least 3-5 feet. Monitor on a monthly time step.	Use manually operated soil moisture sensors to at least 3-5 feet and monitor on a bi-weekly time step. Use information to ensure calculated water is not over/under irrigating trees.	Use automated moisture sensors that store data over time. Review weekly to ensure calculated water is not over/under irrigating trees.
Plant Water Status	Evaluate orchard water status using visual plant cues just prior to irrigation or on a bi-weekly time step.	Use pressure chamber to measure midday stem water potential just prior to irrigation on a monthly time step. Ensure calculated water applications are not over/under irrigating trees.	Use pressure chamber to measure midday stem water potential prior to irrigation on a weekly time step. Ensure calculated water applications are not over/under irrigating trees. Use it to assess when to start irrigating.
Management			
Integrating Irrigation Water Management IWM Practices	Combine irrigation system performance data with "normal year" regional ETc to determine orchard-specific water requirements and schedule irrigations. Check soil moisture with an auger and/or monitor plant water status to verify scheduling.	Use irrigation system performance data with regional estimates of "normal year" ETc to schedule irrigations and adjust based on feedback from monitoring soil moisture or crop water status.	Develop an irrigation schedule based on predicted "normal year" demand, monitor status using soil and plant based methods. Adjust irrigation schedule with real-time ETc as the season progresses.

*A web version of this continuum is in development (Almonds.com/IrrigationContinuum) and will feature in depth information for each of the boxes above explaining how that measurement and subsequent management can be achieved.

Almond Irrigation Improvement Continuum

The Irrigation Continuum was developed in partnership with the many trusted and respected technical experts and resources available, such as University of California Division of Agriculture and Natural Resources Cooperative Extension.

1.0

The [Continuum Level 1.0](#) outlines irrigation management practices that are within reach for all California Almond growers. It is available as a [downloadable PDF](#) and coming soon is an EPUB to read on an iBook or other digital reader app.

In addition to the manual, there are one page summary documents from sections within the manual.

- [Determining When to Begin Irrigation](#)
- [Irrigation Scheduling Using Evapotranspiration \(ET\)](#)
- [Almond Salinity Hazard and Leaching Requirements](#)
- [What to Consider Before Investing in Irrigation in Irrigation Technology](#)
- **[Determining Application Rate](#)**
 - **[Micros](#)**
 - **[Sprinklers](#)**
 - **[Flood](#)**



2.0 and 3.0

While the above tools are available now, development of the Continuum continues with respected irrigation experts to build out levels 2.0 and 3.0.

The Continuum Level 2.0 consists of more intermediate level practices and Level 3.0 address practices at more sophisticated levels to attain even more “crop per drop.” As Level 2.0 and 3.0 manuals are developed, they will be published on this web page.

Why is Irrigation Improvement a Priority?

In 2015, Almond Board of California’s (ABC) Board of Directors adopted Water Management and Efficiency as one of four key components of the [Accelerated Innovation Management \(AIM\)](#) program. ABC has long been a research-based organization and will continue to support traditional research and sustainability initiatives, but is now placing greater emphasis on the innovative almond farming practices that will be required to meet the future needs of the California almond industry, as well as the consumer, the community and the planet.

Almond Irrigation Improvement Continuum

- Where can I find the One Pagers?
 - Back Table
 - ABC Booth (625)
 - www.almonds.com/irrigation#



A close-up photograph of a glass jar filled with almonds. In the foreground, a small white dish contains a dollop of almond butter. The background is a warm, golden-brown color.

Questions?