



# Irrigation and Nutrient Management Training for Grower Self-Certification Ventura County

Version 1.1  
March 2025

The Irrigation and Nitrogen Management Training Program Workbook was a collaborative effort between the California Department of Food and Agriculture, University of California's Agriculture and Natural Resources Division, Central Valley Regional Water Quality Control Board, Ventura County Agricultural Irrigated Lands Group, and Central Valley Water Quality Coalitions.

Published September 2022

Updated for Ventura County March 2025

---

Authored By:

Nicole Nunes – California Department of Food and Agriculture Fertilizer Research and Education Program

Reviewed By:

Trilby Barton – Tule Basin Water Quality Coalition

Daniel Geisseler – University of California Cooperative Extension

Tom Bottoms – Timothy and Viguie Farming

Phoebe Gordon – University of California Cooperative Extension

Mark Cady - California Department of Food and Agriculture

Emad Jahanzad – California Department of Food and Agriculture

Nicholas Clark – University of California Cooperative Extension

Parry Klassen – East San Joaquin Water Quality Coalition

Amanda Crump – University of California, Davis

Jody Switzer – Ventura County Agricultural Irrigated Lands Group

Robert Ditto – Central Valley Regional Water Quality Control Board

Margaret Lloyed – University of California Cooperative Extension

Anthony Fulford – University of California Cooperative Extension

Chelsie Nakasone – Sacramento Valley Water Quality Coalition

Allan Fulton – University of California Cooperative Extension

## Table of Contents

<b>Module 1: Introduction .....</b>	<b>1</b>
Lesson 1: Nitrogen Cycle.....	<a href="#">1</a>
Lesson 2: Impacts of Nitrogen Loss.....	<a href="#">9</a>
Lesson 3: INMP Requirements and Due Dates .....	<a href="#">12</a>
Lesson 4: Statistical Outliers.....	<a href="#">15</a>
<b>Module 2: Parcel Management .....</b>	<b>19</b>
Lesson 1: Management Units .....	<a href="#">19</a>
Lesson 2: Assessor's Parcel Number .....	<a href="#">21</a>
Lesson 3: Crop Name and Age .....	<a href="#">23</a>
<b>Module 3: Irrigation Management.....</b>	<b>26</b>
Lesson 1: Irrigation and Nitrogen Management.....	<a href="#">26</a>
Lesson 2: Irrigation Methods and Sources (INMP Worksheet Box 14 and 15).....	<a href="#">30</a>
Lesson 3: Crop Evapotranspiration (INMP Worksheet Box 1).....	<a href="#">33</a>
Lesson 4: Anticipated Crop Irrigation (INMP Worksheet Box 2) .....	<a href="#">37</a>
Lesson 5: Irrigation Set Times.....	<a href="#">40</a>
Lesson 6: Irrigation Water Nitrogen Concentration (INMP Worksheet Box 3) .....	<a href="#">42</a>
Lesson 7: Irrigation Efficiency Practices (INMP Worksheet Box 16).....	<a href="#">46</a>
<b>Module 4: Harvest Information .....</b>	<b>50</b>
Lesson 1: Production Units (INMP Worksheet Box 4).....	<a href="#">50</a>
Lesson 2: Expected Crop Yield (INMP Worksheet Box 5 and 13A).....	<a href="#">52</a>
Lesson 3: Actual Crop Yield (INMP Worksheet Box 13B) .....	<a href="#">55</a>
<b>Module 5: Nitrogen Management .....</b>	<b>57</b>
Lesson 1: Nitrogen Efficiency and Application Practices (INMP Worksheet 17, 18, & 19) .....	<a href="#">57</a>
Lesson 2: Soil Available Nitrogen (INMP Worksheet Box 11).....	<a href="#">61</a>
Lesson 3: Nitrogen in Irrigation Water (INMP Worksheet Box 10) .....	<a href="#">65</a>
Lesson 4: Nitrogen in Organic Amendments (INMP Worksheet Box 9) .....	<a href="#">68</a>
Lesson 5: Dry/Liquid Nitrogen Fertilizer (INMP Worksheet Box 7) .....	<a href="#">72</a>
Lesson 6: Foliar Nitrogen Fertilizer (INMP Worksheet Box 8).....	<a href="#">76</a>
Lesson 7: Total Nitrogen (INMP Worksheet Box 12).....	<a href="#">79</a>
Lesson 8: Nitrogen Applied Vs Nitrogen Removed .....	<a href="#">83</a>
<b>Module 6: Certification.....</b>	<b>86</b>
Lesson 1: Certification Options and Requirements.....	<a href="#">86</a>
<b>Module 7: INMP Summary Report.....</b>	<b>89</b>
Lesson 1: Reporting Data.....	<a href="#">89</a>
<b>Appendix .....</b>	<b>93</b>
INMP Worksheet .....	93
INMP Summary Report.....	97

## Module 1 Lesson 1: Nitrogen Cycle

### Lesson Overview

Lesson 1 covers the basic movement and transformation of nitrogen in an agricultural system. By the end of lesson 1, participants will demonstrate the ability to:

1. List different forms of nitrogen found in an agricultural system.
2. Identify nitrogen transformation processes relevant to an agricultural system.
3. Recognize major loss pathways of nitrogen in an agricultural system.

Lesson Topic(s)	Page(s) in Workbook
Nitrogen Forms	2 - 3
Nitrogen Cycle Overview	3
Nitrogen Transformations	4 - 6
Nitrogen Losses	7
Summary	7 - 8

### Lesson Resources

- Fernandez, F. G., & Kaiser, D. E. (2021). Understanding Nitrogen in Soils. Retrieved from <https://extension.umn.edu/nitrogen/understanding-nitrogen-soils>
- Khalsa, S. S., & Brown, P. H. (n.d.). Principles of Nitrogen Cycling and Management. Retrieved from University of California Agriculture and Natural Resources: <https://ciwr.ucanr.edu/files/283982.pdf>
- Yara International. (2011, October). Nitrogen Cycle in the Soil Video Clip. Retrieved from YouTube: <https://www.youtube.com/watch?v=Ekx84-T5GLk&t=7s>

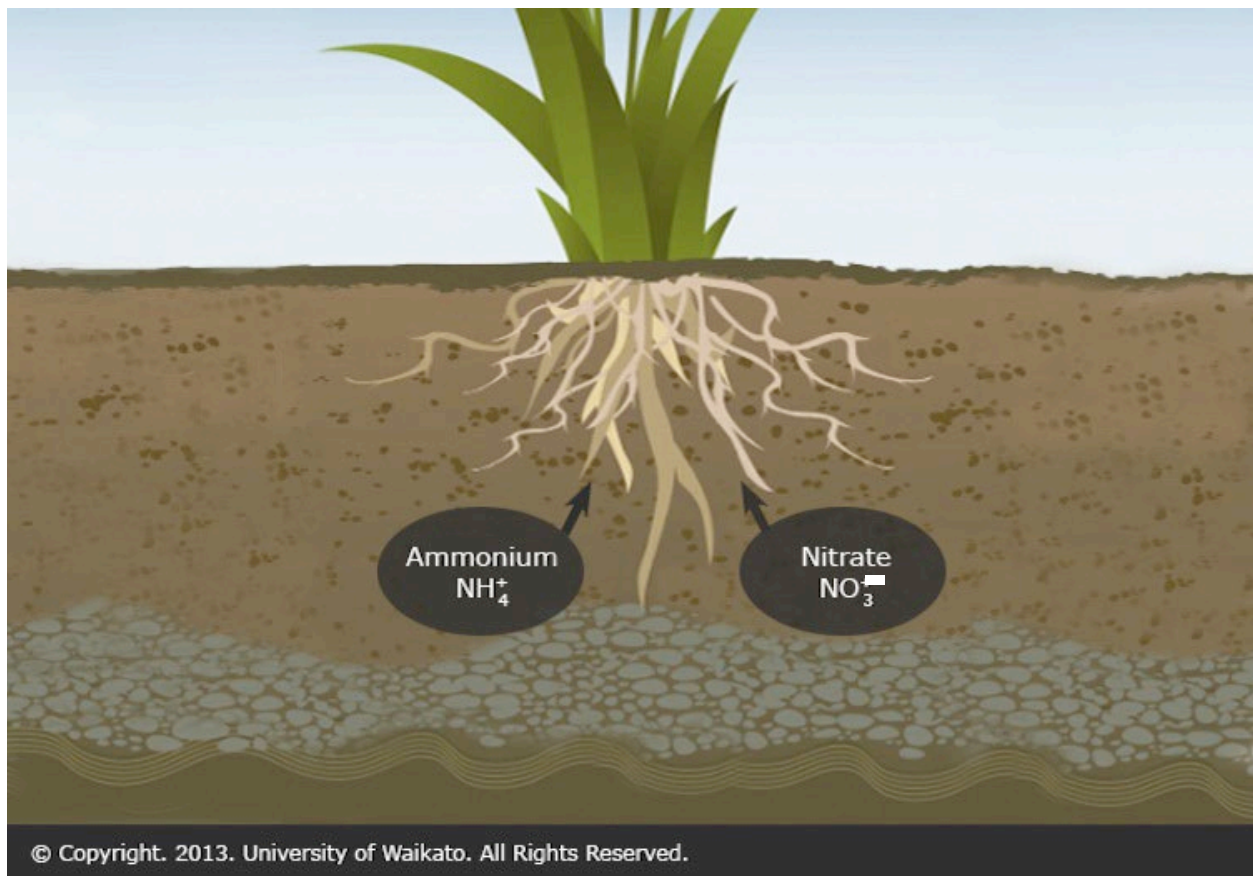
## Nitrogen Forms

---

Nitrogen is one of the most abundant elements on Earth. However, not all forms of nitrogen are available to crops. Nitrogen exists in agriculture in two general forms:

1. Organic Nitrogen:
  - When carbon and nitrogen molecules are linked together
  - Must be transformed to be available to crops
2. Inorganic Nitrogen:
  - Some are directly available to crops like ammonium and nitrate
  - Some like nitrogen gas must be transformed to be available to crops

Crops can take up ammonium and nitrate from the soil. However, nitrate is used more often by crops in agricultural soils. This is primarily because ammonium quickly converts to nitrate in the soil making nitrate the main form available. Also, because nitrate has a negative charge and moves easily through the soil with water.



### **Activity 1.1.1**

Directions: Below is a list of different sources of nitrogen typically used in an agricultural system. Determine whether each source is considered inorganic or mostly organic. An example has been completed in the first row.

Nitrogen Source	Inorganic or Organic?
Urea ( $\text{CO}(\text{NH}_2)_2$ )	Organic
Calcium nitrate	
Crop residues	
Compost	
Ammonium sulfate	
Urea ammonium nitrate	

### **Nitrogen Cycle Overview**

In agricultural systems, nitrogen moves in and out of different environmental spheres. These spheres include the atmosphere, lithosphere, biosphere, and hydrosphere. The movement of nitrogen between environmental spheres is called the *Nitrogen Cycle*.

### **Activity 1.1.2**

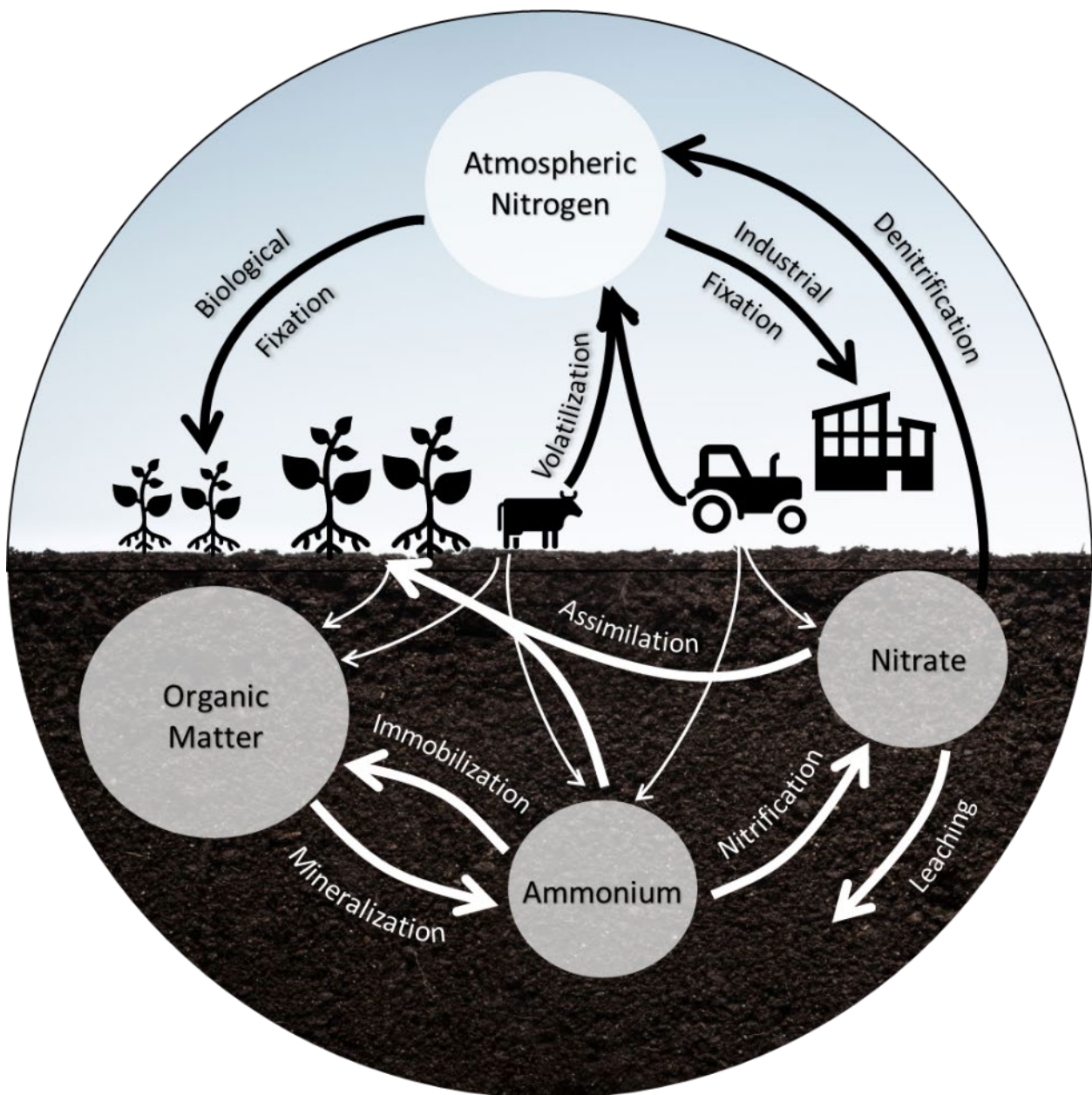
Directions: The nitrogen cycle takes place in 4 environmental spheres: atmosphere, lithosphere, biosphere, and hydrosphere. Match the environmental sphere with its description.

Environmental Sphere	Description
	All living organisms including plants and microbes
	All the soil and rocks contained in Earth's crust
	All the gases in the air surrounding Earth
	All water including surface and groundwater



## Nitrogen Transformations

As nitrogen moves through the cycle it is transformed readily from one form to another. These transformations make up the heart of the nitrogen cycle. Nitrogen transformations include fixation, mineralization, immobilization, nitrification, and assimilation.



## Nitrogen in the Air

---

Earth's atmosphere is 78% nitrogen gas. However, nitrogen gas cannot be used directly by crops. It must first go through a transformation process called *nitrogen fixation*. In agricultural systems, there are two main ways that nitrogen fixation occurs.

1. Biological Fixation- On legumes like alfalfa, microbes living in root nodules transform nitrogen gas into ammonium which can be used by the crop. Additionally, some free-living soil microbes can also fix a small amount of nitrogen.
2. Industrial Fixation- Humans combine nitrogen gas and hydrogen gas to make ammonia which is used to manufacture nitrogen-based fertilizers.

## Nitrogen in the Soil

---

The soil contains both organic and inorganic nitrogen. To be used by crops, organic nitrogen must be transformed.

### Soil Microbes

In the soil, microbes like bacteria and fungi transform nitrogen from one form to another. Microbe activity depends on several factors such as soil moisture, temperature, pH, and oxygen. When the soil is moist and warm, microbes are more active and nitrogen transformations will occur faster.

### Soil Organic Matter

Many microbes in the soil decompose organic matter for energy. Organic matter includes crop residues, organic inputs like compost, and soil organic matter. Soil organic matter forms over time from microbial, plant, and animal residues.

These residues contain carbon and nitrogen. The amount of carbon present in the material compared to the amount of nitrogen present is called the carbon-to-nitrogen (C:N) ratio. A C:N ratio of 20:1 means that there are 20g of carbon for each 1g of nitrogen in the residue. The C:N ratio determines how fast microbes will decompose the residues.

### Nitrogen Mineralization

Residues with a low C:N ratio (less than 20:1), are decomposed quickly by soil microbes. Any nitrogen that the microbes do not use will be released back into the soil as ammonium. This process is called *nitrogen mineralization*. These residues include cover crops, legumes, and raw and composted animal manures.



## Nitrogen Immobilization

Residues with a high C:N ratio (greater than 20:1) are decomposed slowly by soil microbes. If the C:N ratio exceeds 35:1, microbes will consume additional inorganic nitrogen from the soil to break down the carbon. This can decrease the amount of nitrogen available to the crop. This process is called *nitrogen immobilization*. Many crop residues have high C:N ratios like corn stover, straw, and tree prunings.

## Nitrification

Another group of microbes in the soil gain energy by transforming ammonium into nitrate. The nitrate is then released into the soil. This process is called *nitrification*. On average, ammonium is transformed to nitrate within weeks when soils are warm and moist.

### Activity 1.1.3

Directions: When incorporating an organic form of nitrogen into the soil it is important to know whether nitrogen will be mineralized or immobilized. The table below lists several organic forms of nitrogen and their C:N ratio. Determine whether nitrogen will likely be mineralized or immobilized.

Organic Material	C:N Ratio	Nitrogen Mineralized or Immobilized?
Poultry Manure	6:1 – 8:1	
Wheat Straw	80:1	
Hairy Vetch Cover Crop	11:1	
Corn Stover	57:1	
Blood & Feather Meal	3:1 – 4:1	
Vegetable Crop Residues	<15:1	

## Nitrogen in Plants

---

Crop uptake is the most beneficial use of nitrogen in agricultural systems.

### Nitrogen Assimilation

Crops use ammonium and nitrate to form amino acids, chlorophyll, enzymes, and nucleic acids. This process is called *nitrogen assimilation*.

## Nitrogen Losses

---

Excess nitrogen in the soil that is not used by crops, cover crops, or microbes is susceptible to loss. Thus, overapplication of nitrogen can be damaging to a grower's profit and the environment. Potential loss pathways include nitrogen leaching, volatilization, and denitrification.

### Nitrate Leaching

Nitrate ( $\text{NO}_3^-$ ) has a negative charge. Thus, it is not held by clay particles and moves easily through the soil with water. Nitrate that leaches past the root zone is unavailable to crops and can contaminate groundwater. Leaching is a major loss mechanism, especially in coarse-textured soils.

### Denitrification

Saturated or waterlogged soils have low levels of oxygen. Some soil microbes can consume nitrate ( $\text{NO}_3^-$ ) in place of oxygen. In this process, called *denitrification*,  $\text{NO}_3^-$  is converted to gaseous forms of nitrogen. Denitrification mostly results in  $\text{N}_2$  gas which is harmless. However, denitrification can also result in nitrous oxide which is a potent greenhouse gas. This is a normal and unavoidable occurrence in irrigated agriculture. Though, denitrification can be reduced with management practices.

### Ammonia Volatilization

Nitrogen sources containing urea can be susceptible to significant loss, especially when left on the soil surface. These sources include manure and UAN. When urea breaks down, ammonia ( $\text{NH}_3$ ) is produced. The ammonia can escape to the atmosphere unless it reacts with water to form ammonium ( $\text{NH}_4^+$ ). The loss of nitrogen to the atmosphere as ammonia gas is called *volatilization*. *Ammonia volatilization* is most likely to occur when soils have a high pH, are moist and warm, and/or the nitrogen source is surface applied.

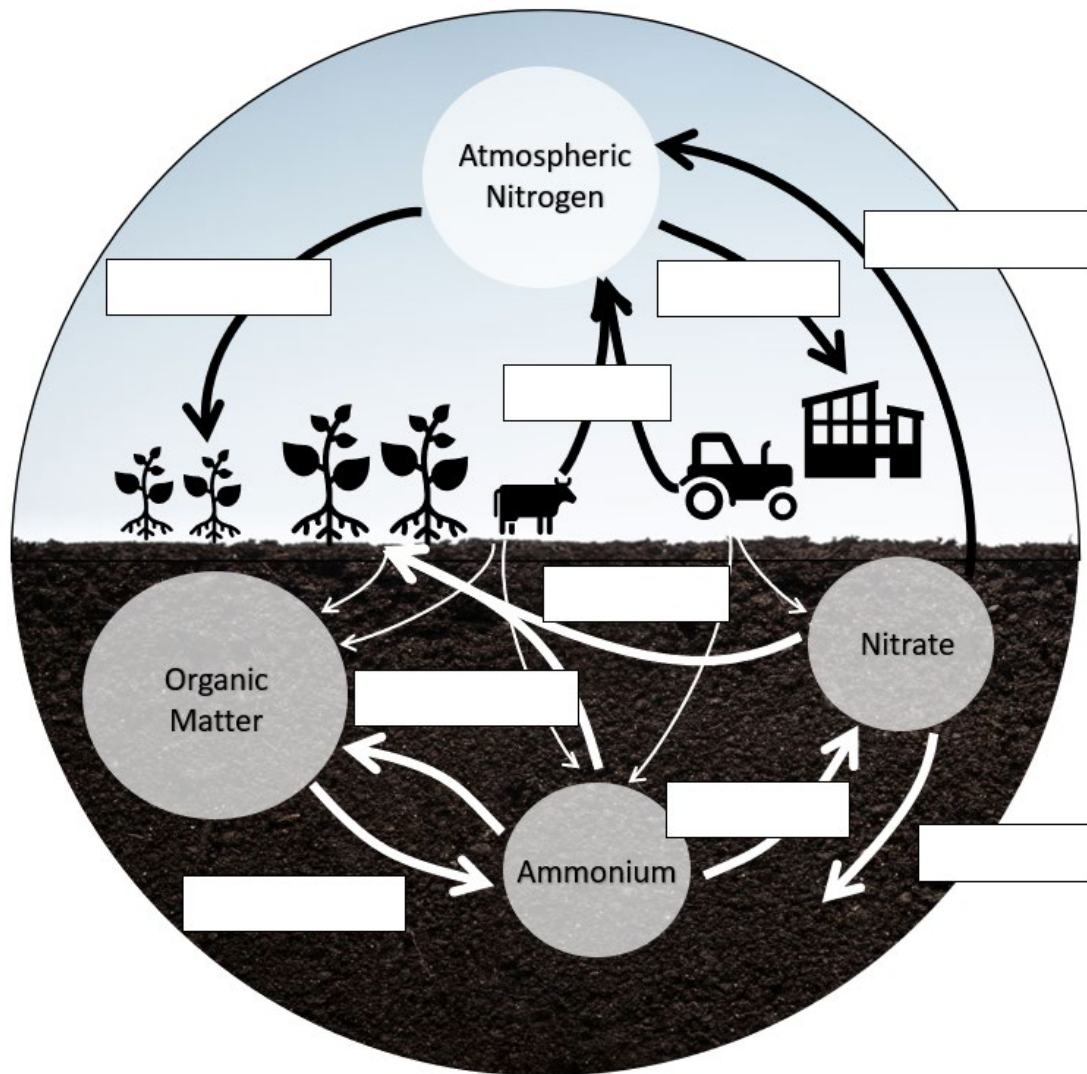
## Module 1 Lesson 1 Summary

---

1. The soil contains both inorganic and organic forms of nitrogen. However, crops mainly take up inorganic nitrogen in the form of nitrate and ammonium.
2. Nitrogen goes through several transformation processes including fixation, mineralization, immobilization, nitrification, and assimilation.
3. Excess nitrogen in the soil is susceptible to loss through leaching, denitrification, and/or volatilization.

### Activity 1.1.4

Directions: Using terminology presented throughout the lesson, label the missing components in the nitrogen cycle diagram. (Biological Fixation, Industrial Fixation, Assimilation, Denitrification, Mineralization, Immobilization, Leaching, Nitrification, Volatilization)



## Module 1 Lesson 2: Impacts of Nitrogen Loss

Lesson 2 covers the impact of nitrogen loss on the environment and human health. By the end of lesson 2 participants will demonstrate the ability to:

1. Identify impacts of nitrogen loss on the environment and human health.
2. Distinguish between nitrate measurements in drinking water reported as nitrate-nitrogen and nitrate.

Lesson Topic(s)	Page(s) in Workbook
Environmental & Health Impacts	10
Measuring Nitrate in Drinking Water	10 - 11
Summary	11

### Lesson Resources

- California State Water Resources Control Board. (2014, December). *Nitrate in Groundwater Frequently Asked Questions*. Retrieved from [https://gispublic.waterboards.ca.gov/webmap/nitrate\\_tool/files/nitrate\\_faq.pdf](https://gispublic.waterboards.ca.gov/webmap/nitrate_tool/files/nitrate_faq.pdf)
- California State Water Resources Control Board. (n.d.). *Is my Property near a Nitrate Impacted Water Well?* Retrieved from <https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/>
- United States Environmental Protection Agency. (n.d.). *Estimated Nitrate Concentrations in Groundwater Used for Drinking*. Retrieved from <https://www.epa.gov/nutrient-policy-data/estimated-nitrate-concentrations-groundwater-used-drinking>
- University of California Agriculture and Natural Resources. (n.d.). *Nitrous Oxide Emissions*. Retrieved from Solution Center for Nutrient Management: [https://ucanr.edu/sites/Nutrient\\_Management\\_Solutions/stateofscience/Nitrous\\_Oxide\\_In\\_focus/](https://ucanr.edu/sites/Nutrient_Management_Solutions/stateofscience/Nitrous_Oxide_In_focus/)

## Impacts of Nitrogen Loss on the Environment and Human Health

---

While nitrogen is essential for crop growth, applying too much nitrogen can be damaging to the environment and human health, as well as your profit. Excess nitrogen can also lead to crop production issues like excess vigor and increased susceptibility to disease.

### Nitrogen in the Atmosphere

Nitrous oxide is a powerful greenhouse gas produced by microbes during the nitrification and denitrification processes. Nitrous oxide is roughly 300 times more potent in warming the climate than carbon dioxide. This means that even a small amount of nitrous oxide produced by microbes can have a large impact. Nitrous oxide can damage the ozone layer of the atmosphere. The ozone layer protects Earth from damaging ultraviolet radiation.

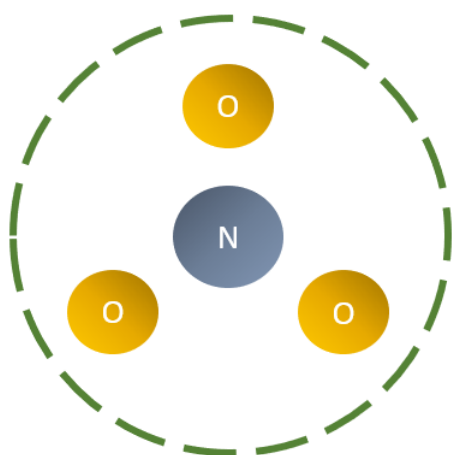
### Nitrate in Drinking Water

When nitrate leaches below the root zone, it can contaminate groundwater. High levels of nitrate in the groundwater can cause illness when used for drinking. Nitrate reduces the blood's ability to carry oxygen. This is especially dangerous for infants under six months of age and pregnant woman. Symptoms include shortness of breath and the appearance of blue skin from the lack of oxygen in the blood. Nitrate in drinking water can also be damaging to livestock.

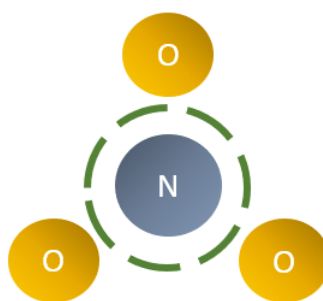
### Measuring Nitrate in Drinking Water

---

When nitrate is measured, it is either reported as nitrate or nitrate-nitrogen. When reported as nitrate, the weight of the nitrogen atom and the three oxygen atoms are reported. When reported as nitrate-nitrogen, only the weight of the nitrogen atom is reported.



Nitrate ( $\text{NO}_3$ )



Nitrate-Nitrogen ( $\text{NO}_3\text{-N}$ )

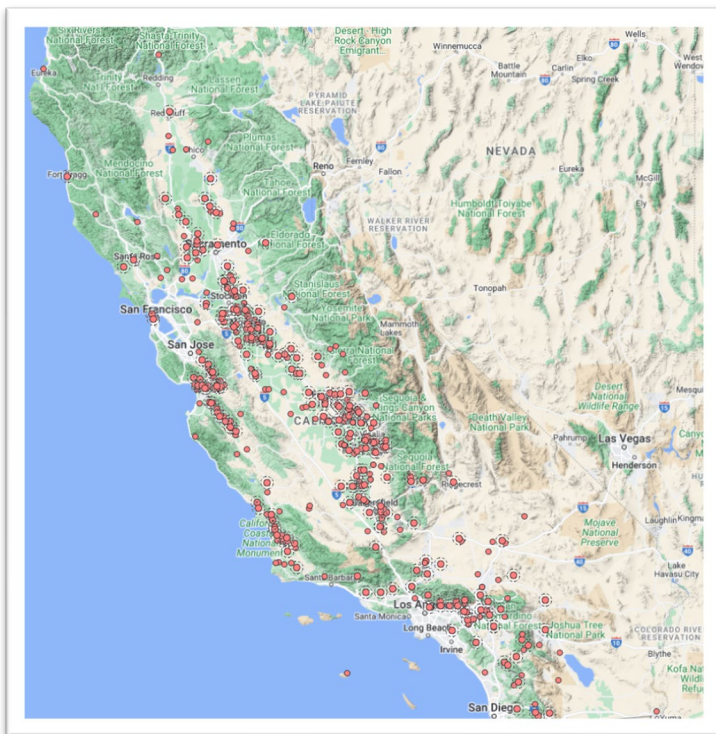
## Maximum Contaminant Level

Due to the possible impacts on human health, the United States Environmental Protection Agency (EPA) has set a standard for nitrate levels in drinking water. The Maximum Contaminant Level for Nitrate-nitrogen is 10 mg/L or 10 parts per million (ppm). This is equivalent to 45 ppm nitrate.

## Nitrate Contaminated Drinking Water

Nitrate contaminated groundwater can be found in agricultural areas throughout California. Nitrate contamination disproportionately affects low-income communities and communities of color. The California State Water Resources Control Board has an interactive map to determine if your well is near a known nitrate impacted well.

<https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/>



### Activity 1.2.1

Directions: Use the interactive map to determine if there is a nitrate-impacted well near your property. \_\_\_\_\_ (yes/no)

## Module 1 Lesson 2 Summary

---

1. Overapplying nitrogen can harm the atmosphere, drinking water sources, and profit.
2. Nitrate in drinking water can be dangerous for infants, pregnant women, and livestock.
3. Nitrate measured in drinking water can be reported as nitrate or nitrate-nitrogen.

## Module 1 Lesson 3: INMP Requirements and Deadlines

Lesson 3 provides an overview of the regulatory requirements in place to protect water quality. Lesson 3 also covers the requirements and due dates for the Irrigation and Nutrient Management Plan (INMP) Worksheet and Irrigation and Nutrient Management Report (INMR). By the end of lesson 3, participants will demonstrate the ability to:

1. Summarize the goals of the INMP Worksheet and INMR.
2. Recall and be able to locate deadlines by which INMP Worksheets must be developed, and INMR submitted.

Lesson Topic(s)	Page(s) in Workbook
INMP Worksheet & INMR	13
INMP Deadlines	14
Summary	14

### Lesson Resources

- Los Angeles Regional Water Quality Control Board. Adopted Waste Discharge Requirements. Retrieved from:  
[https://www.waterboards.ca.gov/losangeles/water\\_issues/programs/tmdl/waivers\\_and\\_wdrs/index.html](https://www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/waivers_and_wdrs/index.html)



## **Irrigation and Nutrient Management Plan & Irrigation and Nutrient Management Report**

---

To comply with ILRP nitrogen management reporting requirements growers must complete the following forms:

- Irrigation and Nutrient Management Plan (INMP) Worksheet
- Irrigation and Nutrient Management Report (INMR)

### **INMP Worksheet**

The INMP worksheet was designed to help growers increase the efficiency of irrigation and nitrogen applications. One or more INMP Worksheets must be completed for each parcel covered under the ILRP. Worksheets are kept on-farm.

### **INMR**

The INMR was designed to help monitor nitrogen applied and removed from the field through harvest. INMRs are submitted annually to the coalitions. The coalitions compile and anonymize the data prior to submitting it to the Regional Water Quality Control Board.

### **Certification Exemptions**

Growers with total farming operation acreage less than 10 acres are exempt from the requirement to certify an INMP. However, they are still required to develop an INMP and submit an INMR.

### **Alternative Reporting**

Growers who meet one of the following qualify for INMR alternative reporting. Alternative reporting requires reporting of all nitrogen and irrigation application but does not require reporting of harvest yield.

1. Growers that (1) operate in areas with evidence of no or very limited nitrogen impacts to surface water or groundwater, (2) have minimal nitrogen inputs, and (3) have difficulty measuring yield
2. Diversified socially disadvantaged growers, as defined by the Farmer Equity Act of 2017, with (1) a maximum total acreage of 45 acres, (2) gross annual sales of less than \$350,000, and (3) a crop diversity greater than 0.5 crops per acre (one crop for every two acres).
3. Growers with (1) a maximum total acreage of 20 acres, and (2) a crop diversity greater than 0.5 crops per acre (one crop for every two acres).

## INMP Worksheet & INMR Deadlines

---

The table below lists INMP Worksheet and INMR deadlines for VCAILG members. Deadlines can also be found in the waste discharge requirements.

Item	Deadline
INMP Worksheet	March 1, 2025, and annually thereafter
INMR	March 1, 2026, and annually thereafter

INMRs must be submitted to the coalition by the deadline outlined above. VCAILG offers an online platform for submitting INMRs. Please check with your coalition prior to the deadline to determine what submittal options are available.

For more information on reporting exemptions and deadlines access the waste discharge requirements below or with the link in the lesson 3 materials section.

- [Ventura County Agricultural Irrigated Lands Group](#) (Appendix 3, pg. 12-17)
- [Los Angeles Irrigate Lands Group](#) (Appendix 2, pg. 11-15)

### **Activity 1.3.2**

Directions: View the waste discharge requirements for one of the coalitions that you are a member of. List one new thing that you learned from the waste discharge requirements.

## Module 1 Lesson 3 Summary

---

1. INMP Worksheets are kept on farm and are designed to help increase efficiency of nitrogen and irrigation applications.
2. INMRs are submitted and are designed to monitor nitrogen applied to and removed from a field.
3. Certification exemptions, alternative reporting qualifications, and deadlines for each coalition can be found in the Waste Discharge Requirements for that area.

## Module 1 Lesson 4: Statistical Outliers

Lesson 4 covers the process and purpose for identifying statistical outliers. Lesson 4 also covers additional requirements that apply to growers with outlier fields. By the end of lesson 4, participants will demonstrate the ability to:

1. Describe the process under which a management unit may be identified as an outlier.
2. Summarize the purpose of outlier identification.
3. Recall additional requirements that may apply to growers with management units identified as outliers.

Lesson Topic(s)	Page(s) in Workbook
Outlier Identification Process	16-17
Purpose of Identifying Outliers	17
Additional Requirements for Outliers	18
Summary	18

## **Outlier Identification Process**

---

### **Step 1: Data Submitted**

INMR data is collected annually by coalitions.

### **Step 2: Nitrogen Applied / Nitrogen Removed Ratio and Nitrogen Applied minus Nitrogen Removed Difference Calculated**

Coalitions use the data from INMRs to calculate the ratio of nitrogen applied (A) to nitrogen removed (R) for each field. A/R and A-R are used as metrics to determine the potential for nitrogen loss.

- Nitrogen Applied: includes nitrogen from fertilizers, organic amendments, and irrigation water.
- Nitrogen Removed: includes all harvested materials and nitrogen sequestered in permanent wood for perennial crops. Calculated based on yield and a nitrogen removal coefficient

### **Step 3: Data Compared across Coalition**

A/R or A-R values are compared across members for each crop in the coalition's area.

### **Step 4: Outlier Threshold Calculated**

A threshold value is determined based on all collected data. Any fields with A/R or A-R values above the threshold are considered outliers.

There are several reasons a field may have a high A/R or A-R value resulting in outlier designation:

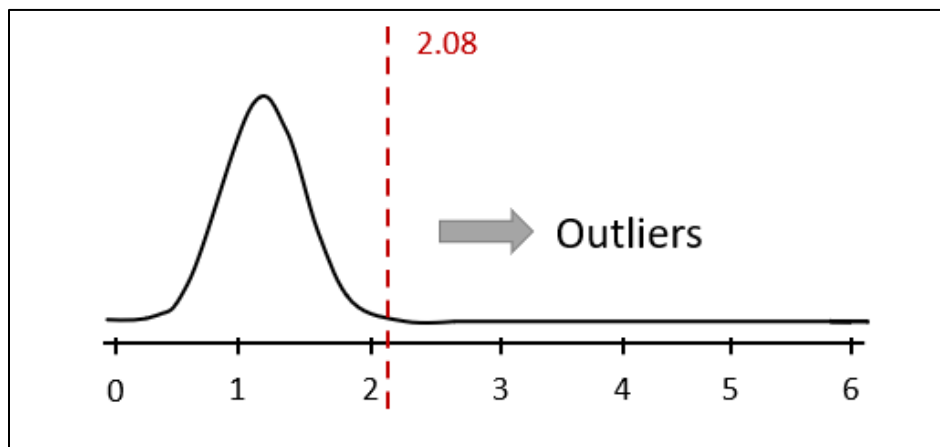
- Nitrogen applications are greater than the crop demand
- Inefficient applications of nitrogen or irrigation water
- Reduced yields due to pest or weather damage
- Crop failure or loss
- Errors were made in data submitted in INMRs

### **Step 5: Notification**

Members receive notification of where their management units are in comparison to other growers in the coalition. Members with management units designated as outliers will also receive information about additional requirements.

### Example

The graphic below shows an example distribution of A/R values for an individual crop type. The peak of the curve represents the calculated A/R value for most growers. The red dashed line represents the calculated threshold value. A/R values to the right of the calculated threshold value are considered outliers. The growers with management units that have an outlier A/R value are notified of their outlier status by the coalition.



### Activity 1.4.1

Directions: There are five steps in the outlier identification process. Using the descriptions below, place the steps in the correct order.

Step # (1-5)	Step Description
	Notification
	A/R or A-R values compared across coalition members for each crop
	Data submitted to the Water Quality Coalition
	A/R or A-R values calculated
	Outlier threshold determined

### Purpose of Identifying Outliers

Being an outlier is an early indicator that excess nitrogen is being applied to a management unit. Identifying outliers can help the coalition and members work together to implement improved management practices.

## **Additional Requirements for Outliers**

---

Members that have one or more outlier management units are subject to additional requirements. Additional requirements may include:

- Indicating “Previously Identified as Outlier” on INMR
- Attending focused education meetings
- Not being able to claim INMP Certification Exemption
- Others, as required by the Regional Water Quality Control Board

## **Module 1 Lesson 4 Summary**

---

1. Ensure the data you submit in your INMR is accurate.
2. If you have outlier management units, make sure you are aware of the additional requirements.

## Module 2 Lesson 1: Management Units

### Lesson Overview

Lesson 1 covers how to combine or subdivide parcels, fields, or blocks into management units for the INMP Worksheet. By the end of lesson 1, participants will demonstrate the ability to:

1. Determine what fields and/or parcels can be combined to create a management unit.

Lesson Topic(s)	Page(s) in Workbook
Management Units	20
Summary	20



## Management Units

---

The first page of the INMP Worksheet has a table covering parcel management. This table is a description of the parcels or blocks for which the plan applies to.

APN	Operator Field / Block Name	Irrigated Acres

A management unit is a group or subdivision of parcels, fields, or blocks that are treated the same and have similar characteristics. A management unit has the same crop, age (for perennial crops) nitrogen and irrigation inputs, and management practices. A management unit must be comprised of contiguous land.

### Perennial Crop Example

The grower has an 85-acre lemon orchard that covers four parcels. The trees in the four parcels were planted in the same year. The fields are irrigated from the same well and have similar fertilizer and irrigation inputs. Thus, the grower can treat the parcels as one management unit and complete one INMP Worksheet.

### Annual Crop Example

The grower has a 30-acre vegetable field. The field is planted in a rotation of cilantro, peppers, and cabbage. The field is irrigated with surface and groundwater. Each crop receives different amounts of irrigation and nutrient inputs. Thus, the grower must complete a separate INMP Worksheet for each crop in the rotation.

#### Activity 2.1.1

A grower has one 100-acre parcel, which is split into a 40-acre and 60-acre field. The 40-acre field has a rotation of cilantro, peppers, and cabbage. The 60-acre field has a rotation of strawberries and celery. Each individual crop rotation is irrigated from the same well and have the same fertilizer and irrigation inputs. How many individual management units are there?

--

## Module 2 Lesson 1 Summary

---

1. A management unit must have the same crop, age (for perennial crops), nitrogen and irrigation inputs, and management practices and be comprised of contiguous land.
2. A management unit can consist of a portion of a parcel or multiple parcels together.

## Module 2 Lesson 2: Assessor's Parcel Number

Lesson 2 covers how to locate the assessor's parcel number (APN) for a given parcel. The lesson also covers the reporting steps for when a management unit has multiple APNs. By the end of lesson 2 participants will demonstrate the ability to:

1. Define an APN.
2. Recall how to locate an APN for a parcel.
3. Outline the reporting process for when a management unit has multiple APNs.

Lesson Topic(s)	Page(s) in Workbook
Assessor's Parcel Numbers	22
Summary	22

### Lesson Resources

County of Ventura Countview webpage: <https://maps.ventura.org/countyview/>

County of Ventura Assessor's property search webpage:  
<https://assessor.countyofventura.org/assessor-data/property-search/>

## Assessor's Parcel Number

---

An assessor's parcel number (APN) is a unique number that a tax assessor assigns to a parcel in a county. It is used by the county for record-keeping and to track ownership of the land. Be sure to include any dashes or zeros in the APN.

### Locating an APN

Your APN can be found on your property tax bill or through your county assessor's office or website. For leased land, the APN may be listed on the lease or available through the property owner.

### Reporting Multiple APNs

If your management unit contains multiple APNs, list each APN with its respective irrigated acreage. The irrigated acreage listed may include a portion of the parcels' total irrigated acreage if there are other management units on the same parcel. For each APN listed, include only the irrigated acreage that is being covered by the management unit for which the INMP is being developed.

Below is an example of a management unit with multiple APNs.

APN	Operator Field / Block Name	Irrigated Acres
141-140-021	Beardsley Ranch	240
141-140-022	Beardsley Ranch	120

## Module 2 Lesson 2 Summary

---

1. An APN is a unique number assigned to a parcel of land by the county tax assessor.
2. An APN for a parcel can be found on the property tax bill, through the county assessor, or property owner.
3. List the APN and irrigated acreage for each parcel in a management unit.

## Module 2 Lesson 3: Crop Name and Age

Lesson 3 covers how to list crop name and age to ensure accurate reporting and data analysis.

By the end of lesson 3, participants will demonstrate the ability to:

1. Describe the importance of identifying crops by a standard name and age.
2. Determine which crops require reporting of age.

Lesson Topic(s)	Page(s) in Workbook
Standard Crop Names	24
Crop Age	24
Summary	24
Module 2 Review Activity	26

## Standard Crop Name

---

Nitrogen removal coefficients, used to calculate nitrogen removed from the field, are unique for different crops and harvest methods. Thus, using a standard name for reporting ensures a fair evaluation of nitrogen applied vs. removed.

VCAILG has a draft list of standard crop names available to growers. In the online member portal, crop names will be presented in a drop-down list. If a crop name is not on the current list, growers can reach out to their coalition to request assistance.

The table below is an excerpt from the N Coefficients by Crop Type for Ventura County. For a full version of this table, refer to VCAILG's Irrigation and Nutrient Management Plan webpage at <https://www.farmbureauvc.com/vcailg/>

Crop Name	N Coefficient
Avocado	4.4 lbs/ton
Blackberry	4.46 lbs/ton
Blueberries	1.56 lbs/ton
Naval Oranges	3.61 lbs/ton
Valencia Oranges	4.66 lbs/ton

## Crop Age

---

Reporting crop age or year planted is required for perennial crops.

Crop age influences expected yield, nitrogen applied, and nitrogen removed with harvest.

Information on the INMP Worksheet and INMR is based on the calendar year in which harvest was completed. For example, if citrus harvest is completed May 2023 the crop age is reported for 2023, regardless of what year fertilization occurred.

### Activity 2.3.1

On the INMP Worksheet, Naval and Valencia Oranges can both be listed as Oranges?

\_\_\_\_\_ (Yes/No)

## Module 2 Lesson 3 Summary

---

1. Using a standard crop name and age ensures accurate data analysis.
2. Crop age is based on the calendar year in which harvest was completed.

## Module 2 Review Activity

---

Directions: Complete the parcel management section of the INMP Worksheet based on the provided scenario.

A grower in Somis planted avocados in October 2018. The avocados were planted in an 85-acre block. The APN for the block labeled as Avocados Westside is 230-0-295-120. The INMP is being developed for the calendar year 2025.

APN	Operator Field / Parcel Name	Crop	Crop Age (Years)	Irrigated Acres

## Module 3 Lesson 1: Irrigation and Nitrogen Management

### Lesson Overview

Lesson 1 covers the relationship between irrigation and nitrogen management. Lesson 1 also touches on the importance of good irrigation efficiency and distribution uniformity. By the end of lesson 1, participants will demonstrate the ability to:

1. Describe the relationship between irrigation and nitrogen management.
2. Differentiate between irrigation efficiency and distribution uniformity.

Lesson Topic(s)	Page(s) in Workbook
Irrigation and Nitrogen Management	27
Irrigation Efficiency	27
Distribution Uniformity	27 – 28
Summary	29

### Lesson Resources

- Amador, S. (n.d.). *Irrigation Evaluation and Maintenance*. Retrieved from Modesto Junior College Irrigation Technology:  
<https://www.mjc.edu/instruction/agens/irrigationtech/dupresentation.pdf>
- Fulton, A. (n.d.). *Irrigation Distribution Uniformity - Why and How?* Retrieved from University of California Agriculture and Natural Resources:  
[http://www.northvalleyagservices.com/public/uploads/Irrigation\\_Distribution\\_Uniformity\\_-\\_Why\\_and\\_How\\_Allan\\_Fulton.pdf](http://www.northvalleyagservices.com/public/uploads/Irrigation_Distribution_Uniformity_-_Why_and_How_Allan_Fulton.pdf)
- Jain Irrigation. (2021, November). *Performing a Distribution Uniformity Test for Irrigation and Identifying Areas for Improvement Video*. Retrieved from JAIN Irrigation:  
<https://jainsusa.com/training/performing-a-distribution-uniformity-test-for-irrigation-and-identifying-areas-for-improvement/>



## Irrigation and Nitrogen Management

---

Nitrate moves easily through the soil profile with water. Thus, poor irrigation management can reduce the efficiency of nitrogen fertilizer applications. Irrigation applications exceeding crop ET can result in nitrate leaching to the groundwater.

### **Activity 3.1.1**

Why does nitrate move so easily through the soil profile with water?

## Irrigation Efficiency

---

Irrigation efficiency (IE) is the percentage of applied water that is beneficially used. Beneficial uses include meeting crop water needs, leaching requirements, and climate control. The main factors that influence irrigation efficiency are: (1) distribution uniformity, (2) irrigation timing and amount, and (3) system maintenance.

Typical irrigation efficiency ranges for different systems can be found in the table below.

Irrigation Method	Typical Efficiency Ranges (%)
Microsprinkler	85-90
Surface Drip	85-90
Subsurface Drip	80-90
Solid Set Sprinkler	70-85
Hand Move Sprinkler	65-85
Furrow	55-75
Basin	60-75

## Distribution Uniformity

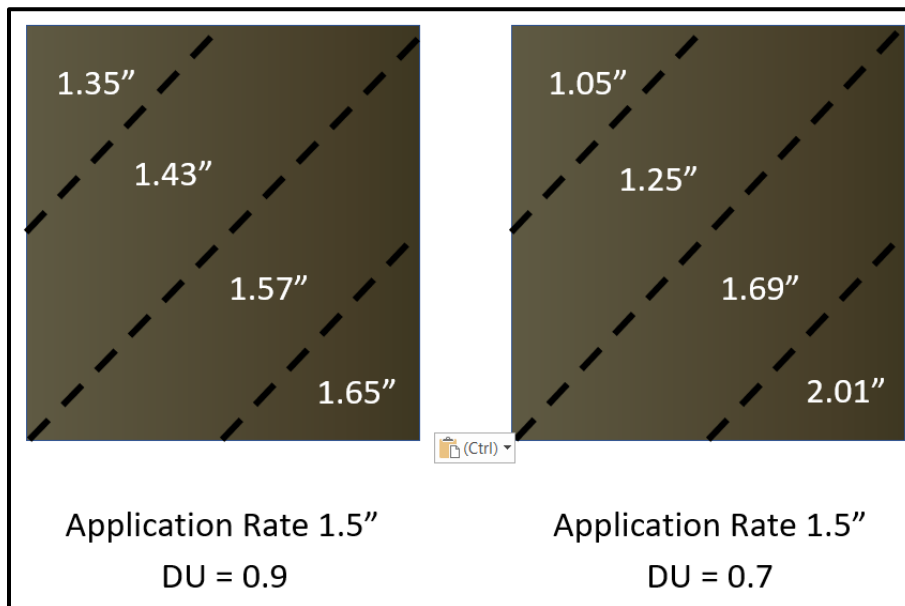
---

Distribution uniformity (DU) is a measure of how evenly water is applied to a field. When irrigation water is applied uniformly, irrigation efficiency will be high if the timing and duration of each irrigation is appropriate.

DU is expressed as a value between 0.1-1.0. A good DU for drip, microsprinkler, and sprinkler systems is between 0.8 and 1.0. Anything less than 0.8 is considered a poor DU. In flood, furrow, and basin systems a good DU is above 0.7.

### Distribution Uniformity Example

In the example below a grower applies 1.5" of water to a field. The example shows the effect of DU on the amount of water applied to different portions of the field. With a poor DU, more water is applied than is needed, to ensure that the "low quarter" gets adequate water. And even then, it might not be enough.



### Testing Distribution Uniformity

Many organizations that specialize in irrigation systems and maintenance will offer irrigation system evaluations.

Some Resource Conservation Districts (RCD) offer free or discounted irrigation evaluations for growers in their area. As part of the evaluation the RCD may provide measurements of DU and application rates. <https://www.conservation.ca.gov/dlrp/RCD/Pages/CaliforniaRCDs.aspx>

- Ventura County RCD

### **Activity 3.1.2**

Directions: Indicate whether the scenarios below are a description of good irrigation efficiency, and/or good distribution uniformity. The first row is completed as an example.

Scenario	Good Efficiency	Good Uniformity
Water was delivered evenly across the field and the application exceeded amount needed to meet leaching requirement.	No	Yes
Water was delivered unevenly across the field and the entire field was underirrigated.		
Water was delivered unevenly across the field and the application met crop demand and leaching requirement.		
Water was delivered unevenly across the field and the application exceeded the amount needed to meet beneficial uses.		
Water is delivered evenly across the field and the application meets crop demand and leaching requirement.		
Water was delivered evenly across the field and the entire field was underirrigated.		

### **Module 3 Lesson 1 Summary**

---

1. Poor irrigation management decreases the efficiency of nitrogen application and can cause nitrate leaching.
2. A well irrigated field has good distribution uniformity and high irrigation efficiency.

## Module 3 Lesson 2: Irrigation Methods

Lesson 2 covers the first box on the Irrigation and Nitrogen Management Plan (INMP) Worksheet. By the end of lesson 2 participants will demonstrate the ability to:

1. Identify the role of a primary irrigation method.
2. Identify common uses for secondary irrigation methods.
3. Identify the irrigation source(s).

Lesson Topic(s)	Page(s) in Workbook
Irrigation Methods	31
Irrigation Sources	31
Summary	32

## Irrigation Methods

---

Under the Irrigation Management section on the INMP Worksheet, box 14 asks growers for their primary and secondary irrigation method.

Primary irrigation is the method used the most for crop irrigation during the growing season. Secondary irrigation systems include those used for purposes beyond immediate crop water need. Some examples include crop establishment and climate control.

<b>Box 14: Irrigation Method</b> <b>(Check one for Primary; if applicable, check one for secondary)</b>		
<input type="checkbox"/>	<input type="checkbox"/>	Drip
<input type="checkbox"/>	<input type="checkbox"/>	Microsprinkler
<input type="checkbox"/>	<input type="checkbox"/>	Furrow
<input type="checkbox"/>	<input type="checkbox"/>	Sprinkler
<input type="checkbox"/>	<input type="checkbox"/>	Border Strip
<input type="checkbox"/>	<input type="checkbox"/>	Flood

## Irrigation Sources

---

Under the Irrigation Management section on the INMP Worksheet, box 15 asks growers to identify their irrigation source(s).

<b>Box 15: Irrigation Source</b> <b>(Check one for Primary; if applicable, check one for secondary)</b>		
<input type="checkbox"/>	<input type="checkbox"/>	Well
<input type="checkbox"/>	<input type="checkbox"/>	Water Purveyor or Agency
<input type="checkbox"/>	<input type="checkbox"/>	Recycled Water
<input type="checkbox"/>	<input type="checkbox"/>	Surface Diversion

### **Activity 3.2.1**

What other purposes may a secondary irrigation system be used for?

### **Module 3 Lesson 2 Summary**

---

1. The primary irrigation method is the system used to provide water for crop growth and development.
2. Some examples of secondary irrigation use include crop establishment and climate control.
3. Be sure to identify all sources of irrigation water.

## Module 3 Lesson 3: Crop Evapotranspiration

Lesson 3 covers how to estimate crop evapotranspiration as a pre-season planning tool. By the end of lesson 3, participants will demonstrate the ability to:

1. Estimate potential crop evapotranspiration for a growing season.
2. Recall where to find resources for estimating crop evapotranspiration.

Lesson Topic(s)	Page(s) in Workbook
Crop Evapotranspiration	34
Estimating Crop Evapotranspiration	34 – 36
Summary	36

### Lesson Resources

- California Department of Water Resources. (n.d.). *California Irrigation Management Information System*. Retrieved from: <https://cimis.water.ca.gov/>
- National Weather Service. (n.d.). *Forecasted Reference Evapotranspiration*. Retrieved from Graphical Forecasts National Weather Service: <https://digital.weather.gov/>
- OpenET. (n.d.). *How to Use Data from OpenET*. Retrieved from <https://openetdata.org/how-to-use-data-from-openet/>
- Steduto, P., Hsiao, T. C., Fereres, E., & Raes, D. (2012). *Crop Yield Response to Water*. Retrieved from Food and Agriculture Organization: <https://www.fao.org/3/i2800e/i2800e.pdf>
- Fox Canyon Groundwater Management Agency. Seasonal ETc estimates: [https://fcgma.org/wp-content/uploads/2022/06/IA\\_Table\\_with\\_map\\_August\\_1\\_2014.pdf](https://fcgma.org/wp-content/uploads/2022/06/IA_Table_with_map_August_1_2014.pdf)



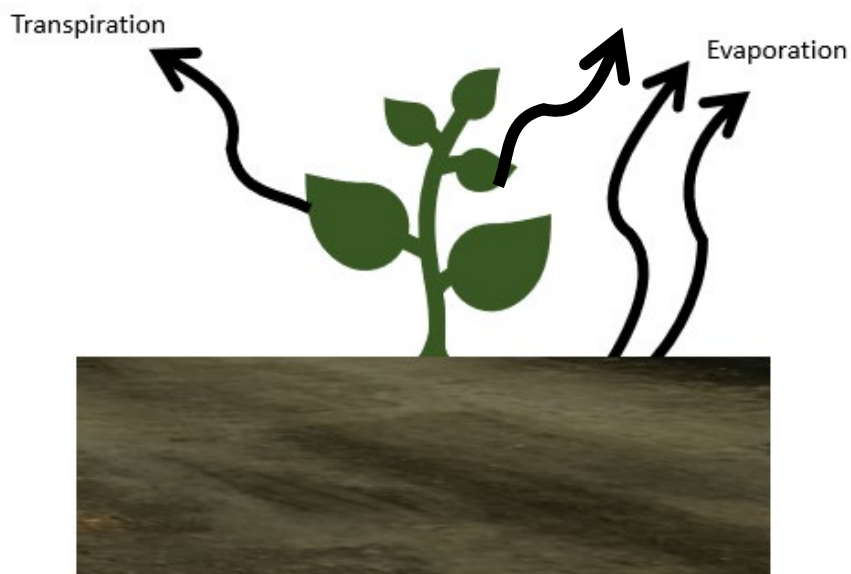
## Crop Evapotranspiration

---

In the irrigation management section of the INMP worksheet, box 1 asks growers to estimate crop evapotranspiration for the season.

Section 1: Pre-Season Planning	
Irrigation Management	
1. Crop Evapotranspiration (ETc, inches)	

Evapotranspiration (ET) is a combination of evaporation and transpiration. Evaporation is the loss of water from the surface of the field. Transpiration is the loss of water from the plants' stomata (pores). ET varies geographically and is influenced by the weather, soil, and plants.



## Estimating Crop Evapotranspiration

---

ET can be estimated for a crop and is called crop evapotranspiration (ETc). Estimating ETc can help growers plan irrigation applications for the growing season. There are two main methods available for growers to estimate seasonal ETc.

1. Calculate ETc using a reference ET (ETo) rate and a crop coefficient (Kc).
2. Use seasonal ETc estimates provided by UCCE or Fox Canyon Groundwater Management Agency.

### Option 1: Calculate ETc

Potential ETc can be calculated by multiplying the ET of a reference crop (ETo) by a crop coefficient (Kc). [ETc = ETo × Kc]

- ETo: Represents water use by a reference crop. In California, the reference crop is well-watered pasture grass. The following sources provide ETo estimates.
  - CIMIS provides historical ETo: <https://cimis.water.ca.gov/Default.aspx>
  - FRET provides daily and weekly ETo forecasts: <https://digital.weather.gov/>
- Kc: A crop coefficient helps account for the difference in water use between the reference crop and your crop. Kc changes with crop type and growth stage. The following sources provide Kc values for annual and perennial crops.
  - FAO Irrigation and Drainage Paper 66: <https://www.fao.org/3/i2800e/i2800e00.htm>
  - Commodity specific research or industry boards

### Option 1 Example

The following example estimates the ETc for an avocado grove in Camarillo. The example uses historical ETo data pulled from CIMIS station 152 in Camarillo and Kc values provided by UCCE.

Month	Kc	ETo	ETc
Jan	2.5	0.85	2.13
Feb	2.7	0.85	2.30
Mar	3.9	0.85	3.32
Apr	4.7	0.85	4.00
May	5.2	0.85	4.42
Jun	5.4	0.85	4.59
Jul	6.0	0.85	5.10
Aug	5.5	0.85	4.68
Sep	4.4	0.85	3.74
Oct	3.4	0.85	2.89
Nov	2.6	0.85	2.21
Dec	2.2	0.85	1.87

### Option 2: Using Existing ETc Estimates

For growers located within the Fox Canyon Groundwater Management Agency boundary, an Eto zone map is available here: [https://fcgma.org/wp-content/uploads/2022/06/IA\\_Table\\_with\\_map\\_August\\_1\\_2014.pdf](https://fcgma.org/wp-content/uploads/2022/06/IA_Table_with_map_August_1_2014.pdf)

### Option 2 Example

The table below is an example from the Fox Canyon Groundwater Management Agency.

	Dry (AF/A)	Typical (AF/A)	Wet (AF/A)
Avocado <20% Shading	1.7	1.6	1.5
Avocado 20-70% Shading	2.5	2.3	2.1
Avocado >70% Shading	3.5	3.1	3.0

### Activity 3.3.1

Directions: Using each of the three methods highlighted in lesson 3, estimate the seasonal ET.

Method 1: Estimate the seasonal ETc using the provided ETo and Kc values below from CIMIS and UCCE.

Kc	ETo	ETc
0.65	40	

Method 2: Determine the seasonal ETc for a blueberry crop with 20-70% ground shading in a typical year in the Oxnard zone using the fox canyon estimates. [https://fcgma.org/wp-content/uploads/2022/06/IA\\_Table\\_with\\_map\\_August\\_1\\_2014.pdf](https://fcgma.org/wp-content/uploads/2022/06/IA_Table_with_map_August_1_2014.pdf)

--

### Module 3 Lesson 3 Summary

---

1. There are two main methods for estimating seasonal crop ET.
2. Estimating crop ET can help you plan irrigation applications for the growing season.

## Module 3 Lesson 4: Anticipated Crop Irrigation

Lesson 4 covers how to estimate maximum seasonal irrigation needs based on all beneficial water uses. By the end of lesson 4, participants will demonstrate the ability to:

1. Estimate leaching requirement based on a crop's salinity tolerance and irrigation water salinity levels.
2. Estimate maximum anticipated crop irrigation rate based on water requirements.

Lesson Topic(s)	Page(s) in Workbook
Anticipated Crop Irrigation	38
Additional Water Requirements	38 – 39
Estimating Crop Irrigation Rates	39
Summary	39

### Lesson Resources

- Brouwer, C., & Heibloem, M. (1986). *Chapter 4: Irrigation Water Needs*. Retrieved from Food and Agriculture Organization:  
<https://www.fao.org/3/S2022E/s2022e08.htm#chapter%204:%20irrigation%20water%20needs>
- Cahn, M., & Bali, K. (2015, November). *Managing Salts by Leaching*. Retrieved from University of California Agriculture and Natural Resources:  
[http://soilhealth.ucdavis.edu/application/files/5315/4222/2064/UC\\_ANR\\_salts\\_leaching\\_management.pdf](http://soilhealth.ucdavis.edu/application/files/5315/4222/2064/UC_ANR_salts_leaching_management.pdf)

## Anticipated Crop Irrigation

---

In the irrigation management section of the INMP Worksheet, box 2 asks growers to estimate their irrigation application amount for the season.

Section 1: Pre-Season Planning	
Irrigation Management	
1. Crop Evapotranspiration (ET <sub>c</sub> , inches)	
2. Anticipated Crop Irrigation (inches)	

The crop irrigation rate for a field is based off the following components:

- Crop demand (ET<sub>c</sub>): water required by the crop to replace water lost through evapotranspiration
- Additional water requirements: water requirements in addition to the water required for crop demand. Requirements include water needed for leaching salts, germination, and climate control.
- Irrigation efficiency: water required to overcome any inefficiencies in the irrigation system

## Additional Water Requirements

---

In addition to crop demand there are other water requirements in an agriculture field. These requirements may include water needed for leaching salts, germination, and/or climate control. If there are additional requirements be sure to account for them when estimating the maximum irrigation rate for the season.

### Leaching Salts

High salinity levels in the root zone reduce the crop's ability to take up water from the soil. Eventually this can cause a decline in yield. Salts can build up in the soil from applications of fertilizers, soil amendments like manure, and poor-quality irrigation water.

Leaching is the process of moving salts below the rootzone with water. Leaching should be conducted when soil nitrate levels are low to avoid moving large amounts of nitrate into groundwater.

## Leaching Requirement

The leaching requirement (LR) is the amount of excess water that needs to be applied to move salts below the rootzone. The LR can be calculated based on the average salinity of the water ( $EC_w$ ) and the soil salinity threshold ( $EC_e$ ) of the crop. For a list of soil salinity thresholds ( $EC_e$ ) for common crops visit:

[http://soilhealth.ucdavis.edu/application/files/5315/4222/2064/UC\\_ANR\\_salts\\_leaching\\_management.pdf](http://soilhealth.ucdavis.edu/application/files/5315/4222/2064/UC_ANR_salts_leaching_management.pdf)

$$LR (\%) = (EC_w \times 100) \div [(EC_e \times 5) - EC_w]$$

### Activity 3.4.1

The orange orchard in Moorpark has an irrigation water salinity level of 1.3 dS/m. The soil salinity threshold for oranges is 1.7 dS/m. What is the leaching requirement?

## Estimating Crop Irrigation Rates

---

Once the crop demand, additional water requirements and irrigation efficiency level have been determined growers can estimate the anticipated crop irrigation rate for the season.

$$\text{Max Irrigation Rate} = \frac{(ET_c \div IE) - \text{Effective Rainfall}}{1 - (LR \div 100)} + \text{additional water requirements}$$

### Activity 3.4.2

Estimate the max irrigation rate based on the following parameters:  $ET_c = 48$  in,  $IE = 0.9$ , Effective Rainfall = 1.5 in,  $LR = 21\%$

## Module 3 Lesson 4 Summary

---

1. In-season rainfall can contribute to crop water needs.
2. Crop irrigation rates are based on water needed to meet crop demand and additional water requirements.

## Module 3 Lesson 5: Irrigation Set Times

Lesson 5 covers how to calculate irrigation set times to fulfill crop water requirements. By the end of lesson 5, participants will demonstrate the ability to:

1. Calculate irrigation set times based on a desired water application in inches.

Lesson Topic(s)	Page(s) in Workbook
Calculating Irrigation Set Times	41
Summary	41

### Lesson Resources

- Washington State University Extension. (n.d.). *Irrigation Calculators*. Retrieved from <http://irrigation.wsu.edu/Content/Select-Calculators.php>

## Calculating Irrigation Set Times

---

Once the desired water application has been determined in inches, growers must translate that into a system run time. Irrigation run times can be calculated based on flow meter data or system application rates.

### Using Flow Meter Data

If you have a flow meter installed, irrigation set times can be determined based on the flow rate. To determine the hours of run time, use the equation below or use the calculator available at: <http://irrigation.wsu.edu/Content/Calculators/General/Set-Times.php>

$$\text{Time (hr.)} = \frac{\text{water application (in)} \times \text{irrigated area (acres)} \times 43,560}{96.3 \times \text{flow rate (gpm)}}$$

### Activity 3.5.1

A grower is irrigating 25 acres with an average water flow rate of 850 gpm. If the desired water application depth is 0.5 in. how long should they run the irrigation system?

### Using System Application Rates

If you do not have a flow meter installed, irrigation set times can be determined based on the system application rate. To determine the application rate of a drip or sprinkler system use the equations or calculator available at: <http://irrigation.wsu.edu/Content/Calculators/Popular.php>

$$\text{Run Time (hr.)} = \text{water application (in)} \div \text{system application rate (in/hr.)}$$

### Activity 3.5.2

A drip irrigation system has an application rate of 0.15 in/hr. How long should the grower run the system to apply 0.5 in of water?

## Module 3 Lesson 5 Summary

---

1. System run times can be calculated based on flow meter data or system application rates.



## Module 3 Lesson 6: Irrigation Water Nitrogen Concentration

Lesson 6 covers sampling irrigation water to estimate the concentration of nitrate-nitrogen. By the end of lesson 6, participants will demonstrate the ability to:

1. Describe how to sample irrigation water for nitrate-nitrogen.
2. Estimate the concentration of nitrate-nitrogen in an irrigation water sample.

Lesson Topic(s)	Page(s) in Workbook
Nitrogen in Irrigation Water	43
Sampling Irrigation Water	43
Estimating Nitrate-Nitrogen	44
Summary	45

### Lesson Resources

- Murphy, L., Cahn, M., & Smith, R. (2014, March). *Accuracy of Test Strips for Assessing Nitrate Concentration in Soil and Water*. Retrieved from Salinas Valley Agriculture Blog: <https://ucanr.edu/blogs/blogcore/postdetail.cfm?postnum=13140>
- University of California Agriculture and Natural Resources. (2017, August). *List of Laboratories for Tissue Soil Water -Agricultural Analysis*. Retrieved from <https://www.sandiegocounty.gov/content/dam/sdc/awm/docs/Private%20Agricultural%20Labs.pdf>
- University of California Agriculture and Natural Resources. (n.d.). *Assessing Water Quality and Taking a Water Sample*. Retrieved from [https://micromaintain.ucanr.edu/Prediction/Source/Groundwater/Assessing\\_Water\\_Quality\\_II-50a/](https://micromaintain.ucanr.edu/Prediction/Source/Groundwater/Assessing_Water_Quality_II-50a/)

## Nitrogen in Irrigation Water

---

In the irrigation management section of the INMP Worksheet, box 3 asks growers to estimate the concentration of nitrate-nitrogen in their irrigation water.

Section 1: Pre-Season Planning	
Irrigation Management	
1. Crop Evapotranspiration (ET <sub>c</sub> , inches)	
2. Anticipated Crop Irrigation (inches)	
3. Irrigation Water N Concentration (ppm or mg/L as NO <sub>3</sub> -N)	

## Irrigation Water Testing

---

An irrigation water suitability test will provide growers with the concentrations of several elements in their water including nitrate-nitrogen (NO<sub>3</sub>-N). Different agricultural labs may have variable sampling methods and instructions. Growers should consult with their lab prior to collecting and sending in samples.

Growers can also use nitrate quick test strips or similar tools to estimate the concentration on-farm. However, it is important to understand strips can vary in accuracy when compared to laboratory testing.

Below are some general guidelines for collecting water samples for on-farm or lab analysis. It is recommended that you contact an agricultural lab prior to collecting and submitting samples. Many labs provide free sampling bottles, guidelines, and any specialized equipment.

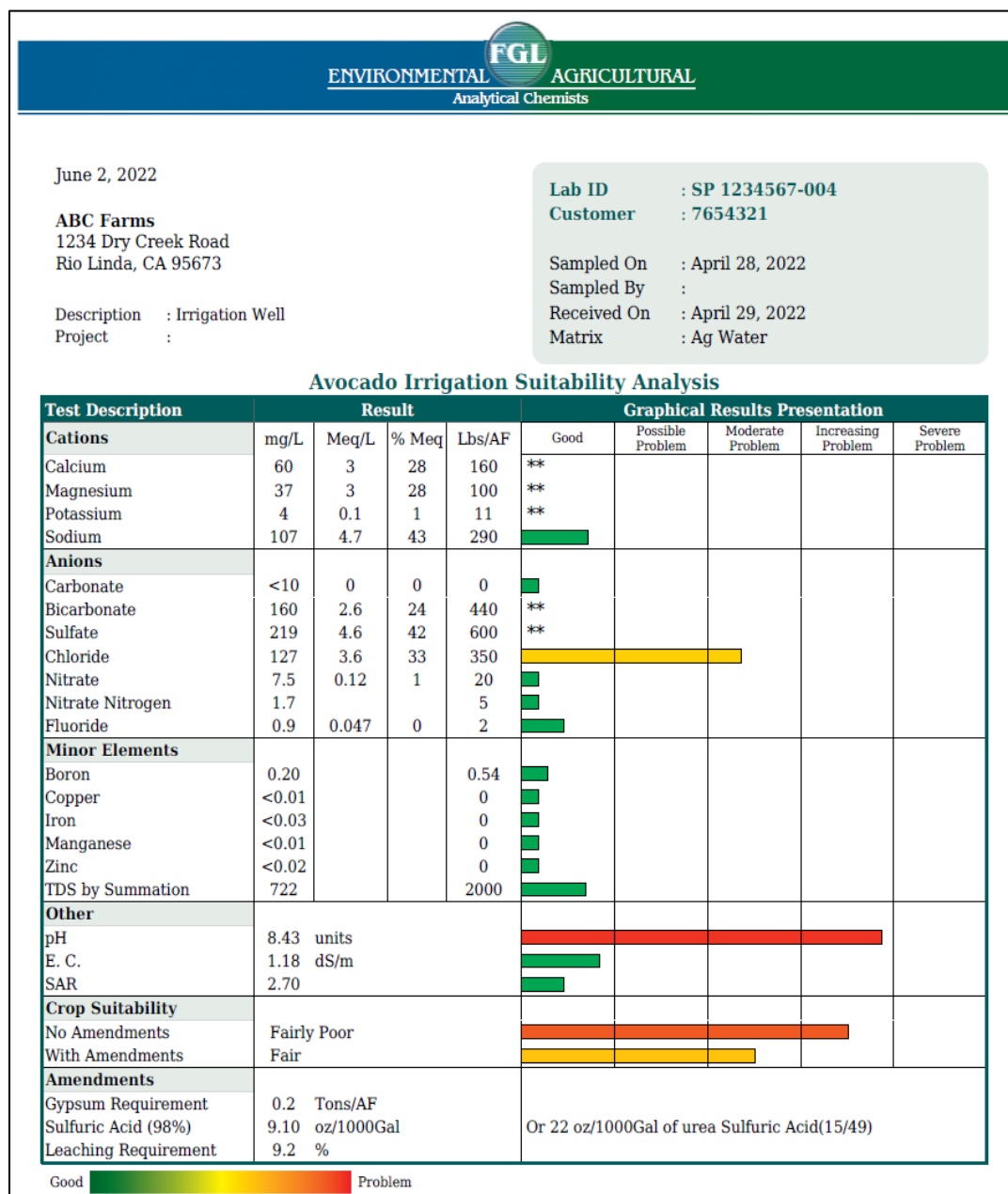
1. Allow irrigation well to run for 30 minutes
2. Take sample prior to injection stations
3. Fill container completely with water (no air gap)
4. Label container based on lab's instructions
5. Keep sample cold during shipment until delivery and deliver within the time frame specified by the lab

## Estimating Nitrate-Nitrogen

Depending on the lab or nitrate quick test strips used, results may be reported as mg/l Nitrate ( $\text{NO}_3$ ) or mg/l Nitrate-Nitrogen ( $\text{NO}_3\text{-N}$ ). If results are reported as mg/l Nitrate ( $\text{NO}_3$ ) a quick conversion can be completed.

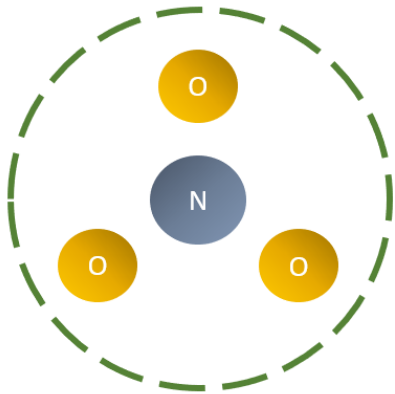
$$\text{NO}_3 \text{ (ppm or mg/L)} \times 0.23 = \text{NO}_3\text{-N (ppm or mg/L)}$$

### Example Irrigation Water Analysis for Avocados

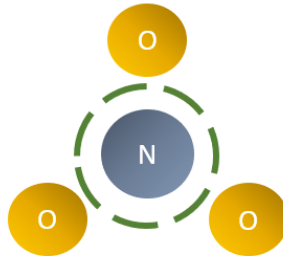


### **Activity 3.6.1**

Which measurement includes the 3 oxygen molecules? (Circle your answer)



Nitrate ( $\text{NO}_3$ )



Nitrate-Nitrogen ( $\text{NO}_3\text{-N}$ )

### **Module 3 Lesson 6 Summary**

---

1. Growers can use a lab or nitrate quick test strips to estimate nitrate-nitrogen in their water.
2. If results are reported as mg/l or ppm Nitrate ( $\text{NO}_3$ ) they need to be converted to nitrate-Nitrogen ( $\text{NO}_3\text{-N}$ ).

## Module 3 Lesson 7: Irrigation Efficiency Practices

Lesson 7 covers irrigation practices that can help growers match their water application with crop needs. By the end of lesson 7, participants will demonstrate the ability to:

1. Identify management practices and tools that can increase irrigation efficiency.
2. Differentiate between the three methods for determining irrigation application timing and rates.

Lesson Topic(s)	Page(s) in Workbook
Irrigation Efficiency Practices	47
Irrigation Scheduling	47 – 48
Irrigation Maintenance	49
Additional Efficiency Practices	49
Summary	49

### Lesson Resources

- Schwankl, L. (n.d.). *Irrigation Scheduling*. Retrieved from University of California Drought Management: [https://ucmanagedrought.ucdavis.edu/Agriculture/Irrigation\\_Scheduling/](https://ucmanagedrought.ucdavis.edu/Agriculture/Irrigation_Scheduling/)
- Schwankl, L. (n.d.). *Maintenance of Microirrigation Systems*. Retrieved from <https://micromaintain.ucanr.edu/>

## Irrigation Efficiency Practices

---

In box 16 of the Irrigation Management section of the INMP Worksheet, growers are asked to record their irrigation efficiency practices. Irrigation efficiency practices are also reported on the INMR.

16 Irrigation Efficiency Practices		(Check all that apply)	
<input type="checkbox"/>	Laser Leveling	<input type="checkbox"/>	Use of Soil Moisture Measurement to Inform Irrigation (e.g. sensor, tensiometer)
<input type="checkbox"/>	Distribution Uniformity Testing Conducted at Least Every 3 Years	<input type="checkbox"/>	Use of Variable Speed Water Pump
<input type="checkbox"/>	Use of ET and/or CIMIS data in Scheduling Irrigations (e.g. atmometer)	<input type="checkbox"/>	Other

Irrigation efficiency (IE) is the percentage of applied water that is beneficially used. Two of the main factors that influence irrigation efficiency are irrigation scheduling and irrigation maintenance.

## Irrigation Scheduling

---

Irrigation scheduling methods can help growers know when to irrigate and how much water to apply with each irrigation event. There are three main methods covered below. A skilled irrigator will use a combination of available methods as each method has its weaknesses.

### Soil-Based Monitoring

Soil moisture monitoring can estimate how much water is available to the crop. Monitoring soil moisture can help growers decide when to irrigate.

Soil moisture sensors show when enough soil moisture has been depleted to warrant an irrigation event. Sensors can also indicate when enough water has been supplied to replace depleted moisture. Two general types of sensors are available: sensors that measure how tightly water is held by the soil (tension) and sensors that estimate the soils moisture content. Sensors that estimate moisture content can be used to estimate available water in the dormant season.

Devices that measure tension include tensiometers and electrical resistance blocks (also known as gypsum blocks). Devices that measure soil moisture content include neutron probes and dielectric soil moisture sensors.

### Plant Based Monitoring

Plant-based monitoring can estimate plant water stress to help growers decide when to irrigate. Plant-based monitoring is the ultimate indicator of whether a plant needs water. However, plant-based methods cannot determine how much water to apply.

Devices that take direct measurements of stress include the pressure chamber, automated water potential sensors, and sap flow sensors. Devices that take indirect measurements, like dendrometers, monitor the shrinkage and swelling of the trunk or petiole.

### Weather Based Monitoring

Weather-based irrigation scheduling uses crop ET estimates to help determine when to irrigate and how long to run the irrigation system. Each irrigation event should be scheduled to replace the water used by the crop since the last irrigation event. Thus, preventing overirrigation and leaching of nitrate.

Weather-based methods should only be used as an irrigation guide. Plant-based and/or soil-based methods should be used as a check.

Weekly ET data is available through CIMIS and local University of California Cooperative Extension Offices. A video series on how to use the weekly crop ET reports for scheduling can be found at [sacvalleyorchards.com/et-reports/](http://sacvalleyorchards.com/et-reports/).

### Activity 3.7.1

Directions: Using the table below list some possible advantages and disadvantages to each scheduling method.

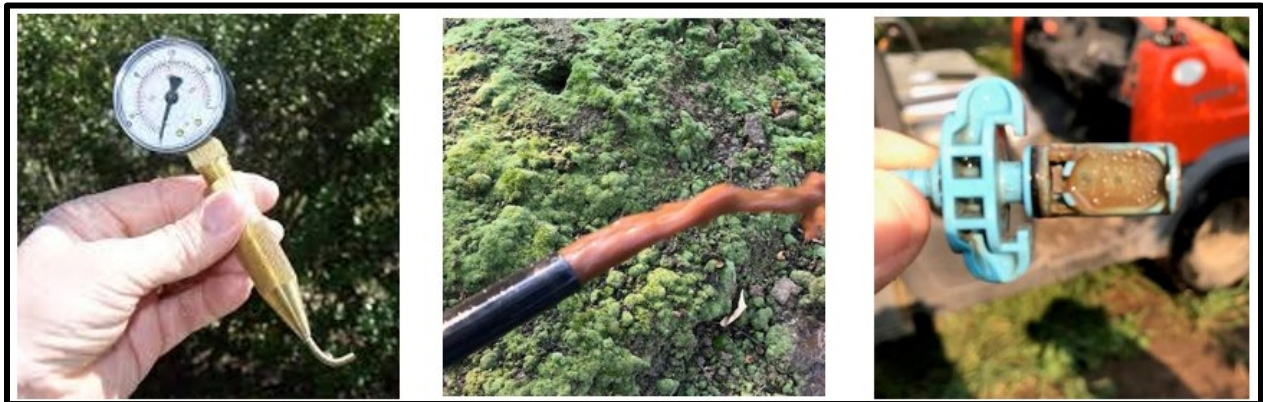
Method	Advantages	Disadvantages
Soil-Based		
Plant-Based		
Weather-Based		

## Irrigation Maintenance

---

Maintaining an irrigation system is essential to ensuring uniform applications and irrigating efficiently. Below are several key maintenance tasks that should be performed throughout the season.

- Clean and inspect media tanks, screen, and disc filters
- Inspect any electronic devices like flow meters and pressure transducers
- Inspect system for leaks or damage
- Check emitters and hose screens for plugging
- Flush lines
- Check system pressure



## Additional Efficiency Practices

---

There are several other practices that can improve the irrigation efficiency of a field or irrigation system. Some of those practices include:

- Laser leveling
- Variable frequency drives: allow the pump to respond efficiently to fluctuations in flow and/or pressure demand
- Using pressure-compensating emitters with drip and microsprinkler systems

## Module 3 Lesson 7 Summary

---

1. There are three main irrigation scheduling methods: soil-based, plant-based, and weather-based.
2. Irrigation maintenance is key to even distribution and efficient irrigation.



## Module 4 Lesson 1: Production Units

### Lesson Overview

Lesson 1 covers how to identify the appropriate production unit for reporting. By the end of lesson 1, participants will demonstrate the ability to:

1. Label production units appropriately for yield reporting.
2. Identify production units that may require additional detail.

Lesson Topic(s)	Page(s) in Workbook
Production Units	51
Summary	51

## Production Units

---

In the Harvest Projection Section on the INMP Worksheet, box 4 asks growers to list a production unit.

Section 1: Pre-Season Planning			
Irrigation Management		Harvest Projection	
1. Crop Evapotranspiration (ET <sub>c</sub> , inches)		4. Production Units (With weight in lbs./tons)	
2. Anticipated Crop Irrigation (inches)			
3. Irrigation Water N Concentration (ppm or mg/L as NO <sub>3</sub> -N)			

The production unit serves as a basis for nitrogen management planning. The most common production units are lbs. and tons. For production units other than lbs. or tons, the approximate weight should be listed. For example, if yield is measured in boxes the weight of the box should be listed.

### Production Unit Exceptions

For some crop types, production units do not need to include a corresponding weight. Below is a list of crop types and associated production units that do not require a corresponding weight:

Standard Crop Name	Standard Production Unit
Nursery Plants	Units or Pots
Cut Flowers	Bunches
Sod	Sq. Feet
U-Pick Operations	Sale Figures

## Module 4 Lesson 1 Summary

---

1. The production unit serves as a basis for nitrogen management planning.
2. If a production unit other than lbs. or tons is used, provide the approximate weight of the unit.

## Module 4 Lesson 2: Expected Crop Yield

### Lesson Overview

Lesson 2 covers how to estimate yield for nitrogen management planning and reporting. The lesson also touches on the potential impacts of overestimating yield. By the end of lesson 2, participants will demonstrate the ability to:

1. Estimate yield based on field conditions, historical yields, and experience.
2. Describe possible impacts of overestimating yield.

Lesson Topic(s)	Page(s) in Workbook
Crop Yield	53
Planned Yield	53 – 54
Summary	54

### Lesson Resources

- California Department of Food and Agriculture. (n.d.). *Links to County Crop Reports*. Retrieved from <https://www.cdfa.ca.gov/exec/county/CountyCropReports.html>
- Ventura County Agricultural Commissioner. *Links to annual County Crop Reports*. Retrieved from <https://www.ventura.org/agricultural-commissioner/reports/>

## Crop Yield

---

In the Harvest Projection Section on the INMP Worksheet, box 5 asks growers to quantify projected crop yield.

Section 1: Pre-Season Planning			
Irrigation Management		Harvest Projection	
1. Crop Evapotranspiration (ET <sub>c</sub> , inches)		4. Production Units (With weight in lbs./tons)	
2. Anticipated Crop Irrigation (inches)		5. Projected Harvest Yield	
3. Irrigation Water N Concentration (ppm or mg/L as NO <sub>3</sub> -N)			

Crop yield is also recorded in Box 13. Box 13 has two columns, one for pre-season planning (A) and one for actuals recorded at the end of the season (B). Yield should be reported on a per-acre basis.

	Planned (A)	Actual (B)
Section 3: Harvest Yield		
13. Harvest Yield (lbs., tons, etc.)		

### Column (A) Planned Yield

---

The expected yield is used to calculate nitrogen requirements for annuals and mature perennial crops. Thus, it is important to provide a realistic yield estimate. Overestimating yield can lead to an overapplication of nitrogen. If field or weather conditions are indicating yields may be lower than predicted, in-season adjustments to nitrogen application rates should be made.

There are several methods available to estimate crop yield. The methods highlighted below are most appropriate for annuals and/or mature perennial crops.

### Method 1: Estimate based on Cropping History

A realistic yield estimate can be made by averaging yields from the previous 3-5 seasons. Unusually bad or good years can be omitted from the average. Additionally, adjustments should be made based on knowledge of field and market conditions.

#### Method 1 Example

A grower has 5 years of data from his fresh market carrot field. In year one, he experienced unusually low yields. Omitting data from year one, what is the average yield?

- ~~580 crates~~, 640 crates, 630 crates, 680 crates, 650 crates
- Average = 650 crates per acre

### Method 2: Estimate based on County Crop Reports

If there is no crop history available for a field or management unit, an estimate can be made based on county crop reports. This method of estimation is most accurate for annual crops.

1. Locate county crop reports:  
<https://www.cdfa.ca.gov/exec/county/CountyCropReports.html>
2. Average yields from previous 3-5 seasons
3. Adjust as needed for current field conditions

#### Activity 4.2.1

Directions: Based on the scenario below, estimate the expected yield for the season using method 2.

A grower is planting a field of strawberries for the first time. He uses the county crop reports to determine the average yields for Ventura County over the last 4 years. The yields are 25.7, 24.1, 21.9, and 24.3 tons per acre. What is the average expected yield?

--

### Module 4 Lesson 2 Summary

---

1. A realistic yield estimate can be made by averaging yields from the previous 3-5 seasons.
2. Overestimating yield can lead to an overapplication of nitrogen.

## Module 4 Lesson 3: Actual Crop Yield

### Lesson Overview

Lesson 3 covers how to report actual yield and yield information. By the end of lesson 3, participants will demonstrate the ability to:

1. Accurately report yield.
2. Indicate what additional yield information should be reported.

Lesson Topic(s)	Page(s) in Workbook
Crop Yield	56
Actual Yield	56
Additional Yield Information	56
Summary	56

### Lesson Resources

- Geisseler, D. (2021). *Nitrogen Concentrations in Harvested Plant Parts – Update 03/2021*. Retrieved from Geisseler Nutrient Management Lab: [http://geisseler.ucdavis.edu/Project\\_N\\_Removal.html](http://geisseler.ucdavis.edu/Project_N_Removal.html)

## Crop Yield

---

In the Harvest Yield Section on the INMP Worksheet, box 13 asks growers to report crop yield. Box 13 has two columns, one for pre-season planning (A) and one for actuals recorded at the end of the season (B).

	Planned (A)	Actual (B)
<b>Section 3: Harvest Yield</b>		
13. Harvest Yield (lbs., tons, etc.)		

## Actual Yield

---

Actual yield is the total amount of crop harvested in units per acre. If the INMP Worksheet covers multiple parcels or a management unit, an average yield should be reported.

Nitrogen removed is calculated using reported yield and a nitrogen removal coefficient. Thus, reporting an accurate yield will ensure an accurate evaluation of nitrogen applied vs. removed.

## Additional Yield Information

---

In the INMR there is a box to provide additional information on yield for a management unit. Growers should provide information in this box if there was no yield, or the field was non-bearing or not farmed. This would also be a good location to note any significant yield loss or difficulty in quantifying yield.

## Module 4 Lesson 3 Summary

---

1. Reporting an accurate yield ensures an accurate evaluation of nitrogen applied vs. removed.
2. Additional information on yield can be reported in the INMR.

## Module 5 Lesson 1: Nitrogen Efficiency Practices

### Lesson Overview

Lesson 1 introduces the concept of nitrogen use efficiency and covers the 4R principles of nitrogen management. Lesson 1 also covers nitrogen efficiency practices listed in the Irrigation and Nitrogen Management Plan (INMP) Worksheet. By the end of lesson 1, participants will demonstrate the ability to:

1. Define nitrogen use efficiency.
2. Describe the 4R principles of nitrogen management.
3. Match nitrogen efficiency practices with their corresponding 4R principle(s).

Lesson Topic(s)	Page(s) in Workbook
Nitrogen Use Efficiency	58
4Rs of Nitrogen Management	58 – 59
Nitrogen Efficiency Practices	59-60
Summary	60

### Lesson Resources

- International Plant Nutrition Institute. (n.d.). *4R Nutrient Stewardship Decision Making Guide Nitrogen*. Retrieved from: [http://www.ipni.net/publication/4rguides.nsf/0/DF7D0BCDBF63D2D685257F72004B746F/\\$FILE/4RGuide-Nitrogen.pdf](http://www.ipni.net/publication/4rguides.nsf/0/DF7D0BCDBF63D2D685257F72004B746F/$FILE/4RGuide-Nitrogen.pdf)
- International Plant Nutrition Institute. (n.d.). *Nutrient Source Specifics*. Retrieved from: <http://www.ipni.net/specifics-en>
- Savidge, M., & Geisseler, D. (n.d.). *The 4Rs of Nutrient Management*. Retrieved from: <http://geisseler.ucdavis.edu/Guidelines/4R.html>
- USDA NRCS. (n.d.). *Effective Root Zone Depth*. Retrieved from: Irrigation Guide Part 652: [https://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/nrcs141p2\\_017640.pdf](https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_017640.pdf)



## Nitrogen Use Efficiency

---

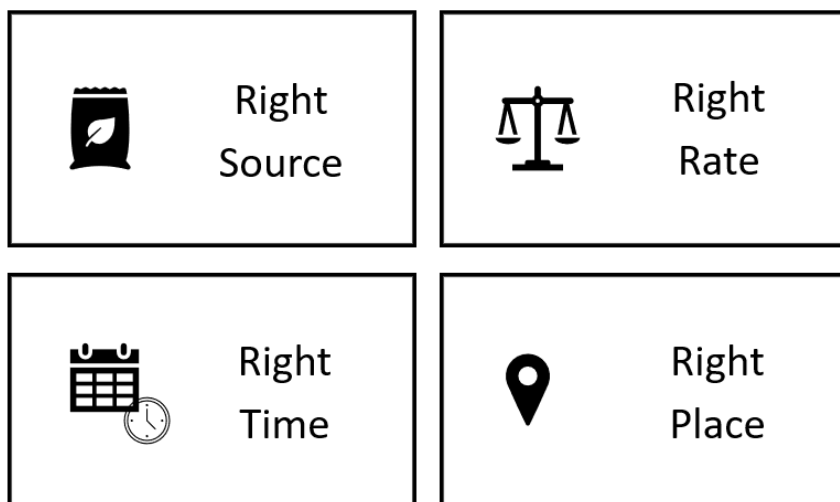
Nitrogen use efficiency is a measure of how well available nitrogen matches nitrogen uptake. Globally, the average nitrogen use efficiency level is 50%. However, with the adoption of efficient irrigation and nitrogen management practices in California agriculture, 70% efficiency is achievable. A 70% nitrogen use efficiency means that 70% of the nitrogen available to the crop was taken up by the crop.

Improving nitrogen use efficiency can increase yields, profitability, and reduce the environmental impacts of nitrogen loss.

## 4Rs of Nitrogen Management

---

Nitrogen use efficiency can be improved by following the 4R principles, applying the right source at the right rate, the right time, and in the right place.



### Right Source

Selecting the right nitrogen source can be a complex decision that involves considering crop requirements, soil conditions, application method, and product price. It is also important to know what form the nitrogen is in. The form of nitrogen will influence how the input behaves in the soil and when the nitrogen will be available for plant uptake.

For more information on specific fertilizer sources, view the nutrient source publications by the International Plant Nutrition Institute (IPNI): <http://www.ipni.net/specifics-en>

### Examples of Right Source

- Selecting a source based on when the nitrogen will be available to the plant
- Selecting a nitrogen fertilizer that is less susceptible to atmospheric or leaching loss

### **Right Rate**

Ensure that the amount of nitrogen available to the crop is sufficient to meet crop demand. Nitrogen rates beyond crop need can result in nitrogen loss. Excess nitrogen can also increase pest and disease pressure.

#### **Examples of Right Rate**

- Use soil and tissue/petiole testing to adjust seasonal application rates
- Adjust nitrogen application rates based on expected crop yield
- Adjust nitrogen fertilizer application rates to account for nitrogen from other sources such as residual soil nitrate, organic amendments, and irrigation water

### **Right Time**

Nitrogen applications should be timed to ensure that nitrogen will be available to the plant during periods of high demand. In annual crops, nitrogen demand is highest during the vegetative growth stage. In mature trees and vines, nitrogen demand is typically highest during early fruit and nut development.

#### **Examples of Right Time**

- Split nitrogen applications to match the crop's nitrogen uptake curve
- Delay nitrogen applications until just before periods of high demand

### **Right Place**

For uptake to occur, applications should be targeted to ensure that nitrogen is available in the crop's effective rootzone. The effective rootzone is the depth of soil where most plant roots obtain moisture and nutrients. A crop's effective rootzone depends on the crop type, development stage, and irrigation system.

#### **Examples of Right Place**

- Planning fertilization events to ensure nitrogen stays in the rootzone
- Using banding or fertigation methods where appropriate to target applications near the effective rootzone
- Incorporation or watering in fertilizers that are prone to ammonia volatilization when left on the soil surface

## **Nitrogen Efficiency and Application Practices**

---

In the nitrogen management section of the INMP Worksheet, growers are asked to report their nitrogen efficiency and application practices in Box 17, 18, and 19. Growers should check all the practices that apply and include additional practices under other.

17. Nitrogen Efficiency Practices* (Check all that apply)		18. Nitrogen Application Practices* (Check all that apply)	
<input type="checkbox"/>	Irrigation Water N Testing	<input type="checkbox"/>	Split Fertilizer Applications
<input type="checkbox"/>	Soil Residual Nitrate Testing	<input type="checkbox"/>	Fertigation
<input type="checkbox"/>	Tissue/Petiole Testing	<input type="checkbox"/>	Foliar N Application
<input type="checkbox"/>	Cover Crops	<input type="checkbox"/>	Variable Rate Applications
<input type="checkbox"/>	Other _____	<input type="checkbox"/>	Other _____

19. Data Informed Decision Making		
Do you adjust fertilizer applications on this management unit based on irrigation water, soil residual, or tissue/petiole testing results?	<input type="checkbox"/>	Yes
	<input type="checkbox"/>	No

### **Activity 5.1.1**

Directions: Match the nitrogen efficiency practices with the corresponding 4R principle. Practices may fit under more than one 4R principle but select the best match.

Practice	4R Principle
Splitting nitrogen fertilizer applications	
Testing nitrogen levels in irrigation water	
Testing for residual soil nitrate	
Applying ammonium-based fertilizer to minimize leaching	

### **Module 5 Lesson 1 Summary**

1. Nitrogen use efficiency is a measure of how well available nitrogen matches nitrogen uptake by the crop.
2. Nitrogen use efficiency can be improved by following the 4R principles, applying the right source at the right rate, the right time, and in the right place.

## Module 5 Lesson 2: Soil Available Nitrogen

### Lesson Overview

Lesson 2 introduces how to sample for residual soil nitrate in annual cropping systems. Lesson 2 also covers how to determine the amount of nitrogen available to the plant from the soil. By the end of lesson 2, participants will demonstrate the ability to:

1. Describe how to take a representative soil sample.
2. Estimate the availability of nitrogen to plants within a given volume of soil.

Lesson Topic(s)	Page(s) in Workbook
Soil Available Nitrogen	62
Taking Representative Soil Samples	62 – 63
Estimating Soil Available Nitrogen	63
Soil Nitrate Quick Test	63 – 64
Summary	64

### Lesson Resources

- Geisseler, D., & Lazicki, P. A. (n.d.). *Soil Nitrate Testing Supports Nitrogen Management in Irrigated Annual Crops*. Retrieved from: <https://calag.ucanr.edu/Archive/?article=ca.2016a0027>
- Geisseler, D., & Horwath, W. 2016). *Sampling for Soil Nitrate Determination*. Retrieved from: [http://geisseler.ucdavis.edu/Guidelines/Soil\\_Sampling\\_Nitrate.pdf](http://geisseler.ucdavis.edu/Guidelines/Soil_Sampling_Nitrate.pdf)
- Geisseler, D., Lazicki, P., & Horwath, W. (n.d.). *Field Specific Nitrogen Fertilization Adjustments*. Retrieved from <http://geisseler.ucdavis.edu/Guidelines/Adjustments.html>
- University of California Agriculture and Natural Resources. (2020). *The Soil Nitrate Quick Test Web-Tool*. Retrieved from <https://smallgrain-n-management.plantsciences.ucdavis.edu/snqt/>
- University of California Agriculture and Natural Resources. (n.d.). *Soil Nitrate Quick Test Step-by-Step Instructions*. Retrieved from: [https://smallgrains.ucanr.edu/Nutrient\\_Management/snqt/instructions/](https://smallgrains.ucanr.edu/Nutrient_Management/snqt/instructions/)

## Soil Available Nitrogen

---

In the nitrogen management section of the INMP Worksheet, Box 11A asks growers to record nitrogen available to the crop from the soil. This value is only required under column (A) to inform nitrogen recommendations and planning.

Nitrogen Credits	Recommended / Planned N (A)	Actual Applied N (B)
11. Soil – Pre-Season Available N in Root Zone (lbs./ac)		

Available nitrogen in the soil can be a significant source of nitrogen in annual cropping systems. Thus, it should be accounted for in the nitrogen budget. For orchards and vineyards, available nitrogen in the soil is not typically accounted for in a nitrogen budget. So, it is appropriate to enter zero in Box 11A

### Residual Soil Nitrate

Available nitrogen in the soil is also known as residual soil nitrate. Residual soil nitrate may include:

- nitrogen left over from the previous crop
- nitrogen from recent fertilizer or irrigation applications
- nitrogen mineralized from crop residues and soil organic matter

## Taking Representative Soil Samples

---

### Sample Timing

A soil nitrate test provides a snapshot of the nitrate available in the soil at the time of sampling. Thus, soil samples should be collected close to a planned fertilizer application.

### Sample Location

It is important to ensure soil samples are representative of the conditions across a field or management unit. A minimum of 20 soil cores should be collected from each field or management unit in a zigzag or “X” shaped pattern. For drip irrigated annual crops, angle the probe in the direction of the drip tape.

### Sample Depth

Soil samples should be collected from the top 1 to 2 feet of soil, depending on the crop rooting depth and architecture. Remove residues from the surface of each sample. Then, mix samples thoroughly in a bucket.

## Handling Samples

If growers are sending samples to a lab for analysis, they should be kept cool and delivered to the lab promptly. If this is not possible the samples should be quickly air dried or frozen to prevent further nitrogen mineralization.

## Estimating Soil Available Nitrogen

---

Soil nitrate test results may be reported in ppm nitrate or ppm nitrate-N. To complete Box 11A on the INMP Worksheet, results will need to be converted to lbs. of nitrogen available per acre.

Step 1: Convert ppm nitrate to ppm nitrate-N

$$\text{ppm nitrate} \times 0.23 = \text{ppm nitrate-N}$$

Step 2: Convert ppm nitrate-N to lbs. of nitrogen per acre

$$\text{ppm nitrate-N} \times 4^* = \text{lbs. nitrogen per acre in the top 12 in of soil}$$

$$\text{ppm nitrate-N} \times 8^* = \text{lbs. nitrogen per acre in the top 24 in of soil}$$

\*In organic soils, the conversion factors are 3 and 6 due to a lower bulk density.

### **Activity 5.2.1**

Convert 20 ppm nitrate to ppm nitrate-N.

## Soil Nitrate Quick Test

---

For routine field monitoring in annual cropping systems, an on-farm nitrate quick test can be completed. Quick test values tend to underestimate nitrate-N concentrations compared to lab methods, particularly for lower concentrations of nitrate-N. While results are not as accurate as a lab analysis, on-farm testing offers quick results that can be helpful for in-season adjustments.

The University of California Agriculture and Natural Resources Division has a set of resources to guide users in completing and understanding a soil nitrate quick test. The resources include an interactive step-by-step guide, an instructional video, and a tool developed to help growers interpret the results. The web-based tool utilizes NRCS soil survey data to provide a lab equivalent value and an estimate of lbs. of nitrogen available per acre.

[https://smallgrains.ucanr.edu/Nutrient\\_Management/snqt/](https://smallgrains.ucanr.edu/Nutrient_Management/snqt/)

A video demonstration of a Soil Nitrate Quick Test conducted by a NRCS conservationist is available here: <https://www.youtube.com/watch?v=V1sDtkGm760&t=466s>

### **Activity 5.2.2**

Following the step-by-step guide developed by UCANR, a grower performed a nitrate quick test and got a result of 14.0 ppm nitrate-N.

The grower then used the Soil Nitrate Quick Test Web-Tool to interpret the results. The tool estimated that the equivalent lab value was approx. 17.5 ppm nitrate-N. Based on this value how many lbs. of nitrogen are available per acre in the top 12 inches of soil?

--

### **Module 5 Lesson 2 Summary**

---

1. For a representative sample, collect a minimum of 20 soil cores throughout the field or management unit.
2. Pounds of nitrogen available in the top foot of a mineral soil can be determined by multiplying ppm nitrate-N by 4.

## Module 5 Lesson 3: Nitrogen in Irrigation Water

### Lesson Overview

Lesson 3 introduces how to estimate the amount of nitrogen in a volume of irrigation water. By the end of lesson 3, participants will demonstrate the ability to:

1. Estimate the amount of nitrate-N applied in a volume of irrigation water.

Lesson Topic(s)	Page(s) in Workbook
Nitrogen in Irrigation Water	66
Pre-Season Planning	66
Post Season Actuals	66-67
Summary	67

### Lesson Resources

- Dickey, J. (2019, January). *Irrigation Water Nitrogen Contribution Calculator*. Retrieved from MPEP: <https://agmpep.com/tools/calc-irrn/>
- Schwankl, J. L., Prichard, L. T., & Hanson, R. B. (2007). *Measuring Applied Water in Surface Irrigated Orchards*. Retrieved from University of California Agriculture and Natural Resources: <https://anrcatalog.ucanr.edu/pdf/8230.pdf>
- Smith, R., Murphy, L., Hartz, T., & Cahn, M. (2017, April). *Field Trials Show the Fertilizer Value of Nitrogen in Irrigation Water*. Retrieved from <https://calag.ucanr.edu/archive/?article=ca.2017a0010>
- Washington State University Extension. (n.d.). *Irrigation Calculators*. Retrieved from <http://irrigation.wsu.edu/Content/Select-Calculators.php>



## Nitrogen in Irrigation Water

---

In the nitrogen management section of the INMP Worksheet, Box 10 asks growers to report nitrogen in the irrigation water. Box 10 has two columns, one for pre-season planning (A) and one for actuals recorded at the end of the season (B).

Nitrogen Credits	Recommended / Planned N (A)	Actual Applied N (B)
10. N in Irrigation Water* (Annualized, lbs./ac)		

### Availability of Nitrogen in Irrigation Water

Nitrogen in irrigation water is as effective as nitrogen applied in inorganic fertilizers. Thus, all nitrogen applied through the irrigation water must be accounted for on the INMP Worksheet.

### Column (A) Pre-Season Planning

---

An estimate for the season can be made using the anticipated crop irrigation rate (Box 2) and the nitrate-N concentration of the irrigation water (Box 3).

$$\text{lbs. nitrogen/acre} = \text{Box 3} \times 0.23 \times \text{Box 2}$$

$$\text{lbs. nitrogen/acre} = \text{ppm nitrate-N} \times 0.23 \times \text{in. of water}$$

#### Activity 5.3.1

A grower anticipates they will apply 27 inches of irrigation water this season. The nitrogen concentration in the well water is 20 ppm nitrate-N. How many pounds of nitrogen will be applied through the irrigation water this season?

--

### Column (B) Post Season Actuals

---

The actual nitrogen applied to the field during the season is based on the actual irrigation application rate and the nitrate-N concentration of the irrigation water (Box 3).

$$\text{lbs. nitrogen/acre} = \text{Box 3} \times 0.23 \times \text{in. of water applied}$$

$$\text{lbs. nitrogen/acre} = \text{ppm nitrate-N} \times 0.23 \times \text{in. of water applied}$$

## Determining Applied Water

### Option 1: Based on Flow Meter Totalizer Data

The totalizer on a flow meter can be used to determine the total amount of water pumped between two points in time. Reading (End of Season) - Reading (Beginning of Season) = total amount of water pumped.

Most meters will report data in gallons or ac-ft. Use the equations below to convert to inches of water applied per acre.

$$\text{in/ac} = \text{gallons} \div 27,154 \div \text{acres}$$

$$\text{in/ac} = (\text{ac-ft} \times 12) \div \text{acres}$$

### Option 2: Based on System Application Rate

$$\text{Applied Water (in/ac)} = [\text{application rate (in/hr.)} \times \text{hours of operation}] \div \text{acres}$$

If system application rate is unknown the following resources can be used.

Drip irrigation application rate calculator:

<http://irrigation.wsu.edu/Content/Calculators/Drip/Drip-Line-Rate.php>

Sprinkler irrigation application rate calculator:

<http://irrigation.wsu.edu/Content/Calculators/Sprinkler/Sprinkler-Application-Rate.php>

### **Activity 5.3.2**

What method do you use to determine how much water you applied over the season?

## **Module 5 Lesson 3 Summary**

---

1. Nitrogen in irrigation water can be estimated based on inches of water and the nitrate-N concentration in the water.

## Module 5 Lesson 4: Nitrogen in Organic Amendments

### Lesson Overview

Lesson 4 covers the availability of nitrogen from organic soil amendments. By the end of lesson 4, participants will demonstrate the ability to:

1. Recall the importance of the carbon to nitrogen ratio and its effect on nitrogen availability.
2. Estimate the seasonal nitrogen contribution of an organic amendment.

Lesson Topic(s)	Page(s) in Workbook
Organic Amendments	69
Plant Available Nitrogen	69
Estimating Nitrogen from Organic Amendments	70 – 71
Summary	71

### Lesson Resources

- Geisseler Lab. (n.d.). *Nitrogen Mineralization from Organic Amendments Calculator*. Retrieved from [http://geisseler.ucdavis.edu/Amendment\\_Calculator.html](http://geisseler.ucdavis.edu/Amendment_Calculator.html)
- Lloyd, M., Lazicki, P., Geisseler, D., Muramoto, J., Smith, R., & Smith, E. (n.d.). *Estimating Nitrogen for Organic Crop Production Worksheet*. Retrieved from University of California Agriculture and Natural Resources: <https://ucanr.edu/sites/SFA/files/322313.pdf>
- Lloyd, M., Lazicki, P., Geisseler, D., Muramoto, J., Smith, R., & Smith, E. (n.d.). *Estimating the Nitrogen Availability in Organic Crop Production*. Retrieved from University of California Agriculture and Natural Resources: <https://ucanr.edu/sites/SFA/files/322312.pdf>
- Sustainable Agriculture Research and Education Program. (n.d.). *Cover Crops Database*. Retrieved from University of California, Davis: <https://sarep.ucdavis.edu/covercrop>

## Organic Amendments

---

In the nitrogen management section of the INMP Worksheet, Box 9 asks growers to report nitrogen from organic amendments. Box 9 has two columns one for pre-season planning (A) and one for actuals recorded at the end of the season (B).

Nitrogen Credits	Recommended / Planned N (A)	Actual Applied N (B)
<b>9. Organic Amendments*</b> (lbs./ac estimate)		

Organic amendments include natural sources of carbon and nutrients that do not have guaranteed nutrient content. Below are examples of common organic amendments:

- Plant and Animal Based Compost
- Animal Manure (i.e., cow, swine, chicken)
- Animal Based Fertilizers (i.e., bloodmeal, feathermeal, guano, pelleted chicken manure)
- Plant Based Fertilizers (i.e., soybean, cottonseed, and alfalfa meals)
- Cover Crop and Crop Residues

## Plant Available Nitrogen

---

Organic amendments contain mostly unavailable organic forms of nitrogen and small amounts of inorganic nitrogen (ammonium). The organic nitrogen in these materials must be transformed by soil microbes to be available to the plant.

How quickly the organic nitrogen becomes available to the plant depends on soil temperature and moisture, the C:N ratio of the amendment, and the level of incorporation into the soil.

Amendment	C:N Ratio	N available after 12 weeks	Releases N in
Yard Waste Compost	13 – 20	<10%	Years
Poultry Manure & Manure Compost	6 – 8	30 – 40%	Weeks – Months
Blood & Feather Meal, Guano	3 – 4	60 – 75%	Days
Cover Crop Residues	12 – 18	4 – 35%	Months
Vegetable Crop Residues	<15	4 – 45%	Weeks – Months

## Estimating Nitrogen Contribution from Organic Amendments

---

The University of California Agriculture and Natural Resources Division has an article, worksheet, and calculator for estimating nitrogen availability in organic crop production. The three resources walk growers through estimating the nitrogen contribution from several sources including composts, crop residues, and cover crops.

- Article: <https://ucanr.edu/sites/SFA/files/322312.pdf>
- Worksheet: <https://ucanr.edu/sites/SFA/files/322313.pdf>
- Calculator: [http://geisseler.ucdavis.edu/Amendment\\_Calculator.html](http://geisseler.ucdavis.edu/Amendment_Calculator.html)

### Using the Organic Amendment Calculator

The calculator estimates nitrogen availability for the following amendments:

- Feather Meal
- Blood Meal
- Guano
- Poultry Manure
- Poultry Manure Compost
- Pelleted Material
- Vermicompost
- Yard Waste Compost

To use the calculator, growers input the region, type of amendment, application date, application rate, and depth of incorporation. Additional information can be put into the calculator if known including %dry matter, %N, and the C:N ratio.

### Organic Amendment Calculator Example

Amendment Application	
Region*:	Central Coast - Ventura ▼
Type of amendment*:	Poultry Manure Compost ▼
Application rate*:	5 tons/ac
Application date*:	10/09/2024 📅
Period of interest:	6 Months ▼
Depth of incorporation*:	6 inches ▼
* Required input.	

Total N applied:	📘 260 lb/ac
Total mineral N applied:	📘 20 lb/ac
Estimated available N from amendment:	📘 60 - 69 lb/ac
Percent available:	📘 23 - 27 %

## Using the Organic Amendment Worksheet

The worksheet walks growers through the calculations for the following organic amendments:

- Cover Crops (Part 2, C1)
  - Inputs required: cover crop's biomass and %N. This information can be found in the UC SAREP Cover Crop Database (<https://sarep.ucdavis.edu/covercrop>).
- Crop Residues (Part 2, C2)
  - Inputs required: previous crop yield, %N of residue, and expected N in the crop residue
- Composts (Part 3, E1)
  - Inputs required: application rate, %N and % water

### **Activity 5.4.1**

Directions: Using the organic amendment worksheet and the UC SAREP cover crop database, estimate the lbs. of nitrogen available per acre from a hairy vetch cover crop.

(<https://ucanr.edu/sites/SFA/files/322313.pdf>) (<https://sarep.ucdavis.edu/covercrop>)

Biomass = 5,000 lbs.    %N = 4.0    30% nitrogen availability over the season

--

## **Module 5 Lesson 4 Summary**

---

1. The availability of nitrogen is closely related to the C:N ratio of the organic amendment.
2. The nitrogen contribution of an organic amendment or cover crop can be estimated using the UCANR worksheet or calculator.

## Module 5 Lesson 5: Dry/Liquid Nitrogen Fertilizer

### Lesson Overview

Lesson 5 covers how to calculate the amount of nitrogen in granular and liquid fertilizers. Lesson 5 also provides information on determining fertilizer application rates based on a target nitrogen rate. By the end of lesson 5, participants will demonstrate the ability to:

1. Identify fertilizer formulations that contain nitrogen based on the fertilizer grade or name.
2. Calculate the fertilizer application rate when presented with a target nitrogen rate.
3. Calculate the amount of nitrogen applied in a known quantity of fertilizer.

Lesson Topic(s)	Page(s) in Workbook
Fertilizer Grade and Guaranteed Analysis	73
Pre-Season Planning	74
Post-Season Actuals	75
Summary	75

### Lesson Resources

- Geisseler, D. (n.d.). *California Fertilization Guidelines*. Retrieved from California Department of Food and Agriculture: <https://www.cdfa.ca.gov/is/ffldrs/frep/FertilizationGuidelines/>
- Sela, G. (2021, May). *How to Calculate Fertilizer Application Rates*. Retrieved from Cropia: <https://croipaia.com/blog/how-to-calculate-fertilizer-application-rates/>

## Fertilizer Grade and Guaranteed Analysis

In the nitrogen management section of the INMP Worksheet, Box 7 asks growers to estimate and record nitrogen applied from granular and liquid fertilizers. Box 7 has two columns one for pre-season planning (A) and one for actuals recorded at the end of the season (B).

Nitrogen Credits	Recommended / Planned N (A)	Actual N (B)
7. Dry/Liquid Fertilizer N* (lbs./ac)		

### Fertilizer Grade and Guaranteed Analysis

A typical fertilizer label contains a grade and guaranteed analysis. The grade shows the percentage of nitrogen (N), phosphate ( $P_2O_5$ ), and potash ( $K_2O$ ). The guaranteed analysis is the manufacturer's guarantee that the product contains the nutrients at the listed percentage.

<b>Super Excellent Grow</b>	
<b>20 – 10 – 10</b>	
Guaranteed Analysis	
Total Nitrogen (N)	20%
Available Phosphate ( $P_2O_5$ )	10%
Soluble Potash ( $K_2O$ )	10%

### Activity 5.5.1

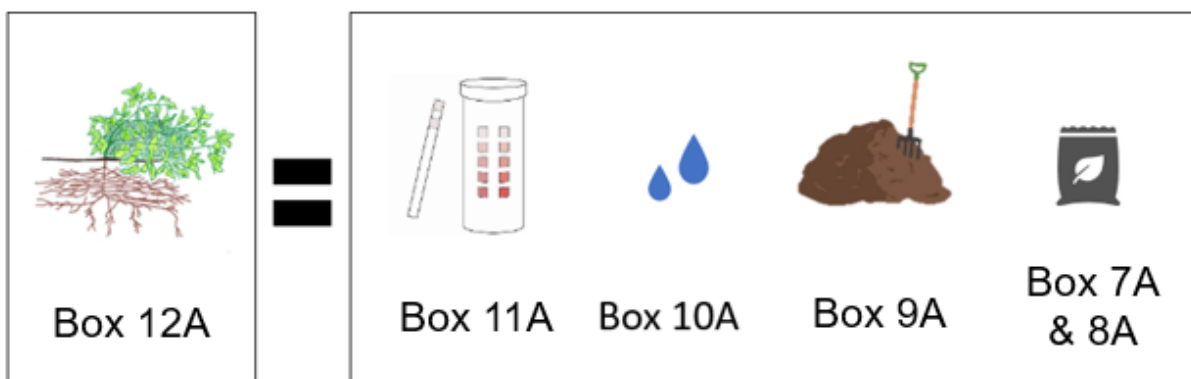
Directions: Based on the fertilizer name or grade listed below determine the %N.

Fertilizer	%N
2-4-6	
CAN-17	
UAN 32	
AN-20	



## Column (A) Pre-Season Planning

At the beginning of the season, growers must determine how much nitrogen to apply through granular/liquid fertilizers. The amount depends on the total nitrogen requirement of the crop (Box 12A) and nitrogen available from other sources (Boxes 9A-11A).



Thus, Boxes 12A and 9A-11A should be completed prior to determining the amount of nitrogen to apply through granular/liquid fertilizer. Once the desired amount is determined, the fertilizer application rate can be calculated.

### Granular Fertilizer Calculation

To determine the amount of granular fertilizer to apply, growers need to know the % N of the fertilizer. %N can be found on the fertilizer label.

$$\text{Fertilizer Application} = [\text{desired nitrogen rate (lb. N/ac)} \times 100] \div \% \text{ N}$$

### Liquid Fertilizer Calculation

To determine the amount of liquid fertilizer to apply, growers need to know the density and % N of the fertilizer. %N and fertilizer density (expressed in lbs./gallon) can be found on the label or on the manufacturer's website.

$$\text{Fertilizer Application} = [\text{desired nitrogen rate (lb. N/ac)} \times 100] \div [\% \text{ N} \times \text{density}]$$

### Activity 5.5.2

A grower needs to apply 50 lbs. of nitrogen fertilizer per acre. How many gallons of UAN 32 would they apply? (UAN 32 density = 11.0 lbs./gallon)

## Column (B) Post-Season Actuals

---

Once the season is over, growers need to report the amount of nitrogen applied through granular and/or liquid fertilizer applications.

### Granular Fertilizer Calculation

To determine the amount of nitrogen in a granular fertilizer, growers need to know the % nitrogen and fertilizer application rate.

$$\text{N Applied} = (\% \text{ N} \div 100) \times \text{application rate (lbs./ac)}$$

### Liquid Fertilizer Calculation

To determine the amount of nitrogen in a liquid fertilizer, growers need to know the fertilizer density, the % N and the application rate in gallons per acre.

$$\text{N Applied} = \text{fertilizer density (lbs./gal)} \times (\% \text{ N} \div 100) \times \text{application rate (gal/ac)}$$

### Activity 5.5.3

Throughout the season, a grower applied 10 gallons of CAN 17 (density = 12.7 lbs./gal) per acre and 200 lbs. of granular urea (46-0-0) per acre. In total how much nitrogen was applied?

## Module 5 Lesson 5 Summary

---

1. The fertilizer grade shows the percentage of nitrogen (N), phosphate ( $\text{P}_2\text{O}_5$ ), and potash ( $\text{K}_2\text{O}$ ) in a product.
2. Understanding the information on a fertilizer label will help determine the amount of nitrogen in a fertilizer application.

## Module 5 Lesson 6: Foliar Nitrogen Fertilizer

### Lesson Overview

Lesson 6 covers the application of foliar nitrogen fertilizers. Lesson 6 also covers how to calculate the amount of nitrogen applied in a foliar application. By the end of lesson 6, participants will demonstrate the ability to:

1. Describe methods of foliar application that can increase absorption.
2. Calculate the amount of nitrogen applied in a foliar fertilizer application.

Lesson Topic(s)	Page(s) in Workbook
Foliar Nitrogen Fertilizers	77-78
Foliar Fertilizer Calculations	78
Summary	78

### Lesson Resources

- Geisseler, D. (n.d.). *California Fertilization Guidelines*. Retrieved from California Department of Food and Agriculture:  
<https://www.cdfa.ca.gov/is/ffldrs/frep/FertilizationGuidelines/>
- Kuepper, G. (2003, March). *Foliar Fertilization*. Retrieved from ATTRA NCAT:  
<https://attra.ncat.org/wp-content/uploads/2019/05/foliar.pdf>
- Scagel, C., & Bi, G. (2007, March). *Nitrogen Foliar Feeding has Advantages*. Retrieved from Oregon State University:  
<https://agsci.oregonstate.edu/sites/agscid7/files/horticulture/osu-nursery-greenhouse-and-christmas-trees/2007BiFoliarUreaNMPRO.pdf>

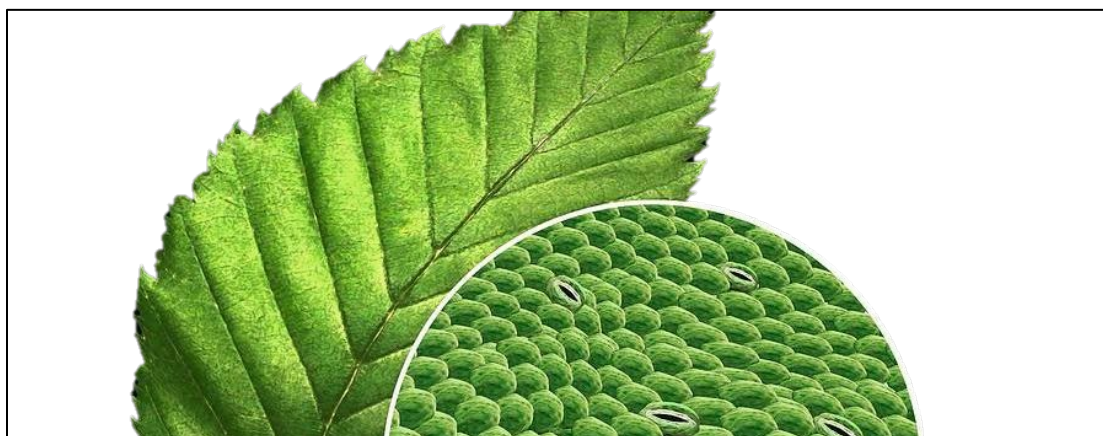
## Foliar Nitrogen Fertilizers

In the nitrogen management section of the INMP Worksheet, Box 8 asks growers to estimate and record nitrogen applied from foliar fertilizers. Box 8 has two columns, one for pre-season planning (A) and one for actuals recorded at the end of the season (B).

Nitrogen Credits	Recommended / Planned N (A)	Actual Applied N (B)
<b>8. Foliar Fertilizer N*</b> (lbs./ac)		

### Application of Foliar Nitrogen Fertilizers

Plant leaves can absorb urea, ammonium, and nitrate through small pores called stomata. Absorption of foliar fertilizers is increased when sprays reach and coat the plant's leaves.



The amount of material reaching the plant's leaves is affected by air temperature and moisture during application. To reduce evaporation, applications should be made in low temperatures or when the relative humidity is high. These conditions are most likely to occur in the early morning or evening. Additionally, adding a surfactant to the spray or using electrostatic sprayers can increase absorption rates.

Highly concentrated sprays have the potential to "burn" plant tissues and cause crop damage. Thus, foliar fertilizers are often applied in dilute amounts.

Foliar fertilizers are not a replacement for soil applied macronutrients but can be beneficial in certain circumstances. Foliar applications can be used as a supplemental source of nitrogen and may provide a small boost in growth or yield for some crops and varieties. For crop specific information on foliar fertilization visit the California Fertilization Guidelines.

<https://www.cdfa.ca.gov/is/ffldrs/frep/FertilizationGuidelines/>

### **Activity 5.6.1**

What are some application techniques that will increase the absorption or efficiency of foliar nitrogen fertilizers?

## **Foliar Fertilizer Calculations**

---

### **Column (A) Pre-Season Planning**

To determine the amount of foliar fertilizer to apply, growers need to know the density and % N of the fertilizer. %N and fertilizer density (expressed in lbs./gallon) can be found on the label or on the manufacturer's website.

$$\text{Application Rate} = [\text{desired nitrogen rate (lb. N/ac)} \times 100] \div [\% \text{ N} \times \text{density}]$$

### **Column (B) Post-Season Actuals**

To determine the amount of nitrogen in a foliar application, growers need to know the product density and %N, and the application rate.

$$\text{N Applied} = \text{fertilizer density (lbs./gal)} \times (\% \text{ N} \div 100) \times \text{application rate (gal/ac)}$$

If the application rate is in ounces use the following conversion rate: 128 oz/gal

## **Module 5 Lesson 6 Summary**

---

1. To reduce evaporation, foliar applications should be made in low temperatures or when the relative humidity is high.
2. The amount of nitrogen in a foliar fertilizer application is based on the product density, % N, and the application rate.

## Module 5 Lesson 7: Total Nitrogen

### Lesson Overview

Lesson 7 covers how to estimate the crop nitrogen requirement based on two common methods. Lesson 7 also provides information for calculating total nitrogen applied based on nitrogen inputs. By the end of lesson 7, participants will demonstrate the ability to:

1. Estimate total nitrogen required for the upcoming season.
2. Calculate total nitrogen applied based on all nitrogen inputs.

Lesson Topic(s)	Page(s) in Workbook
Total Nitrogen	80
Pre-Season Planning	80 – 81
Post-Season Actuals	81
Summary	81

### Lesson Resources

- Geisseler, D. (n.d.). *California Fertilization Guidelines*. Retrieved from California Department of Food and Agriculture: <https://www.cdfa.ca.gov/is/ffldrs/frep/FertilizationGuidelines/>
- Pettygrove, S. (2013). *Crop Nitrogen Budgeting*. Retrieved from University of California Agriculture and Natural Resources Division: <https://ciwr.ucanr.edu/files/205050.pdf>
- SSJV MPEP. (2022, March). *Crop Yield to Nitrogen Removed Calculator*. Retrieved from <https://agmpep.com/tools/calc-y2r/>

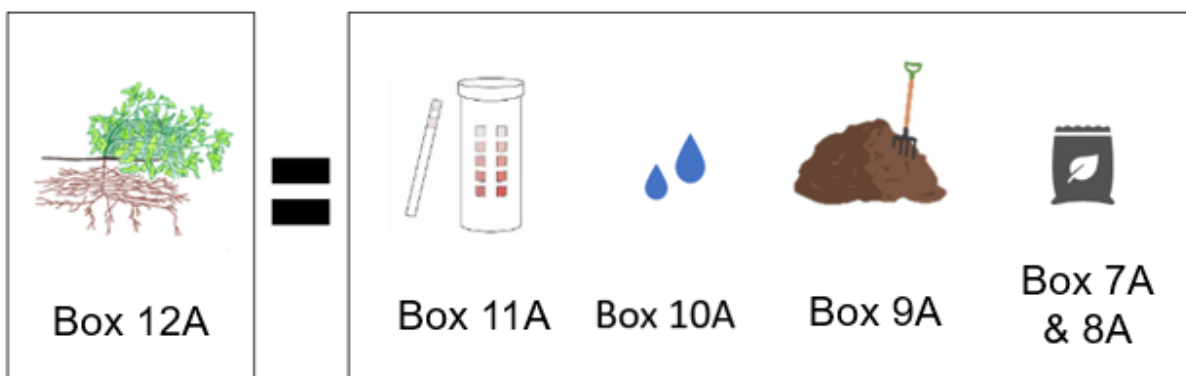
## Total Nitrogen

In the nitrogen management section of the INMP Worksheet, Box 12 asks growers to estimate and record total nitrogen applied from all sources (Boxes 7-10). Box 12 has two columns, one for pre-season planning (A) and one for actuals recorded at the end of the season (B).

Nitrogen Sources	Recommended / Planned N (A)	Actual Applied N (B)
<b>12. Total Nitrogen (7+8+9+10)*</b> (lbs./ac)		

### Column (A) Pre-Season Planning

Box 12(A) is equal to the total nitrogen requirement of the crop. While it is the last box in the nitrogen management section, it should be completed prior to Boxes 7A-11A. Working backwards through the nitrogen management section of the INMP Worksheet will produce the best results.



### Estimating Crop Nitrogen Requirement

There are several approaches to estimating the crop nitrogen requirement. In this training we will cover two common methods. Method 1 is based on the amount of nitrogen removed from the field with harvest and method 2 is based on recommended application rates from field research.

### Method 1: Nitrogen Removed with Harvest

Method 1 is the most appropriate for orchard crops. And for field and vegetable crops where the majority of crop residue is removed from the field during harvest.

In method 1, the crop nitrogen requirement is determined by multiplying estimated yield (Box 5) by a nitrogen removal coefficient. The results are then divided by the expected nitrogen use efficiency (NUE). An achievable NUE for California agriculture is 0.7. A list of nitrogen removal coefficients can be found at: <https://www.farmbureauvc.com/vcailg/>.

$$\text{Total N} = (\text{Expected yield} \times \text{N Removal Coefficient}) \div \text{NUE}$$

For some mature orchard crops, an additional amount of nitrogen is needed for perennial tissue growth. This amount is typically between 10-40 lbs. of nitrogen per acre. Unless indicated, the perennial growth requirement is included in the nitrogen removal coefficient.

$$\text{Total N} = [(\text{Expected yield} \times \text{N Removal Coefficient}) + \text{N for Perennial Growth}] \div \text{NUE}$$

#### Activity 5.7.1

A grower with a 10-year-old avocado orchard estimates his yield will be 2.75 tons/ac. For avocados, 4.4 lbs. of nitrogen are removed per ton of harvested avocados. An additional 15 lbs. of nitrogen are required for perennial tissue growth. The grower estimates his NUE to be 70% or 0.7. How many lbs. of nitrogen should the grower plan to apply?

$$\text{Total N} = [(\text{Expected yield} \times \text{N Removal Coefficient}) + \text{N for Perennial Growth}] \div \text{NUE}$$

### Method 2: Recommended Application Rates from Research

Method 2 is the most appropriate for field and vegetable crops where a significant amount of crop residue is left in the field following harvest. Method 2 is also appropriate for young orchards.

In method 2, the crop nitrogen requirement is based on California field research. Many resources provide recommended nitrogen rates including the California Fertilization Guidelines.

$$\text{Total N} = \text{Crop Nitrogen Requirement}$$

#### Example

A strawberry grower estimates his yield will be 36 tons/acre. Using the California Fertilization Guidelines, the grower finds that the total nitrogen requirement is approx. 200 lbs. per acre.



## Column (B) Post-Season Actuals

---

Following harvest, total nitrogen applied (Box 12B) can be calculated by adding together all nitrogen inputs (Boxes 7B-10B).

### Activity 5.7.2

Based on the values provided below for Boxes 7B-10B, calculate total nitrogen applied (Box 12B).

Nitrogen Sources	Recommended / Planned N (A)	Actual N (B)
7. Dry/Liquid Fertilizer N (lbs./ac)		80
8. Foliar Fertilizer N (lbs./ac)		10
9. Organic Amendments (lbs./ac)		12
10. N in Irrigation Water (lbs./ac)		20
11. Available N in Root Zone (lbs./ac)		--
12. Total Nitrogen (lbs./ac)		

## Module 5 Lesson 7 Summary

---

1. A crop nitrogen requirement (Box 12A) can be estimated based on nitrogen removed during harvest or crop specific field research.
2. Total nitrogen applied (Box 12B) is a sum of nitrogen applied from all sources (Boxes 7B-10B).

## Module 5 Lesson 8: Nitrogen Applied vs. Nitrogen Removed

### Lesson Overview

Lesson 8 covers how to calculate nitrogen removed from the field during harvest. Lesson 8 also covers how to calculate nitrogen applied vs nitrogen removed as a metric for potential nitrogen loss. By the end of lesson 8, participants will demonstrate the ability to:

1. Calculate nitrogen removed during harvest based on yield and a nitrogen removal coefficient.
2. Calculate the ratio between total nitrogen applied and nitrogen removed during harvest.

Lesson Topic(s)	Page(s) in Workbook
Nitrogen Applied (A) vs Nitrogen Removed (R)	84-85
Calculating A/R and A-R	85
Summary	85

### Lesson Resources

- Geisseler, D. (2021). *Nitrogen Concentrations in Harvested Plant Parts*. Retrieved from Geisseler Nutrient Management Lab: [http://geisseler.ucdavis.edu/Project\\_N\\_Removal.html](http://geisseler.ucdavis.edu/Project_N_Removal.html)
- Ventura County Agricultural Irrigated Lands Group draft N removal coefficients <https://www.farmbureauvc.com/vcailg/>
- SSJV MPEP. (2022, March). *Crop Yield to Nitrogen Removed Calculator*. Retrieved from <https://agmpep.com/tools/calc-y2r/>
- USDA NRCS. (n.d.). *Nutrient Content of Crops*. Retrieved from <https://plantsorig.sc.egov.usda.gov/npk/main>

## Nitrogen Applied vs. Nitrogen Removed

---

The Regional Water Quality Control Board is interested in knowing how much nitrogen is being applied to a field (A) versus how much nitrogen is being removed from the field (R). A/R and A-R are used as metrics to determine the potential for nitrogen loss.

Calculating A/R and A-R is not required for the INMP Worksheet or INMR. However, growers can use this information to make informed decisions regarding nitrogen management. The A/R and A-R will be calculated by the Coalition and included in reports required by the Regional Water Board.

### Nitrogen Applied

Nitrogen from the following sources is considered when calculating nitrogen applied (A) for the A/R metric:

- Irrigation Water (Box 10)
- Organic Amendments (Box 9)
- Dry/Liquid Fertilizers (Box 7)
- Foliar Fertilizers (Box 8)

### Activity 5.8.1

Which nitrogen source is included on the INMP Worksheet, but is not included in the A/R or A-R calculation?

### Nitrogen Removed

Nitrogen removed (R) from the field with harvested plant parts is based on the crop yield and a nitrogen removal coefficient. Nitrogen removal coefficients are available for crops covering 95% of acreage in the Central Valley. Research is currently underway to provide reliable coefficients for additional crops.  $(R) = \text{yield} \times \text{nitrogen removal coefficient}$

A list of nitrogen removal coefficients can be found at: <https://www.farmbureauvc.com/vcailg/>

### **Activity 5.8.2**

Directions: Complete the table below using the list of nitrogen removal coefficients found at <https://www.farmbureauvc.com/vcailg/>

Crop	Yield	N Removal Coefficient	N Removed (R)
Lemons	19 tons		
Celery	50 tons		
Strawberries	24 tons		

### **Calculating A/R and A-R**

Once a grower has calculated nitrogen applied (A) and nitrogen removed (R) for the season, A/R can be calculated.

#### **Interpreting A/R Values**

$A/R < 1$ : more nitrogen was removed from the field with harvest than was applied

$A/R = 1$ : the same amount of nitrogen that was applied to the field was removed with harvest

$A/R > 1$ : more nitrogen was applied to the field than was removed with harvest

The greater the A/R value, over 1, the more potential for nitrogen loss and decreased profit.

A/R values are compared across fields with the same crop in each area. Fields with a larger A/R value may be identified as statistical outliers warranting additional reporting requirements.

### **Activity 5.8.3**

A strawberry grower in Oxnard applied 300 lbs. N/ac and yielded 25 ton/ac. The nitrogen removal coefficient for strawberries is 2.8 lbs. N/ ton. Calculate the A/R value.

--

### **Module 5 Lesson 8 Summary**

1. Calculating A/R is not required for the INMP Worksheet or INMR, but it can be useful for monitoring nitrogen efficiency.
2. To calculate A/R or A-R growers need to know total nitrogen applied, yield, and nitrogen removal coefficient.

## Module 6 Lesson 1: Certification Options and Requirements

### Lesson Overview

Lesson 1 covers which INMP Worksheets require certification. Lesson 1 also reviews the options for certification including self-certification and the associated requirements. By the end of lesson 1, participants will demonstrate the ability to:

1. Determine when an INMP Worksheet requires certification.
2. List the options for INMP Worksheet certification.
3. Recall the requirements to obtain and maintain the eligibility to self-certify INMP Worksheets.

Lesson Topic(s)	Page(s) in Workbook
INMP Worksheet Certification	87
Certification Options and Requirements	88-89
Summary	89

### Lesson Resources

- California Department of Food and Agriculture. (n.d.). *INMP Continuing Education*. Retrieved from [https://www.cdfa.ca.gov/is/ffldr/frep/continuing\\_education.html](https://www.cdfa.ca.gov/is/ffldr/frep/continuing_education.html)
- California Department of Food and Agriculture. (n.d.). *Irrigation and Nitrogen Management Training Program*. Retrieved from <https://www.cdfa.ca.gov/is/ffldr/frep/training.html>
- Los Angeles Regional Water Quality Control Board. Adopted Waste Discharge Requirements. Retrieved from: [https://www.waterboards.ca.gov/losangeles/water\\_issues/programs/tmdl/waivers\\_and\\_wdrs/index.html](https://www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/waivers_and_wdrs/index.html)

## INMP Worksheet Certification

---

The last section of the INMP Worksheet covers certification. Fields or management units in high vulnerability groundwater areas must have their INMP Worksheets certified, with the exception of growers with total farming operation acreage less than 10 acres and has not been identified as an outlier. However, growers qualifying for this certification exemption are still required to develop an INMP and submit an INMR.

The person certifying the plan must complete the INMP Certification section including signature, date, and method of certification. The plan certifier should also initial the box in the bottom right corner of the INMP Worksheet.

I, <input type="text"/> , certify this INMP in accordance with the statement above.	
<input type="text"/> (Signature)	<input type="text"/> (Date)

## Certification Options and Requirements

---

INMP Worksheets can be certified by an INMP Specialist or self-certified by an eligible coalition member.

### Option 1: Certified INMP Specialist

INMP Worksheets may be certified by an INMP Specialist. INMP specialists include:

- Certified Crop Advisor
- National Resource Conservation Service (NRCS) Technical Service Provider

### Option 2: Self-Certification

INMP Worksheets may be self-certified by a coalition member if they meet one of the following eligibility requirements:

- Member who completes the CDFA Training Program
- Member who follows a site-specific recommendation from NRCS or UC (documentation required)

### CDFA Training Program

To be eligible to self-certify INMP Worksheets through the CDFA Training Program, members must complete the Irrigation and Nitrogen Management Training and Exam and participate in continuing education courses.

Once a grower has taken the Irrigation and Nitrogen Management Training and passed the exam, they are eligible to self-certify INMP Worksheets for their farming operation(s).

To maintain the eligibility to self-certify INMP Worksheets, growers must participate in 3 hours of continuing education every 3 years. To count towards the continuing education requirement, courses must be approved by the California Department of Food and Agriculture. Approved courses will be advertised with “CDFA INMP Credits”. Courses focus on irrigation and/or nitrogen management. For a list of approved courses visit:

[https://www.cdfa.ca.gov/is/ffldrs/frep/continuing\\_education.html](https://www.cdfa.ca.gov/is/ffldrs/frep/continuing_education.html)

### **Activity 6.1.1**

How do growers maintain their eligibility to self-certify INMP Worksheets?

## **Module 6 Lesson 1 Summary**

---

1. All INMP Worksheets must be certified (exemption for 10 acres or less and not outlier).
2. INMP Worksheets may be certified by an INMP Specialist or self-certified by a member.
3. Under the CDFA Training Program, growers must complete this training and exam and participate in continuing education.

## Module 7 Lesson 1: Reporting Data

### Lesson Overview

Lesson 1 covers which components of the INMP Worksheet are transferred to the INMR. Lesson 1 also reviews the reporting process and deadlines for INMR data. By the end of lesson 1, participants will demonstrate the ability to:

1. Identify components of the INMP Worksheet that are transferred to the INMR.
2. Recognize the deadlines for submittal of the INMR.
3. Outline the process for submitting an INMR.

Lesson Topic(s)	Page(s) in Workbook
INMR	90
Section 1	90
Section 2	90 – 91
Section 3	91-92
INMR Data Submittal	92
Summary	92

### Lesson Resources

- Los Angeles Regional Water Quality Control Board. Adopted Waste Discharge Requirements. Retrieved from:  
[https://www.waterboards.ca.gov/losangeles/water\\_issues/programs/tmdl/waivers\\_and\\_wdrs/index.html](https://www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/waivers_and_wdrs/index.html)



## INMR

---

The INMR was designed to help monitor nitrogen applied and removed from the field through harvest. Many of the components on the INMP Worksheet are transferred to the INMR. Transferred information is marked on the INMP Worksheet with an asterisk \*.

Data from multiple INMP Worksheets can be reported in one INMR.

The Summary Report has three main sections:

1. Management Unit and Parcel Inventory
2. General Information and Irrigation and Nitrogen Management Report
3. Irrigation and Nitrogen Management Practices

### Section 1: Field and Parcel Inventory

---

Section 1 pulls information from the Parcel Management Section of the associated INMP Worksheet(s). Populate the table with all parcels covered in the INMR.

Enter 0 irrigated acres of the parcel or management unit was left fallow or was not in production for the reporting period.

Additionally, there is a comment section to report any abnormalities that may have occurred during the reporting period. This can include fields that were not harvested or experienced stress that may have impacted yields like drought or pest damage.

Management Unit ID	APN	Crop	Crop Age (Years)	Irrigated Acres

### Section 2: Irrigation and Nitrogen Management Plan Summary

---

Section 2 asks for information on outlier status and the certification method for associated INMP Worksheet(s). Section 2 then pulls information from the Nitrogen Management and Harvest Yield sections of the INMP Worksheet.

#### Outlier Notification Receipt

Growers should indicate in the outlier notification section if they had any parcels or management units that were considered outliers in the previous reporting period.

### Alternative Reporting

Growers must indicate whether they meet the alternative reporting qualifications for “A” only reporting (refer to “A” only reporting qualifications listed in the INMP worksheet instructions).

### INMP Certification Method

Select the method of certification used on the associated INMP Worksheet(s).

### INMR

To complete the INMP Summary Table, enter the Field or Management Unit, Crop, Crop Age, and Total Irrigated Acres from the Parcel Inventory Sheet. Then complete the table using Post-Season Actuals from Column (B) of the INMP Worksheet.

The data reported in this table is used to calculate A/R and A-R. Thus, it is important to ensure all the information reported is accurate. If you do not apply nitrogen fertilizer to your fields, you are still required to submit an INMR. In this case, please enter a zero for nitrogen applied.

Total	Nitrogen	Applied	Lbs./Acre	Yield	Production Unit	Yield Info
N in Irrigation Water	Organic Amendments	Dry/Liquid Fertilizers	Foliar Fertilizers	(lbs./ac or tons/ac)	(lbs. or tons)	

## Section 3: Irrigation and Nitrogen Management Practices

Complete the tables in section 3 for each parcel and/or management unit listed in the Management Unit and Parcel Inventory table. Information can be pulled directly from the associated INMP Worksheet(s).

### Irrigation Method

For Irrigation Method, check the box to indicate the primary method used during the growing season. If applicable, indicate any secondary irrigation systems used.

### Irrigation Source

For Irrigation Source, check the box(es) to indicate all sources of irrigation for the management unit or parcel.

## **Irrigation and Nitrogen Efficiency Practices**

For Irrigation and Nitrogen Efficiency Practices, check all boxes that apply to indicate practices used on the parcels and/or management units covered in the report. X

## **Nitrogen Application Practices and Data Informed Decision Making**

Check the box to indicate any nitrogen application practices used in the management unit. Growers should also indicate if they adjusted their fertilizer applications on this management unit based on irrigation water, soil residual, or tissue/petiole testing results.

## **INMR Data Submittal**

---

INMRs must be submitted to the coalition by March 1, 2026 and annually thereafter. All coalitions offer an online platform for submitting INMR data. Some coalitions will also accept Summary Reports via mail or email. Please check with your coalition prior to the deadline to determine what options are available.

For more information on reporting exemptions, alternatives, and deadlines, reach out to your coalition or access the waste discharge requirements:

[https://www.waterboards.ca.gov/losangeles/water\\_issues/programs/tmdl/waivers\\_and\\_wdrs/index.html](https://www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/waivers_and_wdrs/index.html)

## **Module 7 Lesson 1 Summary**

---

1. Components of the INMP Worksheet that transfer to the INMR are marked with an asterisk \*
2. To maintain compliance, INMRs must be submitted by the deadline.
3. Check with your coalition prior to the deadline for submittal options and instructions.