

# Irrigation and Nitrogen Management Training for Grower Self-Certification



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.

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## 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>

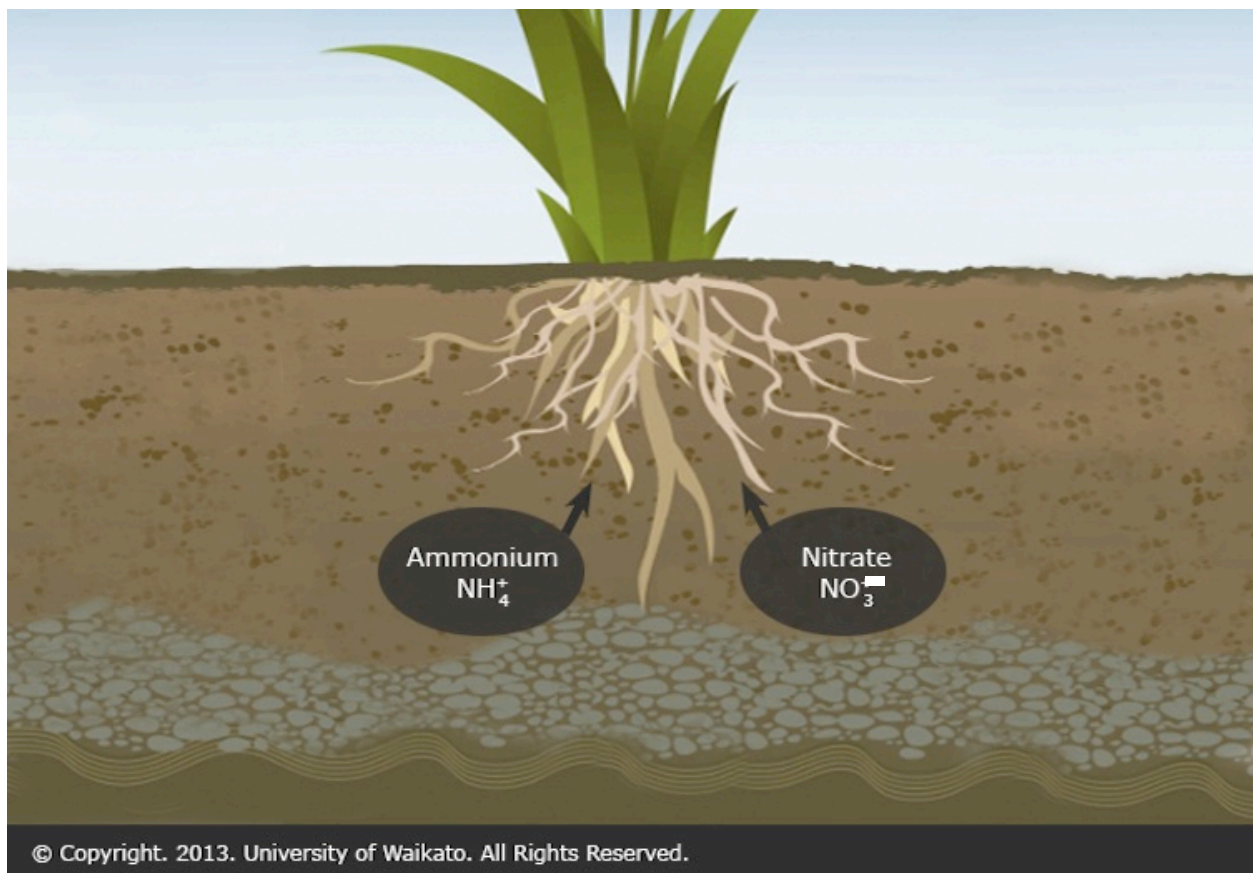
## Nitrogen Forms

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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*.

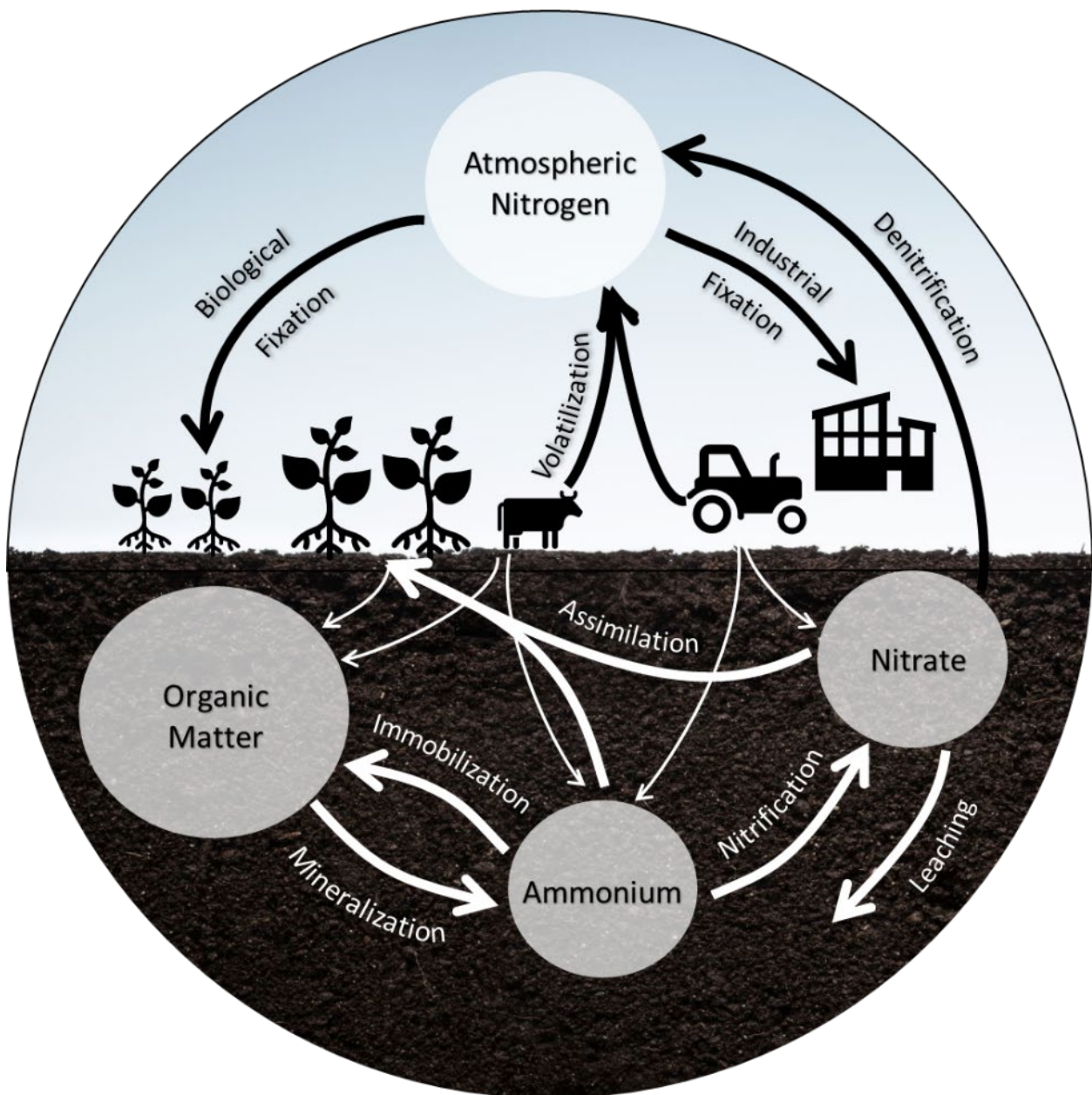
### **Activity 1.1.2**

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

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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

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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

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Crop uptake is the most beneficial use of nitrogen in agricultural systems. Crops use ammonium and nitrate to form amino acids, chlorophyll, enzymes, and nucleic acids. This process is called *nitrogen assimilation*.

## Nitrogen Losses

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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.

### 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.

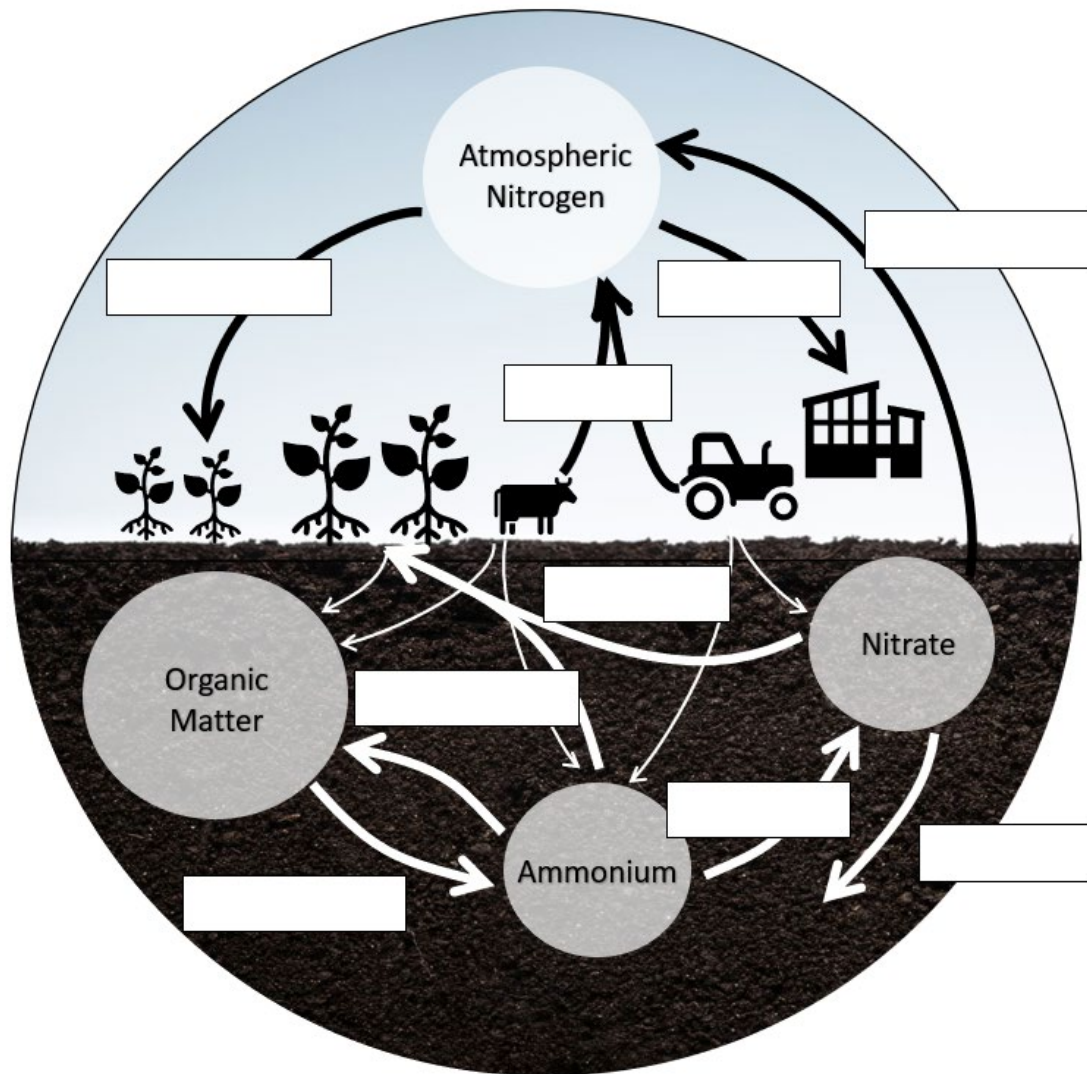
## Module 1 Lesson 1 Summary

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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://gispublic.waterboards.ca.gov/portal/apps/MapSeries/index.html?appid=a884c5cc81844b289b666f15fad3dc7d>
- 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

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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.

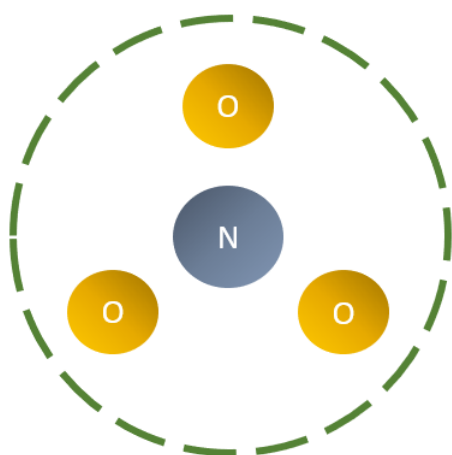
### Nitrate in Drinking Water

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.

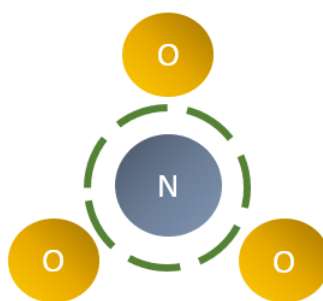
### Measuring Nitrate in Drinking Water

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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 ( $\text{NO}_3$ )

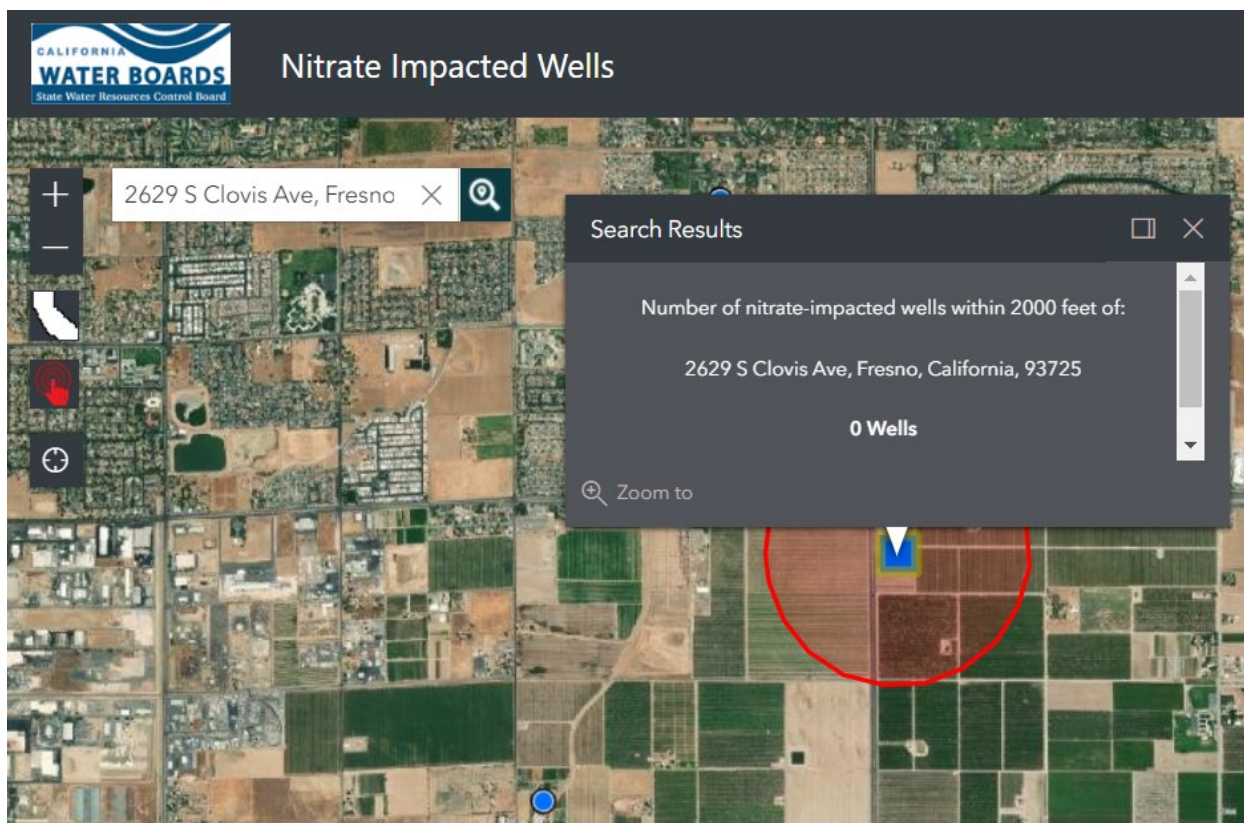


Nitrate-Nitrogen ( $\text{NO}_3\text{-N}$ )

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 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://gispublic.waterboards.ca.gov/portal/apps/MapSeries/index.html?appid=a884c5cc81844b289b666f15fad3dc7d>



### **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 Due Dates

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 Nitrogen Management Plan (INMP) Worksheet and Summary Report. By the end of lesson 3, participants will demonstrate the ability to:

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

Lesson Topic(s)	Page(s) in Workbook
Irrigated Lands Regulatory Program	13
INMP Worksheet & Summary Report	13 - 14
INMP Deadlines	14 - 15
Summary	15

### Lesson Resources

- Central Valley Regional Water Quality Control Board. (2020, January). *Irrigation Lands Regulatory Program (ILRP) Frequently Asked Questions*. Retrieved from [https://www.waterboards.ca.gov/centralvalley/water\\_issues/irrigated\\_lands/ilrp\\_faq.pdf](https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/ilrp_faq.pdf)
- Central Valley Regional Water Quality Control Board. (n.d.). *Adopted Waste Discharge Requirements*. Retrieved from [https://www.waterboards.ca.gov/centralvalley/water\\_issues/irrigated\\_lands/regulatory\\_information/](https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/regulatory_information/)

## **Irrigated Lands Regulatory Program**

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The Irrigated Lands Regulatory Program (ILRP) was established to prevent agriculture discharges, like nitrate, from further contaminating surface and groundwater. The ILRP is managed on a regional level by Regional Water Quality Control Boards. These boards establish regulations that specify what growers and local coalitions must do to protect water quality. The ILRP applies to all growers with land irrigated to produce crops or pasture for commercial purposes. Land covered by the Dairy General Order is excluded from ILRP requirements.

### **Central Valley Water Quality Coalitions**

To comply with ILRP requirements growers can join a third-party coalition. The coalitions are responsible for monitoring surface and groundwater quality, assessing best management practices, and compiling data to submit to the Regional Water Quality Control Board. The coalitions also provide education and outreach for their members.

#### **Activity 1.3.1**

Directions: There are 14 water quality coalitions in the Central Valley. Which coalition(s) are you a member of?

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## **Irrigation and Nitrogen Management Plan & Summary Report**

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

- Irrigation and Nitrogen Management Plan (INMP) Worksheet
- Irrigation and Nitrogen Management Plan (INMP) Summary Report

### **INMP Worksheet**

The INMP worksheet was designed to help growers increase the efficiency of irrigation and nitrogen applications. An INMP Worksheet must be completed for each parcel covered under the ILRP. Worksheets are kept on-farm. For growers in a high-vulnerability groundwater area, the INMP worksheet must be certified.

### **INMP Summary Report**

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

## Exemptions and Alternative Reporting

The INMP requirements do not apply to irrigated pasture with no external nitrogen inputs or to parcels operated exclusively as a managed wetland. Additional exemptions and alternative nitrogen management reporting may exist for some growers in specific watershed areas.

## Irrigation and Nitrogen Management Plan & Summary Report Deadlines

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The table below lists INMP Worksheet and Summary Report deadlines for the coalitions and coalition groups. Deadlines can also be found in the waste discharge requirements for each area.

Coalition / Coalition Group	INMP Deadline
San Joaquin County and Delta Water Quality Coalition	June 15
Westside San Joaquin River Watershed Coalition	April 15
Grassland Drainage Area	April 15
Sacramento Valley Water Quality Coalition*	March 1
Tulare Lake Basin Coalition Groups	March 1

*\*Some Subwatersheds in the Sacramento Valley Water Quality Coalition have a slightly different schedule to account for follow-up and membership size.*

INMP Summary Reports must be submitted to the appropriate coalition by the deadline outlined above. All coalitions offer an online platform for submitting Summary Reports. 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 and deadlines access the waste discharge requirements below or with the link in the lesson 3 materials section.

- [Eastern San Joaquin River Watershed](#) (pg. 34-37)
- [Grassland Drainage Area](#) (pg. 31-34)
- [Sacramento River Watershed](#) (pg. 37-40)
- [San Joaquin County and Delta Area](#) (pg. 36-39)
- [Tulare Lake Basin Area](#) (pg. 35-38)
- [Western San Joaquin River Watershed](#) (pg. 36-39)
- [Western Tulare Lake Basin Area](#) (pg. 35-38)

### **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**

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1. INMP Worksheets are kept on farm and are designed to help increase efficiency of nitrogen and irrigation applications.
2. INMP Summary Reports are submitted and are designed to monitor nitrogen applied to and removed from a field.
3. Exemptions 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 field is identified as an outlier.
2. Summarize the purpose of outlier identification.
3. Recall additional requirements that apply to growers with fields identified as outliers.

Lesson Topic(s)	Page(s) in Workbook
Outlier Identification Process	17 – 18
Purpose of Identifying Outliers	18
Additional Requirements for Outliers	19
Summary	19

## Outlier Identification Process

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### Step 1: Data Submitted

INMP Summary Report data is collected annually by coalitions.

### Step 2A: Nitrogen Applied / Nitrogen Removed Ratio Calculated

Coalitions use the data from INMP Summary Reports to calculate the ratio of nitrogen applied (A) to nitrogen removed (R) for each field. A/R is used as a metric 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 2B: Nitrogen Applied / Yield Ratio Calculated

If nitrogen removal coefficients are not available for a crop, coalitions calculate the ratio of nitrogen applied (A) to crop yield (Y) or A/Y.

### Step 3: Data Compared across Coalition

A/R or A/Y 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/Y values above the threshold are considered outliers.

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

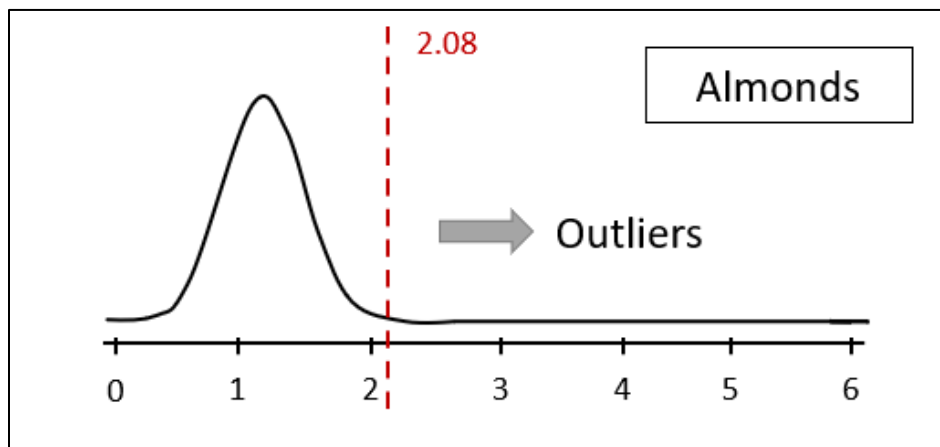
- Nitrogen applications are greater than the crop demand
- Inefficient applications of nitrogen or irrigation water
- Reduced yields due to pest or weather damage
- Crop failure or loss
- Errors were made in data submitted in INMP Summary Report

### Step 5: Notification

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

### Example

The example below shows the distribution of A/R values for almond growers in the East San Joaquin Water Quality Coalition. 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 fields that have an outlier A/R value are notified in their annual nitrogen analysis report.



### 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/Y values compared across coalition members for each crop
	Data submitted to the Water Quality Coalition
	A/R or A/Y values calculated
	Outlier threshold determined

### Purpose of Identifying Outliers

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

## **Additional Requirements for Outliers**

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Members that have one or more outlier fields are subject to additional requirements.

Additional requirements may include:

- Attending focused outreach meetings
- Completing a Management Practice Implementation Report (MPIR)
- Having INMP Worksheet certified by a specialist in irrigation and nitrogen management or attending additional training to continue self-certifying

## **Module 1 Lesson 4 Summary**

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1. Ensure the data you submit in your INMP Summary Report is accurate.
2. If you have outlier fields, make sure you are aware of the additional requirements.

## Module 2 Lesson 1: Management Units

### Lesson Overview

Lesson 1 covers how to combine parcels or fields 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	21
Summary	21

## Management Units

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

Management Unit or Field	APN	County	Crop	Crop Age (Years)	Irrigated Acres

A management unit is a group of parcels or fields that are treated the same and have similar characteristics. A management unit has the same crop, nitrogen and irrigation inputs, management practices, and yields. A management unit cannot exceed 640 acres.

### Perennial Crop Example

A grower has 5 fields with 1st leaf, non-bearing almonds. The fields are irrigated from the same well and have the same fertilizer and irrigation inputs. The total acreage of the 5 fields is 615 acres. The grower can list the 5 fields as a management unit of 1st leaf almonds. The grower will then complete 1 INMP Worksheet for the management unit.

### Annual Crop Example

A grower has 3 fields of lettuce: 2 fields of romaine and 1 field of iceberg. The fields are irrigated from the same well and have similar fertilizer and irrigation inputs. However, the yield and the amount of nitrogen removed from the romaine and iceberg fields is not similar. Therefore, the grower cannot consider the 3 fields a management unit. The grower must complete separate INMP Worksheets.

### Activity 2.1.1

A grower in the Central Valley has 6 fields of winter wheat. The fields are irrigated from the same well and have the same fertilizer and irrigation inputs. The total combined acreage of the 6 fields is 980 acres. Can these fields be combined into one management unit? Explain.

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## Module 2 Lesson 1 Summary

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1. Fields in a management unit must have the same crop, nutrient inputs, management practices, irrigation, and yields
2. Fields in a management unit must not exceed 640 acres.

## 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 field or 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 field or management unit has multiple APNs.

Lesson Topic(s)	Page(s) in Workbook
Assessor's Parcel Numbers	23
Summary	23

## 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 or field contains multiple APNs list each APN with its corresponding county and irrigated acreage. Ensure the management unit name is the same for all APNs listed.

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

Management Unit or Field	APN	County	Irrigated Acres
Early Tomatoes	141-140-021	Tulare	240
Early Tomatoes	141-140-022	Tulare	120
Early Tomatoes	141-222-056	Tulare	28

## 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, county, and irrigated acreage for each field 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 age to report when the growing season covers more than one reporting year.

Lesson Topic(s)	Page(s) in Workbook
Standard Crop Names	25
Crop Age	25
Summary	25
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.

Most coalitions have a list of standard crop names available to growers. In the online member portal, crop names are 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 example from the Tule Basin Water Quality Coalition.

Crop Type	Crop Variety
Grain & Hay Crops	Oats
	Oats (Grain)
	Oats (Hay)
	Oats (Straw)

## 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 Summary Report 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.

## 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.

### Scenario 1

A farmer in Yolo County planted wheat for silage in November 2021. The wheat was planted on 3 parcels covering 566 acres. The fields have similar irrigation and nitrogen inputs and yields. Thus, the farmer considers the fields as one management unit of Wheat -Silage. The fields cover 3 separate parcels with the following APNs: 291-114-903-000 (106 acres), 218-456-765-000 (260 acres), and 291-114-903-001 (200 acres).

Management Unit or Field	APN	County	Crop	Crop Age (Years)	Irrigated Acres

### Scenario 2

A farmer in Tulare County planted Naval Oranges in October 2018. The oranges were planted in an 85-acre field. The APN for the field labeled as Naval Westside is 346-228-019-000.

Management Unit or Field	APN	County	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	28
Irrigation Efficiency	28
Distribution Uniformity	28 – 30
Summary	30

### 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

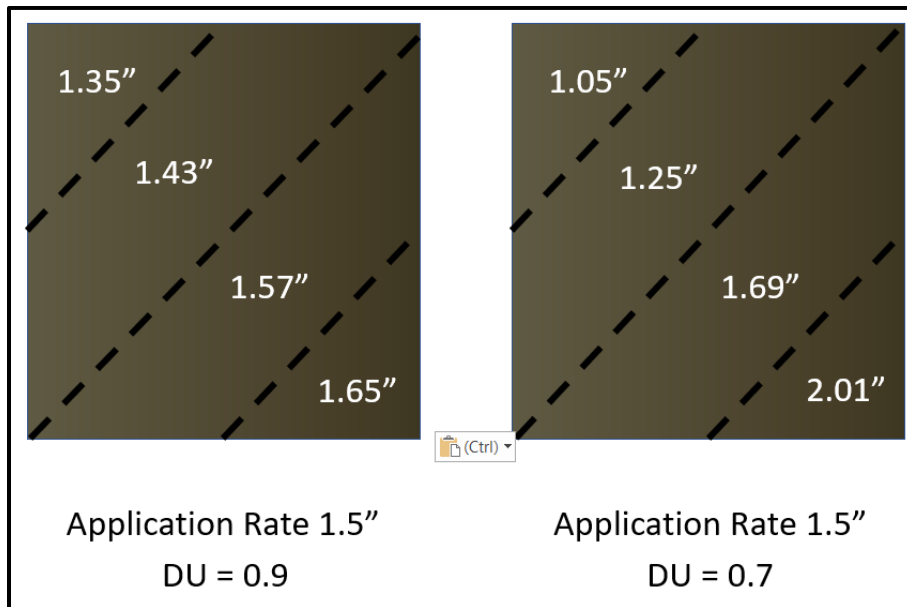
---

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.



### 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>

- Tehama RCD
- Napa RCD
- East Stanislaus RCD
- Cachuma RCD
- North-West Kern RCD
- San Luis 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 amount needed to meet beneficial uses.		
Water is delivered evenly across the field and the application met 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.

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

## Irrigation Methods

---

Under the Irrigation Management section on the INMP Worksheet, the first box 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 seed germination, climate control, salinity management, and groundwater recharge.

Box 1: Irrigation Method*		
(Check one for Primary; if applicable, check one for secondary)		
<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

### Activity 3.2.1

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

--

## Module 3 Lesson 2 Summary

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1. Primary irrigation method is the system used to provide water for crop growth and development.
2. Some examples of secondary irrigation use include seed germination, climate control, salinity management, and groundwater recharge.

## 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	37

### 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>

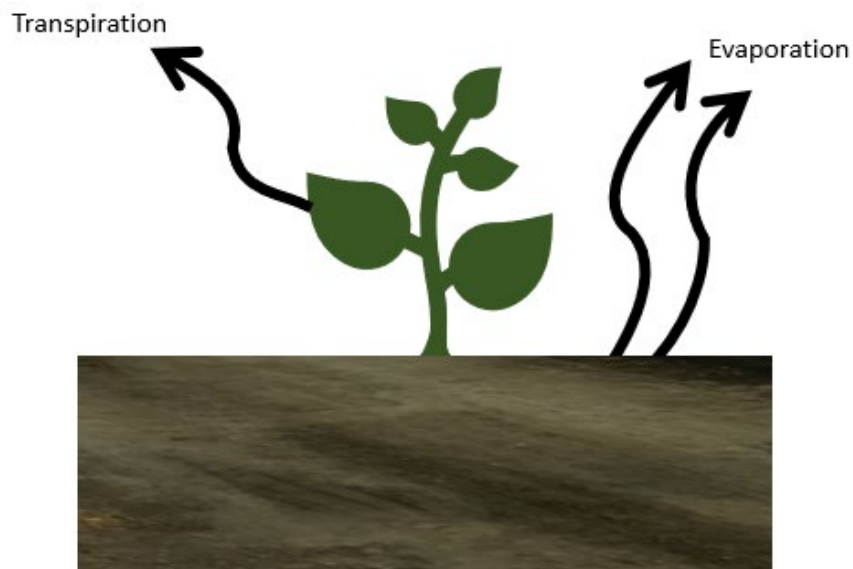
## Crop Evapotranspiration

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In the irrigation management section of the INMP worksheet, box 2 asks growers to estimate crop evapotranspiration for the season.

Pre-Season Planning	
2. Crop Evapotranspiration (ET <sub>c</sub> , 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 (ET<sub>c</sub>). Estimating ET<sub>c</sub> can help growers plan irrigation applications for the growing season. There are three main methods available for growers to estimate seasonal ET<sub>c</sub>.

1. Calculate ET<sub>c</sub> using a reference ET (ET<sub>o</sub>) rate and a crop coefficient (K<sub>c</sub>).
2. Use seasonal ET<sub>c</sub> estimates provided by the coalitions or UCCE.
3. Use actual ET (ET<sub>a</sub>) estimates provided by a platform like OpenET.

### 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 almond orchard in Manteca. The example uses historical ETo data pulled from CIMIS zone 12, and Kc values provided by the Almond Board of California.

Month	Kc	ETo	ETc
Mar	0.62	3.41	2.11
Apr	0.8	5.1	4.09
May	0.94	6.82	6.44
Jun	1.05	7.8	8.2
Jul	1.11	8.06	8.93
Aug	1.11	7.13	7.9
Sep	1.06	5.4	5.73
Oct	0.92	3.72	3.41
Nov	0.69	1.8	1.23
Crop	Season	Total	47.43

## Option 2: Using Existing ETc Estimates

Most coalitions provide a list of seasonal ETc estimates to their members for major crops in the coalitions area. Estimates are typically based on historical averages for the area.

### Option 2 Example

The table below is provided by San Joaquin County and Delta Water Quality Coalition.

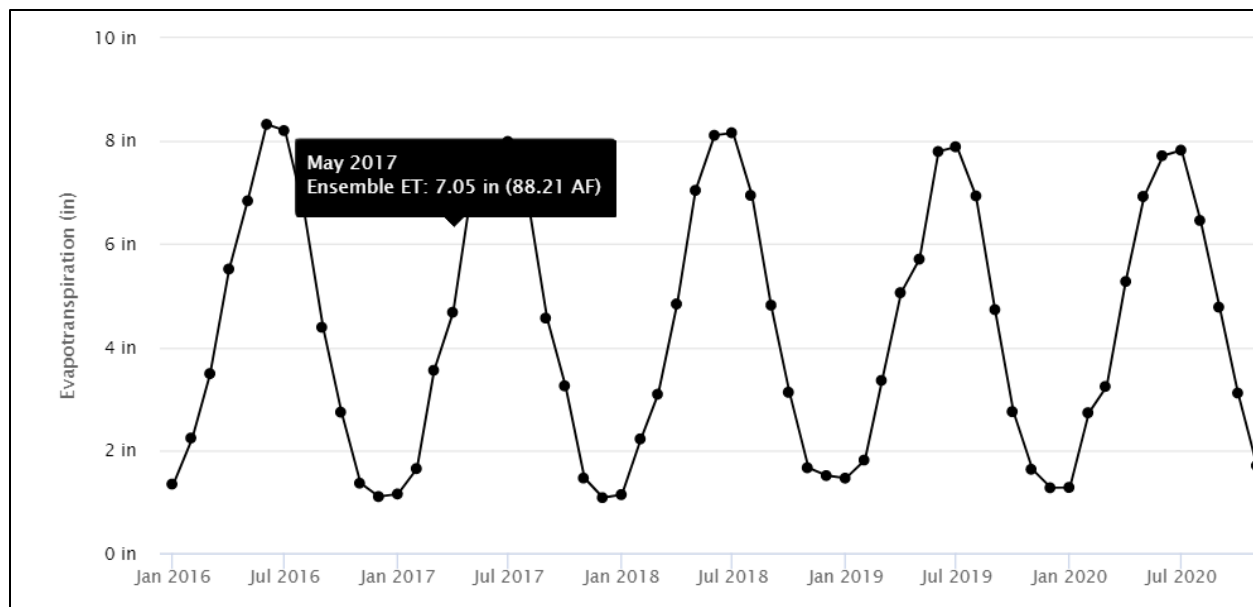
	Leaf Out	Leaf Drop	ETc (in)
Almonds	1-Mar	15-Nov	47.4
Olive	1-Jan	31-Dec	31.9
Stone fruit	1-Mar	15-Oct	44.3
Walnut	1-Apr	15-Nov	42.2

## Option 3: OpenET or Similar Platforms

Open ET is a free platform that provides actual ET on a field level basis. Users can search by address to view monthly and cumulative estimates of actual ET. <https://openetdata.org/>

### Option 3 Example

The following example uses ET estimates from an actual almond orchard in Manteca using the OpenET platform. For seasonal estimates, ET from March-November can be averaged. In this example seasonal ET is 47.7 in.



### **Activity 3.3.1**

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

Method 1: Complete the table below to calculate the seasonal ETc for a processing tomato crop in San Joaquin County. Historical ETo values are sources from CIMIS, and Kc values are based on UC research and approx. canopy coverage.

Month	Kc	ETo	ETc
Apr	0.2	5.1	
May	0.4	6.82	
Jun	0.8	7.8	
Jul	1.00	8.06	
Aug	1.10	7.13	
Crop	Season	Total	

Method 2: Estimate the ETc for a melon crop in San Joaquin County. Use the crop water use table from the San Joaquin County and Delta Water Quality Coalition Website:

<https://sjdeltawatershed.org/nitrogen-management>.

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Method 3: Based on 2021 values provided below from OpenET, estimate the seasonal ET for the walnut field in San Joaquin County. (April 1 -Nov 15)

Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Total
4.23	7.61	8.64	8.31	7.31	5.45	3.12	0.70	

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

---

1. There are three 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 effective rainfall using average monthly precipitation rates.
2. Estimate leaching requirement based on a crop's salinity tolerance and irrigation water salinity levels.
3. Estimate maximum anticipated crop irrigation rate based on water requirements.

Lesson Topic(s)	Page(s) in Workbook
Anticipated Crop Irrigation	39
Effective Rainfall	39 – 40
Additional Water Requirements	40 – 41
Estimating Crop Irrigation Rates	41
Summary	41

### 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 3 asks growers to estimate their irrigation application amount for the season.

Pre-Season Planning	
3. Anticipated Crop Irrigation (inches)	

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

- Crop demand: water required by the crop to replace water lost through evapotranspiration
- Effective rainfall: water available to the crop from precipitation
- 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

## Effective Rainfall

---

Effective rainfall is the water available to the crop from precipitation. Effective rainfall can be estimated for the season using average monthly precipitation rates. Use equation 1 when monthly rainfall exceeds 3 inches and equation 2 when monthly rainfall is less than 3 inches.

1. Effective Rainfall (in/month) = (Rainfall (in/month)  $\times$  0.8) – 1.0
2. Effective Rainfall (in/month) = (Rainfall (in/month)  $\times$  0.6) – 0.4

### **Activity 3.4.1**

Directions: Estimate the effective rainfall using equation 1 or equation 2 as appropriate.

Precipitation (in/month)	Effective Precipitation (in/month)
5.65	
2.30	
0.45	

### Effective Rainfall Example

An almond orchard in Manteca has a growing season between March and November. In this region the average monthly precipitation rates are less than 3 inches. Thus, equation 2 is used to estimate the effective precipitation for each month throughout the growing season.

Month	Precipitation (in/month)	Effective Precipitation (in/month)
March	1.91	0.75
April	1.11	0.27
May	0.57	0.00
June	0.10	0.00
July	0.00	0.00
August	0.00	0.00
September	0.00	0.00
October	0.69	0.01
November	1.40	0.44
<b>Total</b>		<b>1.47 inches for the season</b>

### 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 3.4.2

The almond orchard in Manteca has an irrigation water salinity level of 1.3 dS/m. Almonds are a sensitive crop and the soil salinity threshold is 1.5 dS/m. What is the leaching requirement?

## Estimating Crop Irrigation Rates

---

Once the crop demand, effective rainfall, 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 3.4.3

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	43
Summary	43

### 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

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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	45
Sampling Irrigation Water	45
Estimating Nitrate-Nitrogen	45 – 46
Summary	46

### 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

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In the irrigation management section of the INMP Worksheet, box 4 asks growers to estimate the concentration of nitrate-nitrogen in their irrigation water.

Pre-Season Planning	
4. Irrigation Water N Concentration (ppm or mg/L, as NO <sub>3</sub> -N)	

## Sampling Irrigation Water

---

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

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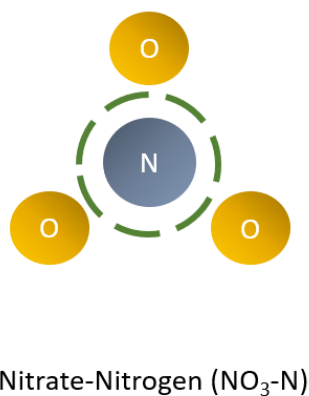
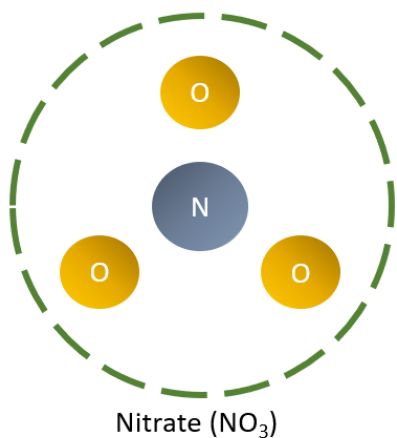
Depending on the lab or nitrate quick test strips used, results may be reported as mg/l Nitrate (NO<sub>3</sub>) or mg/l Nitrate-Nitrogen (NO<sub>3</sub>-N). If results are reported as mg/l Nitrate (NO<sub>3</sub>) a quick conversion can be completed.

$$\text{mg/l NO}_3 \times 0.23 = \text{mg/l NO}_3\text{-N}$$

### Example Irrigation Water Analysis for Mandarins

Description	Date	Time	pH	EC dS/m	NO <sub>3</sub> -N mg/L
Sanger Well	11/17/21	7:04	7.4	0.63	18.1
Low for Citrus			<6.5	-	-
Normal			6.8-7.9	0.60-1.50	0.1-5.0
High for Citrus			>8.4	>2.20	>7.0

#### Activity 3.6.1



What is the main difference between measurements recorded as nitrate and measurements recorded as nitrate-nitrogen?

### 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 (NO<sub>3</sub>) they need to be converted to nitrate-Nitrogen (NO<sub>3</sub>-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	48
Irrigation Scheduling	48 – 49
Irrigation Maintenance	50
Additional Efficiency Practices	50
Summary	50

### 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 5 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 INMP Summary Report.

5. Irrigation Efficiency Practices			
<input type="checkbox"/>	Laser Leveling	<input type="checkbox"/>	Soil Moisture Neutron Probe
<input type="checkbox"/>	Use of ET in Scheduling Irrigations	<input type="checkbox"/>	Pressure Bomb
<input type="checkbox"/>	Water Application Scheduled to Need	<input type="checkbox"/>	Other
<input type="checkbox"/>	Use of Moisture Probe (e.g., tensiometer)	<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.

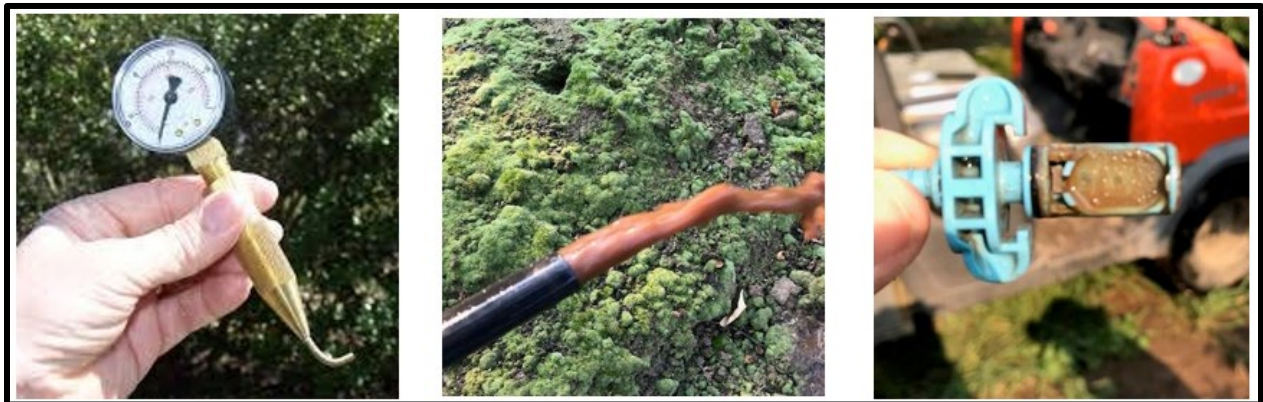
Method	Advantages	Disadvantages
Soil-Based		
Plant-Based		
Weather-Based		

## 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

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

- Laser leveling for furrow, flood, and basin irrigation methods
- Collecting and reusing tailwater runoff from furrow and flood irrigation
- 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	52
Summary	52

## Production Units

---

In the Harvest Information Section on the INMP Worksheet, box 6 asks growers to list a production unit.

			Expected (A)	Actual (B)
6. Production Unit		7. Harvested Yield		

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 sacks the weight of the sack should be listed.

The table below provides examples of standard production units.

Standard Crop Name	Standard Production Unit
Carrots	Crate (50 lbs.)
Melons, Cantaloupe	Crate (40 lbs.)
Onions, Bulb	Sack (50 lbs.)
Wheat, Grain	Bushel (60 lbs.)
Tomatoes, Processing	Lbs.
Almonds	Lbs. of Kernels
Grapes, Raisin	Dry Ton (2,000 lbs.)
Pistachios	Lbs. Dry Weight (CPC)
Walnuts	Lbs. In Shell
Nursery Plants	Units

## 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	54
Expected Yield	54 – 55
Summary	55

### 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>

## Crop Yield

---

In the Harvest Information Section on the INMP Worksheet, box 7 asks growers to report crop yield. Box 7 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.

			Expected (A)	Actual (B)
6. Production Units		7. Harvested Yield		

### Column (A) Expected 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 in Kern County 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 in Sacramento County is planting a field of safflower for the first time. He uses the county crop reports to determine the average yields for Sacramento County over the last 4 years. The yields are 0.8, 1.0, 0.8, and 1.0 ton per acre. What is the average expected yield?

### **Module 4 Lesson 2 Summary**

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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. The lesson also addresses how to adjust yield to a standard moisture content. 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	57
Actual Yield	57
Additional Yield Information	58
Summary	58

### 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)
- Mulvaney, M. J., & Devkota, P. (2020). *Adjusting Crop Yield to a Standard Moisture Content*. Retrieved from University of Florida Extension: <https://edis.ifas.ufl.edu/pdf%5CAG%5CAG44200.pdf>

## Crop Yield

---

In the Harvest Information Section on the INMP Worksheet, box 7 asks growers to report crop yield. Box 7 has two columns, one for pre-season planning (A) and one for actuals recorded at the end of the season (B).

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

			Expected (A)	Actual (B)
6. Production Units		7. Harvested Yield		

### Column (B) Actual Yield

---

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.

#### Adjusting Yield to a Standard Moisture Content

The nitrogen removal coefficient for some crops is based on harvest at a specific moisture content. Thus, for the most accurate analysis of data, crop yields should be adjusted to a standard moisture content. The table below contains examples, a complete list can be found at: [http://geisseler.ucdavis.edu/Geisseler\\_Report\\_U1\\_2021\\_03\\_31.pdf](http://geisseler.ucdavis.edu/Geisseler_Report_U1_2021_03_31.pdf)

Commodity	N Removal Coefficient
Corn, Grain	24.0 lbs. N/ton @ 15.5% moisture
Corn, Silage	7.53 lbs. N/ton @ 70% moisture
Oat, Hay	21.7 lbs. N/ton @ 12% moisture
Grape, Raisin	10.1 lbs. N/ton @ 15% moisture
Walnuts	31.8 lbs. N/ton @ 8% moisture

If an adjustment is needed follow the process outlined in the following resource: <https://edis.ifas.ufl.edu/pdf%5CAG%5CAG44200.pdf>

## **Additional Yield Information**

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In the INMP Summary Report there is a box to provide additional information on yield for a field or 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.

## **Module 4 Lesson 3 Summary**

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1. Reporting an accurate yield ensures an accurate evaluation of nitrogen applied vs. removed.
2. Crop yields should be adjusted to a standard moisture content for accurate data analysis.
3. Additional information on yield can be reported in the INMP Summary Report.

## 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	60
4Rs of Nitrogen Management	60 – 61
Nitrogen Efficiency Practices	62
Summary	62

### 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

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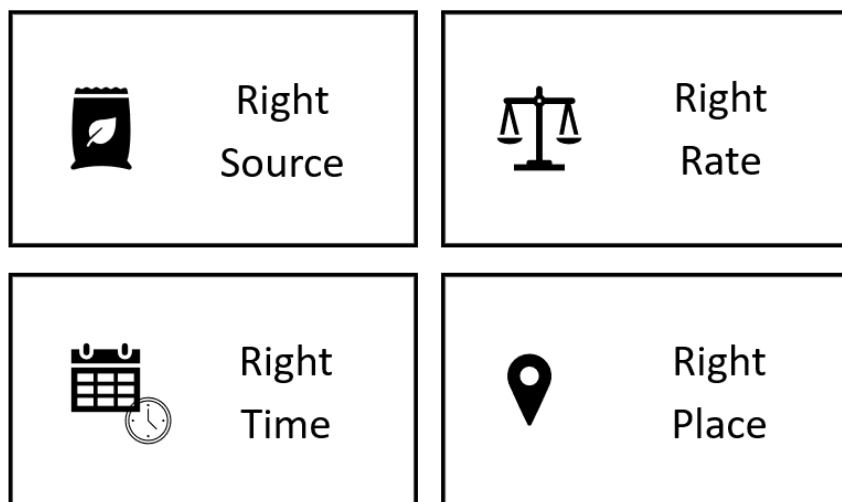
Nitrogen use efficiency is a measure of how well available nitrogen matches nitrogen uptake. Globally, the average nitrogen use efficiency level is 50%. However, with the adoption of efficient irrigation and nitrogen management practices in California agriculture, 70% efficiency is achievable. A 70%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

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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.

Effective rootzone depths for several crops can be found at:

[https://www.nrcs.usda.gov/Internet/FSE\\_DOCUMENTS/nrcs141p2\\_017640.pdf](https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_017640.pdf)

### **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 Practices

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In the nitrogen management section of the INMP Worksheet, growers are asked to report their nitrogen efficiency practices in Box 8. Growers should check all the practices that apply and include additional practices under other.

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

### 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	
Fertigating during the middle third of an irrigation set	
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	64
Taking Representative Soil Samples	64 – 65
Estimating Soil Available Nitrogen	65
Soil Nitrate Quick Test	65 – 66
Summary	66

### 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 9 asks growers to record nitrogen available to the crop from the soil. Box 9 has two columns one for pre-season planning (A) and one for actuals recorded at the end of the season (B). For Box 9, the values will likely be the same for column A and column B.

Nitrogen Sources	Recommended / Planned N (A)	Actual N (B)
9. Soil - 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 a zero in Box 9A and 9B for these systems.

### 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

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### 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 9A and 9B 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

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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/)

### **Activity 5.2.2**

Following the step-by-step guide developed by UCANR, a wheat grower in Colusa County 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	68
Pre-Season Planning	68
Post Season Actuals	69
Summary	69

### 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

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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 Sources	Recommended / Planned N (A)	Actual 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 3) and the nitrate-N concentration of the irrigation water (Box 4).

$$\text{lbs. nitrogen/acre} = \text{Box 4} \times 0.23 \times \text{Box 3}$$

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

#### 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?

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### Column (B) Post Season Actuals

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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 4).

$$\text{lbs. nitrogen/acre} = \text{Box 4} \times 0.23 \times \text{in. of water applied}$$

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

## 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	71
Plant Available Nitrogen	71
Estimating Nitrogen from Organic Amendments	72 – 73
Summary	73

### 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

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In the nitrogen management section of the INMP Worksheet, Box 11 asks growers to report nitrogen from organic amendments. Box 11 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 N (B)
11. Organic Amendments* (lbs./ac estimate)		

Organic amendments include natural sources of carbon and nutrients that do not have a 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

Region*:	<input type="text" value="San Joaquin Valley - Stanislaus"/>
Type of amendment*:	<input type="text" value="Poultry Manure Compost"/>
Application rate*:	<input type="text" value="5"/> tons/ac
Application date*:	<input type="text" value="10/09/2021"/>
Period of interest:	<input type="text" value="6 Months"/>
Depth of incorporation*:	<input type="text" value="6"/> <input type="text" value="inches"/>

\* Required input.

Total N applied:	<input type="text" value="260 lb/ac"/>
Total mineral N applied:	<input type="text" value="20 lb/ac"/>
Estimated available N:	<input type="text" value="56 - 65 lb/ac"/>
Percent available:	<input type="text" value="22 - 25 %"/>

## 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>)

## **Module 5 Lesson 4 Summary**

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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	75
Pre-Season Planning	76
Post-Season Actuals	77
Summary	77

### 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 Cropaia: <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 12 asks growers to estimate and record nitrogen applied from granular and liquid fertilizers. 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 N (B)
12. 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.

#### Super Excellent Grow

**20 – 10 – 10**

#### Guaranteed Analysis

Total Nitrogen (N)	20%
Available Phosphate ( $P_2O_5$ )	10%
Soluble Potash ( $K_2O$ )	10%

### Activity 5.5.1

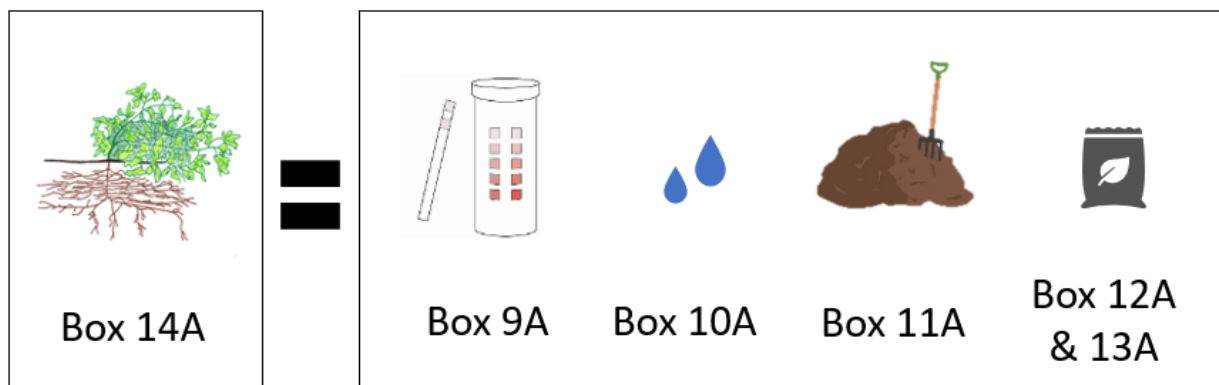
Directions: Based on the fertilizer name or grade listed below determine the %N.

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 14A) and nitrogen available from other sources (Boxes 9A-11A).



Thus, Boxes 14A 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	79 – 80
Foliar Fertilizer Calculations	80
Summary	80

### 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>

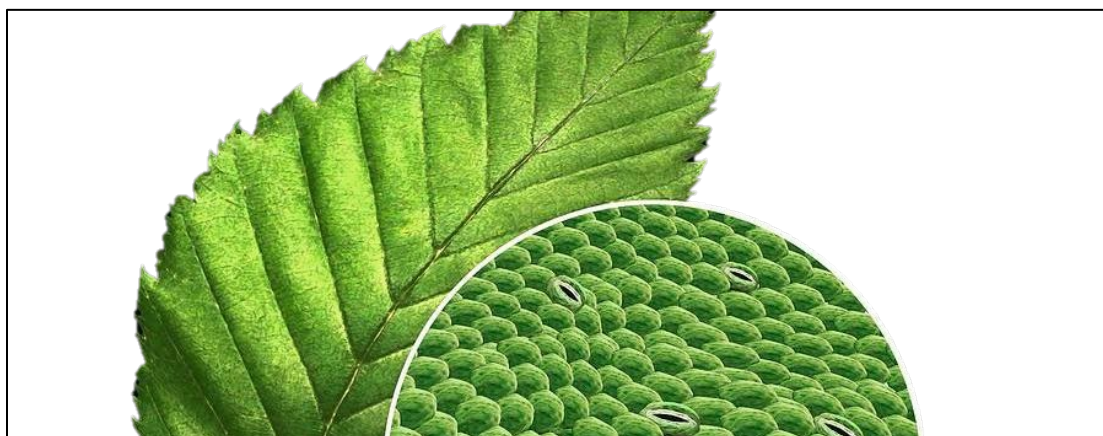
## Foliar Nitrogen Fertilizers

In the nitrogen management section of the INMP Worksheet, Box 13 asks growers to estimate and record nitrogen applied from foliar fertilizers. Box 13 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 N (B)
13. Foliar Fertilizer N* (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**

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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	82
Pre-Season Planning	82 – 83
Post-Season Actuals	84
Summary	84

### 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/>

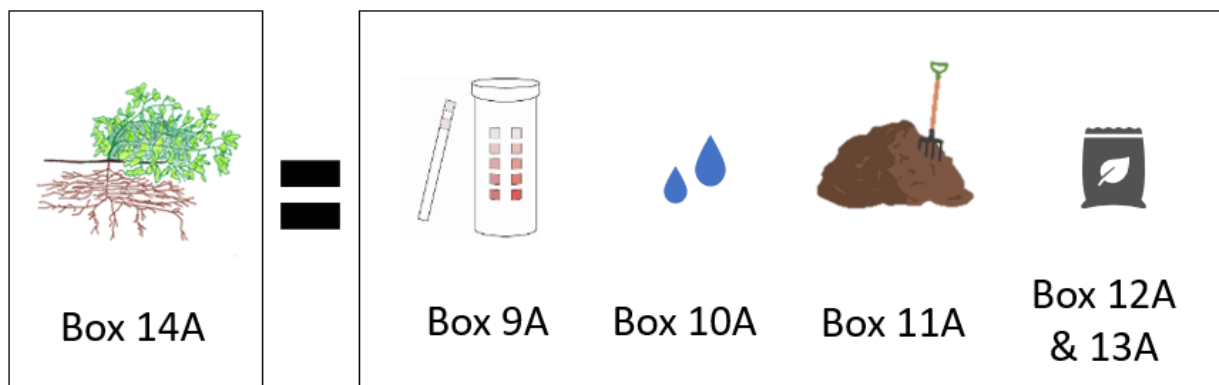
## Total Nitrogen

In the nitrogen management section of the INMP Worksheet, Box 14 asks growers to estimate and record total nitrogen applied from all sources (Boxes 9-13). Box 14 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 N (B)
14. Total Nitrogen* (lbs./ac)		

### Column (A) Pre-Season Planning

Box 14(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 9A-13A. 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 7A) 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: [http://geisseler.ucdavis.edu/Project\\_N\\_Removal.html](http://geisseler.ucdavis.edu/Project_N_Removal.html).

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

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 mature walnut orchard estimates his yield will be 2 tons/ac. For walnuts, 31.8 lbs. of nitrogen are removed per ton of nuts harvested. 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 in the Salinas Valley 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 14B) can be calculated by adding together all nitrogen inputs (Boxes 9B-13B).

### Activity 5.7.2

Based on the provided values below for Boxes 9B-13B calculate total nitrogen applied (Box 14B).

Nitrogen Sources	Recommended / Planned N (A)	Actual N (B)
9. Available N in Root Zone (lbs./ac)		15
10. N in Irrigation Water (lbs./ac)		20
11. Organic Amendments (lbs./ac)		12
12. Dry/Liquid Fertilizer N (lbs./ac)		80
13. Foliar Fertilizer N (lbs./ac)		10
14. Total Nitrogen (lbs./ac)		

## Module 5 Lesson 7 Summary

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1. A crop nitrogen requirement (Box 14A) can be estimated based on nitrogen removed during harvest or crop specific field research.
2. Total nitrogen applied (Box 14B) is a sum of nitrogen applied from all sources (Boxes 9B-13B).

## 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)	86 – 87
Calculating A/R	87
Summary	87

### 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)
- 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

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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 is used as a metric to determine the potential for nitrogen loss.

Calculating A/R is not required for the INMP Worksheet or Summary Report. However, growers can use this information to make informed decisions regarding nitrogen management. The A/R will be calculated by the Coalitions 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 11)
- Dry/Liquid Fertilizers (Box 12)
- Foliar Fertilizers (Box 13)

### Activity 5.8.1

Which nitrogen source is included on the INMP Worksheet, but is not included in the 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.  $(R) = \text{yield} \times \text{nitrogen removal coefficient}$

Keep in mind that these coefficients are based on a standard moisture content at harvest. Converting crop yield data to match the standard moisture content is required to properly estimate nitrogen removed. A list of nitrogen removal coefficients and their standard moisture content can be found at: [http://geisseler.ucdavis.edu/Project\\_N\\_Removal.html](http://geisseler.ucdavis.edu/Project_N_Removal.html).

If your crop is not on this list, there are additional resources available. Keep in mind these resources are not California specific.

- <https://plantsorig.sc.egov.usda.gov/npk/main>

### **Activity 5.8.2**

Directions: Complete the table below using the list of nitrogen removal coefficients found at [http://geisseler.ucdavis.edu/Project\\_N\\_Removal.html](http://geisseler.ucdavis.edu/Project_N_Removal.html)

Crop	Yield	N Removal Coefficient	N Removed (R)
Processing Tomato	50 tons		
Peaches	20 tons		
Cotton	0.75 tons		

### **Calculating A/R**

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Once a grower has calculated nitrogen applied (A) and nitrogen removed (R) for the season, A/R can be calculated. The Southern San Joaquin Valley Management Practices Evaluation Program also has a tool for calculating A/R: <https://agmpep.com/tools/calc-y2r/>

#### **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 sunflower grower in Solano County applied 140 lbs. N/ac and yielded 1.0 ton/ac. The nitrogen removal coefficient for sunflowers is 63.2 lbs. N/ ton. Calculate the A/R value.

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

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1. Calculating A/R is not required for the INMP Worksheet or Summary Report, but it can be useful for monitoring nitrogen efficiency.
2. To calculate 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	89
Certification Options and Requirements	89-90
Summary	90

### Lesson Resources




- California Department of Food and Agriculture. (n.d.). *INMP Continuing Education*. Retrieved from [https://www.cdfa.ca.gov/is/fldrs/frep/continuing\\_education.html](https://www.cdfa.ca.gov/is/fldrs/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/fldrs/frep/training.html>
- Central Valley Regional Water Quality Control Board. (n.d.). *Adopted Waste Discharge Requirements*. Retrieved from [https://www.waterboards.ca.gov/centralvalley/water\\_issues/irrigated\\_lands/regulatory\\_information/](https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/regulatory_information/)

## INMP Worksheet Certification

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The last section of the INMP Worksheet covers certification. Fields or management units in high vulnerability groundwater areas must have their INMP Worksheets certified. Please contact your coalition for more information regarding the vulnerability status of your parcels.

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,  , certify this INMP in accordance with the statement above.	
 (Signature)	 (Date)

## Certification Options and Requirements

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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 Advisors with a California Nitrogen Management Specialty
- Certified Professional Soil Scientists
- Certified Professional Agronomists
- Certified Agricultural Irrigation Management Specialist
- Technical Service Providers certified in nutrient management in California by the National Resource Conservation Service (NRCS)

### 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)
- Member who does not apply nitrogen

## **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 1 hour of continuing education every year. 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**

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1. INMP Worksheets must be certified for fields/parcels in high vulnerability groundwater areas.
2. INMP Worksheets may be certified by an INMP Specialist or self-certified by an eligible coalition 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 INMP Summary Report. Lesson 1 also reviews the reporting process and deadlines for INMP Summary Report 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 INMP Summary Report.
2. Recognize the deadlines for submittal of the INMP Summary Report.
3. Outline the process for submitting an INMP Summary Report.

Lesson Topic(s)	Page(s) in Workbook
INMP Summary Report	92
Section 1	92
Section 2	92 – 93
Section 3	93
INMP Data Submittal	94
Summary	94

### Lesson Resources

- Central Valley Regional Water Quality Control Board. (n.d.). *Adopted Waste Discharge Requirements*. Retrieved from [https://www.waterboards.ca.gov/centralvalley/water\\_issues/irrigated\\_lands/regulatory\\_information/](https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/regulatory_information/)

## INMP Summary Report

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The INMP Summary Report 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 INMP Summary Report. Transferred information is marked on the INMP Worksheet with an asterisk \*.

Data from multiple INMP Worksheets can be reported in one INMP Summary Report. Separate INMP Summary Reports are only necessary if a grower has parcels or management units in more than one coalition.

The Summary Report has three main sections:

1. Field and Parcel Inventory
2. Irrigation and Nitrogen Management Plan Summary
3. Irrigation and Nitrogen Management Practices

### Section 1: Field and Parcel Inventory

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

Select Not Farmed if the field 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 or Field ID	Not Farmed	APN	County	Crop	Crop Age (Years)	Irrigated Acres
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					

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

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

### Outlier Notification Receipt

Growers should indicate in the outlier notification section if they had any fields or management units that were considered outliers in the previous reporting period. The date that outlier notification was received from the coalition should also be recorded.

### INMP Certification Method

Fields or management units in high vulnerability groundwater areas must have their INMP Worksheets certified. Select the method of certification used on the associated INMP Worksheet(s).

### INMP Summary

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. 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 a Summary Report. 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 field and/or management unit listed in the Field and Parcel Inventory. 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 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.

## INMP Data Submittal

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The table below lists INMP Summary Report deadlines for the coalitions and coalition groups. Deadlines can also be found in the waste discharge requirements for each area.

Coalition / Coalition Group	INMP Deadline
San Joaquin County and Delta Water Quality Coalition	June 15
Westside San Joaquin River Watershed Coalition	April 15
Grassland Drainage Area	April 15
Sacramento Valley Water Quality Coalition	March 1
Tulare Lake Basin Coalition Groups	March 1

INMP Summary Reports must be submitted to the appropriate coalition by the deadline outlined above. All coalitions offer an online platform for submitting Summary Reports. 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 and deadlines, reach out to your coalition or access the waste discharge requirements:

[https://www.waterboards.ca.gov/centralvalley/water\\_issues/irrigated\\_lands/regulatory\\_information/](https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/regulatory_information/)

## Module 7 Lesson 1 Summary

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1. Components of the INMP Worksheet that transfer to the Summary Report are marked with an asterisk \*
2. To maintain compliance, Summary Reports must be submitted by the deadline outlined in the Waste Discharge Requirements.
3. Check with your coalition prior to the deadline for submittal options and instructions.

**IRRIGATION AND NITROGEN MANAGEMENT PLAN (INMP)  
WORKSHEET**

**Member ID #:** \_\_\_\_\_ **Member Name:** \_\_\_\_\_

**Was this management unit identified as a statistical outlier by the Coalition last year?**  
☐ Yes ☐ No

**Crop Year (Harvested):** \_\_\_\_\_

PARCEL MANAGEMENT					
Management Unit (MU) or Field	APN	County	Crop	Crop Age (Years)	Irrigated Acres
Total Acres:					

Comments/Notes:

## IRRIGATION AND NITROGEN MANAGEMENT PLAN (INMP) WORKSHEET

Member ID: \_\_\_\_\_ INMP Field or MU: \_\_\_\_\_ Crop: \_\_\_\_\_ Total Acres: \_\_\_\_\_

IRRIGATION MANAGEMENT					
<b>1. Irrigation Method*</b>			<b>Pre-Season Planning</b>		
(check one for Primary; if applicable, check one for Secondary)  <div style="display: flex; justify-content: space-between;"> <span>Primary</span> <span>Secondary<sup>1</sup></span> </div> <div style="display: flex; justify-content: space-between;"> <input type="checkbox"/> <input type="checkbox"/> Drip             <input type="checkbox"/> <input type="checkbox"/> Micro Sprinkler             <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           </div>			2. Crop Evapotranspiration (ET, inches)		
			3. Anticipated Crop Irrigation (inches)		
			4. Irrigation Water N Concentration (ppm or mg/L, as NO <sub>3</sub> -N)		
			<b>5. Irrigation Efficiency Practices*</b> (Check all that apply)		
			<input type="checkbox"/> Laser Leveling <input type="checkbox"/> Soil Moisture Neutron Probe <input type="checkbox"/> Use of ET in scheduling irrigations <input type="checkbox"/> Pressure Bomb <input type="checkbox"/> Water application schedule to need <input type="checkbox"/> Other _____ <input type="checkbox"/> Use of moisture probe (e.g. tensiometer) <input type="checkbox"/> Other _____		
HARVEST / YIELD INFORMATION					
Harvest / Yield Information			Expected (A)	Actual (B)	
<b>6. Production Unit</b> (lbs, tons, etc.)		<b>7. Harvested Yield*</b>			
NITROGEN MANAGEMENT					
<b>8. Nitrogen Efficiency Practices*</b> (Check all that apply)		Nitrogen Sources	Recommended/ Planned N (A)	Actual N (B)	
<input type="checkbox"/> Split Fertilizer Applications <input type="checkbox"/> Irrigation Water N Testing <input type="checkbox"/> Soil Testing <input type="checkbox"/> Tissue/Petiole Testing <input type="checkbox"/> Fertigation <input type="checkbox"/> Foliar N Application <input type="checkbox"/> Cover Crops <input type="checkbox"/> Variable Rate Applications using GPS <input type="checkbox"/> Other: _____ <input type="checkbox"/> Other: _____		9. Soil – Available N in Root Zone (Annualized, lbs/ac)			
		10. N in Irrigation Water* (Annualized, lbs/ac)			
		11. Organic Amendments* (Manure/Compost/Other, lbs/ac estimate)			
		12. Dry/Liquid Fertilizer N* (lbs/ac)			
		13. Foliar Fertilizer N* (lbs/ac)			
		14. TOTAL NITROGEN (lbs/ac)			

<sup>1</sup> A secondary irrigation system could be used for crop germination, frost protection, crop cooling, etc.

**\*(Bold Text)** Data to be reported to the Coalition on the INMP Summary Report, based on Actual Yield and Actual N.

Plan Certifier Initials

## INMP CERTIFICATION

The person signing this Irrigation and Nitrogen Management Plan (INMP) certifies, under penalty of law, that the INMP was prepared under his/her direction and supervision, that the information and data reported is to the best of his/her knowledge and belief, true, accurate, and complete, and that he/she is aware that there are penalties for knowingly submitting false information. Where the person signing the INMP is not the Member, he/she may rely on the information and data provided by the Member and is not required to independently verify the information and data.

The person signing the INMP below further certifies that he/she used sound irrigation and nitrogen management planning practices to develop irrigation and nitrogen application recommendations and that the recommendations are informed by applicable training for meeting the crop's agronomic needs while minimizing nitrogen loss to surface water and groundwater. Where the person signing the INMP is not the Member, he/she is not responsible for any damages, loss, or liability arising from subsequent implementation of the INMP by the Member in a manner that is inconsistent with the INMP's recommendations for nitrogen application. **This certification does not create any liability for claims for environmental violations.**

Certification:

- ☐ Certified INMP Specialist (e.g. Certified Crop Adviser who has completed the CDFA training program)
- ☐ Self-Certified by Member who has completed the CDFA training program
- ☐ Self-Certified by Member who follows NRCS or UC site-specific recommendations (documentation required)
- ☐ I do not apply nitrogen

I, \_\_\_\_\_, certify this INMP in accordance with the statement above.

\_\_\_\_\_ (Signature) \_\_\_\_\_ (Date)

If the certifier is not the Member, the Member additionally agrees as follows:

I, \_\_\_\_\_, Member, have provided information and data to the certifier above that is, to the best of my knowledge and belief, true, accurate, and complete, that I understand that the certifier may rely on the information and data provided by me and is not required to independently verify the information and data, and that I further understand that the certifier is not responsible for any damages, loss, or liability arising from subsequent implementation of the INMP by me in a manner that is inconsistent with the INMP's recommendations for nitrogen application. I further understand that the certification does not create any liability for claims for environmental violations.

\_\_\_\_\_ (Signature) \_\_\_\_\_ (Date)

## ILRP PARCEL AND FIELD INVENTORY

### STEP 1: GENERAL INFORMATION

Member ID: \_\_\_\_\_ Crop Year (harvested): \_\_\_\_\_

Name: \_\_\_\_\_

### STEP 2: FIELD AND PARCEL INVENTORY

Populate the following table with parcels for which the INMP Summary Report is being submitted. You can define a field or a "Management Unit" as a parcel or parcels with the same crop, fertilizer inputs, irrigation management practices, and nitrogen management practices.

If you do not apply nitrogen fertilizer to your fields these forms are still required to be returned. Please enter a 0 (zero) for nitrogen applied on the INMP Summary Report.

Field ID or Management Unit (MU)	Not Farmed*	APN	County	Crop	Crop Age (Perennial only)	Irrigated Acres
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					
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	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					
	<input type="checkbox"/>					

\*Not Farmed refers to Fallow, Open, or fields that were not in production.

Please add comments if any fields experienced drought, pest, or salt stress. If fields were not harvested due to economic reasons please indicate below. Any additional information pertaining to the harvest year can be included with your comments.

Comments:

# IRRIGATION AND NITROGEN MANAGEMENT PLAN (INMP) SUMMARY REPORT

Refer to your Irrigation and Nitrogen Management Plan (INMP) Worksheet and Parcel Inventory for information to complete an INMP Summary.  
Report for each field or Management Unit.

STEP 1: GENERAL INFORMATION		STEP 2: OUTLIER NOTIFICATION RECEIPT	STEP 3: INMP CERTIFICATION METHOD
Member ID: _____	<p>On (Date) _____, the Coalition provided information about this membership's nitrogen efficiency for the previous crop year and identified management units that were considered outliers compared to other Coalition members growing the same crop.</p> <p>Please check the box below if you were identified as an outlier by the Coalition.</p> <div style="text-align: center;"> <input type="checkbox"/> </div>	<input type="checkbox"/> Certified INMP Specialist (e.g. certified crop adviser who has completed the CDFA training program)	
Forms Completed By: _____		<input type="checkbox"/> Self-Certified (CDFA training program)	
Crop Year (Harvested): _____		<input type="checkbox"/> Self-Certified (follows NRCS or UC Cooperative Extension site-specific recommendations)	
Submittal Date: _____		<input type="checkbox"/> Self-Certified (No fertilizers applied)	

## STEP 4: INMP SUMMARY REPORT

Complete the table below for each field or management unit for this membership. *All values should be on a per acre basis.*

[illegible]

**\*Use this column to provide information about yield i.e. nonbearing; crop not harvested; type of harvest (e.g. silage, grain). If you harvest straw, please contact your Coalition.**

## IRRIGATION & NITROGEN MANAGEMENT PRACTICES

Complete the following tables for each field or Management Unit (refer to ILRP Parcel and Field Inventory Sheet).

[illegible][illegible][illegible]