

Calculating Nutrient Application from Liquid Manure Irrigations Using Flow Meter Measurements

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The Central Valley Regional Water Quality Control Board's Waste Discharge Requirement General Order for Existing Milk Cow Dairies restricts nutrient application and requires documentation of total nutrients applied to each land application area. Even if you have a professional prepare your annual report, keeping your own running totals of nutrients applied during the cropping season will help you make management decisions that protect yields and avoid surprises at reporting time.

With good records, calculating the nutrients applied to each field can easily be done using a calculator and this simple worksheet.

To find out how much nitrogen you applied to each field, you will need a measure of the amount (volume, in gallons or acre-inches) of undiluted lagoon water applied to each field, and a laboratory analysis of a representative sample of that same undiluted lagoon water. Your flow meter will make it easy to determine the gallons applied if the beginning and ending totalizer reading is recorded for each field. A field data collection sheet specifically designed for use with flow meters is available for download on the UC Manure Nutrient Management website:

<http://manure.ucdavis.edu> or <http://anr.sites/ucmanure.edu>

These instructions will help you fill out a worksheet to help you do these calculations by hand if you used a flow meter to measure how much went out. Use one of the other guides and worksheets if you used flow rate (gpm) and run time or pond drop to measure volume applied. These guides and worksheets are available on the UC Manure Nutrient Management website. Excel-based spreadsheets with automatic calculations are also available.

When using the hand calculation worksheet, it is recommended that one worksheet be used for each field each cropping year so that you can keep a running total of the nutrients applied to each field. This will help you determine if you are meeting your application targets for each field so that you can make in-season adjustments if needed.

Flow Meter Hand Calculation Worksheet Instructions

1. Transfer information from the field data sheet to the calculation worksheet
2. Calculate volume applied in 1000 gallons
3. Choose a sample analysis to use with each application
4. Calculate pounds of total and ammonium nitrogen applied to each field
5. Divide total pounds per field by the number of acres to get pounds per acre
6. Determine how much of the nitrogen applied is actually usable by the crop.

1. Transfer the data collected on the irrigation data sheet to the calculation worksheet.

It is best to use a separate sheet for each field. You only need to transfer the location, acres, start date and meter start and meter end data from your field record sheet to the calculation sheet. The average observed gpm (gallons per minute) and end date and times information are optional.

Many meters are set to display in x1000 or Kgals. If this is how your meter reads, use this number just the way it is. To increase accuracy, you may prefer to set your meter to read in hundred gallons. If so, divide 100 gallons (hgal) by 10 to get thousand (K) gallons before putting the data in columns H and I.

Example: The example field is 40 acres, the start date for the first irrigation was May 15, the meter at the start read 47937000 gals or 47,937 Kgal and at the end of the irrigation the reading was 52,282 Kgal

2. Calculate the volume of lagoon water applied in 1000 gallons.

Subtract the beginning totalizer reading from the ending totalizer reading:

$$\text{column I} - \text{column H} = \text{column J}$$

Example: 52282 Kgal - 47937 Kgal = 4345 Kgal

Make sure the liquid manure volume in column J is in 1000 gallons, or gallons times 1000 before proceeding.

$$42,282 \text{ Kgals} = 42,282,000 \text{ gal}$$

3. Choose a sample to correspond to each application.

The WDR General Order requires a minimum of quarterly sampling of liquid manure during land application events. These quarterly samples must be analyzed by a qualified laboratory for: **ammonium-nitrogen, total Kjeldahl nitrogen, total phosphorus, and potassium**. You may have taken additional analyses to help you manage your nutrients more accurately. Evaluating all the samples that were collected, choose the sample which best represents each liquid manure application. Write the sample identification in column L, and the total Kjeldahl nitrogen

Special Case: The lagoon water flow was split and went to more than one field after being measured by the meter.

You will have to estimate what percent of the total flow went to each field. This can be difficult; that is why it is recommended that each portion of the split stream be measured and throttled separately.

Calculate the total gallons applied by subtracting the ending totalizer reading from the beginning reading. Multiply the total gallons applied by the percentage that went to each field.

Ending Kgals* - start Kgals = total Kgals
If Field 1=70%, Field 2=30%
Total Kgals x .7 = Kgals for Field 1
Total Kgals x .3 = Kgals for Field 2
Put the calculated Kgals associated with each field in column J

*Kgals = thousand gallons = 1000 gals

Converting Gallons to Acre-Inches

$(\text{gallons} \div 27,154) \div \text{acres} = \text{acre-inches}$
 $(\text{Kgals} \div 27.154) \div \text{acres} = \text{acre-inches}$

Atoms vs. Molecules

The “-N” designation means that this is the concentration of just the nitrogen in the ammonium or TKN

. If the concentration of the entire molecule that contains the nitrogen atoms were reported, it would be written as NH₄. It makes a difference because NH₄-N will always be in lower concentration than NH₄. When working with more than one form of nitrogen, it is easier to deal with just the nitrogen portion of the molecules. Be sure to check which reporting method is being used by your laboratory.

(sometimes written TKN) and ammonium nitrogen (sometimes written NH_4^+ -N) concentrations in columns M and N. The laboratory results should have this data reported in either mg/L or ppm; these are exactly the same and either can be used without further conversion.

Example: Lab report states TKN-N is 80 mg/L and NH_4 -N is 180 mg/L

4. Calculate the amount of nitrogen applied per field

a. TKN (Total N)

TKN is a measurement of total nitrogen. It includes both the ammonium and organic forms of nitrogen. The water board determines compliance based on total nitrogen applied.

$$\text{TKN-N applied (lbs)} = \text{TKN-N (ppm or mg/L)} \times \text{volume applied (gal x1000)} \times 0.008345$$

$$\text{column J} \times \text{column M} \times 0.008345 = \text{column O}$$

Example: $2172 \times 258 \times 0.008345 = 4676$ lbs Total N (TKN)

(Note: 0.008345 is the conversion factor for the x1000 gallons unit specified earlier.)

b. Ammonium-N

$$\text{NH}_4^+\text{-N applied (lbs)} = \text{NH}_4^+\text{-N (ppm or mg/L)} \times \text{Volume applied (gal x1000)} \times 0.008345$$

$$\text{column J} \times \text{column N} \times 0.008345 = \text{column P}$$

Example: $2172 \times 180 \times 0.008345 = 3263$ lbs NH_4 -N applied

5. Calculate the amount of nitrogen applied per acre.

Divide the total pounds of TKN N and ammonium-form N applied to the field by the number of acres in the field.

$$\text{Total lbs TKN or ammonium per field} \div \text{acres/field} = \text{lbs/acre N applied}$$

$$\text{column O} \div \text{column B} = \text{column V}$$

Example: $4676 \div 40 = 117$ lbs Total N (TKN)/acre

$$\text{column P} \div \text{column B} = \text{column Q}$$

Example: $3263 \div 40 = 81$ lbs NH_4 -N/acre

Do your results look like they are reasonable? If not, check to see if the data was transcribed accurately and recalculate as needed. If they still don't look right, multiply the average observed gpm (gallons per minute) by the run time in minutes to confirm or correct the recorded totalizer readings.

The calculations that you have completed to this point are all you need to report to the water board. However, in order to manage your crop, you will also need to calculate how much of the total nitrogen applied is in a form that the crop can actually use.

6. Calculate the amount of available nitrogen applied

While all forms of nitrogen applied need to be reported, crops can only use nitrogen in two forms: ammonium nitrogen ($\text{NH}_4^+\text{-N}$) and nitrate-nitrogen ($\text{NO}_3\text{-N}$). A significant portion of the nitrogen in liquid manure and most of the nitrogen in dry manure is in the organic form, which must be broken down by microbes into ammonium or nitrate before the crops can use it.

TKN, or Total Kjeldahl Nitrogen, measures the nitrogen in both the organic and ammonia forms. Calculate the amount of organic nitrogen applied by subtracting the ammonium content from the TKN.

$$\text{TKN-N lbs/acre} - \text{NH}_4^+\text{-N lbs/acre} = \text{Organic-N applied lbs/acre}$$

$$\text{column V} - \text{column Q} = \text{column R}$$

Example: 117 – 81 = 36 lbs organic-N/acre

Now that we know the amount of organic nitrogen that was applied, how much of it will become available to this crop? The process of converting organic nitrogen to crop-available nitrogen is called mineralization. How fast this occurs depends on

- How much entered the soil vs. what remained on the surface in the crust
- soil temperature
- how resistant the material is to being broken down by microbes the time left in the crop season
- soil moisture content

A common conservative estimate is that 30 to 50 percent will become available for the current crop. However, be careful not to assume too much is available right away and inadvertently short your crop. Record your estimate of what percent of the organic nitrogen will become available to the crop either in the next couple weeks or for the crop season in Column S. Divide the percent by 100 and multiply by the pounds per acre of organic form nitrogen to calculate estimated available nitrogen.

$$\text{Organic nitrogen lbs/acre} \times \% \text{ available} = \text{available N lbs/acre}$$

$$(\text{column S} \div 100) \times \text{column R} = \text{column T}$$

Example: (40 ÷ 100) × 36 = 14 lbs of available organic N

Add the available N lbs/acre from organic N to the ammonium-form N that was already in the available form to find the total amount of available nitrogen from this application:

$$\text{column Q} + \text{column T} = \text{column U}$$

Example: 81 + 14 = 95 lbs total amount of available N in this application

Compare the amount of available nitrogen you applied to the amount that your crop needs. Remember that significant losses of nitrogen can occur during irrigation if the amount of water applied exceeds the amount of water the soil can store. Available nitrogen that was present early in the season may not still be there when the crop needs it.

If you need to exceed the 1.4 x crop removal limit, regulations require that you must test the plant tissue for total nitrogen prior to any nutrient application.