

# Using Dairy Lagoon Nutrients to Produce High Yielding Crops: System Design and Use

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## ABSTRACT

Dairy lagoon nitrogen and other nutrients can be a cost effective, manageable source of crop nutrients by using a nitrogen quick test and a system of measuring and regulating the flow rate of the lagoon nutrients. This system is being successfully operated on a number of San Joaquin Valley dairies. The dairy operators have found that the system is, for the most part, simple and practical to use in their operations and have been able to replace all or most of the commercial fertilizer that was previously purchased with lagoon nutrients without negative impacts on crop production.

**Key Words:** manure, lagoon water, waste water, silage corn, winter forage, fertilizer, dairy

Dairy lagoon water contains nitrogen, phosphorus and potassium which, when properly applied, can supply virtually all of the nutritional requirements of forage crops. However, overapplication of this nutrient water can result in groundwater contamination and crop injury from excess salts, while underapplication can result in not enough nutrients for optimum crop production.

In order to properly apply lagoon nutrients, an operator must be able to determine the concentration of nutrients in the water, and also be able to measure and control the amount of nutrient water being applied onto the field. This needs to be done with enough precision to allow the operator to meter into the irrigation water just the amount of lagoon nutrients needed to meet the immediate needs of the crop.

A system which will allow this amount of control has recently been developed by the University of California Cooperative Extension and is being demonstrated on several San Joaquin Valley dairies. These dairies are now using their lagoon nutrients in a way very similar to applying commercial nitrogen such as anhydrous ammonia. Instead of handling the dairy's manure as an animal waste discharge operation, it is run as a fertilizer resource operation.

The three key ingredients to utilizing lagoon water as a fertilizer are:

1. Use of a field quick-test method that allows the operator to quickly determine the concentration of both forms of nitrogen in the nutrient water prior to and during the irrigation.
2. Use of a flow meter on the lagoon pump discharge to measure the amount of nutrient water being applied, along with a special clog-resistant throttling valve which can be used to adjust the proportion of nutrient water injected into the irrigation water.

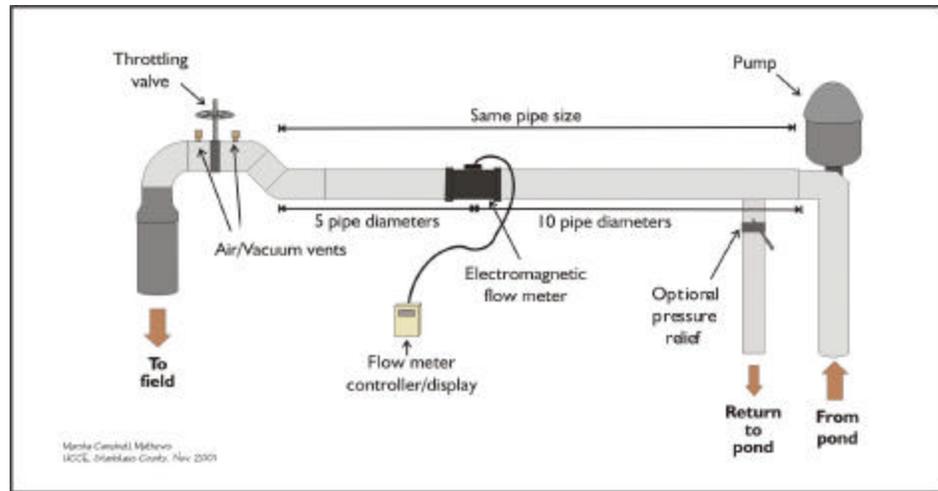
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3. Use of a computer spreadsheet or paper recordkeeping system to keep a running total of the nitrogen applied and determine the amounts and flow rates needed in each irrigation to supply the crop with just the right amount of nitrogen throughout the growing season.

Proper selection and installation of the flow metering system is essential to accurate flow measurement and control. An electromagnetic type flow meter is recommended because these meters have minimal projections into the pipe and are not prone to with fouling by debris. The meter needs to be installed in a stretch of straight pipe to ensure a flow pattern that is uniform across the cross section of the pipe.

The installation also requires a rise of at least one pipe diameter downstream of the meter to ensure that the meter sees a completely full pipe without air gaps. The flow control valve needs to be located such that the distortion in flow pattern it produces will not affect the meter reading.



**Typical metering run for flow measurement and throttling of dairy nutrient water.**

*Note: one pipe diameter is the distance across the cross section of the pipe (pipe size). Ten pipe diameters of a 10 inch pipe would be 100 inches.*

In practice, the following steps are used to target applications of lagoon nitrogen to a particular field:

1. Determine number of acres to be irrigated. Some growers keep track of nutrient application according to each field, and others prefer to track application on every irrigation check or set within a field. Since often the only nutrients the crop will receive come from the lagoon, crop performance will be affected by the accuracy of the application. More management is needed in situations where each check irrigates differently, and less when each irrigation set within a field is essentially identical.
2. Estimate the time the irrigation will run.
3. Decide on the amount of nitrogen to apply in this irrigation. Factors involved in this decision include the amount of nitrogen expected to be needed by the crop in the immediate future and further into the cropping season, the sensitivity of the crop to salt or ammonia injury, the ability of the soil to retain nutrients, and the rate at which the ammonium and organic nitrogen in the nutrient water will be converted into nitrate and ammonium.

4. Take a sample of the same lagoon water that will be applied. Often, a sample taken from the flush will not adequately predict the concentrations of nitrogen in the nutrient water actually being used during irrigation, especially if the flush pump is drawing from near the surface of the pond and the irrigation pump draws from the bottom. Samples dipped from the pond, or estimated from previous sampling, may be better in this instance to provide a preliminary estimate, which will later need to be confirmed during irrigation.
5. Determine the concentration of the sample using a quick test for ammonium and organic form nitrogen. Because the nitrogen in the organic form must be mineralized before being available for crop use, only a portion of this form is considered when determining the concentration of nitrogen in the nutrient water. The available nitrogen concentration to use for calculating application rates is the sum of all the ammonium nitrogen plus the percentage of the organic form nitrogen that is presumed to become available during the cropping season.
6. Consult a chart, calculator or computer spreadsheet to calculate a target pond water gpm based on the concentration and expected irrigation time.
7. Record the starting gallons on the meter totalizer and record the starting time of the irrigation
8. Begin the irrigation, adjusting the valve until the flow meter gpm (flow rate in gallons per minute) display matches the target gpm.
9. Periodically check the lagoon water nitrogen concentration if there is reason to suspect that the lagoon water nitrogen content is not uniform, and adjust the target flow as necessary. The target gpm should also be readjusted if the irrigation runs significantly longer or shorter than expected.
10. At the completion of the irrigation, record the ending time and the total number of gallons applied through the meter.
11. Using confirmed nitrogen concentrations and run times, calculate the actual amount of nitrogen that was applied per acre.
12. Adjust the target nitrogen application rate in the next irrigation according to crop needs.

These steps are repeated for each subsequent irrigation where nutrient water is applied.

## **USING DAIRY LAGOON NUTRIENTS TO PRODUCE HIGH YIELDING CROPS: CLAUSS DAIRY FARMS, HILMAR, CA**

### **Jeff Strom, Farm Manager**

Each of our three dairies average 1000 milking Jersey cows. All heifer replacements are raised on one central dairy. This dairy also houses and mixes feed for all animals.

All milking cows are housed in freestall barns and 60% of the cows have access to exercise corrals when weather permits. About 70% of heifer replacements are on flush with covered barn. These animals are locked under roof during the winter.

Two of the dairies have separators. This nutrient is used in our composting system. All these have settling basins to retrieve as many solids as possible. There are three separate lagoons on each dairy that nutrient water flows through after flushing the feed lane. This helps to keep the main lagoon cleaner. It also gives us more flexibility when applying nutrient water to crops. I can use the cleaner nutrient water for small corn and use nutrient water with more organic material for larger corn.

We are able to transfer of our nutrient water between all three dairies. This helps us deliver nutrients to crops at the right agronomic rate.

Each dairy has its own flow meter, separator, nutrient pump and pipe system to deliver nutrient water to crops. Each are designed the same to make it easy for irrigators to use. Nutrient water may be taken from two separate lagoons to give us flexibility on amount of organic material needed to best-fit crop type and size.

Nutrient water samples are taken directly from the delivery systems for each irrigation by the irrigator and stored in a refrigerator. I pick up the sample to run a quick test to determine ammonium nitrogen and organic nitrogen percentages. These numbers are entered into a spreadsheet that calculates total amounts applied.

Before each irrigation the irrigator is given a number to set the flow meter for each field. He is also responsible for writing down total number of gallons of nutrient water used for each field.

We have been using only nutrient water to grow corn for the past two years for 350 acres. Results have been great with almost \$60/acre savings on fertilizer. In February of 2001 we used nutrient water with well water to supply nutrients for my winter forage. Results were good with plans to repeat in 2002.

Some of the key things to look at when setting a system up include having separate pump from your flush system and piping nutrient water so that it is delivered to the head of your water source for better mixing. A flow meter and a quick test kit will help. Once this system is in place management time is not more than ordering  $\text{NH}_3$ .

USING DAIRY LAGOON NUTRIENTS TO PRODUCE HIGH YIELDING CROPS:  
BAR VEE DAIRY, TURLOCK, CA

Arthur G. Crowell, Co-Proprietor

Our business name is Bar Vee Dairy Inc. and we are located 2 miles north west of Turlock, California. My grandfather started in the dairy business in 1900, a mile and a half east of our present location. My brother, Michael Crowell and his son, Adam, manage the dairy. I, Gary Crowell, do the farming. Our dairy herd consists of 700 Holsteins and we raise our 550 replacement heifers on site. Our dairy site consists of 320 acres connected by one pipeline system. We also farm a 300-acre ranch 1 1/2 miles south of our dairy, which we lease from our father, Verne Crowell. He has a 650 head feed lot at that site and we custom feed his cattle on a monthly basis. That ranch is irrigated with reclaimed water from the city of Turlock/out fall line to the river.

Until 1997, we only had one pond. All our dairy and freestall lanes flushed, entered sand traps, and then the water was pumped up over a static separator and back into the pond to be re-used. This pond encompassed an overall area of about 3 acres and holds about 25 acre feet of water. Our problem was that in the rainy periods, all the corral and barn roof area water ends up in the holding pond. So, we had to apply this water to forage crops to reduce the pond storage volume. One application works but two or more may kill areas of one's forage. Our answer was to build another lagoon that encompasses 9 acres; holding about 95 acre feet next to the original one. The original pond was made into a digester pond. The second pond is used as extra holding capacity. At that point, Marsha Campbell Mathews told us we need to move this water from the liability column to the asset column on our books and make proper use of it. We have done that and it has been a very positive experience.

Thanks to Marsha and Allison Eagle (Project Manager BIFS Dairy Manure Project), we now test and monitor all "nutrient" water as it is pumped out. We have two flush pumps. One is for heifer freestalls and the other is for the dairy area.

When dealing with a field, I do a soil test and then decide how much nitrogen, potassium and phosphate I need to add to produce a specific tonnage of, say, silage corn. Then the water is tested to see my nutrient values (I can't personally test for P+K so this is done outside). I then decide how many irrigations I have, in order to apply these nutrients in the proper amounts. I project my irrigation time in acres per hour (by my prior experience) and then decide on a flow rate in GPM. We had to install flow control valves and reconfigure pump discharge lines. The flow monitor tells given flow and records total gallons used during irrigation. This helps to verify overall output on field.

Both ponds can be accessed with these pumps and both pumps have been plumbed to accept flow meters. We can adjust flow of pond water in a range of 800 GPM to 2200 GPM, depending on what our fertilization needs are on a given field. This flow is co-mingled with our standard 15-cfs head of water delivered by our irrigation district.

This system takes a lot of management, but the rewards are great. This year I have saved over \$18,000.00 in fertilizer expenses compared to years past. Many fields were fertilized with this water only, no commercial fertilizer, resulting in production savings of about \$100.00 per acre. I am watching my soil tests. If my nutrient values drop in any fields, I will add special elements as needed.

After pre-plant fertilizer, I normally had to spend some time managing my NH<sub>3</sub> application and so, this routine just takes a little more time than that. My biggest problem is testing the water samples. I've purchased all the components needed for the "quick test" for nitrogen, but it really isn't that quick when you are only doing one sample at a time. You tend to fudge a bit and say, "Well, I don't think my values have changed since last time," but that's not the UC way, so we must test it!

As far as yields are concerned, we are in our third year of testing results from one field which is a total of 80 acres. 40 acres are fertilized with only commercial fertilizer and 40 only with pond water. We have tried to apply the same values of N-P+K to each parcel. I have been very pleased, as they have consistently produced almost identical yields.

In summation, I should say I probably would not have gotten so involved so soon with extensive nutrient management if it wasn't for the guidance and prodding by the UC staff. I didn't realize up front how successful and monetarily rewarding this program is. Not only does your investment pay off rapidly, but it automatically makes one in compliance with any ground water pollution questions that are looming in our future.

As far as system design, the only point I would make has to do with sizing the lagoon capacity. I would say decide what would be adequate and then make it a little bigger. It doesn't cost much more, but maximum capacity in a wet winter is the total key.

## **USING DAIRY LAGOON NUTRIENTS TO PRODUCE HIGH YIELDING CROPS: LORINDA DAIRY, DENAIR, CA**

Loren Lopes

We operate a 500 cow Holstein dairy near Turlock. We raise all our replacements, so there are also about 400 heifers on the dairy. We do some of our own farming, and some we hire out. We hire out the ripping, harvesting and some of the planting. My father and I do all our own irrigating.

All the milking cows are in freestalls that are flushed and the other stock are in open pens with flushed feed lanes. The flush water first goes into a settling pond which is then pumped into the main holding pond. We have two settling basins. We pump into one for about a year, and we switch to the empty one in the spring to allow the first pond to dry out. The manure in the basin is dried and spread onto the surrounding fields. We handle all our manure through the flush system. All the corral manure is dried in the corrals and put in the freestalls. From there it eventually winds up in the settling basin and from there into the lagoon.

Because we were having trouble with too many solids in the lagoon, we installed settling basins in the spring of 2000. We installed a flow meter as part of that project because it was the only way we could see that would allow us to get a handle on how much nitrogen we were putting out in our lagoon water.

The same pump runs both the irrigation and the flush. When we need to irrigate with nutrient water, we just skip that flush. Since it takes us about 20 hours to irrigate, we might miss two flushes. Occasionally I may need to stop using the nutrient water to flush during an irrigation, in which case I write down what happened.

Just before I want to irrigate, I run the flush. Then I will switch the valves, and let out a little bit to pull a sample so I can run a test. I enter those numbers into a spreadsheet so I can tell how to set the flow based on how long I expect each field to irrigate. I pull a couple samples towards the beginning and again near the end of the irrigation to check the concentration. The pond usually runs pretty uniform during the corn, unless we do something to it, like add water. I write down the totalized flow and change times for each check. I enter the numbers into the spreadsheet to figure how much nitrogen I have applied and how much more I need to apply in the next irrigation.

Since I am responsible for much of the day-to-day management of the dairy including doing the feeding, it is hard for me to get the numbers entered in a timely way. I am looking into getting a portable computer that will allow me to put the numbers in while I am still in the field and have time while I'm waiting for the water.

The only part of managing the system that I find to be a particular hassle is finding time to focus on running the quick test. I still can't do it very quickly and have to concentrate when doing the measurements.

Overall, I have been satisfied with how the system operates. It really does enable us to be able to tell exactly what we are applying. We still have some improvements we would like to make in order to get the entire nutrient management program where we want it. It is still difficult to get the proper amount on the winter crop because canal water is not available to dilute the nutrient water and our freshwater pump doesn't put out quite enough to do the job. I have been experimenting with adding fresh water to the pond in winter to make it less concentrated when I apply it. But it is hard to make myself do it before the pond is full. Also, I find that I can irrigate quicker (and put less nitrogen out at a time) if I irrigate when the ground still has some dampness to it. Because the nitrogen in the lagoon water is in the ammonium and organic form, and during the winter these forms don't rapidly convert to nitrate, the nitrogen isn't very likely to leach even if the ground was not dry when the nutrient water was applied.

We were able to get some funding from the EQIP (USDA Environmental Quality Assurance Program) to help offset the cost of the settling basin. Before we started managing our nutrients, we didn't use much commercial fertilizer. So we haven't really saved on fertilizer costs as much as someone who was buying fertilizer. But I do think that by being careful in how we use our nutrient water, we are avoiding salt and other problems, and that we will not have to buy as many amendments to correct them.

Advice I would have for someone considering installing a nutrient management system would be to look at other peoples, size your pumps, pipelines, and ponds correctly and make sure you have room to expand your ponds and settling basins because you might find you have to do that once you start operating your system.