Circular 1091

UF UNIVERSITY of FLORIDA
IFAS Extension

Water Budgets for Florida Dairy Farms[1]

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Water use is essential in all dairies. Drinking water is indispensable for life of cattle; some water is necessary for cleaning and sanitation procedures; moderate amounts are important in periods of heat stress for evaporative cooling of cows to improve animal production and health; and additional amounts can be used in labor-saving methods to move manure and clean barns by flushing in properly designed facilities. The more water a farm uses, however, the greater the potential for surface runoff and penetration to the ground water, with possible environmental impacts offsite. Heightened environmental concerns and the need for resource conservation have caused implementation of water use permits and other possible regulatory actions. Thus, it is important to measure exactly how much water is necessary for all the various procedures on a dairy farm and to look for ways to reuse some water when re-use is feasible.. The following are common uses of water on dairies:

- drinking by dairy cattle
- cleaning of dairy cows before milking
- cleaning of dairy equipment
- sprinkling cows for evaporative cooling
- flushing manure
- irrigating crops grown to recycle nutrients from manure
- irrigating additional crops

The objective of this fact sheet is to provide estimates of amounts of water commonly used for various purposes so that water use budgets for dairy farms can be developed on a per-cow and total-farm basis.

Units

1 gallon of water = 8.346 lb

1 cubic ft of water = 7.48 gallons

1 acre = 43,560 sq ft

1 acre-inch of water = 27,152 gallons

1. This document is Circular 1091, one of a series of the Animal Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date February 1993. Reviewed June 2003 and May, 2008. Visit the EDIS Web Site at http://edis.ifas.ufl.edu.

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Calibration methods to estimate use. If water meters are not in place to measure gallons pumped, it will be necessary to estimate usage. This can be done by capturing flow through various water lines for specified times and multiplying by the time water is flowing through those lines each day.

Drinking

Table 1 provides estimates of drinking water requirements in gallons per cow per day. Consumption of about 25 gallons of water per day by lactating cows is common, with variation depending on milk yield, dry matter intake, temperature, and other environmental conditions.

Table 1. Predicted daily water intake of dairy cattle as influenced by milk yield, dry matter intake (DMI), and season.[1,2]

	Cool season (e.g., Feb)		Warm season (e.g., Aug)	
Milk yield (lb)	**DMI (lb)**	**Water intake (gal)**	**DMI (lb)**	**Water intake (gal)**
0	25	11.5	25	16.3
60	45	22.2	44	26.8
100	55	28.6	48	31.9

[1]Drinking water intake predicted from equation of Murphy et al. (J. Dairy Sci. 66:35. 1983): Water intake (lb/day) = 35.2 x DMI (lb/day) + .90 x milk produced (lb/day) + .11 x sodium intake (grams/day) + 2.64 x weekly mean minimum temperature (°C = (°F - 32) x 5/9). For examples above, diet dry matter was assumed to contain .35% Na. Predicted water intakes (lb) from formula calculations were divided by 8.346 lb water/gallon to convert to gallons.
[2]Average minimum monthly temperatures for February (43.5°F) and August (71°F) used with prediction equation were 70-yr averages for specified months at Gainesville, FL (Whitty et al., Agronomy Dept., Univ. FL, 1991).

Cow Washing

Currently most dairies in warm climates bring cows to be milked into a holding area equipped with floor-level sprinklers that spray water upward to wash cows. Cows usually have about 15 square feet per cow and typically are washed for 3 minutes. The amount of water used per cow should be calculated for each dairy. An estimate for conservative use is that a holding area for 300 cows is 30 ft x 150 ft (15 sq ft per cow) and is equipped with sprinklers with 5-ft spacing (say 7 across and 30 rows) giving 210 sprinklers. If each sprinkler applies 5 gallons per minute, total usage is 1,050 gal/min or 3,150 gal for 3 min; average per cow would be 3,150/300 = 10.5 gal/cow/wash cycle. If cows are milked 3X this would require 31.5 gal/cow/day.

The washing system previously described also helps in cooling cows while they are crowded together waiting to be milked. However, the cooling effect could be accomplished with less water sprinkled from above, alternating with fans to give evaporative cooling, if the cows were clean enough so that extensive washing would not be necessary.

Washing Milking Equipment and Milking Parlor

The amount of water needed to wash infrastructure is not as directly related to the number of cows in an operation as are many other uses for water on a dairy farm. For washing milking equipment, a common wash vat volume is 75 gal. If this is filled for rinse, wash, acid rinse, and sanitizer at each of three milkings, this amounts to 900 gal for the herd, e.g. with 300 cows, only 3 gal/cow/day. This is an extremely small component of the total water budget. The amount used to wash out the milking parlor is more variable. If hoses only are used, the amount may be as little as 2 gal/cow/milking or 6 gal/cow/day if cows are milked 3X. If flush tanks are used, the amount may be more nearly 3,000 gal/milking or 9,000 gal/day for 3X, equivalent to 30 gal/cow/day for a 300-cow system.

Sprinkling and Cooling

Sprinklers along with fans are used for evaporative cooling to relieve heat stress in dairy cows in hot periods of the year. Their use has shown

increased cow comfort (lowered body temperature and respiration rates) and economic increases in milk production and reproductive performance. Application rates used by producers who have adopted this practice vary. Recent Florida experiments compared application rates of 51, 88, and 108 gal/cow/day at 10 psi in one experiment and 13, 25 and 40 gal/cow/day in another experiment. The 13 gal/cow/day is close to the estimated evaporation rate from the cow and surrounding floors. This component should be considered in water use but not in runoff water that must be managed in the manure management system. At this time, we are estimating 25 gal/cow/day as the minimum practical application rate in order to get adequate coverage of cows to cool them because often they are not in the sprinkled area. Total days per year for application may vary from 120 to 240 days. A separate water well or reserve tank and booster pump may be needed to supply short-term high demand needed by the sprinkler system.

Flushing Manure

If facilities are designed with concrete floors with enough slope to permit the use of water propelled by gravity to move manure, flushing is a clean and labor-saving method to move manure. The amount of water used per cow will vary widely depending on the size and design of facilities and the frequency of flushing. Amounts need to be calculated individually for each farm. However, usually a flush of about 3,000 gal is needed to clean an alley width of 10 to 16 ft. If four alleys are common for every 400 cows and alleys are flushed twice daily, this would be an average use of 60 gal/cow/day. Many dairies use more flushings per day.

Draining Rainwater from Roofs and Concrete Areas

Rainwater entering wastewater holding areas accumulate significant quantities on many dairies. For the example dairy representing typical minimum water usage with a flush system (Table 4), the net accumulation during the hot season (also the wet season in Florida) was calculated as follows: assumed wastewater holding area is one acre surface area/100 cows, net rainfall accumulation in holding area is 3 inches more than evaporation per month, concrete areas and/or undiverted roof areas that capture rainfall are 15,000 sq ft/100 cows that divert 15,000/43,560 sq ft per acre of the 3 inches to the wastewater holding facility. Thus, 3 inches plus 0.344 x 3 = 4.03 acre-inches per month or essentially 1.0 acre-inch per week/100 cows (approximately 27,000 gallons/100 cows).

Recycling Wastewater through Crop Irrigation

Most often nitrogen is the nutrient on which manure application rates are budgeted. To maximize nutrient uptake, crop growth should be as vigorous as possible. This requires irrigation during most of the year in Florida. Thus, flushed wastewater can be disposed through an irrigation system that also serves to apply additional amounts of irrigation water to optimize the nutrient recycling. In southern regions, multiple cropping systems are possible which will effectively recycle nitrogen excretions from 100 cows on a sprayfield or manure application field of about 30 acres (see Van Horn et al., IFAS Circular 1016).

Tentative estimates of total water needs of the growing crops average about 1.75 inches of water per week (.25 inches per day) from irrigation plus rainfall with a minimum of .5 inches per week tolerated even in rainy season on sandy soils. The basis for this follows.

Florida receives 50 to 60 inches of water per year from natural rainfall. This amount of rainfall could provide much of the water required to produce relatively good yields for crops to grow continuously 12 months out of the year. However, most of this water comes during the summer months so that distribution is inadequate for good utilization. Estimated total water requirements for two triple cropping forage systems are shown in Table 2. These total water requirements were developed from the estimated amount of water required per unit of dry matter produced for different crops and estimates of dry matter yield.

Another problem with utilization of either rainfall or irrigation water is the sandy texture of most Florida soils. Sands will only hold small amounts of water for crop use at any one time. When

we have large amounts of rainfall some may run off the soil surface, some is evaporated, some percolates through the soil quickly, and very little is held for crop use.The sandy soils of north central Florida will likely only hold about 1.0 inch of water per foot of soil depth. This amount would be higher in the clayey soils of northwest Florida, maybe about 1.5 to 1.75 inches per foot of soil depth. From research and personal experience, it has been estimated that 8 to 10 inches of extra irrigation water are needed above rainfall to net the total 20 to 25 inches required to grow a corn crop.

There is limited information on water use for multiple cropping. Data suggest spring corn could require 8 to 14 inches of irrigation and the fall crop slightly less. If 6 to 8 inches were applied to supplement rainfall for winter wheat or rye, then for triple cropping systems of wheat-corn-corn or rye-corn-forage sorghum one might need total supplemental irrigation in the range of 25 to 35 acre-inches per year. These estimates are for efficient utilization of water

Table 3 utilizes previous logic to estimate water use per week in a triple cropping program which would maximize fertilization with manure nutrients. Average weekly use of water by triple cropping is about 1.75 inches per week.

Developing a Water Budget for the Dairy Farm

A wide range exists in amount of water usage on dairy farms. If the dairy waste management system was designed to utilize flushed manure nutrients through cropping systems grown under irrigation, the water used at the dairy should be reused through irrigation. If water amounts are small in relation to irrigation needs for crop production, liberal use of water for cow washing, cow cooling, and manure flushing is not a use problem. For some farms it might make sense to consider constructing storage structures for holding wastewater until it is needed for irrigation. The example water use budgets shown in Table 4

Table 2. Crop yield and water requirement estimates for two triple cropping forage systems.[1]

Crop		Silage yield			Water required			
No	Name	Ton/A 35% DM	Ton/A DM	lb/A DM	lb/ lb DM	lb/A total	gal/A total	A-inch total
1	Wheat	10	3.5	7,000	500	3,500,000	419,362	15.4
2	Corn	24	8.4	16,800	368	6,182,400	740,762	27.3
3	Corn	14	4.9	9,800	368	3,606,400	432,111	15.9
	TOTAL	**48**	**16.8**	**33,600**		**13,288,800**	**1,592,235**	**58.6**
1	Rye	10	3.5	7,000	500	3,500,000	419,362	15.4
2	Corn	24	8.4	16,800	368	6,182,400	740,762	27.3
3	F. Sorghum	18	6.3	12,600	271	3,414,600	409,130	15.1
	TOTAL	**52**	**18.2**	**36,400**		**13,097,000**	**1,569,254**	**57.8**

[1]A = acre, No = number, DM = dry matter.

Limited data are available on the maximum amount of water that could be applied without reducing yield or quality of forage or resulting in pollution of ground water with nitrates and other minerals. However, the maximum probably is at least 35 to 45 inches per year above the minimum acre-inch totals previously discussed if the water is distributed adequately throughout the cropping cycles and if nitrogen concentrations are not too high

illustrate that water usage on dairies is probably small in comparison to irrigation needs when there are 30 acres of sprayfield/100 cows. Conversely, the amounts used in most Florida dairy systems would be large and unmanageable if application through irrigation were not an option or if less acreage for irrigation were available than needed for application of all manure nutrients.

If a dairy does not have acreage available close by to utilize manure nutrients and water through an

environmentally accountable sprayfield application system, it will be necessary to export nutrients off the farm, preferably as solid wastes to avoid excessive hauling or pumping costs. Under these conditions it will be important to exclude as much water as possible from the manure management system. If the water and manure nutrients cannot be used through irrigation, a non-flush system should be utilized. However, usually some irrigation is possible, permitting some use of water for flushing to further clean up areas such as feeding lanes after the bulk of the manure is scraped and hauled.

Strategies to Minimize Water Usage

Table 4 presents one column indicating a theoretical minimum amount of water use on a dairy. This system implies that cows are clean enough and cool enough that sprinkler washers are not needed to clean and cool them while they're being held for milking. Also, it is assumed that all of the manure is scraped and hauled to manure disposal fields or transported off the dairy in some other fashion. Intermediate steps might include:

- Scraping and hauling manure from high-use areas such as the feeding barn so that this manure can be managed off the dairy.
- Using wastewater rather than fresh water to flush manure from feeding areas and freebarns.
- Using a housing system that will keep cows clean enough so that cow washers are not needed to clean cows before milking. This system, however, may require use of altersprinklers and fans to keep crowded cows cool during hot weather.

If flushing is desired in conjunction with scraping and hauling from heavy use areas, perhaps the feeding area could be flushed with recycled water after scraping to clean the area. These procedures would reduce total nutrient loads retained in wastewater and would significantly reduce the size of the sprayfield needed for water and manure nutrient recycling

Suggested References

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Table 3. Average daily and weekly water used by triple cropping systems based on crop water use and rainfall assumptions. All values are in inches.

Irrigated water needed to triple crop	Estimated yearly rainfall	Total water	Average daily water	Average weekly water
20	50	70	.19	1.34
25	50	75	.21	1.44
30	50	80	.22	1.53
35	50	85	.23	1.63
40	50	90	.24	1.73
45	50	95	.26	1.82
20	55	75	.21	1.44
25	55	80	.22	1.53
30	55	85	.23	1.63
35	55	90	.24	1.73
40	55	95	.26	1.82
45	55	100	.27	1.92
20	60	80	.22	1.53
25	60	85	.23	1.63
30	60	90	.24	1.73
35	60	95	.26	1.82
40	60	100	.27	1.92
45	60	105	.29	2.01

Table 4. Estimated water budgets for three example dairies. All values are gallons unless otherwise noted.

Water use in the dairy	Typical need during hot season	Common usage on some dairies	Theoretical minimum	Worksheet for your dairy
Drinking (cows)	25	25	25	
Cleaning cows	32	150	0	
Cleaning milking equipment	3	5	3	
Cleaning milking parlor	30	30	6	
Sprinklers for cooling	25	130	12	
Flushing manure	60	80	0	
Total use/cow/day	175	400	46	
Total use/100 cows/day	17,500	40,000	4,600	
Use/100 cows/week	122,500	280,000	32,200	
Water in milk/100 cows/week	4,500	4,500	4,500	
Estimated evaporation (@20% of use)	24,500	56,000	6,440	
Average rainfall and watershed drainage into storage facility/100 cows/week	27,000	27,000	13,000	
Wastewater produced from 100 cows/week	120,500	246,500	38,760	
Acre-inches/100 cows/week	4.44	9.08	1.43	

Example calculations (column 1):
Total use/cow/day = 175 gal
Total use/100 cows/wk = 122,500 gal less 4,500 in milk and 24,500 gal evaporation = 93,500 gal/wk
Net rainfall and watershed drainage to storage/100 cows/wk = 27,000
Acre inches/100 cows/wk = (93,500 + 27,000)/27,152 gal per acre-inch = 4.44
If 30 acres were in sprayfield, 4.44/30 = .15 inches/wk
If crop needed 1.75 acre-inches/wk (a common average), a total of 1.75 inches x 30 acres x 27,152 gal/acre-inch = 1,425,480 gal is needed of which only 120,500 gallons (8.5%) would come from dairy wastewater. The remaining (91.5% of total) would have to come from rainfall or fresh irrigation water.