Scientific Data for Developing Water Budgets on a Dairy

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Introduction

The water needs of lactating cows, milk parlor usage, and other functions on the dairy require a minimum water supply of 40 to 50 gallons per day per cow (gpd/d; Allen el al., 1974; Bailey et al., 1993; Beede, 1992; MWPS-7, 1997). Ten to 20 percent of the daily water requirements of a dairy cow can come from feed (Ishler, 1998), but lactating cows require anywhere from 25 to 40 gallons of drinking water per day (gpd). Brouk et al (2001) metered water flow into water troughs located on several freestall dairies and found that Holsteins' water requirements ranged from 30 to 40 gpd/cow and less than 25 gpd/cow for Jerseys.

Water Consumption by Dairy Cows

Dairy cows require large amounts of daily water. Sources of water for the dairy cow include: 1) drinking or free water, 2) water (moisture) in feed, and 3) metabolic water. Metabolic water is insignificant compared with water ingested freely or contained within feeds. Some major factors affecting water intake by dairy cattle are dry matter intake, milk production, dry matter content of the diet, temperature and environment, and sodium intake (NRC, 2001).

Brouk et al (2001) studied the difference in water consumption based on the location of the water trough in a freestall building during summer months on three dairies in northeast Kansas. Results showed that more water was consumed at the center cross alleys than end cross alleys (Table 1). McFarland et al (1989) reported similar results in an earlier study. Brouk et al (2001) also found that cows consumed about 8 percent of their daily water needs at watering troughs located near the parlor exit. In addition, daily refilling of water troughs after tipping was equal to 10 to 15 percent of the daily drinking water requirements. They reported average water consumption ranged from 35.0 to 45.2 gpd/cow when cows were housed in the 4-row freestall barns. The ratio of water consumption to milk production ranged from 3.6 to 5.4 lbs of water per lb of milk, while average milk production per pen ranged from 56 to 98 lbs/cow/day. Water consumption ranged from 24.2 to 28.1gpd/cow in the 2-row freestall, and the water to milk ratio ranged from 2.6 to 3.5. These values did not include water drunk at the milk parlor exit. Approximately 9 percent of the drinking water requirements were met from the two additional water troughs located along the back alley of the free stall. On a third dairy, water consumption ranged from 28.8 to 30.3 gpd/cow with milk production ranging from 64.3 to 85.6 lbs/cow/day. The water to milk ratio ranged from 2.9 to 3.8, while the water to feed ratio averaged 4.2. The general trend showed decreased total water usage as milk production increased. The water to milk ratio generally ranged from 3 to 4 lbs of water per lb of milk. When the water requirements for the milk parlor and heat abatement were included, the values are similar to those reported by Reinemann and Springman (1992).

Table 1: Percentage of drinking water utilization at various locations within pens in a dairy containing two water troughs in each cross-over alley

Location of Water Trough	Location in Cross-over	Percentage of Total Utilization	Percentage of Location within Cross-over	Percentage of Total Water Utilization by Cross-over
Pen Exit Cross-over	Feedlane	12.0	62.2	19.3
	Stall	7.3	37.8	
Cross-over between exit and middle	Feedlane	16.1	62.2	25.9
	Stall	9.8	37.8	
Middle Cross-over	Feedlane	15.9	58.2	27.3
	Stall	11.4	41.8	
Cross-over between middle and end of pen	Feedlane	10.9	62.3	17.5
	Stall	6.6	37.7	
Pen End Cross-over	Feedlane	5.5	55.0	10.0
	Stall	4.5	45.0	

Peak water intake for cows occurs during the hours when feed intake is greatest. When given the opportunity, cows tend to alternately consume feed and drink water. Ideally, fresh, clean water should be available within 50-60 ft of the feeding area whenever the cows consume feed. If a cow's water consumption declines by 20%, then dry matter intake will decrease by 1 to 2.5 lb/d; this reduction in water intake could suppress milk yield up to? 5 percent.

Andersson and Lindgren (1987) studied cows' water consumption by restricting access to water during feeding. The treatments included a control (in which cows had free access to drinking water), no drinking water for one hour after feedings, and no drinking water for two hours after feedings. They reported that cows prefer to have water available during feeding. However, cows will consume 60 to 80% of total water intake within a few hours after feeding. There were no differences in water intakes between treatments once water was made available; however, the cows with free access to drinking water drank within 15 minutes after eating (Andersson and Lindgren, 1987).

Severe water restrictions can have a profound impact on productivity and feeding behavior of cattle. Steiger Burgos et al. (1999) evaluated the impact of 50 and 75% restrictions of water intake for 8 days. Restricting water intake by 50% resulted in a 21.3% decrease in 24-h feed intake, a 57.4% reduction in the size of the first meal, and a 41% increase in the number of meals per 24 hours. The 75% reduction in water intake resulted in an 11.3% decrease in 24-h feed intake, a 53% reduction in the size of the first meal every day, and a 31% increase in the number of meals per 24 hours. A reduction in the size of the first meal each day by greater than 50% accounted for most of the suppression in feed intake.

Data collected during a study comparing the impact of fiber (Dado and Allen, 1995) indicated cows drink about 1.5 gal of water per trip to a watering trough at a 1.27 gallons per minute (gpm). Dado and Allen (1995) results showed t cows will consume their daily water requirements in 12 to 16 minutes (Dado and Allen, 1995).

Dry matter content of the diet has been shown to affect the free water intake. Holter and Urban (1992) showed a decrease in ration dry matter from 50 to 30 percent resulted in a decrease in free water intake by 8.75 gpd. Ration dry matter percent can have a negative impact when considering total water intake. When ration dry matter percent increases, free water intake increases but total water intake decreases. Murphy (1992) attributed for this because of the need to excrete more N and K in urine when feeding wet diets. Holter and Urban (1992) concluded that this is only relevant to cows on high protein pasture or succulent silage. Table 2 shows the ration water (gpd) available as a function of dry matter and ration moisture content. For example, 6 gallons of moisture (water) are available if a ration is formulated for 50 lbs of dry matter intake and has a moisture content of 50 percent.

Table 2: Gallons of ration water available as a function of dry matter intake and ration moisture content (%)

Ration MC (% wet basis)	Dry Matter Intake (lb/c/d)		
	40	50	60
	Feed Water Intake, gal/d		
40	3.2	4.0	4.8
45	3.9	4.9	5.9
50	4.8	6.0	7.2
55	5.9	7.4	8.8
60	7.2	9.0	10.8
65	9.0	11.2	13.4

Dewhurst et al. (1998) performed an experiment to examine the effects of silage characteristics on water intake. In this study, 16 silages were used with dry matter ranging from 15.9 to 28.0 percent. Free water intake ranged from 5.3 to 23.8 gpd, total water intakes from 12.8 to 32.8 gpd, and milk production from 36 to 85 lb/d. They found that free water intake increased with increasing silage dry matter concentration. Their study also confirmed other reports suggesting that free water intake replaces silage water at a rate less than 1:1.

Winchester and Morris (1956) found water intake per unit of dry matter intake remained constant from 10 to 40°F. From 10 to 40°F, cows consumed about 0.16 gal (1.36 lb) of water per lb of dry matter intake. At the peak of 90°F, cows consumed 0.38 gal (3.18 lb) of water per lb of dry matter intake.

Andersson et al. (1984) looked at the effect of 0.5, 1.8 and 3 gal/min water flow rates on water consumption of Swedish Red and White Breed cows in tied stalls. Using flow rates of 0.5, 1.8 and 3 gal/min, they reported the cows drank 2.5 and 3.3 gpd more water with the increased flow rates, while each group’s time spent drinking decreased from 37 min/d on the low flow rate to 7 min/d on the high flow rate. The cows also had more drinking events per day with low flow rates (40 times/d) than with high flow rates (30 times/d). While the cows spent more time drinking, the flow rates did not affect milk production or dry matter intake. However, at the high flow rates there was a tendency for increased milk production. These results indicate that cows will adapt to slower flow rates by changing their drinking behavior (Andersson et al., 1984).

Murphy et al. (1983), Holter and Urban (1992), Little and Shaw (1978), Stockdale and King (1983), Castle and Thomas (1975), and Dahlborn et al., (1998) have published formulas for predicting water consumption. The Murphy et al. (1983) formula is as follows:

$$FWI = 15.99 + 1.58 \times DMI + 0.90 \times MY + 0.05 \times SI + 1.20 \times Temp_{min}$$

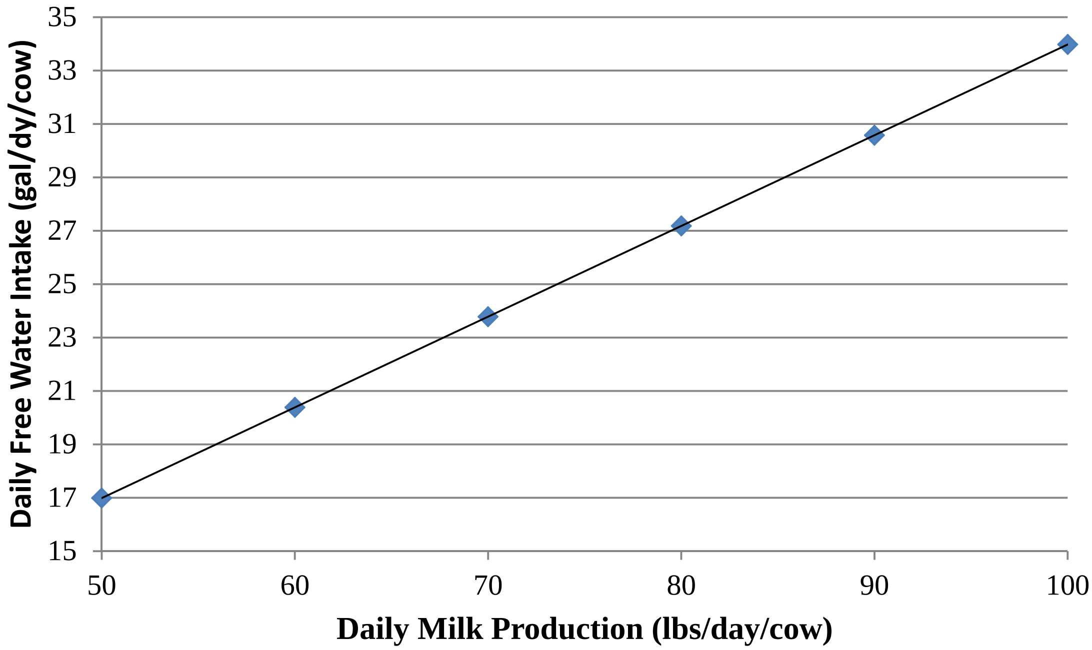
Where: FWI is free water intake (kg/d),
DMI is dry matter intake (kg/d),
MY is milk yield (kg/d),
SI is sodium intake (g/d) and
$Temp_{min}$ is minimum temperature (°C).

The 2001 NRC recommendations used the formula developed by Murphy et al. (1983) to estimate free water intake. This formula shows that drinking water changes 1.58 kg for every 1 kg of change in dry matter intake (DMI), .90 kg for every 1 kg in milk yield, 0.05 kg for each 1 g change in Na intake, and 1.20 kg for every 1°C change. This also shows that dry matter intake, minimum temperature, and milk yield have more influence on drinking water intake than sodium intake. Potts (2012) developed a meta-analysis using data from 50 individual studies recording water intake by dairy cattle. Ration water intake (RWI) was calculated from the dry matter intake and percent dry matter reported. Table 3 reports the actual free water intake from the data set and what the prediction equations estimate for FWI using the meta-analysis data points. Using the 116 data points, the ratio of free water intake to milk yield averaged 2.82, and Figure 1 shows the relationship between daily milk production and free water intake based on this average, as reported by Potts (2012). Daily water requirements are proportional to increased milk production.

Table 3: Comparison of four prediction equations of FWI[1] regarding actual water intakes and milk efficiency from all data points (116) where dry matter intake, ration water intake and milk yield were reported

Data Source	Estimated Free Water Intake (gal/cow /day)	Predicted milk efficiency (lb water/ lb milk)
Actual	21.4	2.82
Little and Shaw (1978)	20.1	2.64
Stockdale and King (1983)	10.2	1.35
Potts et al. (2012)	21.4	2.82
Castle and Thomas (1975)	22.6	2.92
Dahlborn et al. (1998)	18.7	2.46

Figure 1: Relationship between daily milk production and free water intake assuming an average water intake to milk ratio of 2.82 across all milk production levels (Potts, 2012)



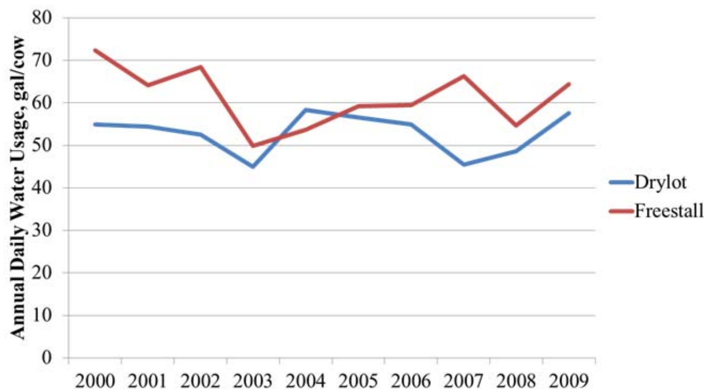
Overall Water Usage on Dairies

Brugger and Dorsey (2008) compiled total dairy farm water usage from January 1, 2005 to December 31, 2006. This study was conducted on a 1,000 cow dairy farm in northwest Ohio where the average high temperature was 60˚F and the average low temperature was 39˚F. Over 2 years, the total farm water usage (parlor, drinking, cooling, etc) averaged 29.6 gpd/cow. Free water intake by the dairy cows was lowest at 11.6 gpd/cow during the month of December 2005 and highest at 33.8 gpd/cow in July 2005. The cows alone consumed an average of 23.3 gpd/cow of free water intake over the entire study. No information on milk yields, dry matter intakes or ration moisture content was provided.

Bray et al. (2008) published water budgets for Florida dairy farms by using the equation shown previously from Murphy et al. (1983) to predict water intakes. The estimated average consumption was 25 gpd/cow. It was noted that cows under heat stress can require 1.2 to 2 times more water per day. The study by Brugger and Dorsey (2008) showed peak summer water consumption was 1.45 times the annual average.

In the state of Kansas, dairies diverting more than 15 acre-feet of water are required to have meters on their wells to monitor and regulate fresh water pumping (KDHE, 2008). Potts (2012) evaluated dairy farms that were using 15 acre-ft or more of water located in western Kansas. Fresh water pumping records were accessed from the state's Division of Water Resources in Topeka, KS. Twenty-four dairy farms consisting of 10 dry lot dairies, 12 freestall dairies, and 2 dairies using both freestalls and drylots were used to compile 10 years (2000-2009) of fresh water pumping records (Figure 2). The dry lot dairies' average size was 4,387 cows and the freestall dairies averaged 3,632 cows. During this time, all of the farms together averaged 57 gpd pumped/cow. The dry lot dairies averaged 52.6 gpd/cow and the freestall dairies averaged 61.4 gpd/cow. The variation in water usage by facility may be caused by differences in parlor water usage, milking frequency, cow cooling, wash pens, herd size, heifer production and water recycling.

Figure 2: Comparison of average use of water by DL and FS facility over 10-year period with outliers removed



Zuagg (1989) summarized the daily water usage on five dairies in Arizona (Table 4). Early lactating cows drank between 29 and 35 gpd/cow while late lactating cows drank 25 to 28 gpd/cow. This was a function of milk production and feed intake. Water consumption was less than 20 gpd/cow during the dry cow period on all of the farms. Water usage on a dairy varied from 72 to 186 gallons per lactating cow per day and averaged 127 gpd/cow. In reviewing the data in Table 4, wash pens accounted for 37.5% of the total water usage per cow on average. Comparing water usage on Dairies B, C, and D, where some form of heat abatement was implemented and heifers beyond 6 months were not raised on the dairies, the average water usage was 89.3 gpd/cow when considering the water used in a wash pen and 58.6 gpd/cow when the water used in the wash pen was omitted. For the 5 dairies, the wash pen water usage ranged from 19 to 93 gpd/cow and averaged 50 gpd/cow. However, on dairies B, C, and D, the water usage in the wash pen averaged 30.6 gpd/cow. Water usage in the milk center, excluding the wash pen, ranged from 2.3 to 18.3 gpd/cow and averaged 11.2 gpd/cow. Dairies A and E (Table 4) utilized about 6 gpd/cow with the vacuum pump.

Brugger and Dorsey (2008) conducted the most thorough study metering water at 13 different locations on a dairy in northwest Ohio. The average fresh water usage was 29.6 gpd/cow. However, milk production and feed ration composition were not included in this paper. In addition, only 1 gpd/cow was used for cooling so there was minimum heat abatement on the dairy.

Table 4: Summary of daily water usage on five dairies (adapted from Zaugg, 1989)

	Dairy Identification and Milking Frequency				
	A(3X)	B(3X)	C(2X)	D(2X)	E(3X)
Calf include from 0 to 6 month	No	Yes	Yes	Yes	Yes
Heifers include from 6 to 22 months	No	No	No	No	Yes
Dry & Close-ups cow (D–dry * C- close ups)	D	D & C	No	No	D & C
Cooling (M – Milk Center & P – Pen)	M only	M & P	M & P	M & P	M & P
Total Water Usage per Lactating Cow (gpd)	186	101	95	72	182
Wash Pen Usage per Lactating Cow (gpd)	93	49	19	24	65
Drinking Water per Lactating Cow (gpd)*	71.2	32.2	59.3	40.1	81.1
Milk Center Usage per Lactating Cow (gpd)**	18.3	2.3	7.7	3.3	14.5

* Includes water for dry cows, close-ups, calves and heifers
** Includes water reported usage for vacuum pump

Water Usage at the Milk Center

The milking parlor facilities in a dairy have been shown to use the largest amounts of water (Sweeten and Wolfe, 1993; Gamroth and Moore, 1995, Meyer et al. 2006). Meyer et al. (2006) evaluated parlor water use on 16 dairies to calculate the amount of water flowing into dairy lagoons and holding ponds. The data for this study was collected over a 9 to 12 month period from August 1998-August 1999. Parlor water use was based on readings from the milk house, milking parlor, and sprinkler pens, and included water used for udder hygiene, milk equipment sanitation, parlor cleaning, plate coolers, and ice makers. They found parlor and udder hygiene water comprised an average of 56% of the total water entering the farms' lagoons. The water usage ranged from 45 to 194 gpd/cow with an average of 78.5 gpd/cow, showing the variability among farms and the large amounts of water that are used in milking facilities. Like the other studies, they reported that parlor water use was consistent throughout the year on each farm (Meyer et al., 2006). A second study in California (Castillio and Burrow, 2008) measured parlor water use in Merced County dairies. They chose 3 different dairies and installed 64 water meters. The average water use in the parlors on the 3 farms was 44, 51, and 49 gpd/cow. It should be noted that water usage tends to be higher in Western states since irrigation is required to raise crops. Dairies tend to utilize the pumped water first for an application on the dairy and then the water is recycled with nutrients onto cropland. . In this scenario, the net water depletion may be neutral depending on irrigation scheduling and crop water utilization.

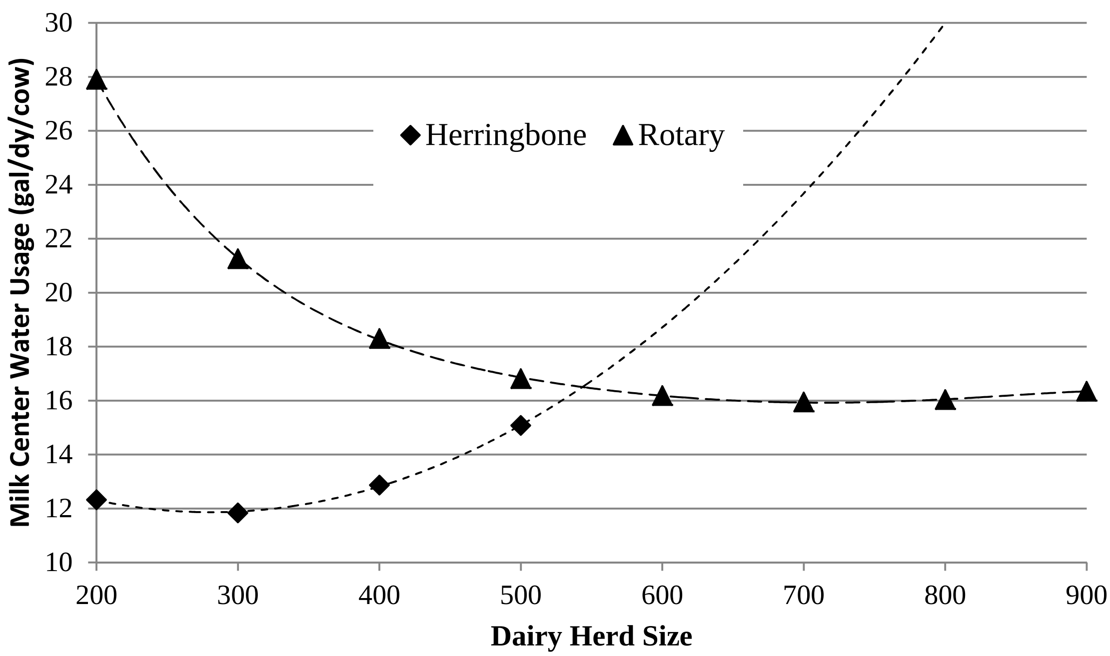
In contrast to the previous warm climate California studies, Janni et al. (2009) measured parlor water use on 16 Minnesota dairy farms. These dairies were much smaller in size, ranging from 41 to 130 milking cows. A range of 2.3 to 9.86 gpd/cow was used in the parlor, similar to the values reported by Zaugg (1989) on dairies B, C, and D in Table 4.

In Northwest Ohio, Brugger and Dorsey (2008) found that the average water intake was 6.3 gpd/cow for parlor water. They also noted that this was a consistent annual usage rate without seasonal variation. Bougie (1993) studied milk house waste water characteristics on 5 farms in Wisconsin and reported average usage ranging from 3.0 to 5.5 gpd/cow (Bougie, 1993).

Meyer et al. (2006) reported that dairies with wash pens averaged 80 gpd/cow, while dairies without averaged 53.4 gpd/cow. This data is similar to the findings of Zaugg (1989). On Texas dairies, Sweeten and Wolfe (1993) found that milk centers with flush systems used 47 gpd/cow and scrape systems used 20 gpd/cow.

The most comprehensive study involving water usage in the milk center was conducted in Victoria, Australia, where water usage on 780 dairies was analyzed (Williams, 2009). Water usage varied among herds of similar size, as noted in previous studies. Figure 3 shows the predicted 75th percentile recommended water usage for dairies based on herd size, defined by the industry as the "upper limit of what is 'reasonable' dairy water use for Victorian dairy farmers." Figure 3 show with herringbone parlors use more water per cow as herd size increases With rotary parlors, water usage tends to level out after 500 cows at 16 gpd/cow. This extensive data suggest an upper limit of 'reasonable' dairy water use equal to 16 gpd/cow in the milk center.

Figure 3. 75th percentile recommended reasonable water usage for Australian dairies based on parlor type and herd size.



Many dairies have reduced water usage in the milk parlor by changing udder prep procedures. Dairies using hand-operated wash hoses or automatic prep systems utilize between 1 and 4 gallons per cow per milking. Water usage can be reduced to less than ½ gallon per day when using low water techniques such as single service towels. Ludington and Sobel (1992) reported hot water usage dropped from 3.4 gpd/cow to 0.69 gpd/cow when changing to dry prepping with pre and post dip. Reinemann and Springman (1992) recommend sizing the water requirements of plate coolers based on 1 to 2 lbs of water per lb of milk. Water usage may be less than 1 to 1 if no attempts are made to control water and milk flow. Spencer (1992) also notes water usage with a pre-cooler may be twice as much as the milk production while accounting for 30 to 50 percent of the cooling requirements.

Fresh or clean water is required when flushing the parlor platform and holding pen. Water can be recycled from the plate cooler to perform this task. Weeks (1992) reported that 7.5 gpd/cow was required for flushing the milk parlor and holding pen. However, the milk parlor was only used several hours per day. Some data suggest an adequate flush can be obtained using 1.3 gallons per sq. foot per flush (Moore, 1989).

Heat Abatement

Low pressure sprinkler systems are used to wet the cow's skin surface for evaporative cooling and can be used in the holding pen and along the feed lane. Bray et al. (1994) reported water usage for low pressure systems ranging from 18.6 to 56 gpd/cow. They referred to a study by Montoya (1992) which found that 23 percent of the water was generally evaporated and 15 percent of the total water applied evaporated from the cow's body. This rate of evaporation equaled about 1.1 gallon per cow per hour. Bray and Bucklin (1995) recommend applying 0.05 inches per cycle when sprinkling cows. This converts to 0.03 gallons per square foot of wetted area. A cow will have about 12 square feet of wet area based on 2 ft along the feed line and 6 ft for cow length.

Sprinkler water usage was also recorded in a study by Meyer et al. (2002). This study was conducted over a 70-day period on 156 Holstein cows in August and September on a commercial dairy in Kansas. Three different cooling systems were studied to determine which was the most effective. Axial fans were used over freestalls and feed line, ceiling fans were used over freestalls, and poly tube cooling was also used over freestalls. Sprinklers were set up on 15 min cycles of 3 min on and 12 min off and were activated above 75°F with a rate of application of 16 gpm. Total water usage from the sprinklers from across all experiments came to 2,651gpd or 17 gpd/cow.

Lin et al. (1998) also recorded sprinkler water usage over a 2-year study during the summer months. During the first summer, maximum daily temperatures ranged from 81.5 to 90.5°F and the sprinklers used 11.3 gpd/cow. During the second summer, daily temperatures ranged from 89.4 to 99.5°F and the sprinklers used 27.2 gpd/cow. Sprinklers were set to run 3 min out of every 15 min and turned on when ambient temperature exceeded 82°F (Lin et al., 1998).

Evaporative pads are another method used to cool cows. Evaporative pads are designed to cool the air around a cow's body to reduce heat stress (Harner et al., 2007). Harner et al. (2007) presented their findings on the water usage of evaporative pads. The water usage data in this presentation were collected from a cross ventilated barn which housed 1,200 dairy cows in the upper Midwest. Water measurements were taken from July 1 to July 31. Total water used during this time was 480,000 gallons and average use per cow was 13 gpd/cow (Harner et al., 2007).

Developing Water Budgets based on Scientific Data

Scientific data collectively may be used as an initial step to developing a water budget on a dairy. The following assumptions are based on the data presented in this paper and routine mathematical calculations:

- Milk production per cow is 80 lbs/d
- Feed consumed is 52 lb dry matter at 50% dry matter

- Water consumption is 3X milk production.
- Plate cooler water is 1.5X milk production.
- Milk center water is 6 gpd/cow, excluding deck flushing.
- Decking flush requires 12 gpd/cow.
- Dry cows are 20% of lactating cows and drink 15 gpd.
- Water troughs are cleaned daily at 10% of free water intake. Most will only clean once per week unless the water is used to flush the cross-over.
- Free water intake is 90% of total water requirements.
- Heat abatement lasts 120 days and requires 15 gpd/cow during abatement season.

These assumptions were used in developing the water budget for a dairy, as shown in Table 5. The total clean or potable water required per day was equal to 72.0 gpd/cow; however, 14 gpd/cow used for milk cooling were assumed to be used for drinking water or flushing the decks.
This results in an annual average daily net water usage (pumped from groundwater or purchased) of 57.2 gpd/cow. If milk inspection allows decks to be flushed with non-potable water, then the plate cooling water would be used for drinking purposes and the net requirement is only 43.2 gpd/cow. The water budget in Table 5 shows that the three biggest uses of water are for drinking, plate cooling, and deck flushing. Immediate water uses include parlor cleaning and heat abatement. There are limitations in using the data for developing water budgets, however, since data on water used for calf and heifer production and in hospital areas are not included. The data may provide a realistic estimate of water usage on a dairy, though, and a starting point for developing a water footprint for a dairy based on scientific data.

Table 5: Average water budget for a lactating cow based on stated assumptions in the text and current scientific data

	Annual Daily Water Required per Lactating Cow (gallon/day)	Percentages	
		Net Water Pumped Required*	Total Clean Water Required**
Free Water Intake	28.8	50.0	40.0
Ration Water Intake	3.2		
Total Water Intake	32.0		
Dry Cow Allowance	2.2	3.9	3.1
Water Trough Cleaning	2.9	5.0	4.0
Parlor Usage	6	10.1	8.4
Decking Flush	12	21.1	16.9
Heat Abatement	4.9	8.7	6.9
Plate Cooler	14.4		20.2
Total Clean Water Required	71.2		
Clean Water Reused	14.4		
Net Water Required	56.9		

*Newt water is the percentage of water pumped from ground water or purchased
** Total clean water is the percentage of total clean water required per day and assumes the plate cooler water is recycled and used in an application where potable water is required such for drinking

Summary

Many scientific controlled and field studies have explored water usage on dairies and water intake by dairy cattle. Unfortunately, comparing data is difficult due to the uniqueness of each study. Based on information reviewed, the following is a summary of the water data supported by multiple studies.

- Drinking Water & Cooling
  - 80 to 90 % of water consumed is free water.
  - 3 lbs of free water are drunk per 1 lb of milk produced.
  - Depending on milk production, cows will drink 25 to 40 gpd.
  - Water consumption is higher during the summer months and may be 1.5 to 2 times more than in cooler months.
  - 50% of water is consumed within 1 hour after eating.
  - Heat abatement, while dependent on location, requires 15 to 20 gpd/cow during summer months.
  - Cows will consume 8% of drinking water requirements at watering trough located near the milk center when exiting.
  - If water troughs are tipped and cleaned daily, assume increase in drinking water requirements of 10%.

- Wash Pens
  - Wash pen usage ranges from 20 to 100 gpd/cow and, depending on the study, averages 50 to 75 gpd/cow.
  - Reasonable usage may be 30 to 40 gpd/cow.
  - Wash pens on average account for 30 to 40% of total water used on a dairy.

- Milk Center
  - Water usage is variable, but 15 gpd/cow seems to be upper reasonable limit.
  - Many dairies are operating milk centers using less than 5 gpd/cow, so a reasonable target is 5 to 10 gpd/cow.
  - Water flow through plate coolers should be monitored and reduced on many dairies.
  - Reasonable plate cooler ratio is 1 to 2 lbs of water per lb of milk with a target of 1.5 or lower.
  - Dairies using water for cooling milk should recycle the water for other clean water applications such as flushing decks or drinking.

- Overall
  - Total water usage on dairies is 4 to 5 lbs of water per lb of milk but with a target of 4 if parlor decks are scraped and 5 if parlor decks are flushed with potable water. The water/milk ratio will be higher for dairies using wash pens.
  - Without wash pens, water usage should be less than 60 gpd/cow with a reasonable target of 50 gpd/cow. For herds with lower milk production, 40 gpd/cow may be reasonable.
  - Water usage on dairies will be 50% in housing areas and 50% in the milk center; however, the actual ratio is dependent on milk center procedures, manure handling,

housing of non-lactating animals such as heifers or dry cows, heat stress management etc.

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