

## Water Quality for Virginia Dairies

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## Essential Functions of Water

- Water is second only to oxygen to sustain life
- A high-producing dairy cow has the highest water requirement per kg of bodyweight of any land mammal



- 87% of milk is water
- digestion and metabolism
- nutrient transport
- excretion of wastes
- proper fluid & ion balance
- thermoregulation
- environment for fetus

## Yet....

- Many wait until there is a suspected problem to monitor drinking water quality – testing is often a last resort to figure out what is going on with herd health, production, etc.
- Routine testing of a water source is the only way to know what is normal – allows understanding of baseline
- Rations developed with precision – shouldn't water quality be a factor?




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## Water Requirement

- Many factors influence water requirement
  - physiological stage
  - milk yield
  - body size
  - level and kind of activity
  - environment ( $T^0$ , relative humidity, and air movement)
  - diet composition (% of conc. and forages)
  - nutrient composition (N,  $Na^+$  and  $K^+$  %)
  - quality of water source



- 97% total DWI of a dairy cow is from drinking water

## Predicting Water Intake – Lactating Cows

- Significant factors: milk yield (MY), DMI, dietary DM
- Other factors: sodium intake, daily temperature
- Predicting equations:

$$DWI (kg) = 2.53 \times (MY, kg/d) + 0.45 \times (DM\%) - 15.3$$

(Castle and Thomas, 1975)

$$DWI (kg) = 0.90 \times (MY, kg/d) + 1.58 \times (DMI, kg/d) + 0.05 \times (\text{sodium intake, g/d}) + 1.20 \times (\text{average minimum daily temperature, } ^\circ\text{C}) + 15.99$$

(Murphy et al. 1983)

## Predicting Water Intake – Lactating Cows

MY (lb/d)	DMI (lb/d)	DM%	Drinking Water Intake (DWI)	
			Castle & Thomas, 1975	Murphy et al, 1983*
55	44	60	165 lb	191 lb
66	48	60	193 lb	208 lb
77	53	60	221 lb	225 lb

\*Sodium intake = 44g/d and average minimum  $T^0$  = 12°C

- These are only estimates of mean water intake; many factors affect.
- Actual water intake of a group of cows can range from PREDICTED VALUE  $\pm$  (15 – 20% of the predicted value)

## Predicting Water Intake – Dry Cows

$$DWI \text{ (kg)} = 2.212 \times (DMI, \text{ kg/d}) + 0.2296 \times (DM\%) + 0.03944 \times CP\% - 10.34$$

(Holter and Urban, 1992)

DMI (lb/d)	DM%	CP%	Drinking Water Intake (DWI)
			Castle and Thomas, 1975 kg (lb)
22.1	45.0	14.0	49.9 (99.8)
26.4	45.0	14.0	59.6 (131.8)
30.8	45.0	14.0	69.3 (152.6)

### Factors Affecting Water Intake

- Mineral and iron content of feed and ration
  - High K diet (>4.25% of DM) increases water consumption
  - Dietary CP (increasing from 12% to 13% increases water intake by 2.2 lb/day)
- Environmental temperature
  - At 90°F drink 2 to 4x more water than 36 - 50°F
- Drinking water temperature has no effect on energy and protein digestibility or production
  - 70% of cows prefer warm water (≈80°F) over cold water even when it's warm

### Factors Affecting Water Intake

- Competition occurs when inadequate supply
  - Dominant cows:
    - produced more (6.2 lb/d more milk)
    - drank more frequently (29 vs. 25 times)
    - consumed more water (24 vs. 22 gal/d) compared to submissive cows



### How much water will they consume?

- **Lactating cows:**
  - Quick estimate: 4 lb. of water for every pound of DMI (at least 21-26 gallons per day)
- **Dry cows:** at least 12-19 gallons per day
- **Weaned heifers:** 1-1.5 gallons per 100 lbs BW per day
- **Calves 1-5 weeks:** 2.5 gallons per day

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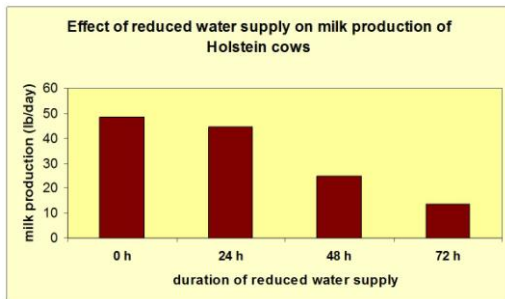
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### Water Supply Affects PRODUCTION!




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### Water Nutrition for Calves

- Water is a necessity for maximizing growth
  - Calves given water consume more milk replacer and grow faster
  - A 1-5 week calf consumes 2.5 gal/day
- Trough or bucket should be cleaned daily
- Consider bacteria testing
- Special attention in winter to prevent freezing




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### Common Guidelines for Water Sources

1. Provide 1 – 2 ft of linear space per cow in return alleys or breezeways from the milking parlor
2. Position waterers close to parlor exit
3. Provide a minimum of two water sources per group in areas where cows are housed
4. Cleanliness is crucial!
5. Be certain that the water filling capacity of the system is sufficient
6. Use shallow trough: 1) to prevent stagnant water, 2) for easy cleaning 3) for rapid filling
7. At least 3" deep to allow animals to submerge muzzles
8. Head clearance around water trough should be at least 2 ft; less may impede optimal water consumption
9. Height: 24-32 inches (a bit shorter for Jerseys)

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### Water Quality

- Term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose (USGS, 2011)
- Limited research on water quality and dairy cows
  - Differences in risk perception
  - Extrapolation of human drinking water standards

} Disagreements in guidelines

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### Two basic questions:

1. Is water consumption normal, considering physiological state and environment?
2. Are (anti-)quality factors present that may affect:
  - INTAKE?
  - NORMAL METABOLIC OR PHYSIOLOGICAL FUNCTION?

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### Criteria of (cow) water quality

- Organoleptic properties– taste and smell can affect how much cows drink
- Physiochemical – e.g., nitrate, TDS, sulfate
- Toxic compounds – metals, organophosphates, hydrocarbons
- Excess minerals
- Bacteria and algae




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### Organoleptic Qualities

- Cows detect offensive odors and tastes
  - Cow perception of offensive not well understood

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Symptom	Description	Recommended Tests
Stained plumbing fixtures	Red or brown	Iron
	Reddish-brown slime	Iron bacteria
	Black	Manganese
	Green or Blue	Copper
	Chalky white	Hardness

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Off-color water	Cloudy Black Brown or yellow	Turbidity, sediment Hydrogen sulfide, manganese Iron, tannic acid

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Off-color water	Cloudy Black Brown or yellow	Turbidity, sediment Hydrogen sulfide, manganese Iron, tannic acid
Unusual taste or odor	Rotten egg Metallic Salty Septic, musty, earthy Alkali, bitter Gasoline or oil Soapy	Hydrogen sulfide pH, corrosivity, Fe, Cu, Zn, Pb TDS, chloride, sodium Coliform, methane pH, TDS Hydrocarbon scan Surfactants or detergents

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## Total Dissolved Solids

- Water is a great solvent: TDS is a measure of all dissolved impurities in water
- < 1000 ppm, usually not problematic for cows
- Higher levels may affect palatability
- May need additional tests to determine common constituents
  - Hardness ( $\text{Ca}^+ + \text{Mg}^+$  expressed as calcium carbonate)
    - Common in western Virginia due to limestone deposits
    - May result in scaling of pipes or equipment
  - NaCl or other salts/salinity
  - Sulfates

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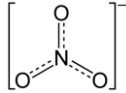
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## Nitrate



- Source of N in rumen for synthesis of bacterial protein
- Reduction to nitrite can reduce oxygen-carrying capacity of blood
  - Extreme cases: labored breathing, rapid pulse, blue muzzle
  - Lower levels: linked with poor growth, infertility, abortions, reduced milk production
- 2009 USGS m study found >1 mg/L NO<sup>3</sup>-N in 40 % of U.S. private water wells; surface water often much higher
- Rations should be evaluated for nitrates if there is a problem – combination from feed and water is additive.

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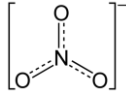
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## Nitrate



NO <sub>3</sub> (ppm)	NO <sub>3</sub> -N (ppm)	Effects
0-44	10	No harmful effects
45-132	11-20	Safe, if diet balanced and low in nitrates
133-220	21-40	Could be harmful over a long period
221-660	41-100	Dairy cattle at risk. Possible death.
>661	>101	Do not use, high probability of death losses

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## Sulfate and Hydrogen Sulfide

- Sulfate (SO<sub>4</sub><sup>-</sup>)
  - Recommendations not well defined
  - If exceeding 500 mg/L, identify source
  - < 500 mg/L for calves; < 1000 mg/L for cows no ill effects
  - Sodium sulfate or magnesium sulfate can have laxative effect, especially if livestock are unaccustomed to water
- Hydrogen sulfide (H<sub>2</sub>S)
  - Dissolved gas – originates from shale deposits or sulfur bacteria
  - Low concentrations can create foul sulfur smell
  - Concentrations of < 0.1 ppm can limit water intake

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## Iron

- Very important consideration for dairy cows
  - Common in parts of Virginia geology
  - Two forms:
    - Ferric ( $Fe^{3+}$ ) – particulate (common in feedstuffs)
    - Ferrous ( $Fe^{2+}$ ) – dissolved (more common in water)
- For humans and cows, levels higher than 0.3 mg/L a risk
  - Decreased palatability and intake
  - Ferrous iron > 0.3 mg/L can affect Cu and Zn absorption
  - Excess free iron can lead to iron toxicity and oxidative stress – transitioning and fresh cows most affected: reduced immunity, increased mastitis, diarrhea, etc.
  - Remove or use another source of water if a problem




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## Iron and Manganese

- Iron bacteria
  - Not harmful to health; make water unpalatable
  - Produce an orange-brown slime by-product that can clog pipes, filters, and line bottom and sides of trough
  - Remove by scrubbing with chlorine; shock chlorination or treating to remove iron
- Manganese
  - Often occurs with iron in Virginia; effects not well understood for cows
  - Bitter or metallic taste may make water unpalatable




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## Potentially Toxic Nutrients and Contaminants

Parameter	Upper-Limit Guideline (ppm)
Aluminum	0.50
Arsenic	0.05
Barium	10.0
Boron	5.0
Cobalt	1.0
Copper	1.0
Fluoride	2.0
Iron	0.3-2.0
Lead	0.015
Manganese	0.05
Mercury	0.01
Selenium	0.05
Zinc	5.0

Notes:

- Fluoride often present in groundwater in Eastern Va at concentrations approaching 6-10 mg/L
- Iron and manganese common throughout Western Virginia in levels exceeding 0.3 and 0.05 mg/L
- Lead and copper may be present in pipes, solder and fixtures; more likely to leach with low pH or corrosive water (common in central Virginia, ridges of W. Virginia)

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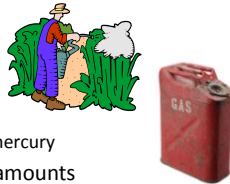
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## Toxic compounds

- Include:
  - Pesticides
  - Herbicides
  - Petroleum/VOCs
  - Heavy metals – lead, arsenic, mercury
- May not be an issue in trace amounts
- Can be expensive/difficult to analyze; need to know what you're looking for
- Little information on effects on dairy cow health and performance
- Threshold guidelines available in Beede (2008)




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## Bacteria

- Limited research on effects of quantities of total coliform bacteria and fecal coliform in water on herd health and production
  - For young calves: total and fecal both < 1MPN/100 mL
  - Older animals: total (<15/100mL);fecal (<10/100mL)
  - Total bacterial counts should be < 500/100 mL
- Bottom line: If there is manure in the water....
  - Johne's, Crypto, TB, etc....
  - Impacts palatability and consumption



[http://www.kitencentral.com/microorg/tescherichia\\_coli.jpg](http://www.kitencentral.com/microorg/tescherichia_coli.jpg)

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## Grab samples from Dec 2011

- 5 farms; milk rooms and troughs

Sample #	MPN/100 mL		Type
	Total Coliform	E. coli	
COW 6	68	13	milk room
COW 10	0	0	milk room
COW 11	>5136	33	milk room
COW 14	>5136	23	milk room
COW 2	0	0	milk room
COW 5	0	0	trough
COW 7	2082	95	trough
COW 8	>5136	499	trough
COW 12	>5136	5136	trough
COW 13	>5136	378	trough
COW 15	>5136	2082	trough

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Sample #	MPN/100 mL		Type
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COW 6	68	13	milk room
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COW 5	0	0	trough
COW 10	0	0	milk room
COW 7	2082	95	trough
COW 11	>5136	33	milk room
COW 14	>5136	23	milk room
COW 12	>5136	5136	trough
COW 15	>5136	2082	trough
COW 13	>5136	378	trough

## Algae

- Algae growth can affect palatability
- Blue-green algae blooms have been linked with warm weather, ample nutrients, slow moving water.
  - Cyanobacteria linked with diarrhea, liver failure



## Water Testing Recommendations

- Use a certified lab
- Follow collection instructions carefully
  - If checking bacteria, take sample after treatment and before the trough to ascertain source quality
- Test (at least) annually for total coliform, E. Coli, pH, TDS, nitrate, sulfate
  - Iron, manganese, hydrogen sulfide if warranted
  - Other tests based on local land uses, symptoms, or characteristics of water (staining, color, smell)

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## A Brief Overview

Virginia Household Water Quality Program  
Virginia Master Well Owner Network

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### Private Water Supplies in Virginia

- Majority of households in 60 of Virginia's 95 counties rely on private water supply systems (wells, springs, and cisterns) – about 1.7 million households (USGS, 2010)
- In 52 counties, the number of households using private wells is increasing faster than the number connecting to public systems (VA Dept of Env Quality, 2009)
- Homeowners relying on private water supplies:
  - Are responsible for all aspects of water system management
  - Often lack knowledge and resources to effectively manage
  - Usually don't worry about maintenance until problems arise



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### What is the VAHWQP?



- Established in 1989
- County-based Drinking Water Clinics
  - Coordinated with trained local extension educators or volunteers
  - Kickoff Meeting – distribute sample kits
  - Homeowners collect sample; samples analyzed at VT BSE lab
  - Interpretation Meeting: test results, interpretation and basic information about maintenance and addressing problems
  - 14,600 wells analyzed in 87 counties



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### Drinking water clinics



• Testing for :

- Total coliform (present/absent)
- E. coli
- Nitrate
- Fluoride
- Sodium
- Manganese
- Copper
- pH
- Total Dissolved Solids
- Sulfate
- Hardness
- Arsenic
- Lead

Cost is \$45 per kit.




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### VAHWQP Supporting Resources

- Revision and creation of new Virginia Cooperative Extension water quality publications
- Website: [www.wellwater.bse.vt.edu](http://www.wellwater.bse.vt.edu)
- Evaluation reports – common WQ problems by county
- Brochures
- Newsletter
- Listserv




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### Virginia Master Well Owner Network (VAMWON)

- Includes Extension agents (ANR and FCS) and volunteers

**Training workshops across VA**

- Groundwater hydrology
- Proper well location, construction and maintenance
- Land use impacts /wellhead protection
- Water testing and interpretation
- Solving water problems
- Education and outreach ideas
- Water conservation



**VAMWON volunteer outreach:**

- Fairs and home shows
- Speak to church or civic groups
- One-on-one conversations with neighbors and friends
- Write an article for local paper
- Help with drinking water clinic

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**Virginia Household Water Quality Program**  
**Virginia Master Well Owner Network**

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