Livestock Watering
FACTSHEET

BRITISH COLUMBIA
Ministry of Agriculture and Lands

Order No. 590.304-1
January 2006

LIVESTOCK WATER SYSTEM DESIGN #1

Selecting Flow Rate, Pressure, Trough Size & Storage

This Factsheet (one in a series of four on design) describes how to estimate flow rate, pressure, water trough, and storage requirements for a livestock watering system used on pasture or range. Two examples are given.

Introduction

Livestock watering systems vary with different livestock and pastures. When planning a water trough system, flow rate, pressure, storage and trough size must be determined. The following are general guidance "rules-of-thumb" for livestock watering systems - add personal experience to get the final system requirements. Note that:

- the following points mainly apply to grazing areas over 20 acres (see below)
- the following points apply to systems used year around
- the trough sizing points apply to non-freezing conditions
  - winter troughs are usually smaller in size than this Factsheet would indicate
  - refer to ***Factsheet #590.307-1*** for winter condition information and to other Factsheets in this series for guidance with other system components.

Livestock Watering Habits

The following are some observed livestock watering habits that can influence the layout of a livestock watering system (livestock type, density, pasture size, etc. will affect the following points):

- livestock drink individually when on small pastures (20 ac or less)
  - these typically use small troughs (25 – 50 USgal) and flow rates (2 – 4 USgpm) and <u>shouldn't be sized using the methods in this Factsheet</u>
- the farther that livestock have to move to water the more likely it is they will move as a group (herd drinking) and need larger toughs
  - <u>use the methods outlined here for distances over 500 feet to troughs</u>
- troughs located inside fenced pastures encourage individual drinking
- troughs located outside fenced pastures (alley access) encourage herd drinking
- animals may drink up to 1/3 of their daily requirement in a hour
- beef cows can drink up to 2 USgpm
- low fill rates force livestock to wait - "boss animals" will dominate the trough

Water Flow Rate

To determine the water flow rate to a trough, some assumptions must be made as to the drinking habits of the animals. System costs are reduced if animals spread out their drinking over a long, rather than short, time. However, if too long a time is assumed, livestock may not be adequately watered.

Many questions affect the flow rate required, such as:

- *how often do animals drink in a day?*
- *how much water do they drink at one time?*
- *do they drink singularly or in groups?*

The trough supply flow rate must keep up with the draw down rate of the trough when the herd is drinking. The following are methods that will give a range of flow rates; choose the method that best fits the situation or use the "*rule-of-thumb*":

- allow for 10 percent of the herd to drink at once (see Example 1, Step 1, pg 4)
  - have a minimum flow rate of 1/2 USgpm per head for this 10 percent group. or
- allow the whole herd to get total daily water: (see Example 1, Step 1, pg 4)
  - in 4 hours – 240 minutes (preferred flow rate), or
  - in 6 hours maximum – 360 minutes (minimum flow rate)
- where the water supply rate is low, may use a reduced flow rate by allowing the trough volume to be used up during the drinking period (and refilled later)
- whatever flow rate is chosen, it should fill the trough within 1 hour

Flow Rate "*Rule-Of-Thumb*"

FLOW RATE (USGPM) = THE DAILY WATER REQUIREMENT (USGAL) ÷ 240

AND, FLOW RATE MUST FILL TROUGH IN 1 HOUR

Water Pressure

Pressure is required to deliver the water from the source to the trough. While a gravity system may have "free" pressure, pumping water involves an energy cost. To minimize costs, while ensuring adequate water flow, use this "*rule-of-thumb*":

- provide 3 psi per USgpm flow rate (see Example 1, Step 2, pg 4)
  - but not less than trough manufacturers recommendation
  - and usually not over 50 to 60 psi

Note: this is pressure at the trough - account for pipe friction losses in the supply system! (see Factsheet #590.304-2, ***Livestock Watering System Design #2***)

Pressure "*Rule-Of-Thumb*"

SYSTEM PRESSURE (PSI) = THE FLOW RATE (USGPM) X 3

Water Trough

The size, location and spacing between troughs depend on many site and herd factors. The following are some "*rules-of-thumb*" as well as good practices.

Trough Volume. Trough volume is a combination of in-flow rate to the trough and the number of animals expected to drink at one time:

- volume must be sufficient to water all animals that water in a cycle
- low inflow rates and "herd drinking" will require larger volume troughs
- high inflow rates and individual drinking will allow smaller volume troughs
- provide a minimum trough volume of (see Example 1, Step 3, pg 4)
  - 2 USgal per animal for large animals (such as cows)
  - 1 USgal per animal for smaller animals (such as sheep)
- provide a maximum trough volume of 1/3 of the herd daily requirement

Trough Volume "*Rule-Of-Thumb*"

MINIMUM TROUGH SIZE (USGAL) = THE HERD SIZE X 2 (FOR COWS)

MAXIMUM TROUGH SIZE (USGAL) = HERD DAILY REQUIREMENT (USGAL) X 1/3

Trough Dimensions. The trough size is mainly determined by livestock size:

- provide trough space for 10 percent of the herd to drink at once
- provide 1 ft^2 water surface area per 25 beef cows (see Example 1, Step 4, pg 4)
- provide 1 ft^2 water surface area per 50 beef cows for heated winter troughs
- provide 1 ft^2 water surface area per 40 head sheep

- provide minimum perimeter watering space (see Example 1, Step 4, pg 4)
  - 20 inches (cows) / 12 inches (sheep) per head on round troughs
  - 24 - 30 inches (cows) / 16 to 20 inches (sheep) per head on straight side troughs
  Note: the perimeter needs to be in "complete increments" to be useful
- if both sides are to be used at once, provide a minimum 2 ft width
  Note: cannot assume use at ends at this width as the corners will be too crowded
- maximum trough throat height (see Example 1, Step 4, pg 4)
  - 22 inches for mature cattle; 18 inches for calves, heifers, feeders
  - 15 inches for ewes; 13 inches for lambs
- - provide a 2-inch freeboard to avoid water spillage
  - maximum water depth is the desired throat height minus this 2-inch freeboard

Note: the trough sizes chosen must be checked for the volume and the surface area needed (see Example 1, Step 5, pg 5) and checked with the flow rate chosen to ensure the trough can be refilled within 1 hour (see Example 1, Step 6, pg 5).

Trough Watering Space "*Rule-Of-Thumb*"

TROUGH DEPTH (FEET) = APPROPRIATE THROAT DEPTH
TROUGH WIDTH (FEET) = 2 FEET (MINIMUM)
ROUND TROUGH SPACE (FEET) = 10% OF HERD x 1.7 FEET (FOR COWS)
STRAIGHT-SIDE TROUGH SPACE (FEET) = 10% OF HERD x 2.5 FEET (FOR COWS)

Trough Location. Trough location in a pasture will affect grazing patterns and forage utilization:
- a "small" square-shaped pasture can have the trough at one corner
- a larger, and rectangle-shaped pasture, should have the trough at the midpoint of the long side
- on intensively grazed rotational pastures, moving the trough location to each pasture will reduce the impacts from a permanent, centralized trough location
- locate in shaded areas in summer and behind windbreaks in winter, but troughs in shaded areas may encourage loitering in summer

Trough Spacing. This will also affect grazing patterns and forage utilization:
- 1 trough per site is sufficient when a 20-25 head drink individually
- to encourage "even" grazing of pastures, have a maximum distance of 500 - 1,000 feet for animals to walk to water
- for large pastures and rangeland areas with multiple troughs, this is a maximum distance of 1,000 to 2,000 feet between troughs

Back Siphoning. Where the water supply is connected to other users (such as domestic) back siphoning should be prevented (i.e., that could occur if a trough float valve is immersed in the water, allowing water to move from the trough back into the supply if a significant line pressure drop occurred). Do one of the following:
- keep an air gap between the trough outlet pipe (float valve) and the trough water, or
- install a backflow prevention device in the supply line

Water Storage

If the water supply flow rate is less than the demand (for cows, less than a minimum trough size of 2 USgal per head that can be refilled trough in 1 hour), use one of the following water storage "*rules-of-thumb*" (see also Factsheet #590.304-7):
- have one day storage
  - either over-sized trough(s) or in separate water storage tank(s)
  - storage can be reduced by the water volume coming into the trough over the 4 to 6 hours-allowed drinking time (see Example 2, Step 2, pg 6)

- have 2 to 3 days storage for a pumping system using an intermittent energy source such as solar or wind
  - usually stored in a separate tank(s)
  - pumping systems using direct current (DC) electricity may store "energy-in-batteries" rather than "water-in-tanks" (this option requires a higher pumping rate when livestock are drinking which the water supply must be able to supply)

Storage (when required) "*Rule-Of-Thumb*"

SYSTEM STORAGE (USGAL) =	HERD DAILY REQUIREMENT (USGAL)
INTERMITTENT ENERGY SOURCE SYSTEMS =	HERD DAILY REQUIRE.(USGAL) x 3

Bringing It All Together

The following two examples put these "*design rules-of-thumb*" to estimate a livestock watering system requirements:

- Example 1, below, sizes flow rate, pressure, volume and the trough
- Example 2, page 6, has the same conditions but storage is required

Example 1 – Flow Rate, Pressure and Trough Requirements

Assume a herd of 100 beef cow-calf pairs will summer graze a pasture that has a water trough.

QUESTION **What are the flow rate, pressure and trough requirements ?**

STEP 1
- select the highest or most appropriate flow rate calculated using one of the following methods
  - supply 10% of herd with 1/2 USgpm
  10% of 100 head = 10 head; at 1/2 USgpm for each head = **5 USgpm** (minimum flow rate)

  Or, from *Factsheet #590.301-1*, require 12 x 1.5 = 18 USgal per day per cow-calf in summer
  - total daily requirement = 100 head x 18 = 1,800 USgal per day
  - then, choose the maximum daily watering time for the whole herd
  assume a 4 hr time period: 1,800 USgpd ÷ 240 min = **7.5 USgpm** (preferred flow rate)

  Or, if the trough volume of say, 200 USgal is to be drawn down ('run dry'), a lower flow rate may be used
  - 1,800 USgal - 200 USgal trough volume = 1,600 USgal to be supplied during drinking period
  - assume a 4 hr watering time: 1,600 USgpd ÷ 240 min = **6.7 USgpm**
  - Or, if using the minimum flow rate of 5 USgpm watering time = 1,600 USgpd ÷ 5 ÷ 60 = 5 1/3 hours

  - **supply rate??** select either the minimum rate of 5 USgpm (for a daily watering time of 6 hours for 1,800 USgal or 5 1/3 hours for 1,600 USgal)
  Or, select either preferred rate of 7.5 or 6.7 USgpm (for a daily watering time of 4 hours)

STEP 2
- determine the trough pressure
  - assume 3 psi per USgpm flow rate = 3 x 5 USgpm = **15 psi** (minimum trough pressure)
  - **Or**, for the shorter, preferred watering time = 3 x 7.5 USgpm = **22 psi** (preferred trough pressure)

STEP 3
- determine the trough minimum volume
  - trough min. volume to be 2 USgal per head x 100 head = **200 USgal** (minimum trough vol.)
  - trough max. volume @ 1/3 of herd daily requirement = 1/3 of 1,800 = **600 USgal** (maximum trough vol.)

STEP 4
- determine the trough dimensions

  1st. *estimate minimum area and trough perimeter space*
  - start off by assuming a single trough will be able to water the herd
  - provide a minimum 1 ft^2 surface area for every 25 head; for 100 head = 4 ft^2
  - provide a perimeter space for 10% of herd to drink at once = 10 head

2nd. *choose a rectangular trough*

- minimum perimeter is 30 inches length / cow x 10 head = 300 inches = 25 ft
- in "30 inch increments", a width of 3 ft and a length of 10 ft would water 10 cows
  4 cows per side (and 1 per end) = 10 cows at once = <u>3 ft x 10 ft</u>
- surface area = 3 x 10 = 30 ft^2 (OK, as 4 ft^2 is minimum)
- but this trough may be too crowded at the corners if both ends are used
- *(a common range trough 4 ft x 8 ft [24 ft perimeter] is often considered OK for 100 head)*
- alternatively, use 2 troughs 3 ft x 5 ft (5 cows per trough) = **<u>2 troughs @ 3 ft x 5 ft</u>**

Or, 3rd. *choose a round trough*

- minimum perimeter is 20 inches length / cow x 10 head = 200 inches = 16 2/3 ft perimeter length
- a circular trough with 16 2/3 ft perimeter length (16 2/3 $\div \pi$) = **<u>5.3 ft diameter</u>**
- surface area = $\pi \times 5.3^2 \div 4$ = 22 ft^2 (OK, as 4 ft^2 is minimum)

4th. *set trough depth*

- throat depth for cows is 22 inches maximum
- allowing a 2-inch freeboard, trough water depth is 22 - 2 = **<u>20 inch water depth</u>**

STEP 5 • <u>check these dimensions: do they provide the required volume?</u>

- the rectangular troughs are 3 ft x 5 ft x 20 inches water depth = 25 ft^3 each trough
- at 7.48 USgal per ft^3 = 185 USgal each = <u>370 USgal total</u> (volume is OK – minimum is 200 USgal)

- the circular trough is 5.3 ft diameter x 20 inches water depth = 36 ft^3
- at 7.48 USgal per ft^3 = <u>275 USgal</u> (volume is OK – minimum is 200 USgal)

STEP 6 • <u>check the flow rate against the volume: can the trough be filled in 1 hour?</u>

- minimum rate of 5 USgpm = <u>300 USgal in 1 hour</u> (OK for single round trough option only)
- preferred rate of 7.5 USgpm = <u>450 USgal in 1 hour</u> (OK for both trough options)

ANSWER

This livestock watering system should be setup to:

- **have a flow rate of 5 to 7.5 USgpm**
- **have a minimum pressure of 15 to 22 psi**
- **have a trough that is 22 inches deep, with a 2-inch freeboard and 20 inches of water**
- **have 2 rectangular troughs at 3 ft x 5 ft (185 USgal each - 370 USgal total)**
  - having drinking space for 10 cows at a time at 30-inch space each
  - with a flow rate of 7.5 USgpm to refill trough in 1 hour
  (the common 4 ft x 8 ft range trough - with sloped sides - contains 350 USgal)
- **Or, have a round trough at 5.3 ft diameter (275 USgal total)**
  - having drinking space for 10 cows at a time at 20-inch space each
  - with a flow rate of 5 USgpm to refill trough in 1 hour

Example 2 – Water Storage Requirements

QUESTION *Assuming the same conditions as in the previous example, but the water source has a flow rate of only 3 USgpm ?*

STEP 1

- information given: the required flow rate was calculated to be 5 USgpm (minimum – 6 hr watering time) to 7.5 USgpm (preferred – 4 hr watering time)
  - as only 3 USgpm are available, water storage is required

STEP 2

- determine storage requirements
  - provide one day storage (from page 3)
  - from Example 1, for the 100 cows, the daily requirement is 1,800 USgal
  - this is the maximum volume that must be stored on site to feed the trough

But, this can be reduced by the volume available during the drinking time (3 USgpm from the water source)

- calculated in Example 1, to be a maximum time of 6 hrs
  - 1,800 gal - (6 hr x 60 min/hr x 3 USgpm) = 1,800 gal – 1080 gal = **720 USgal storage (minimum)**
- **Or**, for the minimum watering time of 4 hrs
  - 1,800 gal - (4 hr x 60 min/hr x 3 USgpm) = 1,800 gal – 720 gal = **1,080 USgal storage (maximum)**
- this storage may be as:
  - extra rectangular water troughs: 2 more troughs at 360 USgal (for 720 USgal) or 3 (for 1080 USgal)
  - **Or** an extra oversized circular trough (8 3/4 ft dia. x 20 inch deep = 740 USgal)
  - **Or** 2 oversized circular troughs (7 1/2 ft dia. x 20 inch deep x 2 = 1,100 USgal)
  - **Or** any combinations of tanks or troughs giving the required capacity

For a 6-hour drink time, 1,080 USgal will be supplied by the water source (at 3 USgpm) and 720 from storage. After the drinking period, the storage is refilled in 4 hours (at 3 USgpm) for a 10 hour total water delivery period and ready for the next day (10 hr x 3 USgpm = 1,800 USgal).

For a 4-hour drink time, 720 USgal will be supplied by the water source (at 3 USgpm) and 1,080 USgal from storage. After the drinking period, the storage is refilled in 6 hours (at 3 USgpm) for a 10-hour total water delivery period and ready for the next day (10 hr x 3 USgpm = 1,800 USgal).

ANSWER

To provide the daily water requirements of the 100 head cow-calf herd, this livestock system, with a low water supply, will require water storage:

- **with a flow rate of 5 USgpm (6-hr watering time) - a minimum of 840 USgal storage, or**
- **with flow rate of 7.5 USgpm (4-hr watering time) - 1,080 USgal storage, or**
- **a full day water supply - a maximum of 1,800 USgal storage**

(The information is adapted from previous Ministry of Agriculture and Lands publications, along with material from Alberta and Ontario agricultural factsheets; Universities of Iowa, Kentucky and Nebraska factsheets; Midwest Plan Service publication and the Canadian Farm Building Code.)

RESOURCE MANAGEMENT BRANCH
Ministry of Agriculture and Lands
1767 Angus Campbell Road
Abbotsford, BC V3G 2M3 Phone: (604) 556-3100

WRITTEN BY
Lance Brown
Engineering Technologist
Kamloops Office