TECHNICAL NOTE

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Watering Facility Design Criteria for Cattle

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<u>Background</u>
The size of watering facilities should be based upon storage volume and access space. The required storage volume is based on the dependability of the water supply, herd watering habits, and supply rate. Additionally, the facility needs to be sized to provide adequate space for the number of animals expected to use the facility at any given time.

Sizing the watering facility based upon flow rate and water storage can be difficult because cattle watering behavior is somewhat hard to predict. It depends on herd size, stock densities, and topography of a pasture. The goal of sizing the watering facility is to provide the needed water in a reasonable amount of time so that every animal has a chance to get the water it needs. This can be more of an art than a science. Animals will tend to learn when water is available (Bingham 2005). Therefore, as long as the daily requirement is supplied, the animals will obtain what they need. Specific design guidance is provided in the design criteria.

There are four basic strategies to consider when calculating supply rates and storage: 1) undependable water supply, 2) low stock densities, 3) moderate stock densities, and 4) management intensive systems. These four strategy categories will be defined here and simply referred to in the remainder of this technical note. Stock densities and stocking rates are rough estimates, and should only be used as guidelines.

<u>Undependable water supply</u> – These are defined as water sources that are inspected infrequently, sources with high maintenance requirements, or sources which have power requirements that are not dependable (solar, wind, etc.). A minimum of three days of storage is required for these water sources. The maximum storage is determined by the dependability of the water source and the power source. For practical purposes, a maximum of seven days of storage is recommended. The South Dakota Natural Resources Conservation Service Form SD-ENG-47, Water Storage Capacity Worksheet, should be used to determine the storage volume for this type of facility.

<u>Low stock densities</u> – These systems include relatively large herds in typically large pastures and are characterized by lower stock densities (typical stock densities are less than 0.5 animals per acre and stocking rates are often less than 0.8 animal unit month (AUM)/acre, Bailey, et al., 2004, Roath, et al., 1982). While it is difficult to predict what size group will come to water at one time, cattle in these situations tend to form smaller social groups (Roath, et al., 1982). Also, cattle will normally not wait to water into the late night hours (Roath, et al., 1982, Dwyer 1961, Bailey, et al., 2004). The combination of tank storage and pipeline flow rate must to able to supply the daily water requirements of the livestock in the 12-hour period that the livestock would typically use the watering facility. If pipeline flow is increased, more water is supplied over time and the result will be a decrease in tank size.

<u>Moderate stock densities</u> – These systems include relatively smaller herds, in moderate to smaller pastures, and are characterized by more moderate stocking densities (typical stock

densities are often greater than 0.5 animals per acre, and stocking rates are generally greater than or roughly equal to 0.8 AUM/acre, Porath, et al., 2002, Plumb, et al., 1984). The ideal design is to provide storage for half of the daily water need minus the system flow rate in one hour. This will minimize the amount of time the cattle will loaf around the water facility and maximize the time spent grazing in the pasture.

Management intensive systems – Systems managed intensively tend to have smaller pastures with watering facilities spaced closely. These systems are characterized by high stock densities (typical stock densities are often greater than one animal per acre, while stocking rates are variable, Hacker, et al., 1988, Walker, et. al., 1989,) and animals are moved relatively frequent. The animals will come to water in singles and pairs as long as the water source is reliable and travel distance to water is not excessive (Bingham 2005). Because of this tendency, the total amount of water consumed is less at a time and limited by the number of animals at the watering facility. If these systems are supplied by pipelines capable of delivering the peak demand of the animals, the watering facility will require very little storage. These systems should be designed based upon the system flow rates. If more storage is desired, the system may be designed based upon a combination of storage and flow rates.

Watering Facility Access - To determine the water access perimeter needed for cattle, it is generally assumed that they will come to water less frequently when the travel distance to water is excessive (Hart, et al., 1993), and, therefore; it is assumed that they may come in larger numbers if trips are less frequent. Research does not provide a definitive number but roughly cattle utilization tends to drop off at distances of between one-quarter to three-quarter mile (or greater) from water sources (Vallentine 1980, Harris, et al., 2002, Porath, et al., 2002, Epps 2002, Fusco, et al., 1995, and Bailey, et al., 1996, Bailey, et al., 2004). For the purposes of this technical note, a distance of 1,980 feet will be the assumed distance at which cattle will begin to reduce their frequency of trips to water sources.

Storage volumes and access space also reflect these distances in pastures where multiple watering facilities are used. For watering facilities spaced less than three-quarters of a mile apart (maximum travel distance of 1,980 feet), the storage volume and access space in each facility can be added together to meet the minimum storage volume and access space. If the facilities are more than three-quarters of a mile apart, each facility must be considered as the sole source of water and be sized to meet the minimum storage volume and access space. Consideration should be given to the fact that cattle trailing and subsequent erosion may be increased with increased distances to water. Also, grazing distribution may not be as even with increased distance to water.

Tank configuration should also be considered. Calves generally will not be able to reach water much deeper than 20 inches below the top of the tank. Therefore, only the water stored in the upper 20 inches of the tank should be considered as available water unless a separate tank is provided for calves.

Design Criteria

Troughs and tanks will be designed based upon three criteria; system flow rates, storage capacity, and access area for animals. A combination of criteria will generally be most successful.

Criteria 1. Supply Rates and Storage

- Undependable water supply – An approach based upon three or more day's storage volume is needed for these systems. This approach would require a minimum of three days storage and up to seven or more days to provide a dependable supply for the herd.

The flow rate of the pipeline or pump does not enter into the determination of tank size since the flow rate may be extremely variable or sporadic, nor is there a reduction in storage volume given for the replenishment from the pipeline. Page one of the SD-ENG-47 uses this approach. This approach requires larger amounts of stored water.

- Management intensive systems – Cattle will drink at a rate up to two gallons per minute (GPM). This design approach is to supply the water at the rate they can drink. Two GPM per animal drinking space is the maximum flow rate required. If only one animal is drinking at once, then a supply rate of two GPM would be adequate. If there is space for two animals to drink at once, then a flow rate of four GPM would be required. In this case, a minimal amount of reserve capacity would be required since the supply rate would replenish the tank as soon as it begins to empty. For a large trough or tank; however, there may be room for as many as 15 animals at a time. A flow rate of 15 head x 2 GPM/head = 30 GPM is usually unattainable and not practical. However, for management intensive systems where multiple, less expensive tanks or even portable tanks are used, or for winter pastures, this is a good approach.

- Winter Watering Facilities – The facility should be designed similarly to a facility for a management intensive system. Winter watering facilities generally have access holes in the lids or floats covering the openings that limit the number of drinking spaces. The pipeline supplying the water should be designed based upon the number of drinking spaces. The pipeline shall have the capacity to supply two GPM per drinking space. Most commercial automatic waterers have a recommended number of head of cattle that it will service. This recommended number of head shall not be exceeded. For fabricated tanks, provide no less than 1 drinking space or opening per 100 cattle.

- Winter watering facilities may be sized without regard to travel distance or access space. Systems without the pipeline capacity to deliver 2 GPM per drinking space may be designed using a combination of storage and pipeline flow (10 gallons per day (GPD) winter water use for cattle).

Generally, neither of these approaches is solely used except in cases of undependable water sources or for small herds for winter grazing. Normally, a combination of pipeline flow and storage designed as a complete system will provide the daily needs of the livestock in the most feasible and efficient manner.

- Moderate stock densities – The ideal design is to provide storage for half of the daily water need minus the system flow rate in one hour. Generally, cattle will loaf in the watering area up to one hour (Bailey 2003, Dwyer 1961). Also, they will generally travel at least twice a day to the watering facility (Plumb, et al., 1984, Hart, et al., 1993). The desired design is to supply one half of the daily water requirement each time they come to water.

  The total capacity of the watering facility would be the sum of the storage in the tank plus the amount of water that would flow into the tank in one hour. For example, a 100-head herd needs 1,800 GPD. One-half of that would need to be supplied each time they come to water = 900 gallons. The pipeline can supply four GPM. In one hour, the pipeline would supply 4 GPM x 60 minutes = 240 gallons. The tank would have to supply the balance of the storage = 900 gallons – 240 gallons = 660 gallons.

- Low stock densities – The combination of tank storage and pipeline flow rate must be able to supply the daily water requirements of the livestock in the 12-hour period that the livestock would typically use the watering facility. If pipeline flow is increased, more water is supplied over time and the result will be a decrease in tank size.

The required tank volume would be the daily water requirement of the livestock less the 12-hour pipeline flow volume. For example, a 500 head herd at 18 gal./hd./day needs 9,000 GPD. The pipeline can supply 10 GPM. In 12 hours, the pipeline would supply 10 GPM x 12 hours x 60 minutes per hour = 7,200 gallons. The tank would have to supply the balance of the daily water requirement = 9,000 gallons – 7,200 gallons = 1,800 gallons.

Criteria 2. Water Access Perimeter

- Provide 1 space for every 20 animals (5 percent of herd) when water is available in each field and livestock generally drink 1 at a time or in small groups. Generally, travel distances should be less than 1,980 feet from the tank to the edge of the field.

- Provide 1 space for every 10 animals (10 percent of herd) to drink at 1 time at a tank where travel distances are greater than 1,980 feet, at a centralized water supply, or in areas where animals will congregate and fight for access to tank.

- Allow 12 inches of perimeter for circular tanks and 18 inches for straight side tanks per animal.

<u>The general procedure for sizing the tank is as follows:</u>

1. Calculate the total daily water needs for all of the livestock served. Use Page 1 of the SD-ENG-47. The drop-down menus provide minimum gallonages for each type of livestock.

2a. Undependable water source – Calculate the storage required by multiplying the daily need by the number of days storage required. The number of day's storage will be determined by the dependability of the source. Calculate the size of tank needed using the tank calculator at the bottom of page 1 of the SD-ENG-47.

2b. Dependable water source - Systems serving small herds with travel distances less than 1,980 ft. and served by pipelines capable of delivering peak rate of 2 GPM per drinking space. Minimum storage required. Size tank for drinking space for five percent of herd or for winter grazing commercial waterers may be used. Pipeline capacity must be capable of providing two GPM for each drinking space.

2c. Dependable water source not meeting criteria 2a and 2b above – Systems utilizing a combination of pipeline flow rate and tank storage.

Low stock densities - The storage required is equal to the daily water need less a 12-hour pipeline flow. Size tank for drinking space for 10 percent of herd.

Moderate stock densities - The storage required is equal to one-half of the daily water need less a one hour pipeline flow. Size tank for drinking space for 10 percent of herd.

The following examples show four different scenarios that might be encountered and how to manually make these calculations. This procedure has been automated by incorporating it into SD-ENG-47.

Example 1

Determine tank size for a system using a solar power pump and 50 cow/calf pairs requiring 18 GPD.

1. Since this is an undependable source, the operator would prefer to store a five-day supply. Use page 1 of the SD-ENG-47 to calculate the storage volume required.

   50 hd. x 18 GPD x 5 days = 4,500 gal.

2. Use the tank calculator on page 1 to determine the diameter required.
   A 21.5-foot diameter tank 20 inches deep will store 4,533 gal., therefore, use a 22-foot steel rim tank or (4) 10.5 foot tire tanks.

Example 2

Determine tank size for a system with a dependable water supply and 80 cow/calf pairs requiring 18 GPD. A management intensive system will be used and travel distance is less than 1,980 feet. The operator would prefer minimal storage.

1. Determine the required pipeline design capacity necessary to deliver the peak flow rate of two GPM for each drinking space. Since the travel distance is less than 1,980 ft., the tank needs access for just 5 percent of herd.

   80 head x 5 percent = 4 head x 2 GPM/head = 8 GPM.
   8 GPM is a high flow rate but it can be achieved on many systems.

2. Size tank perimeter for four head.
   4 hd. x 12 in./hd. = 48 inches = 4 feet of perimeter.
   Determine diameter = 4 feet/ π = 1.3 feet diameter tank

   Use minimum size tank of six or eight feet.

Example 3

Determine tank size for a system with a dependable water supply and 200 cow/calf pairs requiring 28.8 GPD. The 28.8 GPD is a designer decision based upon measured amounts during summer. Assume low stock densities and travel distance is greater than 1,980 feet. Pipeline is capable of providing six GPM.

1. Since the water supply is dependable and the distance to water is over 1,980 feet, a combination of storage and flow will be used to size the tank. Low stock densities will be used. The required storage is equal to the daily need less the 12-hour pipeline flow.

2. Determine the daily water requirement. Use SD-ENG-47.
   28.8 GPD/hd. x 200 hd. = 5,760 gallons

3. Determine the 12-hour pipeline flow.
   6 GPM X 60 min./hr. X 12 hr. = 4,320 gal.

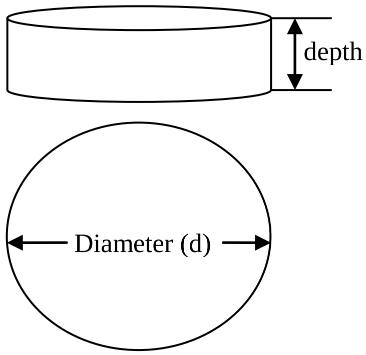
4. Required storage = 5,760 gal. – 4,320 gal. = 1,440 gal.

5. Determine tank size (available water volume and perimeter length) based upon a 20-inch depth.

   Volume of a circular tank = area of tank x depth

   1 cu. ft. = 7.48 gallons, area = $(\pi \times d^2)/4$, perimeter = $\pi \times d$

π = 3.1416 d = diameter of the tank



Required volume in cubic feet = 1,440 gallons/7.48 gallons/cu. ft. = 192.5 cu. ft.

$$192.5 \text{ cu. ft.} = \left(\frac{\pi \times d^2}{4}\right) \times 1.667 \text{ ft. deep}$$

π = 3.1416 d = diameter of the tank

$d^2 = (192.5 \times 4)/(1.667 \times 3.1416)$

d = 12.1 feet

Use a 12-foot diameter tank, this will be close enough.

$$\text{Volume} = \frac{\pi \times (12)^2}{4} \times 1.667 \text{ ft. deep}$$

= 188.5 cu. ft. = 1,410 gallons

Perimeter = 12 x 3.1416 = 37.7 ft.

6. Determine the required perimeter based on providing access for 10 percent of herd. Perimeter = 200 hd. x 10 percent x 12 inches/12 inches/ft. = 20 ft. (The planned tank exceeds the minimum required).

The 12-foot tank has adequate storage and perimeter to satisfy the design criteria.

Example 4

Determine tank size for a system with a dependable water supply and 160 cow/calf pairs requiring 18 GPD. Moderate stock densities are used. Travel distance is less than 1,980 feet.

1. Determine the required pipeline design capacity necessary to deliver the peak flow rate of two GPM for each drinking space. Since the travel distance is less than 1,980 ft., the tank needs access for just 5 percent of herd.

   160 head x 5 percent = 8 head x 2 GPM/head = 16 GPM.
   Sixteen GPM is not considered a practical design volume for the pipeline, and in this situation, the well and pump will not yield that amount. Use a combination of storage and flow to size the tank.

2. Moderate stock densities require storage be equal to one-half the daily need less a one hour pipeline flow. Determine the daily water requirement. Use SD-ENG-47.
   18 GPD/hd. x 160 hd. = 2,880 gallons ½ day = 1,440 gal.

3. Determine the one hour pipeline flow. The pipeline will be designed for a min. of five GPM.
   5 GPM x 60 min./hr. x 1 hr. = 300 gal.

4. Required storage = 1,440 gal. – 300 gal. = 1,140 gal.

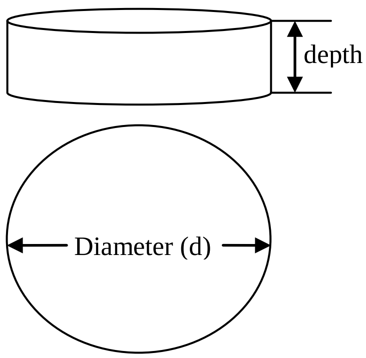
5. Determine tank size (available water volume and perimeter length) based upon a 20 inch depth.

   Volume of a circular tank = area of tank x depth

1 cu. ft. = 7.48 gallons, Area = $(\pi \times d^2)/4$, Perimeter = $\pi \times d$

$\pi = 3.1416$ d = diameter of the tank

Required volume in cubic feet = 1,140 gallons/7.48 gallons/cu. ft.
= 152.4 cu. ft.



$$152.4 \text{ cu. ft.} = \left(\frac{\pi \times d^2}{4}\right) \times 1.667 \text{ ft. deep}$$

$\pi = 3.1416$ d = diameter of the tank

$d^2 = (192.5 \times 4)/(1.667 \times 3.1416)$

d = 10.8 feet

Use an 11 or 12 foot diameter tank.

Perimeter = 11 x 3.1416 = 34.6 ft.

6. Determine the required perimeter based on providing access for five percent of herd. Perimeter = 160 hd. x 5 percent x 12 inches/12 inches/ft. = 8 ft. (The planned tank exceeds the minimum required.)

An 11- or 12-foot tank has adequate storage and perimeter to satisfy the design criteria.

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