Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

WATERING FACILITY

CODE 614

(no)

DEFINITION

A watering facility stores or provides drinking water to livestock or wildlife.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Supply daily water requirements
- Improve animal distribution
- Provide a water source that is an alternative to a sensitive resource

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where there is a need for a watering facility for livestock or wildlife, where there is a source of water that is adequate in quantity and quality for the purpose, and where soils and topography are suitable for a facility.

This practice is not intended for constructed earthen embankment or excavated ponds. For ponds, refer to NRCS Conservation Practice Standard (CPS) Pond (Code 378).

CRITERIA

General Criteria Applicable to All Purposes

All planned work must comply with Federal, State, Tribal, and local laws and permit regulations.

For purposes of this standard, watering facilities include storage facilities, drinking facilities, combination drinking and storage facilities, and watering ramps. Dependable water supplies include pumping systems powered by electricity, systems served by rural water districts or other public water systems, and ponds and streams that are accessible to livestock that typically do not go dry (Ref. EFH Chapter 11, Table 11-3).

Capacity

Identify the type of livestock or wildlife that will be the primary users of the facility. If the watering facility will supply water to different species of animals, provide sufficient water to meet the sum of the seasonal high daily water requirements for all of the animals.

Refer to the NRCS National Range and Pasture Handbook (Title 190), Chapter 6, “Livestock Nutrition, Husbandry, and Behavior,” State guidance, or university publications for information on livestock water quantity and quality requirements. For wildlife, base water quantity and quality requirements on targeted species needs.

User needs
Design the watering facility so that access is adequate to accommodate the number of animals that will be drinking at the same time. Include design elements to meet the specific needs of the primary users. Include specific design needs such as antler size, species, and ingress and egress requirements.

Materials and appurtenances
Construct the watering facility from durable materials that meet or exceed the lifespan of the practice. Follow NRCS design procedures for the selected materials. Use industry standards where NRCS procedures do not exist.

Stabilization of disturbed areas
Stabilize areas disturbed by construction in accordance with the planned use of the facility. Use the criteria in NRCS CPS Critical Area Planting (Code 342) to establish vegetation. If establishment of vegetation is precluded by site conditions, use the criteria in NRCS CPS Mulching (Code 484), as appropriate.

Water Quality
Water should be of adequate quality for wildlife and/or livestock consumption. Use criteria found in NRCS CPS Well Water Testing (355), or the National Range and Pasture Handbook, 600.0603(e) (5) and Table 6 - 8, Water Quality Standards for Livestock.

Definitions
“Storage facilities” are tanks that hold water and serve other facilities via pipelines. These are usually taller structures and no animals drink from them.

“Drinking facilities” are small troughs or tanks that have no significant storage and provide drinking space for a limited number of animals. These facilities are dependent on quick recharge. Flow rates must be adequate to supply 2.0 GPM / Drinking Head for large livestock. Flow rates for small livestock such as sheep, pigs and goats are to be based on 0.5 GPM / Drinking Head. The number of drinking head is limited by the drinking space around the facility. The system shall be designed to water all the livestock in the grazing unit within two hours. Freeze-proof tanks and energy-free fountains are also considered to be drinking facilities. When an energy free fountain is used, it shall be the primary source of water for the pasture in order to make the fountain function without freezing.

“Combination drinking and storage facilities” are tanks or troughs with a wall height such that animals drink from it; however, it shall be large enough to store the drinking water required by the design.

“Portable watering facilities” are watering facilities that have the ability to be moved to different locations. These facilities work best in situations for distributing grazing, intensive rotational systems and offsite water to minimize use of ponds and streams without the use of a fence to exclude access. These facilities generally are not designed, but shall be selected with adequate capacity to meet the livestock purpose.

“Wildlife watering facilities” typically include concrete lined watering basins, tanks or troughs, and guzzlers.

“Watering Ramps” are livestock or wildlife erosion resistant ramps installed along the shoreline of fenced ponds or along fenced stream banks in order to provide a stabilized access to water.

Troughs and tanks
Capacity
Design troughs and tanks with the storage volume necessary to provide water between periods of replenishment. To determine the storage volume, use the availability of water, replenishment rate, location, and planned operation.

A complete watering system includes both the storage part and the drinking part of the facility. Storage and drinking facilities can be provided in combination or they can be provided separately by connecting the components with pipelines to meet the livestock and/or wildlife demand.

Watering systems and facilities for livestock shall be planned to include the needed storage, delivery rates, and spacing requirements for the anticipated herd size for the grazing unit, the projected carrying capacity (based on a grazing plan and forage inventory), and/or the highest anticipated demand. In general, livestock water twice a day and drink half of their daily requirement at each watering. Each animal will drink for approximately 5 minutes. It is recommended that a herd take no longer than 2 hours to complete a watering.

Livestock watering needs shall be based on the guidelines in Table 1. For both “combination drinking and storage facilities” and “drinking facilities”, the water in a facility shall be accessible to livestock. Any storage volume in the these facility types that is more than 6 inches below the top of the apron elevation shall be considered inaccessible to livestock and deducted from the available storage capacity in the facility.

Table 1. Livestock Water Requirements

Animal	Gallons / 1,000 lbs. Live Animal Weight
Beef Cattle	15
Dairy Cattle	20
Goats	25
Horses	15
Sheep	25
Swine	20
Poultry	120
Bison	15

The water system shall provide a total system capacity for a 5-day storage if the supply is dependent upon a windmill or solar system.

A minimum of a 2-day storage shall be provided for systems powered by electricity, by rural water districts or other public water systems.

In order to attain additional distribution of grazing within a single grazing unit and within the confines of the spacing established in Table 3a of this standard, the 2-day storage requirement may be met by more than one facility. However, “combination drinking and storage facilities” used with multiple facilities shall be designed for no less than a 1-day storage.

“Drinking facilities” installed where a system malfunction or interruption in service is immediately evident and are checked for proper functionality a minimum of once a day (i.e. house wells or pipelines tied to livestock feeding operations for poultry, swine, dairy, etc.) are not required to meet the 2 days of storage, however a minimum tank capacity of 100 gallons shall be provided. This 100 gallon storage requirement is waived for freeze-proof tanks and energy-free fountains.

Table 2. Wildlife Water Requirements

Species	Number of Animals	Gallons / Day
Antelope	Each	1 - 2
Deer	Each	1 - 2
Elk	Each	5 - 8
Quail	Covey	1 - 2
Turkey	Flock	2 - 3
Pheasant	Local Population	2 - 5
Dove	Local Population	2 - 5
Songbirds	Local Population	1 - 2

For wildlife purposes, design watering facilities with adequate capacity and supply to meet the daily water requirements of wildlife planned to use the facility. Include the storage volume necessary to provide water between periods of replenishment. Because each facility is unique to species, habitat, topography, and climate; watering facilities must be planned and installed according to a wildlife management plan and adapted to the specific site.

The effective water storage capacity for any wildlife watering facilities will be no less than 82.5 gallons, the minimum designed storage specified by Oklahoma Standard Engineering Drawing 518b. With the exception of meeting the minimum storage requirements described above in Table 2, the design shall be sized to accommodate the expected and/or anticipated consumptive rates of target and non-target species as described in Table 2.

The storage reservoir(s) associated with wildlife watering facilities that are dependent on normal precipitation as the primary water source shall be filled with water immediately after installation.

Wildlife watering facilities that are dependent on normal precipitation as the primary water source shall require a precipitation collecting structure that empties into the facility reservoir and has a minimum area of 144 square feet. This criterion applies to prefabricated facilities, as well.

Concrete lined wildlife watering basins require permanent water supplied by a spring, pipeline, or well. The outside dimensions of concrete lined watering basins will be no less than 6 feet by 6 feet and no greater than 12 feet by 12 feet. Designed water depths will be between 1 foot and 2 feet. Slopes will be 3 horizontal to 1 vertical or flatter. Concrete will be 4 inches in thickness and textured to provide solid footing for hoofed wildlife species. Use the criteria in NRCS CPS Lined Waterway or Outlet (Code 468), for the materials criteria and installation requirements.

Location

Locate the watering facility to meet the needs of the managed livestock or wildlife species. Select a site that will promote even grazing distribution and reduce grazing pressure on sensitive areas. Where multiple watering facilities are planned, place the watering facilities at distances that are appropriate for the given topography, climate, and species that will be managed. Slope, barrier, and pasture design and travel distance are to be included in the design and layout to address grazing distribution.

Establish water facilities in locations that will minimize adverse impacts on the land. The location should be relatively level. Locate the watering facility to minimize erosion problems caused by animal traffic on steep topography.

To minimize the chance of contamination from fecal contamination or surface pollution. Locate the watering facility away from streams, ponds, or riparian areas.

When a watering facility is installed adjacent to a well, provide positive drainage away from the well head.

Locate watering facilities on well drained sites or otherwise install drainage measures as needed.

Spacing requirements in a grazing unit shall be based on the following guidelines:

- Other dependable drinking facilities within the grazing unit,
- The need for water in a given location, and
- Terrain, as described in Table 3a.

Table 3a. Livestock Watering Facility Spacing

Type of Terrain	Spacing Between Water Sources (miles)
Rough (slopes > 15%)	1/4 - 1/2
Rolling (8 - 15%)	3/8 - 3/4
Level (<8%)	3/4 - 1

Table 3b. Wildlife Watering Facility Distribution

Species	Distribution of Water Sources
Antelope	1 per 1-2 square miles
Deer	1 per square mile
Elk	1 per 2-4 square miles
Quail	1 within 1/4 mile of food and cover areas
Turkey	1 within 1 mile of roost areas
Pheasant	1 within 1/2 miles of feeding areas
Dove	1 within 2 miles of feeding areas
Songbirds	1 within 1/4 miles of feeding areas

The distribution and spacing of facilities serving wildlife shall be based on the required travel distance to water, proximity to other required habitat components, and the home range, territory size, and distribution of the target species as indicated in Table 3b.

Foundation and Anchoring
Install the watering trough or water storage tank on a firm, level foundation that will not settle differentially. Examples of suitable foundation materials are bedrock, concrete, compacted gravel, and stable, well-compacted soils. Where necessary, prepare the foundation by removal and disposal of materials that are not adequate to support the design loads.

Anchor or brace the watering facility as needed to prevent overturning by wind and animals, or as required by the watering facility manufacturer.

Tanks
Analyze the foundation conditions and provide a design that will ensure the stability of the storage tank. For a vertical storage tank with a tank height greater than the tank diameter, also analyze the potential for overturning and identify the anchoring requirements.

Use NRCS design procedures or manufacturer's guidelines to ensure that buried tanks will withstand all earth and vehicle loads anticipated for the site.

Stabilization
For a permanent trough, protect the area around the watering facility where animal concentrations or overflow from the watering facility will cause resource concerns. Provide heavy use aprons surrounding all watering facilities to protect areas that will be trampled by livestock or wildlife. Use NRCS CPS Heavy Use Area Protection (Code 561) to design the protection.

Watering facilities shall withstand heavy use in the area immediately surrounding the trough or tank. Current research indicates that the protected area aroundfacilities where livestock concentrations cause resource concerns is 12 feet wide or greater. Designers may use less than 12 feet based on local knowledge of soil conditions, herd size and management, or other operational measures. If the facility is located in naturally rocky or gravelly areas, an apron may be eliminated completely unless such is a structural component of the watering facility. When applied, the protected area around watering facilities where livestock congregate to drink shall be a minimum of 8 feet wide from the outer edge of the facility. Where the type of facility requires a concrete floor extension as part of the design of the facility, the width of such an extension can be included in the total protected area. The minimum width shall apply to all areas around the watering facility where livestock have access.

For a portable facility, either stabilize as mentioned above or move the trough when needed to prevent damage from animal concentrations.

Materials
All materials shall have a life expectancy that meets or exceeds the planned useful life of the installation. Common construction materials are reinforced concrete, steel, fiberglass, brass, plastic and wood.

Precast (freeze proof) concrete tanks and factory fabricated fiberglass tanks may be used. All designs shall meet the industry standards for the material being used. Tanks may also be constructed from heavy equipment tires. Used steel tanks (oil, gasoline, etc.) can be used provided the supplier certifies the tank's use for livestock and/or wildlife.

Dimensions
The watering facility outside height, measured from the top of the apron to the top of the facility, may vary from 18 to 24 inches for beef and dairy cattle, 22 to 36 inches for horses, and 8 to 22 inches for sheep and goats. When Heavy Use Area Protection (HUAP) apron is used, ensure the finished heights are measured from the finished surface of the apron.

The drinking space requirement for "combination drinking and storage facilities", is governed by the water demand for the herd and not by drinking space. For "drinking facilities" the perimeter of the facility shall be a minimum of 1 inch per head in the herd. This requirement is waived for freeze-proof tanks and energy-free fountains. Table 1 is to be used as a guide to animal space requirements (Divide the facility perimeter by the Drinking Space/Head).

Table 4. Drinking Space Requirements

Animal	Drinking Space per Head (inches)
Beef	20
Dairy	24
Goats	12
Horses	20
Sheep	12
Swine	12
Poultry	3
Elk	20
Deer	12
Antelope	12
Bison	24

Appurtenances
Use the criteria in NRCS CPS Livestock Pipeline (Code 516) to select the components needed to attach the water supply to the trough or tank. Include Shut-off valves, where needed, to control and/or cut off flow to repair or protect the pipeline associated with the watering facility and to preserve the supply in case of pipeline failure. Include backflow prevention devices or an air-gap on facilities connected to wells or to domestic or municipal water systems. If an air-gap is used, the air-gap must be at least twice the inside diameter of the supply pipe or valve opening, or 1 inch, whichever is greater

When served by windmills or systems that operate on a timer an overflow pipe to maintain the water level at 1 ½ inches below the top of the facility is required. The minimum diameter of the overflow pipe shall be 1 ½ inches. The overflow pipe shall extend a minimum of 12 feet from the outer rim of the facility or to the edge of the apron, whichever is greatest, and be marked or otherwise protected from damage. Provide a stable outlet for the overflow pipe when an overflow pipe is included in the design. Direct overflow from the trough to another beneficial use or to the original watercourse, if possible.

Where water is supplied to a trough or tank under pressure, use an automatic water level control or float valve to control the flow of water to the facility and maintain the water level at 1 ½ inches below the top of the facility in order to reduce energy use and prevent overflows. Water level control or float valves must be designed in a manner to prevent unnecessary restrictions of flows or changes to the system's ability to deliver the flow as designed.

Provide a suitable drainage outlet to allow for maintenance and cleaning.

As needed, install a float valve on a gravity-fed trough to avoid draining the water source.

Protect valves and controls from damage by livestock, wildlife, freezing, and ice. Freeze protection may be accomplished by heat tape, earth sheltering, combination insulation and heat sink, an ice prevention valve, or other approved means.

Flow Rate
Pipelines serving a trough or tank shall be adequate to meet the delivery requirements of the trough or tank. The type of facility served by the pipeline will influence the pipeline requirements.

The flow rate to a watering facility is governed by the water source and recharge rate. The recharge rate for all systems except wind and solar powered systems shall be 2.0 times the daily use in a 24 hour period. The recharge rate for wind and solar powered systems shall be such that it delivers 1.5 times the daily livestock or wildlife need in a 24 hour period. Use the criteria in NRCS CPS Livestock Pipeline (Code 516) to select the components needed to attach the water supply to the trough.

Escape features
For sites west of the 100th meridian, incorporate escape features for wildlife into the design of an open-surface watering facility. For sites east of the 100th meridian, install escape features where local knowledge and experience indicate that wildlife may be at risk of drowning.

An effective escape device must—

- Touch the inside wall of the tank or trough.
- Reach from the rim to the bottom of the trough or tank.
- Be firmly secured to the trough or tank.
- Be built of durable material with a rough surface that animals can grip.
- Have a slope no steeper than 45 degrees.
- Be located to cause minimal interference with livestock.

Provide one escape device for every 30 linear feet of rim.

Refer to Bat Conservation International's "Water for Wildlife—A Handbook for Ranchers and Range Managers" (Taylor and Tuttle, 2012) for additional information on escape features.

Watering ramps
Where livestock or wildlife will drink directly from a pond or stream, use a watering ramp to provide stabilized access to the water. Evaluate existing and proposed fences, grazing patterns, shoreline slope, and water depth when choosing the optimum location for the ramp.

Width
Make the ramp wide enough to accommodate the expected usage. The minmum width of a watering ramp shall be 8 feet. Design watering ramps to provide 1.0 foot of width per 10 animal units.

Length
Extend the ramp into the stream or pond far enough to achieve the desired depth.

Surface drainage
Divert surface runoff from the approach to the ramp.

Slope
Make the slope of the watering ramp consistent with planned animal usage but not steeper than 3 horizontal to 1 vertical (3:1). The slope of the ramp shall match as close as practical the slope of the pond shoreline or stream bank to aid in construction. In no case should the slope of the watering ramp be flatter than 5 horizontal to 1 vertical (5:1)

Side slopes
Make all side slope cuts and fills stable for the soil materials on the site. Make the side slope cuts or fills in soil materials no steeper than 2 horizontal to 1 vertical (2:1). Make rock cuts or fills no steeper than 1.5 horizontal to 1 vertical (1.5:1).

Foundation
Where necessary, prepare the foundation by removal and disposal of materials not adequate to support the design loads.

Surface material
Use the criteria in NRCS CPS Heavy Use Area Protection (Code 561) to design the ramp surface. The selected material must be of adequate quality to withstand underwater conditions.

Access
Use fencing or other barriers to delineate the boundaries of the ramp. Barriers must be of sufficient size, strength, and quality to meet the intended use of the facility.

Ramps in streams
If there is a need to provide a stream crossing in conjunction with a watering facility, use the criteria in NRCS CPS Stream Crossing (Code 578) for the design and construction of ford crossings, except as noted above in Watering Ramps.

Locate the watering ramp so that it does not impede the movement of aquatic organisms in the stream.

Ramps in ponds
Extend the ramp into the pond until a minimum water depth of 5 feet is reached, measured from the design normal water level. Where the pond depth is greater than 5 feet at the ramp location, excavate the ramp into the pond bank or use other means to provide a stable base at the lower end. Extend the ramp a minimum of 0.5 feet above the normal water level.

Fencing
Use criteria found in NRCS CPS Fence (Code 382) for the design and construction of fences associated with the watering facility. Ensure designs that allow safe ingress and egress for area wildlife species. To protect species that access water by skimming across the surface, make fencing materials highly visible with appropriate openings. Add permanent streamers or coverings to wire fences that extend across a watering facility to make them more visible to skimmers.

CONSIDERATIONS

General Considerations
Consider the implementation of NRCS CPS Prescribed Grazing (Code 528) when installing a watering facility to address water quality and animal distribution resource concerns.

When possible, locate the watering facility away from streams, ponds, or riparian areas to minimize chance of fecal contamination or surface pollution.

Consider the quality of the water provided to the watering facility and the effects on animal health, animal production, water intake, and feed and forage consumption.

Not all species need or benefit from supplemental water. Consider impacts to both target and nontarget wildlife species before installation of a watering facility. Observed or documented use of a facility by wildlife does not necessarily indicate net benefits. Introducing a new water source within an ecosystem can have effects such as the concentration of grazing, predation, entrapment, drowning, disease transmission, and expansion of the wildlife populations beyond the carrying capacity of the available habitat. Providing a water source for wildlife could enhance the habitat for species that compete with or prey on at-risk species.

Consider designing the facility to benefit wildlife. Such designs would include providing ground-level access to water for species that cannot use raised structures, such as troughs. Ground-level access can be provided through creation of an overflow collection area or a secondary ground-level water source. Depending on the target species, planners may want to consider protecting these areas using suitable fencing (marked as needed) that excludes livestock and larger wildlife species while allowing access of the site to small ground-dwelling species.

Wildlife populations within desert or arid regions of the country can become dependent on supplemental watering facilities. Consideration should be given to maintaining year-round water even if livestock are not present.

Consider disease transmission prevention at watering facilities. Consider suitable controls/treatments for local water-transmissible diseases and parasites.

When windmill, solar, or other potentially unreliable power sources are used, consider a battery backup system, or an alternate water source.

Consider the effects of water development on the balance or budget of water resources in the area of the new project. In some settings, this could be important and may result in effects to adjacent or associated habitats and species.

If there is the potential for small livestock, such as lambs or kids, to fall into the trough, provide a ledge or similar structure in the trough to provide an escape route or provide a second trough that has a shorter height.

Debris and algae can collect in watering facilities resulting in the need for frequent cleaning. Covers that shade the facility and reduce debris from falling into the facility, while still allowing animal access, will keep the water cooler, cleaner, and more palatable to animals.

When using tall storage tanks, consider a closed top system to eliminate the need for escape ramps, prevent drownings, and reduce debris from falling into the facility. The closed top will keep the water cooler, cleaner, and more palatable to animals.

Where debris or algae is a problem, consider increasing pipe sizes for inlets and outlets or installing a feature such as an inverted elbow at the inlet to the overflow pipe to reduce the chances of clogging. Consider installing a method to completely drain the watering facility to increase the ease of maintenance. Protect the drain outlet from erosion.

Consider adding ane overflow pipe when using floats or other automatic shut off valves as a primary level control device in case the float fails. A removable overflow should be considered to provide a method of draining the facility by its removal when maintenance needs to be performed.

Consider installation of a permanent means of ingress and egress for maintenance of a storage tank, where needed.

Additional Considerations for Watering Ramps

Where livestock exclusion from a stream is part of the planned installation, consider installing a watering ramp that can be used if emergency access to water is needed. Use a gate to restrict access to the ramp.

The slope of the ramp can influence animal behavior. Steeper slopes tend to discourage loitering in the ramp area.

Select a surface material for the ramp that will discourage loitering but still provide a stable footing. The larger stone will make the hoof contact slightly uncomfortable.

Avoid locating watering ramps in shady places, where possible, to discourage loitering.

Where possible, extend the fence completely across the stream. Use swinging gates to restrict animal movement.

PLANS AND SPECIFICATIONS

Provide plans and specifications that describe the requirements for applying this practice to achieve its intended purpose. As a minimum, include—

- A map or aerial photograph showing the locations of the facilities and any associated pipelines.
- Type and number of animals expected to use the facility.
- Special conditions for access, as needed.
- Foundation stability requirements.
- Site-specific detail drawings showing the facility size, dimensions, and necessary appurtenances (foundations, pipes and valves, escape features, anchoring, outlet stabilization and protection, etc.).
- Requirements for stabilization of any areas disturbed by the installation of the facility.
- Fencing, as needed.
- Materials and quantities.
- Construction specifications describing the installation of the facility.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan and review it with the operator. The plan will describe the actions that must be taken to ensure the facility functions properly for its design life. As a minimum, include—

- Regularly checking for damage to the facility. Check for leaks, site erosion, and damage to fences, heavy use areas, and appurtenances associated with the watering facility. Repair or replace damaged components as needed.
- Checking the performance of the automatic water level device, if present.
- Ensuring that the outlet pipe, if present, is freely operating and is not causing erosion.
- Cleaning the facility as needed.
- Monitoring and maintaining the facility to ensure that there is adequate inflow and outflow.
- Preparing the facility for winter as dictated by the climate. This may include draining supply pipes, emptying tanks, or ensuring that float valves will not be damaged by ice.
- For a portable facility, the plan for moving the facility and for monitoring/repair of the areas around the facility.

REFERENCES

Brigham, W. and C. Stevenson. 2003. Wildlife Water Catchment Construction in Nevada, Technical Note 397. U.S. Department of the Interior, Bureau of Land Management. Denver, CO.

National Research Council. 1996. Nutrient Requirements of Domestic Animals. Washington, D.C.: The National Academies Press.

New York State Grazing Lands Conservation Initiative and USDA NRCS. 2000. Prescribed Grazing and Feeding Management for Lactating Dairy Cows. Syracuse, NY.

Taylor, D.A.R. and M.D. Tuttle. 2012. Water for Wildlife—A Handbook for Ranchers and Range Managers. Bat Conservation International. Austin, TX.

Tsukamoto, G. and S.J. Stiver. 1990. Wildlife Water Development, Proceedings of the Wildlife Water Development Symposium, Las Vegas, NV. U.S. Department of the Interior, Bureau of Land Management.

USDA NRCS. 2012. National Engineering Handbook (Title 210), Part 650, Chapter 12, Springs and Wells. Washington, D.C. https://directives.sc.egov.usda.gov/

USDA NRCS. 1997. National Range and Pasture Handbook (Title 190), Chapter 6, Livestock Nutrition, Husbandry, and Behavior, p. 6-12, Table 6-7 and 6-8. Washington, D.C. https://directives.sc.egov.usda.gov/

USDA NRCS. 1980. National Engineering Handbook (Title 210), Part 650, Chapters 11, Ponds and Reservoirs. Washington, D.C. https://directives.sc.egov.usda.gov/

Yoakum, J. and W.P. Dasmann. 1971. Habitat Manipulation Practices. *In* Robert H. Giles, Jr. (ed.). Wildlife Management Techniques, Third Edition. The Wildlife Society. 633 pp.