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TECHNICAL NOTE

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VEGETATIVE TREATMENT SYSTEMS GUIDE

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Introduction

Traditionally, holding ponds have been used to collect and store runoff from feedlots until this runoff water can be practically land applied. This document introduces the use of VTSs as an alternative to holding ponds for treatment of feedlot runoff water. Research and monitoring is currently ongoing to determine the quality of treatment that a VTS provides.

This technical note is limited in nature, and intended to give suggestions, recommendations, and criteria to plan, design, operate, and maintain a VTS in SD. For a comprehensive review of VTSs, it is recommended to review *Vegetative Treatment Systems for Open Lot Runoff, A Collaborative Report* which was developed under the leadership of the United States Department of Agriculture Natural Resources Conservation Service (NRCS) and released in June 2006.

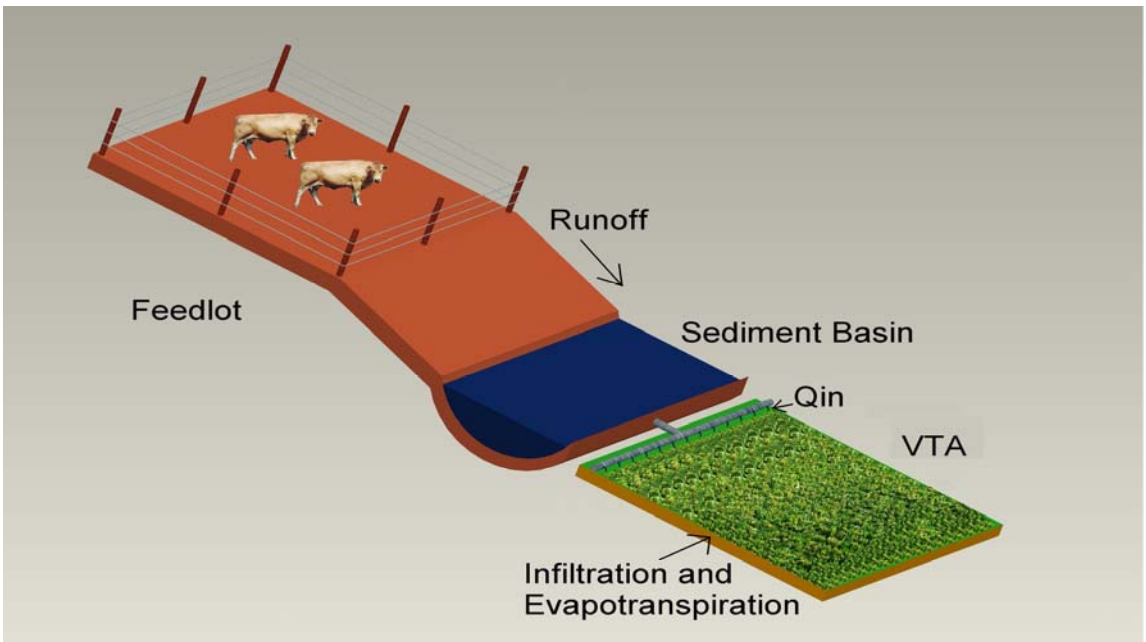
The knowledge, time, research, and expertise of the SD State University (SDSU) Agricultural and Biosystems Engineering Department, University of Nebraska (NE) - Lincoln Agricultural Engineering Department, and the NE NRCS were greatly appreciated in the development of this technical note.

Section 1: Planning VTSs in SD

What is a VTS?

A VTS is an exciting new alternative for livestock producers to use in the effort to protect water quality in SD. A VTS refers to a combination of treatment steps for managing feedlot/ animal waste runoff. A VTS is composed of two primary components – a solids removing component (usually a sediment basin), and a liquid and nutrient treatment component typically referred to as a VTA.

A sediment basin is a shallow basin, usually about three to four feet deep, that can be easily accessed for solids cleanout. This basin collects and slowly distributes the runoff from the lot to the VTA. Sediment basins for a VTS are generally larger than those for holding ponds. Experts recommend that a sediment basin for a VTS be able to control the largest expected rainstorm. Specific size requirements for sediment basins that are used in conjunction with a VTA can be found within the SD Conservation Practice Standard (CPS) Sediment Basin (350). Heavy rainfall and feedlot runoff entering a VTA at the same time can overwhelm the soil's ability to absorb the water. The VTA performance is improved if the outlet between the sediment basin and the VTA is controlled by a valve or pump to allow for appropriate controlled liquid release.



When released from the sediment basin, the runoff flows into the (VTA) where soil and vegetation further filters the runoff and prevents it from leaving the farm. Once the runoff infiltrates the soil, natural processes allow plants to use the nutrients. The VTA consists of perennial vegetation such as a grass or forage. The VTA is used to treat runoff from a feedlot or barnyard by settling, infiltration, and nutrient use.

A VTA is commonly confused with vegetative buffer (or filter) strips. A buffer strip is a narrow strip of vegetation (usually 30-60 feet wide) between cropland or a water source (i.e., stream, lake, or river). Runoff passes through buffers with some "filtering" of pollutants but no attempt is made to control solids or flow. A VTS; however, collects runoff

from a barnyard or feedlot, separates the solids from the liquids, and uniformly distributes the runoff to the vegetated area. Little or no runoff should leave a VTA.
Two methods are commonly used to size a VTA. Typically, the most conservative method to size the VTA is to use the nutrients (nitrogen (N)) in the run-off water. The second method is a water balance method, where the soil's infiltration rate is balanced with the largest expected rainfall. A good rule is that a VTA needs to be at least as large as the feedlot area. The specific design procedure for sizing a VTA can be found in *Chapter 5: VTS Design*.

Advantages of a VTS/VTA

- May provide lower initial investment and operating costs.
- More aesthetically palatable than large ponds.
- No long-term storage of runoff required, such as holding or evaporation ponds.
- Fewer safety issues.
- Land designated for VTA can produce usable forage.

Disadvantages of a VTS/VTA

- A VTA may not be a "closed" system; saturated soils from previous rains could allow a discharge.
- Special management required during runoff events.
- The VTAs can be damaged by a lack of maintenance and attention - gullies, erosion, and poor vegetation stands dramatically reduce their effectiveness.
- Not currently permitable in SD by the Department of Environment and Natural Resources (DENR).
- The VTAs may not provide the same level of water quality improvement as a total runoff containment system, such as holding or evaporation ponds provide.

Section 2: Eligible Operations for a VTS

A VTS may not be appropriate for every operation. Typically, a VTS is most appropriate for an open feedlot or possibly as a treatment option for liquid leaving a manure stacking pad or feed storage area. Both the size of operation and site specific details of the facility should be taken into consideration when deciding whether a VTS is appropriate for a site.

Size of Operation Criteria for a VTS

- >1,000 Animal Units (AU) (all operations over 1,000 AU require a SD DENR permit and, at this time, VTSs are not an alternative that is accepted by DENR.
- 500–999 AU (VTS is appropriate if site conditions are ideal and no DENR permit will be required.)
- < 500 AU (very appropriate for this size operation as long as the site criteria is conducive to the building and functioning of VTA and no DENR permit is required.)

Site Criteria for a VTS

- Most appropriate for animal feeding operations with less than 500 AUs.
- Preferable that operations in the 500-999 AU category be at least 1,320 feet away from major receiving waters such as lakes, streams, rivers, etc.
- 0.5 percent – six percent slopes in VTA area.
- Not located in a floodplain or on any soils prone to frequent flooding.
- Site of proposed VTA is not currently a natural wetland.
- Consider ground water levels.

- Good underlying soils; loams are best but especially avoid very sandy, gravelly, or very heavy clay soils.
- Enough land down slope of the feedlot to match a 1:1 to 1:2 ratio of feedlot to VTA.
- Current phosphorus levels in the area where VTA will be are <50 parts per million (ppm) on the Olsen scale or <75 ppm on Bray 1 scale.

Section 3: Types of VTAs

There are several types of VTAs that have been used to provide runoff treatment throughout the country. The three common types of VTAs that are used to provide runoff treatment, in SD, are the sloped VTA, terrace VTA, and sprinkler VTA.

Sloped VTA – A sloped VTA refers to a treatment area that is slightly sloped. The slope allows liquid to uniformly spread across the width of the treatment area and flow the length of the VTA. Sloped VTAs should be between one percent and six percent slope and level from side to side. Borders, berms, furrows, ditches, curbs, gated pipe, and level spreaders have been used create and maintain uniform flow. A bermed area or a Vegetative Infiltration Basin (VIB) is a level grassed or cropped area designed to stop liquids from running off of the end of a sloped VTA. These berms or VIBs can be useful at the bottom sloped VTA to keep liquids from entering lakes or streams.

Sprinkler VTA – A sprinkler VTA is an area of perennial vegetation with runoff distributed by a sprinkler irrigation system. A solid set sprinkler, tow line, or side roll can be used to distribute the runoff collected in the sediment basin. Although these may be more expensive than a sloped VTA, a sprinkler VTA may provide more uniform application of runoff and nutrients. These are applicable to situations where a gravity system is not feasible, and can be used with most soil textures. An all-weather pumping station is required for a sprinkler VTA.

Terrace VTA – A terrace VTA uses terraced channels to contain and treat runoff on fields with steep slopes. They must be fairly large and well maintained and should be planted to grass. Two types of terrace systems exist: (1) a flow through terrace system that acts similar to a sloped VTA, and (2) a flat channel storage terrace (water storage) similar to a VIB. Terraces used to control erosion in crop fields should not be used as a VTA without modification.

Section 4: VTA Vegetation

Selecting the plant species for a vegetative system is critical. Grasses should be selected to minimize erosion in the VTA and maximize nutrient uptake. Grasses are more effective than broadleaf species for reducing erosion. Sod forming grasses are well suited for most VTAs. The plant species selected should be appropriate for the soil and climate of the area. The grasses selected for a VTA should be able to survive occasional flooding. Plants used in a VIB should be able to survive frequent flooding. Local recommendations for grass or forage species selection should be followed. Plants that provide more than one harvest are best for a VTA and allow for a smaller VTA than single cutting plants. Also, timing the harvest to avoid field ruts is more critical than high quality hay.

Species Selection
At least three species are recommended to be included in each mixture and one of these should be tolerant to flooding and/or saturated soil conditions such as creeping foxtail, reed canarygrass, etc.

If salts/salinity is a potential concern (electrical conductivity (EC) >4.0 mmhos/cm, or a sodium adsorption ratio (SAR) >10), then at least one salt/saline tolerant grass should be included such as slender wheatgrass, tall wheatgrass, etc. Sod forming grasses are preferred; however, bunch grasses can be included in mixtures which include at least two sod forming species.

Since most flow will occur during the spring and early summer months, it is advisable to use cool-season grasses for a majority of the mix. If warm-season grasses are to be included, consider developing cells within the vegetated treatment area and seed one or more cells to a dominant mixture of warm-season species.

Species that are desirable as forage hay are advantageous since they will be the preferred method of biomass removal.

Species with large, fibrous root masses are desirable; whereas, species with large tap roots are not desirable because they increase the chance of preferential flow.

Including legumes in the mixture is only recommended in areas where rodents such as pocket gophers, will not compromise the integrity of the VTA. Adding legumes to mixtures may help alleviate compaction layers that develop during grading and shaping activities. Legumes may be added to initial seeding at no more than 10 percent of the total rate. Legumes should not be added to warm season grass plantings. If necessary, legumes can be removed with herbicides after initial compaction has been alleviated (two-to-four years).

Please refer to Table 7 and Table 8 of the SD NRCS Range Technical Note No. 4 at http://efotg.nrcs.usda.gov/references/public/SD/RangeTechNote4.pdf for assistance with species selection. All mixtures should be adapted to suit the predominant ecological site (ES)/soils of the VTA and take into consideration how engineering modifications may change the site's hydrology, soil structure, etc. Seeding rates for VTAs will be four times the rate in Table 2 of SD NRCS Range Technical Note No. 4 (recommended rate in Table 2 multiplied by four).

The following table lists potential species to consider for VTAs.

Species	Season Of Use	Flood Tolerance	Salt Tolerance	N Uptake lbs./ton
big bluestem	Su	Good	Poor	20 lbs./ton***
creeping foxtail	Sp, Su, F	Very good*	Poor	29 lbs./ton***
intermediate wheatgrass	Sp	Fair	Fair	28 lbs./ton***
meadow brome	Sp, F	Fair	Poor	35 lbs./ton***
orchardgrass	Sp, Su, F	Poor	Poor	29 lbs./ton***
pubescent wheatgrass	Sp, F	Fair	Fair	28 lbs./ton***
reed canarygrass	Sp, Su	Very good*	Poor	27 lbs./ton***
smooth bromegrass	Sp, F	Good	Poor	39 lbs./ton***
switchgrass	Su, F	Good	Fair	23 lbs./ton***
tall wheatgrass	Sp, F	Good	Good**	28 lbs./ton***
western wheatgrass	Sp, Su	Good	Good**	28 lbs./ton***
alfalfa	Sp, Su	Poor	Poor	45 lbs./ton***

*Include one of these species if flooding or saturated soil conditions are anticipated.
**Include one of these species if high salt/salinity conditions are anticipated.
***Good choices for uptake of high levels of N.
Sp – Spring; Su – Summer; F – Fall

Management and Maintenance of the VTA

VTAs are sometimes mistakenly promoted as an option requiring low management inputs. For a well performing VTA, producers must be willing to do the following:

- All seeding, mowing, and haying activities should be conducted perpendicular to flow to prevent rills and gullies from forming.
- Maintain a dense, vigorous stand of vegetation.
- Adjust inlets to evenly spread runoff across the VTA.
- Inspect the VTA after heavy rainstorms.
- Repair areas of erosion or wheel tracks.
- Regularly test the soil. A well planned fertility program is essential to maintaining vegetation.
- At least yearly, harvest the vegetation to remove accumulated nutrients. More frequent harvesting may promote better weed control and higher quality feed.
- Harvest when soil conditions will not create tire tracks or ruts. If practical, drive the equipment across the slope to prevent downhill ruts and ditches from forming.
- Keep grazing animals off of the VTA. Grazing removes very few nutrients and damages the vegetation.

Section 5: VTS Design

The following are specific sizing criteria listed in the SD CPSs for Vegetated Treatment Area (635) and Sediment Basin (350):

1. Base the total treatment area for the VTA on the soil's capacity to infiltrate and retain runoff within the root zone and the vegetation's agronomic nutrient requirements.

2. Design the VTA based on the need to treat the runoff volume from the 25-yr., 24-hr. storm event from the agricultural animal management facility.
3. For sediment basins that have controlled outflow to the VTA with the use of shut-off valves, pumps, etc., the design liquid volume is the entire runoff volume from the design storm event with the design solids volume contained in the sediment basin.

   For sediment basins that have uncontrolled outflow to the VTA, the design storage volume can either be the entire runoff volume from the design storm event with the design solids volume contained in the sediment basin or flood routing the design storm event through the sediment basin with the design solids volume contained in the sediment basin. If using the flood routing method, the maximum liquid elevation during the flood routing is considered the top of the design storage volume.

Sediment basin sizing should use the same general equations and procedures for sediment basins that are used in conjunction with waste storage facilities (NRCS CPS Waste Storage Facility (313)).

VTA Sizing
The *SD VTA Design Spreadsheet* can be used to determine the minimum size of a VTA to meet the criteria listed above. This spreadsheet is located on the SD NRCS Web site at http://www.sd.nrcs.usda.gov/technical/Engineering_Tools.html. Within this spreadsheet, use the **VTA Size sheet** to compute the VTA minimum size. The following is a description of the different items shown on the **VTA size sheet**:

The following items are entered by the user on the **VTA size sheet**:
- Landowner
- Conservation District
- Field Office
- County
- MLRA – see the **MLRA map sheet**
- Designer and date
- Checker and date
- Each portion of the drainage area
    - Building Roof Area – This area is considered in the computation of the 25-yr., 24-hr. storm event but not in the computation for N in the runoff.
    - Dirt Feedlot Area – This area is considered in the computation of the 25-yr., 24-hr. storm event and N in the runoff.
    - Concrete Feedlot Area – This area is considered in the computation of the 25-yr., 24-hr. storm event and N in the runoff.
    - Other Area – This area is considered in the computation of the 25-yr., 24-hr. storm event but not in the computation for N in the runoff.
    - Other Area CN (one day) – This is the one day Runoff Curve Number used to determine the runoff from the other area.
- Type of Vegetation in VTA – The type of vegetation to select should be the dominant type of vegetation that is expected in the VTA.
- Description of Soil in VTA – Choose the dominant soil classification in the VTA area.
- Names of Soils within the VTA – Choose each soil that is located within the VTA.

The VTA size sheet calculates the following items:

- Total Area – The sum of the four areas that are listed in the Drainage Area Information.
- Other Area CN (30-day) – The 30-day curve number is calculated from the 1-day curve number that the user entered.
- Rooting Depth (ft.) – The rooting depth is taken from the Type of Vegetation in VTA. The rooting depth values for each vegetation species are listed in the **Data and Comps sheet**.
- Irrigation Design Group - These are the Irrigation Groups that correspond to each soil. These groups can be found in the Irrigation Guide for South Dakota.
- Available Water Capacity in Root Zone - This value is calculated from soil survey information and the Rooting Depth for the vegetation species. The available water capacity totals for each soil are listed in the **SD Soils sheet**.
- Maximum Intake Rate - These soil intake rates correspond to each soil type. The rates can be found in the Irrigation Guide for SD and the **SD Soils sheet**.
- 25-yr., 24-hr. rainfall depth (inches) – The storm rainfall depth for the county selected. These values can be found on the **Data and Comps sheet**.
- Weighted Curve Number – The weighted curve number calculated from the areas listed in the Drainage Area Information.
- Associated Storm Runoff – The runoff calculated from the 25-yr., 24-hr. rainfall depth and the Weighted Curve Number from the feedlot drainage area.
- 25-yr. Storm Runoff Volume – The runoff volume calculated from the storm runoff depth.
- Mean Annual Rainfall - The annual rainfall depth for the county selected. These values can be found on the **Data and Comps sheet**.
- Percent Annual Runoff (Dirt Area) – The dirt areas percent annual runoff for the county selected. These values are from the Animal Waste Management Field Manual (AWMFM), Notice SD-1, dated March 6, 1981, and can be found on the **Data and Comps sheet**.
- Percent Annual Runoff (Concrete) – The concrete percent annual runoff for the county selected. These values are from the AWMFM, Notice SD-1, dated March 6, 1981, and can be found on the **Data and Comps sheet**.
- Annual Runoff Volume from Dirt and Concrete Lots (cubic feet and acre-inches) – The calculated annual runoff from the Dirt Feedlot and Concrete Feedlot areas. These values do not include the runoff from the Building Roof Area and Other Area.
- Total Annual Runoff Volume (cubic feet and acre-inches) - The calculated annual runoff from of the total drainage area.
- VTA Size Calculated by the 25-yr., 24-hr. Storm
    - AWC for the Design Soil (inches) – The AWC for the Design Soil is the lowest AWC of the soils listed in the VTA information.
    - Fraction of AWC to use for storage (%) – The percent of the AWC that is used for storage of the volume from the 25-yr., 24-hr. storm runoff volume. See **Appendix A** for details how this percentage is developed.

- AWC to be used for design (inches) – This is calculated by multiplying the AWC for the Design Soil by the Fraction of AWC to use for storage. This answer is the depth used to store the 25-yr., 24-hr. storm event volume.
- Minimum VTA area for runoff (acres) – This is the surface area coverage required to handle the 25-yr. storm runoff volume at a depth of the AWC to be used for design.

- VTA Size Calculated by the annual N uptake by vegetation
  - Annual N applied to VTA in runoff (lbs. of N) – This value is computed by multiplying the Annual Runoff Volume from Dirt and Concrete Lots (acre-inches) by the lbs. of N in runoff. The amount of N in runoff used for each county can be found on the **Data and Comps sheet**. See **Appendix B** for more details regarding the lbs. of N in runoff.
  - Yield of VTA vegetation (tons/acre) – The vegetation yield is calculated by using the vegetation type and Major Land Resource Area (MLRA). The yield is estimated as the nonirrigated yield plus 25 percent for MLRAs 54, 58D, 60A, 61, 62, 63A, 64, and 65. The yield is the nonirrigated yield plus 50 percent for MLRAs 53B, 53C, 55B, 55C, 63B, and 66. The yield that is used is the nonirrigated yield plus 75 percent for MLRAs 54, 56, 58D, 60A, 61, 62, 63A, 64, and 65. These yields and computations are shown on the **Data and Comps** and **grass yields sheets**.
  - Vegetation N uptake (% dry harvested material) – This value ranges from 1 percent to 2.5 percent depending on the species of vegetation. These values can be found on the **Data and Comps sheet**.
  - Annual N uptake by VTA vegetation (lbs/acre) – The yield in lbs./acre is multiplied by the percent uptake of N to calculate the annual amount of N that is harvested by the VTA area.
  - Minimum VTA area to utilize N (acres) – The minimum VTA size is calculated by dividing the annual N applied to the VTA by the annual N uptake per acre.
- Minimum Size of VTA (acres) – The minimum VTA size is the larger of the VTA size calculated from the 25-yr., 24-hr storm and the VTA size calculated from the N uptake.

The spreadsheet also contains a **Sprinkler Sizing sheet** that can be used as a design aid if a pump and sprinkler system is being used for application of the runoff water from the sediment basin to the VTA. The **MLRA Map**, **SD Soils**, **Data and Comps**, and **grass yields sheets** contain the background information and computations used to calculate the minimum VTA size.

Water Delivery to the VTA

Uniform application of the runoff water is critical to maximize the amount of infiltration and to uniformly apply the nutrients throughout the VTA. The water is generally applied through the VTA as sheet flow with the use of a ditch, curb, gated pipe, or level spreader. Another option is to use a sprinkler system to deliver water uniformly throughout the VTA. Background information and design criteria for water application methods are described below.

Sheet Flow Delivery
Water flow down a slope normally begins as sheet flow. As the flow of water progresses down the slope, the sheet flow becomes shallow concentrated flow and then concentrates to a channel flow condition. This effect can significantly affect the effectiveness of a VTA by decreasing the ground surface to which the flow of water is exposed to. As stated in SD CPS Vegetated Treatment Area (635), “Discharge into and through treatment areas shall be applied as sheet flow. Where sheet flow is planned, some means, such as a ditch, curb, gated pipe, level spreader, or a sprinkler system, shall be provided to disperse concentrated flow and ensure sheet flow across the area.”

With this in mind, the design for a VTA that includes water flow down a slope should consider the use of spreaders at the top and within the areas of the VTA. The common types of constructed spreaders are listed above, with some types being more applicable than others, depending on the situation and the specifics of the VTA site. The spacing for spreaders should be such that concentrated flow does not develop. The recommended spacing of level spreaders is:

- VTA slope less than 2 percent - use maximum spreader spacing of 200 ft.
- VTA slope between 2 percent and 5 percent - use maximum spreader spacing of 100 ft.
- VTA slope greater than 5 percent - use maximum spreader spacing of 50 ft.

While the hydraulics of the spreaders would theoretically follow the principles of water flow such as the Weir equation, the Manning’s equation, and other basic fluid mechanics principles, it will almost certainly be the case that level spreaders will require maintenance periodically. This maintenance could be adjustment of the spreaders to maintain a level flow distribution, removal of accumulated sediment, repair of damage to the spreaders, erosion repair for spreaders that utilize earth, and other similar adjustments to facilitate even water spreading though the VTA. Also, proper harvesting of the vegetation should be part of the operation and maintenance procedure for a VTA, as wheel tracks are a common cause of concentrated flow developing within a VTA. These items should be included in the operation and maintenance document that is prepared for a VTA.

Land shaping and level grading across the VTA width are also useful avenues to achieve and maintain uniform flow within the VTA. Adverse affects such as increased compaction, soil profile disruption, loss of topsoil depth, etc., should be considered when shaping and leveling the VTA area. The combination of spreaders and level grading across the VTA width may also help to obtain and maintain uniform flow throughout the VTA.

Design methods for surface irrigation methods of runoff water to the VTA can be found in Chapter 6 of the National Engineering Handbook, Part 652, Irrigation Guide. As referenced within this chapter, the Agricultural Research Service’s publication, *Surface Irrigation Model, SRFR* can be used for surface irrigation designs by NRCS. WinSRFR software can be found at http://www.wsi.nrcs.usda.gov/products/W2Q/water_mgt/Irrigation/irrig-mgt-models.html.

Sprinkler Delivery
One of the most effective methods that can be employed to give complete coverage of a VTA is the use of sprinkler type irrigation. The type of systems available for sprinkler irrigation include center pivots, linear move systems, traveling systems, solid set systems,

hand move type systems, and side roll systems. Some of the important criteria to be considered when determining what type of system to use are:

- Operator familiarity with the type of system selected
- Availability of equipment for the system
- Site layout/topography
- Cost and labor
- Irrigation scheduling and pumping capacity requirements
- Soil type, specifically the intake rate of the soil, groundwater conditions, and water holding capacity

For a large area to be irrigated, it is common to employ a center pivot sprinkler system. One benefit of a center pivot type system is that more automation is able to be employed and thus less labor is required for this type of system. However, the availability of equipment, cost of the equipment, access to pumping capacity and power, and the access to other sources of water to further utilize the system should be considered before implementing this type of system. Linear move systems function in much the same manner as center pivots with the exception of their path of traveling being along a field instead of circular. Thus, the considerations for a linear move system are essentially the same.

The use of traveling systems (such as a big gun type applicator), hand move systems, and side roll systems will often involve more manual labor requirements than center pivots. This indicates that availability of labor should be a consideration when applying this type of a practice. One example of a hand move system that has been used as part of a vegetated treatment practice is the K-Line irrigation product. This system consists of sprinkler 'pods' that are mounted on a flexible irrigation line and can be pulled to different alignments with an all-terrain vehicle. This system is usually constructed with a properly sized impact sprinkler and allows for even distribution of water across a VTA. Solid set type irrigation systems can also be effectively used as part of a VTS.

For all of the different systems of sprinkler irrigation that can be used, there are notable criteria to consider before applying this technology to VTAs. Of primary importance is the presence of solids in the water that leaves the feedlot and sediment basin. The solids content of the water from the feedlot or the solids settling system should be analyzed so that the pumping equipment and irrigation equipment suitability for the specific water quality can be determined. It is highly recommended that a filtration system in the irrigation line be employed to prevent line plugging, nozzle plugging, or other similar effects from occurring within the system. Commonly used filters can be found by contacting irrigation equipment suppliers. An additional item for consideration is the matching of a pumping rate to the desired emptying time of a basin. This involves a simultaneous consideration of the soil intake rate in the VTA to the desired pumping rate out of the VTA. This consideration could also have a direct effect on the size of the VTA that is to be utilized.

Sprinkler systems should be designed by typical irrigation methods. The NRCS National Engineering Handbook (NEH), Part 652.0602, contains more complete design guidance for sprinkler irrigation systems and many alternate methods for design of sprinkler irrigation systems may be employed as well. The **Sprinkler Sizing sheet** on the VTA design spreadsheet can also be used to assist in a sprinkler VTA design.

VIB/Berms at the lower end of VTA
Installing containment berms at the end of the VTA will reduce or eliminate untreated discharge to surrounding surface water. This contained area would form a basin area at the end of the VTA that would catch excess runoff that exits the end of the VTA.

- Containment berms <u>should be considered</u> when the facility is located one-half mile or less from surface waters to reduce the risk of runoff into surface waters or when discharge will adversely affect water quality.
- Containment berms <u>are required</u> when the outflow from the sediment basin is not controlled by the use of shut-off valves, pumps, etc.
- Containment berms <u>are not recommended</u> when outflow from the sediment basin is controlled by the use of shut-off valves, pumps, etc., and the sediment basin has sufficient storage during periods when frozen or saturated ground is present in the VTA. In this instance, proper management of the outflow from the sediment basin should be used to ensure that water is not applied to the VTA when it is saturated or frozen.

The bermed area at the end of the VTA should be designed to contain the 25-yr., 24-hr. event. No freeboard is required above the 25-yr., 24-hr. storm event storage level and a spillway may be used above the 25-yr., 24-hr. storm event storage level if the berm extends above the storm event level. The storage provided by the bermed area does not replace all or part of the VTA area. Slopes should be between zero to two percent within the bermed storage section. The management of this basin is intended to reduce runoff but not intended to be pumped as a form of operation and maintenance.

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Appendix A
Estimation of Available Water Holding Capacity in Vegetated Treatment Areas

Background

Predicting the water holding capacity that may be available in the soil profile at any given point in time should be recognized as impossible. Numerous climatic factors, soil type, type of crop, stage of crop growth, etc., all may influence the water holding capacity. Recognizing these difficulties, a conservative estimate is desired in order to provide a reliable starting point to use in the design of the VTA system.

Rationale

The SD Irrigation Guide was used as a reference to evaluate the soils available water holding capacity to be used in a VTA. For the purpose of irrigation, the State of SD is broken down into five distinct areas based on similar climatic conditions. (See Figure 2 below.) The soils staff in the SD NRCS State Office was consulted to select the most common soil mapping units in each of the five climatic areas. The available water holding capacity in the top four feet of the soil profile was tabulated for each of these soils.

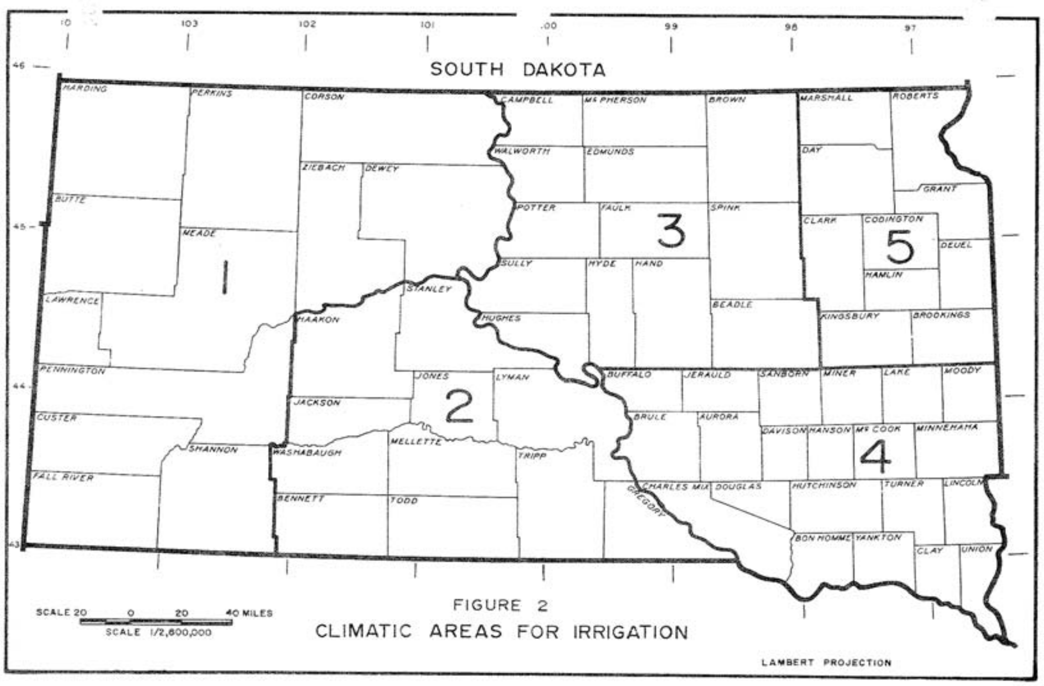

FIGURE 2
CLIMATIC AREAS FOR IRRIGATION

Tables in the Irrigation Guide also provide consumptive use and net irrigation information for eight separate crops in each of the climatic areas. These tables were utilized to determine the percentage of the consumptive use supplied by rainfall in each of the five climatic areas. The crops selected for this evaluation were grass and alfalfa, assuming that these would be most similar to the crops selected for use in a VTA.

The percentage of each soils water holding capacity in the top four feet <u>not provided by rainfall</u> was computed and an amount equal to one half of the capacity available in the top two feet of soil was subtracted from this available capacity.

The resulting value was compared to the total water holding capacity and expressed as a percentage. This percentage should provide a conservative estimate of the available water holding capacity to be utilized in VTA design. The computation for MLRAs 54, 58D, and 60A are shown below (the calculations for areas 2 through 5 are shown at the end of this appendix).

SD Climatic Area for Irrigation	Seasonal Consumptive Use (Grass) (inches)	Seasonal Consumptive Use (Alfalfa) (inches)	Typical Soil	Intake Family	Water Holding Capacity 1st Foot (inches)	Water Holding Capacity 2nd Foot (inches)	Water Holding Capacity 3rd Foot (inches)	Water Holding Capacity 4th Foot (inches)	Water Holding Capacity Total(4') (inches)
I (West)	26.7	23.2	Promise	0.1	1.4	1.3	1.3	1.3	5.3

Effective Seasonal Rainfall (Grass) (inches)	Effective Seasonal Rainfall (Alfalfa) (inches)	Percent of use supplied by Rainfall (Grass)	Percent of use supplied by Rainfall (Alfalfa)	Deduct 50% WHC in Top 2' of Soil	% of WC Available	MLRAs	WC Available %
6	5.2	22.5%	22.4%	1.35	**52.09%**	54, 58D, 60A	**50**

(((5.3" Available X (1 – (22.5%+22.4%) / 2)) – 1.35") / 5.3") X 100 = **52.09%**

The statewide values obtained in this procedure were utilized to select a value to be used in the Black Hills area due to the extreme variability in elevation and rainfall.

The resulting values are tabulated below according to the MLRA's in SD.

ESTIMATED AVAILABLE WATER HOLDING CAPACITY

SD Climatic Area for Irrigation	MLRA's	Estimated WC Available
I (West)	54, 58D, 60A	**50**
	61,62	**40**
II (W.R. South Central)	63A, 63B, 64, 66	**45**
	65	**55**
III (E.R. North Central)	53B, 53C, 55B	**50**
IV (Southeast)	55C	**40**
	102B, 102C	**35**
V (Northeast)	102A	**40**

Estimated Available Water Holding Capacity for MLRA 61 and 62

SD Climatic Area for Irrigation	Seasonal Consumptive Use (Grass) (inches)	Seasonal Consumptive Use (Alfalfa) (inches)	Typical Soil	Intake Family	Water Holding Capacity 1st Foot (inches)	Water Holding Capacity 2nd Foot (inches)	Water Holding Capacity 3rd Foot (inches)	Water Holding Capacity 4th Foot (inches)	Water Holding Capacity Total(4') (inches)
I (West)	26.7	23.2	Millboro	0.1	1.6	1.3	1.3	0.6	4.8

Effective Seasonal Rainfall (Grass) (inches)	Effective Seasonal Rainfall (Alfalfa) (inches)	Percent of use supplied by Rainfall (Grass)	Percent of use supplied by Rainfall (Alfalfa)	Deduct 50% WHC in Top 2' of Soil	% of WC Available	MLRAs	WC Available %
6	5.2	22.5%	22.4%	1.45	**47.35%**	61,62	**40**

Estimated Available Water Holding Capacity for MLRA 63A, 63B, 64, and 66

SD Climatic Area for Irrigation	Seasonal Consumptive Use (Grass) (inches)	Seasonal Consumptive Use (Alfalfa) (inches)	Typical Soil	Intake Family	Water Holding Capacity 1st Foot (inches)	Water Holding Capacity 2nd Foot (inches)	Water Holding Capacity 3rd Foot (inches)	Water Holding Capacity 4th Foot (inches)	Water Holding Capacity Total(4') (inches)
II	29.5	26.1	Promise	0.1	1.4	1.3	1.3	1.3	5.3

Effective Seasonal Rainfall (Grass) (inches)	Effective Seasonal Rainfall (Alfalfa) (inches)	Percent of use supplied by Rainfall (Grass)	Percent of use supplied by Rainfall (Alfalfa)	Deduct 50% WHC in Top 2' of Soil	% of WC Available	MLRAs	WC Available %
7.2	7.1	24.4%	27.2%	1.35	**48.72%**	63A,63B,64,66	**45**

Estimated Available Water Holding Capacity for MLRA 65

SD Climatic Area for Irrigation	Seasonal Consumptive Use (Grass) (inches)	Seasonal Consumptive Use (Alfalfa) (inches)	Typical Soil	Intake Family	Water Holding Capacity 1st Foot (inches)	Water Holding Capacity 2nd Foot (inches)	Water Holding Capacity 3rd Foot (inches)	Water Holding Capacity 4th Foot (inches)	Water Holding Capacity Total(4') (inches)
II	29.5	26.1	Reliance	0.3	2.3	1.8	2	2	8.1

Effective Seasonal Rainfall (Grass) (inches)	Effective Seasonal Rainfall (Alfalfa) (inches)	Percent of use supplied by Rainfall (Grass)	Percent of use supplied by Rainfall (Alfalfa)	Deduct 50% WHC in Top 2' of Soil	% of WC Available	MLRA	WC Available %
7.2	7.1	24.4%	27.2%	2.05	**57.53%**	65	**55**

Estimated Available Water Holding Capacity for MLRA 53B, 53C, and 55B

SD Climatic Area for Irrigation	Seasonal Consumptive Use (Grass) (inches)	Seasonal Consumptive Use (Alfalfa) (inches)	Typical Soil	Intake Family	Water Holding Capacity 1st Foot (inches)	Water Holding Capacity 2nd Foot (inches)	Water Holding Capacity 3rd Foot (inches)	Water Holding Capacity 4th Foot (inches)	Water Holding Capacity Total(4') (inches)
III	26.4	24.1	Williams	0.3	2.3	2.2	2	2	8.5
			Agar	0.5	2.5	2.4	2.2	2.2	9.3
			Highmore	0.5	2.5	2.4	2.2	2.2	9.3

Effective Seasonal Rainfall (Grass) (inches)	Effective Seasonal Rainfall (Alfalfa) (inches)	Percent of use supplied by Rainfall (Grass)	Percent of use supplied by Rainfall (Alfalfa)	Deduct 50% WHC in Top 2' of Soil	% of WC Available	MLRAs	WC Available %
6.5	6.2	24.6%	25.7%	2.25	**48.36%**	53B, 53C, 55B	**50**
				2.45	**50.63%**		
				2.45	**50.63%**		

Estimated Available Water Holding Capacity for MLRA 55C

SD Climatic Area for Irrigation	Seasonal Consumptive Use (Grass) (inches)	Seasonal Consumptive Use (Alfalfa) (inches)	Typical Soil	Intake Family	Water Holding Capacity 1st Foot (inches)	Water Holding Capacity 2nd Foot (inches)	Water Holding Capacity 3rd Foot (inches)	Water Holding Capacity 4th Foot (inches)	Water Holding Capacity Total(4') (inches)
IV	29.2	25.7	Houdek	0.3	2.3	2.3	2.2	2.2	9
			Clarno	0.3	2.2	2.2	2.1	2.1	8.6

Effective Seasonal Rainfall (Grass) (inches)	Effective Seasonal Rainfall (Alfalfa) (inches)	Percent of use supplied by Rainfall (Grass)	Percent of use supplied by Rainfall (Alfalfa)	Deduct 50% WHC in Top 2' of Soil	% of WC Available	MLRA	WC Available %
10.1	9.5	34.6%	37.0%	2.3	**38.67%**	55C	**40**
				2.2	**37.48%**		

Estimated Available Water Holding Capacity for MLRA 102B and 102C

SD Climatic Area for Irrigation	Seasonal Consumptive Use (Grass) (inches)	Seasonal Consumptive Use (Alfalfa) (inches)	Typical Soil	Intake Family	Water Holding Capacity 1st Foot (inches)	Water Holding Capacity 2nd Foot (inches)	Water Holding Capacity 3rd Foot (inches)	Water Holding Capacity 4th Foot (inches)	Water Holding Capacity Total(4') (inches)
IV	29.2	25.7	Moody	0.5	2	2	2	1.8	7.8

Effective Seasonal Rainfall (Grass) (inches)	Effective Seasonal Rainfall (Alfalfa) (inches)	Percent of use supplied by Rainfall (Grass)	Percent of use supplied by Rainfall (Alfalfa)	Deduct 50% WHC in Top 2' of Soil	% of WC Available	MLRAs	WC Available %
10.1	9.5	34.6%	37.0%	2	**34.74%**	102B, 102C	**35**

Estimated Available Water Holding Capacity for MLRA 102A

SD Climatic Area for Irrigation	Seasonal Consumptive Use (Grass) (inches)	Seasonal Consumptive Use (Alfalfa) (inches)	Typical Soil	Intake Family	Water Holding Capacity 1st Foot (inches)	Water Holding Capacity 2nd Foot (inches)	Water Holding Capacity 3rd Foot (inches)	Water Holding Capacity 4th Foot (inches)	Water Holding Capacity Total(4') (inches)
V	23.4	20.4	Poinsett	0.5	2.5	2.4	2.4	2.2	9.5
			Vienna	0.3	2.5	2.2	2	1.9	8.6
			Barnes	0.3	2.1	2.1	2	2	8.2

Effective Seasonal Rainfall (Grass) (inches)	Effective Seasonal Rainfall (Alfalfa) (inches)	Percent of use supplied by Rainfall (Grass)	Percent of use supplied by Rainfall (Alfalfa)	Deduct 50% WHC in Top 2' of Soil	% of WC Available	MLRAs	WC Available %
7.9	7.3	33.8%	35.8%	2.45	**39.44%**	102A	**40**
				2.35	**36.74%**		
				2.1	**35.35%**		

Appendix B
Nitrogen Loading of Vegetated Treatment Areas

The analysis of a VTA can be evaluated in terms of the anticipated loading of nutrients. The two nutrients that are typically the focus of an analysis are N and phosphorus (P). When a solids settling system is included as part of a VTS, the primary nutrient of concern becomes the N. The P in waste is primarily contained in the feces portion of the waste; therefore, the primary P load remains in the solids settling system. The N; however, is often distributed between both the solids and liquids portion of waste; therefore, the loading and accumulation of N within a VTA is an important design consideration to be addressed.

The amount of N present in runoff from confined animal feeding operations (CAFO) an vary widely based on the conditions which are present at the time of the runoff. The amount of N present in the runoff will vary due to weather conditions, including rainfall intensity, duration, air temperature, and other factors that are inherent to the local climate for the location of the site. The condition of the feedlot and the VTA can also have a significant effect on the amount of N present. The time elapsed since the last manure removal event, the saturation condition of the ground, the antecedent moisture condition, and the compaction level of the areas from which runoff occurs will also have an effect on the amount of N present. While these items are the most significant in terms of effect on N present in runoff, there are also numerous other factors to consider, including lot stocking density, solids removal efficiency, and other items that are specific to a particular feedlot.

With these conditions and their variability in mind, it is evident that the amount of N can be significantly different for different facilities or for the same facility at different times of the year. Thus, the ideal way to determine the amount of N present in runoff is to sample the water where it enters the VTA and then use a water quality testing procedure or laboratory to obtain a site-specific measurement of the N present in the runoff. Multiple tests will be even more useful than will one test, thus periodic testing of the liquid entering the VTA is recommended. If this is not feasible, then other estimation methods should be employed. Even when measured, these numbers should be considered estimates only.

The *Vegetative Treatment Systems for Open Lot Runoff, A Collaborative Report* paper and *NRCS, Part 651, Agricultural Waste Management Field Handbook – Chapter 4,* include tables that estimate the N that is anticipated to leave a CAFO based on the type of animal(s), annual rainfall, or condition of the feedlot. While useful, these tables are general in nature and do not provide for a site-specific N calculation. The difficulty that remains with the data in these tables is that the N concentration of the wastewater can vary significantly from feedlot to feedlot and year to year.

Research is currently underway that is seeking to evaluate the effectiveness of VTAs. Notable projects are in progress in Iowa, NE, SD, and Minnesota. A sampling of some recent results from these projects is outlined in the table below. It should be noted that higher number of animals in a more confined space can significantly increase the amount of N that is present in the runoff from a site or in the water that is leaving a settling system.

System Type	TKN (lb/acre-in) Average	TKN (lb/acre-in) High	TKN (lb/acre-in) Low
Animal Feeding Operations, Eastern SD	58.94	117.61	24.47
Animal Feeding Operations, Western SD	25.90	71.15	1.70
Concentrated Animal Feeding Operations, Iowa	187.28	378.20	25.38

TKN = Total Kjehldahl N

For use in the *SD VTA Design Spreadsheet*, the average TKN will be used for the design value for SD counties. As we gather more N runoff data, this number may be updated in future years to more accurately match actual measured field data. Also, it is the hope in the future to add adjustments to the N concentration design value based on feedlot condition, feedlot location, stocking density, animal type, feedlot slope, and extent of feedlot utilization.

In summary, when considering the N loading of a VTA, it is necessary to consider all of the site-specific factors that could have an effect on the concentration of the N. It must be accepted that the concentration of N leaving a solids settling system and entering a VTA can and will vary significantly. Soil testing of the VTA is recommended as part of the operation and maintenance (O&M) to help maintain long-term sustainability of the VTA.

Appendix C
Operation and Maintenance for Vegetated Treatment Areas

Soil Sampling a VTA

A regular soil testing program should be a part of the O&M plan to monitor the fertility status of the VTA. Soil samples will be taken as per land grant university recommendations found on the back of the SDSU Soil Testing Laboratory soil sample information sheet or SDSU-FS935, "Recommended Soil Sampling Methods for South Dakota." For the purposes of soil nutrient monitoring, one set of samples should be taken at (zero to six inches) for plant available P and potassium, micronutrients, pH, soil electrical conductivity, and salts (sodium, calcium, and magnesium). A second set of samples should be taken at (6-24 inches) and should be analyzed for nitrate-N. Because greater nutrient settling and runoff infiltration is expected near the inlet end of the VTA, collect separate soil samples from the first 50 feet from the inlet area and separate samples from the rest of the VTA.

The salt level in VTA soils should be monitored. Salts may accumulate in the root zone during periods of small rain and runoff events that do not saturate the soil and leach salts. Check soil electrical conductivity as part of a soil-sampling program. The frequency of soil sampling will vary depending on the purpose but it is recommended that sampling should be completed at least annually and preferably at the end of each growing season. Apply supplemental nutrients and soil amendments as needed based on SDSU guidelines to maintain the desired species composition and stand density of herbaceous vegetation.

Possible Corrective Action Based on Soil Test Data

<u>If high or very high soil test P levels are found:</u>

- Reduce the nutrient loading rate to the VTA either by reducing outflow from the solids removal area or by increasing the efficiency of pretreatment solids removal.
- Over-seed or introduce legumes into the VTA to increase harvest of P from the VTA forage.
- Treat the VTA with P adsorbing material (iron or aluminum).
- Stop use of the VTA until harvesting lowers the soil test.

<u>If high soil nitrate levels are found:</u>

- Increase forage removal by possibly changing harvesting frequency. Check the nitrate concentrations of the forage.
- Consider alternative grasses or forages that remove greater amounts of N.
- Stop use of the VTA until harvesting lowers the soil test results.

<u>High or very high soil test K levels are found:</u>

- If harvested forage is used for livestock feed, monitoring forage K levels, and visit with nutritionist about need for modifying use of forage in the diet.

High or toxic levels of soil micro-nutrient levels are found:

- If harvested forage is used for livestock feed, visit with nutritionist about need for modifying use of the forage in diet.
- Stop the use of vegetation as a forage source.
- Discontinue use of the VTA.

High soil electrical conductivity (EC) is found:

- Irrigate the VTA with fresh water.
- Provide drainage to leach away excess salts. Ensure that the criteria are met restricting subsurface drainage in the SD CPS Vegetated Treatment Area (635).
- Divide the VTA into two sections so that one section can be rested except during high intensity rainfall or large runoff events. Resting a VTA section will allow rainfall to move salts out of the root zone.

Harvesting a VTA

Another requirement for maintaining a healthy stand of vegetation is periodic mowing and removal of the crop. The VTAs should be harvested at least once a year (between June 1 and August 31) so that the nutrients contained in the plant material are removed from the treatment area. Depending on the plant species used in the VTA, more frequent harvesting may promote a more vigorous stand of vegetation, greater utilization and removal of nutrients, and higher quality feed. Frequent mowing promotes thicker sod and controls weeds. When harvesting, leave a minimum stubble height of three inches to ensure the required stem density and stiffness to maintain sheet flow through the VTA. Species such as big bluestem, Indiangrass, and switchgrass should not be cut below eight inches in order to maintain long-term plant vigor. For all species, the last harvest in the fall should be early enough (prior to August 31st) to allow sufficient regrowth prior to dormancy for proper functioning during the winter. Grazing the VTA should be avoided, as livestock hoof action can disrupt sheet flow.

It is imperative that harvesting of a VTA occurs when soil moisture conditions will not produce tire tracks or ruts. Tire tracks that are parallel to the direction of runoff flow create channel flow and substantially reduce the effectiveness of a vegetative system. It is strongly recommended that equipment should travel perpendicular to the flow of water of the VTA at all times.

Sometimes there are toxic levels of some salts and ions, (NH_4^+) in the runoff from concentrated livestock areas. These can have a major deleterious effect on the vegetation. If this occurs, pre-treat (usually by dilution) the outflow from the solids removal area to reduce toxic levels. The key here is to maintain vigorous crop growth and density to maximize nutrient uptake and disperse overland flow.

Solids Management

Manure and other solids in the system must be managed to ensure the proper function of the treatment components. Solids should be harvested from earthen lots at least once after each pen of cattle is marketed. More frequent solids removal will have value for animal management and odor and dust control and may have value to reduce solids in runoff. The maximum solids volume in a sediment basin should be clearly identified (marked on a level gage) and solids should be removed in advance of solids accumulation to that point. As a minimum, the solids settling basin should be cleaned out once a year. The solids should be removed frequently from settling benches and siltation fences to maintain their effectiveness, possibly after each major runoff event. Proper feedlot surface maintenance and solids settling should prevent the buildup of solids in the VTA. If solids begin to accumulate in a VTA, they can damage forage and contribute to concentrated flow. If solids accumulation within the VTA is observed, first attempt to reduce this problem with improved management of the feedlot surface and sediment basin. If solids remain a concern in the VTA, a light tillage operation such as harrowing should redistribute the solids while allowing some grass to survive. If solids accumulation is a severe problem, a more aggressive tillage operation may be necessary followed by replanting of grass.

Vegetation Maintenance

The health and vigor of vegetation within a VTA should be checked regularly for potential developing problems. Some common concerns that can be monitored visually include:

- Indications of fertility deficiencies as identified by crop color (recommend soil testing).
- Indications of ponding causing loss or thinning of forage (recommend reseed to more moisture tolerant species such as creeping foxtail, reed canarygrass, or prairie cordgrass).
- Indications of solids accumulation causing loss or thinning of forage (recommend harrowing VTA to redistribute solids).
- Indications of undesirable plant species (recommend controlling undesired weed species, especially state-listed noxious weeds using mechanical, chemical, or biological weed control options. If herbicides are used, follow all federal, state, and local guidelines and always follow label directions).
- Indications of high areas where infiltration is not occurring; plants may show signs of low fertility or drought. (Recommend checking infiltration rate using an infiltration ring).
- Indications of burrowing animals such as pocket gopher, badgers, etc., that would bypass the infiltration role of soils (recommend trapping or poisoning burrowing animals within the VTA. Follow all federal, state, and local laws for pest removal).

Liquid Release:

- Maintain daily onsite precipitation records.
- Check the system after every rainfall event for any damage.
- Remove solids from the sediment basin in order to maintain adequate storage within the sediment basin. Land apply solids as per the nutrient management plan.
- It is recommended to avoid releasing the runoff to the VTA when the soil is saturated or frozen. If the sediment basin is designed to store winter runoff, close outlet valves to prevent release of runoff to the VTA during periods of frozen or saturated soil conditions.
- If the outlet can be controlled by a valve, it is recommended that the soil moisture within the VTA be checked by “feel and appearance” as shown in the

USDA NRCS Program Aid Number 1619, Estimating Soil Moisture By Feel and Appearance, to determine the soil moisture conditions. Follow the recommendations in the water management plan for the VTA as to the timing of release at the proper soil moisture condition for the soil type.

- Monitor outflow to the VTA. If solids are entering the VTA and causing problems with flow distribution and/or vegetation stands, check the trash screen in the sediment basin and make necessary adjustments.
- Attempt to restrict the flow in the sediment basin so that the runoff water is released over a 30-to-72-hour period. This will aid in solid settling and the rate of runoff infiltration of the VTA. For example, close the gate valve on the outlet pipe to restrict the outflow.
- Monitor the outflow from the distribution area at the beginning of the VTA to ensure that sheet flow is occurring. Make necessary adjustments to the distribution pipe, ditches, etc., to maintain sheet flow.
- Monitor the VTA for concentrated flows during runoff releases. Make any necessary adjustments to the VTA by repairing gullies, reestablishing vegetation, reducing the runoff release rate, and/or installing other structural measures within the VTA to maintain sheet flow throughout the VTA.
- Monitor the VTA for runoff discharge at the end of the designated vegetated area. If discharge is occurring after rainfall events, if possible, adjust the outflow from the distribution pipe to slow down the runoff release rate to the VTA or increase the area designated for the VTA to limit discharges from occurring.
- If pumping system and/or sprinkler system is utilized to distribute the runoff, ensure that all valves, sprinkler heads, pipelines, pumps, and other mechanical parts of the system are checked periodically and worn or damaged parts replaced as needed. Always replace a worn or improperly functioning nozzle with a new nozzle of the same design size and type. Sprinkler heads operate efficiently and provide uniform application when they are plumb, in good operating condition, and operate at planned pressure. Maintain all pumps, piping, valves, electrical, and mechanical equipment in accordance with manufacturer recommendations. Check and clean screens and filters as necessary to prevent unnecessary hydraulic friction loss and to maintain water flow necessary for efficient pump operation.
- Protect pumping plant and all associated electrical and mechanical controls from damage by livestock, rodents, insects, heat, water, lightning, sudden power failure, and sudden water loss. Provide and maintain good surface drainage to prevent water ponding around pump and electrical equipment. Assure all electrical/gas fittings are safe and secure. Always replace worn or excessively weathered electric cables and wires and gas tubing and fittings when first noticed. Check periodically for undesirable stray currents and leaks. Display appropriate bilingual operating instructions and warning signs as necessary. During nonseasonal use, drain pipelines and valves and secure and protect all movable equipment.

OPERATION AND MAINTENANCE PLAN
VEGETATED TREATMENT AREA
CODE 635

Landowner/Operator____

Job Location ____ GPS_______________________________________

Prepared By ____ Date _______________________________

Operation and Maintenance Items

Operation and maintenance (O&M) is necessary for all conservation practices and is required for all practices installed with Natural Resources Conservation Service (NRCS) assistance. The landowner is responsible for proper O&M throughout the life of the practice and as may be required by federal, state, or local laws or regulations.

Operation refers to operation of the practice in compliance with all laws, regulations, ordinances, and easements; and in such a manner that will result in the least adverse impact on the environment and will permit the practice to serve the purpose for which it was installed. Maintenance includes work to prevent deterioration of the practice, repairing damage, or replacing components which fail.

Necessary operation and maintenance items for this practice include:

- ❑ Maintain vigorous growth of vegetative coverings. This includes reseeding, fertilizing, and applications of herbicides when necessary. Periodic mowing may also be needed to control height. Limit machinery to vegetative growth periods when vegetation root systems will not be damaged or soil compacted.
- ❑ Inspect and repair treatment strips after storm events to remove sediment, fill in gullies to prevent concentrated flow, and reseed disturbed areas.
- ❑ Monitor nitrogen and phosphorus levels in the soils of the treatment strip to minimize potential water quality concerns. Take appropriate corrective action if necessary.
- ❑ Monitor salinity and/or sodicity as appropriate for excessive salt and sodium buildup. Take appropriate corrective action if necessary.
- ❑ De-thatch or aerate treatment strips to promote infiltration where appropriate.
- ❑ Control undesired weed species, especially state-listed noxious weeds.
- ❑ Avoid excessive travel on any portion of the system that will harm or destroy vegetative cover.
- ❑ Repair any rodent, burrowing animal, vandalism, or vehicle damage.
- ❑ Maintain fences to prevent unauthorized human and animal access.
- ❑ Conduct maintenance activities only when the surface layer of the vegetated treatment area is dry enough to prohibit compaction.

Other____

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Appendix D
Vegetative Treatment Systems Fact Sheet (SD-FS-58)

A fact sheet summarizing the information about Vegetative Treatment Systems is available for distribution by the SD NRCS. The fact sheet is posted on the SD NRCS Web site and can be found at:

ftp://ftp-fc.sc.egov.usda.gov/SD/www/News/FactSheets/SD-FS-58_VTS.pdf.