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Comparison of Construction Costs for Vegetated Treatment Systems in the Midwest

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***Abstract*.** Vegetated treatment systems (VTSs) provide an alternative to containment basin systems for beef feedlot runoff control. Beef producers in the Midwestern United States have shown an increasing interest in using VTSs as a perceived lower cost option to containment basin systems. This paper reports the actual construction costs associated with 21 VTSs (eight on permitted Concentrated Animal Feeding Operations (CAFOs) and 13 on non permitted Animal Feeding Operations (AFOs)) located within Iowa, Minnesota, South Dakota, and Nebraska. The VTS construction costs are reported on a per head basis in 2009 adjusted dollars for each system. Cost comparisons are presented between CAFO and AFO facilities, by location and by system type. Additionally, estimated construction cost comparisons between open feedlots with VTS systems, open feedlots with containment basins, monoslope barns and hoop structure beef production systems are provided. Results from the cost comparison indicate that monoslope barns with concrete floors are the highest cost at $621 per head on average followed by hoop structures at $395 per head. Vegetated Treatment Systems designed for CAFO facilities ($77 per head avg.) are less expensive to construct than a traditional containment basin ($129 per head avg.) The same results indicated that an AFO VTS ($62 per head avg.) was less expensive to build than a containment basin on a similar facility ($195 per head). The data indicated that the least expensive VTS for an AFO is a sloped or sloped and level VTA ($42 per head avg.) followed by a pump sloped VTA ($68 per head avg.) and a sprinkler VTS ($87 per head avg.).

Keywords. Beef feedlot runoff, vegetated treatment systems, economic analysis, manure management

Introduction

The Environmental Protection Agency (EPA) rules require that concentrated animal feeding operations (CAFOs) contain all of the wastewater and runoff produced from a 25-year, 24-hour design storm (USEPA, 2008). The 2003 CAFO rule allowed the use of alternative technologies that meet or exceed the performance of traditional containment basin systems. Manure containment systems can be costly to construct and require manure storage over a long period of time. Generally these containment basins are pumped twice a year (spring and fall) and the runoff is applied as either fertilizer or irrigation water when field conditions allow manure application (MWPS-18, 2001). Beef producers have expressed interest in non-basin technology systems that eliminate the need for the long term storage of feedlot manure runoff (Woodbury et al., 2005).

Current manure management systems for CAFO beef feedlot facilities consist of a containment basin designed to collect feedlot runoff (effluent) into an earthen or lined storage structure. Periodically, the effluent in these structures needs to be land applied to maintain sufficient storage capacity for a 25-year, 24-hour rain event. The difficulty with this system occurs when land application areas contain growing crops, therefore making field application of manure difficult. This results in larger containment basins to enable greater storage between application periods which in turn raises the construction cost associated with the manure handling systems. For these reasons, beef producers in the Midwestern United States have shown an increasing interest in using vegetative treatment systems (VTSs) as a lower cost option to containment basins.

Beef animal feeding operations (AFOs) are defined by the EPA as a facility where animals are confined on a lot or in a facility that does not sustain vegetation for at least 45 days in a 12 month period. Animal Feeding Operations that meet the regulatory definition of a CAFO may be regulated under the NPDES permitting program (USEPA, 2008). Concentrated animal feeding operations that have 1,000 head of cattle or greater are typically permitted under the National Pollutant Discharge Elimination System (NPDES). Animal Feeding Operations may be designated as a CAFO by the permitting authority and be required to obtain an NPDES permit; thus these producers have an incentive to manage their runoff to avoid violations.

This paper reports the actual construction costs associated with 21 VTSs (eight on permitted CAFOs and 13 on non-permitted AFOs) located in Iowa, Minnesota, South Dakota, and Nebraska. Additionally, estimated cost comparisons were made between open feedlots with VTSs, open feedlots with a containment basin system, monoslope barns, and hoop structure beef production systems.

System Descriptions

Vegetative Treatment Systems

Vegetative treatment systems provide an alternative to containment basins for feedlot runoff control. Typical components of a VTS are shown in figure 1 and consist of a solid settling basin (SSB), optional vegetated infiltration basin (VIB), and a vegetated treatment area (VTA). During a rainfall event, feedlot runoff is contained by berms surrounding the lot and conveyed into a solid settling basin where solids are allowed to settle out of suspension. The effluent is then pumped or allowed to gravity flow evenly across a VTA where it is infiltrated into the ground keeping it from entering nearby surface water sources. Some systems contain an optional VIB between the solid settling basin and the VTA. The VIB receives effluent from the SSB and is constructed with a grid of tile lines buried approximately 1.2 meters (4 feet) under the ground surface to encourage effluent infiltration. This soil above the tile lines acts as a filter to further remove solids and nutrients still in suspension. The effluent collected from the tiles then enters a sump where a pump supplies the effluent to a VTA. Gated pipe and concrete spreaders are typical devices used to evenly apply effluent to a VTA. VTAs can be either sloped (1-5%) or level (0-1%). Sloped VTAs use overland flow to distribute effluent across the VTA, while level VTAs use a flooding effect to obtain even distribution.

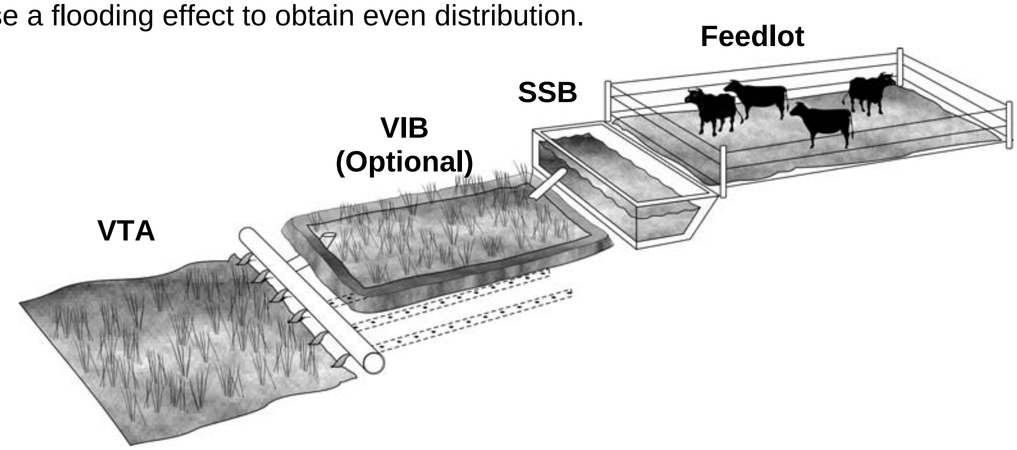

Figure 1. A typical VIB-VTA gravity flow vegetative treatment system (Photo courtesy UNL)

Pump VTSs (Figure 2) are a variation of the gravity sloped VTS and have the advantage of being used on sites that cannot accommodate a gravity system. Like a gravity flow system, these rely on the even distribution and overland flow of a gravity sloped or level VTA. Some pump VTS are designed to re-circulate effluent from the bottom of a VTA back into the sump. This essentially creates a closed system where releases from the VTS are less likely to occur.

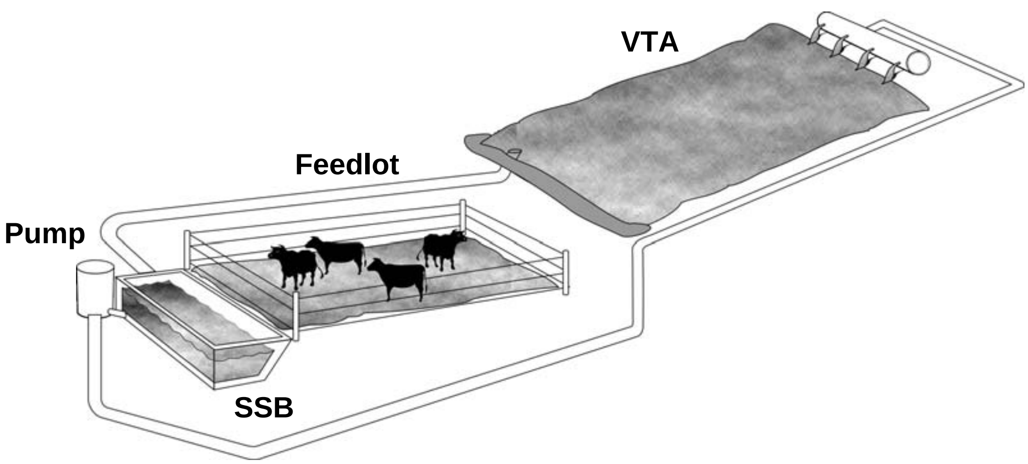

Figure 2. A typical pump VTS system (Photo courtesy UNL)

Some VTSs utilize an irrigation system to apply effluent to a VTA. Irrigation VTS systems can use various irrigation systems, including solid set sprinklers, traveling gun systems and towline systems to apply effluent to a vegetated area. Examples include the sprinkler irrigation of dairy parlor water to a sod filter area using a solid-set sprinkler system (Winker, 1989) and solid set sprinkler irrigation of milk-house waste water to a vegetated infiltration area (Christopherson et al., 2003). More recently this same approach has been used to apply beef feed-lot run-off to vegetated treatment areas in Nebraska (Gross and Henry, 2007). These systems are constructed similar to a gravity flow VTS described above except for the addition of a pump and irrigation sprinklers (Gross and Henry, 2007). Irrigation systems allow effluent disposal on rolling and irregular land and generally cost more to construct than other manure application systems but overcome topographical challenges where gravity systems would not work. The irrigation VTS cost information presented in this paper is for the Sprinkler VTS (Figure 3) developed in Nebraska for beef feed-lot runoff (Gross and Henry, 2007).

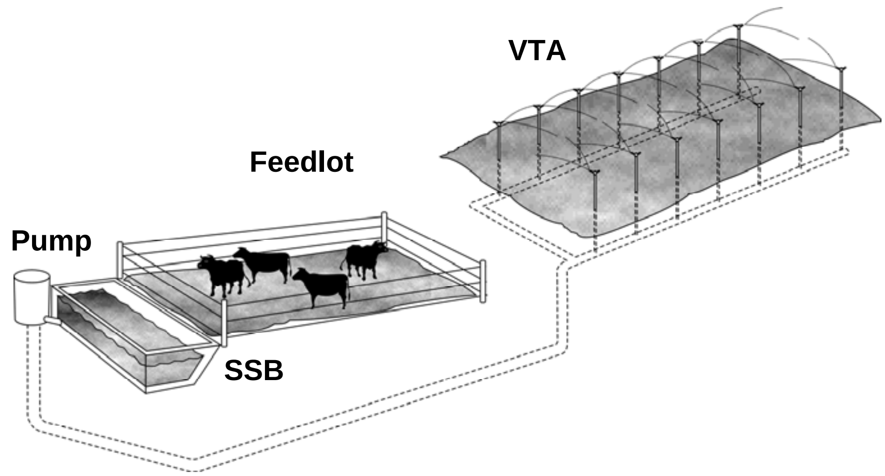

Figure 3. VTS sprinkler system (Photo courtesy UNL)

VTS designs and terminology vary depending on the location and local regulations. In some Midwestern states, VTS systems are allowed to utilize a level VTA at the end of the system for run-off containment from the system. This level VTA consists of a small berm preventing runoff from leaving only the VTA. The berm creates short term storage until the effluent infiltrates into the ground.

Containment Basin System

Open feedlots that maintain manure containment basins usually consist of an earthen or concrete lot, a solid settling basin, and a detention basin (Figure 4).The lots are typically designed for 23.2 square meters (250 square feet) of pen space per animal (Lawrence et al., 2006). During a rainfall event, effluent travels down the feedlot gradient and collects in the solid settling basin where solids are allowed to settle out of suspension. After adequate time has passed for solid settling, the effluent is released into a detention basin to be stored until land application.

Containment basin systems produce both solid and liquid manure. The solid manure comes from cleaning out the settled particles in the settling basin and cleaning the feedlot itself. The manure from these two components needs to be removed periodically and either land applied or stockpiled until appropriate field conditions occur.

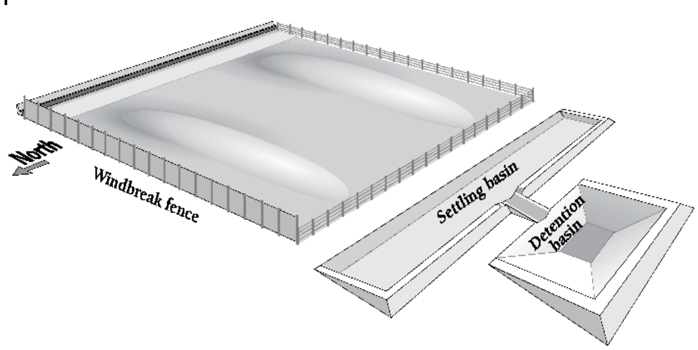

Figure 4. Open feedlot with a containment basin system (Lawrence et al., 2006)

Roofed Systems with Manure Storage

Monoslope barns feature complete animal confinement with solid concrete floors (Figure 5). These barns are designed for approximately 3.7 square meters (40 square feet) of open space per animal (Lawrence et al., 2006). Bedding is placed in the middle of the pens forming a bedding pack to absorb manure and is typically scraped twice a week depending on management practices. Manure from these facilities is handled as a solid and stockpiled for field application when conditions are appropriate. Feeding bunks are typically located on both sides of the barn to allow 0.3 meters (one foot) of bunk space per head (Lawrence et al., 2006).

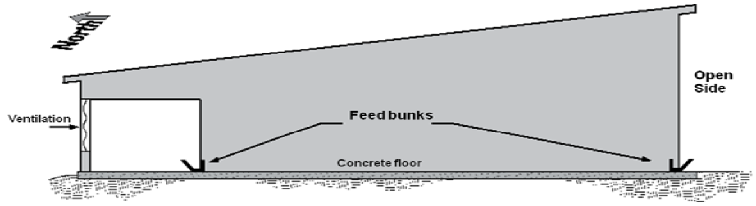

Figure 5. Monoslope barn with a solid concrete floor (Lawrence et al., 2006)

Hoop barns were first developed in Canada during the early 1990's (Connor, 1993) and were introduced to the United States in the mid- 1990s (Honeyman, 2005). These structures were rapidly accepted by many farmers due to their low cost and versatility in agricultural production systems. The framework of these structures (Figure 6) consists of tubular steel arches (trusses) spanning across the sidewalls of the barn (Honeyman, 2005). These arches are attached to posts on each side of the structure creating a steel framework to support a UV-resistant, polyvinyl tarp (Shouse et al., 2004). The floor covering in this system is either concrete or a dirt floor depending on the producer's decision. Hoop barns are designed for natural ventilation and contain curtains on the sidewalls to adjust ventilation rates especially in the summer months. These facilities are typically designed with an overhang covering the feed bunks to exclude any rainfall that might enter the system.

Manure management for hoop barns is handled by selective cleaning or by applying additional layers of bedding to soak up moisture (Shouse et al., 2004). Bedding typically consists of corn stalks applied evenly throughout the facility's flooring. If selective cleaning is chosen, the collected manure needs to be stockpiled in a way that meets state and federal regulations. Typically the manure is then spread directly on fields when appropriate conditions are met.

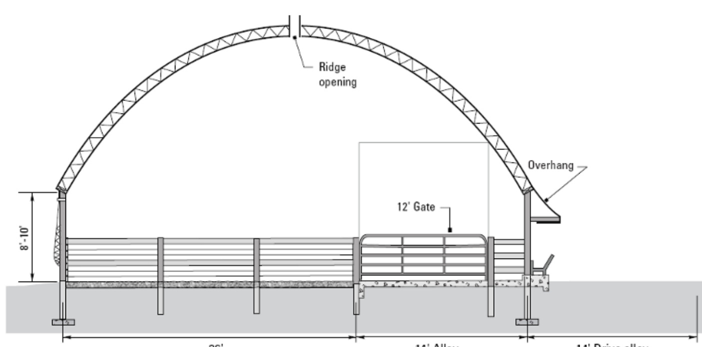

Figure 6. Hoop barn with feed bunk overhang (Honeyman, 2008)

Methods

Cost Estimation for Vegetative Treatment Systems

The VTS feedlot construction data for this paper was provided by Iowa State University, University of Nebraska-Lincoln, and South Dakota State University. The feedlots are located throughout Iowa, Nebraska, Minnesota, and South Dakota representing both AFO and CAFO feeding operations. The presented costs are actual system costs paid by producers and represent the cost associated with integrating a VTS system into an existing feedlot.

The VTS construction costs are reported on a per head basis for each system based on actual cost in the year they occurred and were adjusted to 2009 dollars. The average yearly inflation rate was calculated from the Consumer Price Index compiled by the Bureau of Labor Statistics for the years 2005 through 2009 (Financial Trend Forecaster, 2003-2009); the calculated rates were used in conjunction with the future worth equation to adjust the construction cost for inflation to a common 2009 base year.

Some feedlot sites reported in this paper were designed by public entities and an engineering design cost was unavailable for the system. For these sites, an estimate was used to calculate an engineering cost based on the design hours spent and an assumed annual salary of $75,000 plus benefits contributing an additional 36 percent of the annual salary. This equates to approximately $50 per hour based on 2,080 work hours in a year. One particular AFO VTS project was designed between a graduate student and the feedlot owner. For this site, a graduate student’s pay rate was estimated at $23 per hour and the feedlot owner’s time at $30 per hour based off of a typical graduate student and owner’s salary with benefits.

The cost analysis for each site was based only on the VTS construction and did not include the following items: feedlot construction, feed and cattle handling facilities, fencing, and feeding equipment. The values reported in this paper represent the amount a producer might expect to pay to implement a VTS on an existing feedlot.

Cost Estimation for Traditional Containment and Roofed Facilities

The construction cost information for traditional open beef feedlots and monoslope facilities was collected from the Beef Feedlot Systems Manual produced by Iowa State University and the Iowa Beef Center. This publication reported feedlot cost based on new feedlot construction and current Iowa regulations at the time of publication. Additional items included in the cost of a new feedlot are feed storage structures, cattle handling facilities, and feeding equipment. For the purpose of this paper, these items were removed from the analysis since existing feedlots already contain these items.

Basic assumptions for both the open feedlot and monoslope facilities are as follows based on the Beef Feedlot Systems Manual (Lawrence et al., 2006):

- Each pen contains 150 head
- 0.3 meters (one foot) of bunk space per head for all systems
- Earthen lots have 4.9 meters (16 feet) wide concrete aprons placed along the feed bunks
- Outdoor lots over 1,000 head have settling and detention basins designed for a 132 mm (5.2 inch) storm
- All lots assume fence and gates at $33 per meter ($10 per foot)

For comparison purposes, the construction cost for an AFO with a containment system was estimated based on the following assumptions; CAFO engineering costs/efforts would remain constant for an AFO system of the same type, the feedlot area, run-off volume, and basin size would be proportional to a 1,500 head operation. According to the Feedlot Systems Manual (2006), the engineering costs for a 1,500 and 5,000 head operation are reported as the same value since the design time will be approximately the same for both feedlot sizes (i.e., the same calculations are performed just different numbers). In order to justify the estimate using proportions between a 750 and 1,500 head feedlot, the AFO is assumed to be designed for a 25 year, 24 hour rain event. Accounting for these assumptions, the construction cost and irrigation was calculated for the 1,500 head CAFO facility on a per head basis, and multiplied by 0.5 to yield the estimated total cost for each system component (SSB, detention basin, and irrigation system) for a 750 head feedlot.

Results and Discussion

The animal feeding operation VTS facilities were separated into three categories: sloped or sloped and level VTA, pumped sloped VTA, and sprinkler VTS. The sloped or sloped and level VTAs are gravity flow systems where effluent is applied via gated pipe or concrete spreaders. These systems may contain a level VTA to prevent a discharge. The pump sloped VTA category is similar to the sloped and level VTAs except for the need to pump effluent to the VTA (i.e., gravity flow is not utilized). These systems are more expensive due to the additional expense of a pump and have a slightly higher operating cost compared to a gravity flow VTA system. The sprinkler VTS category consists of a pump and irrigation equipment to apply effluent to a VTA. The VTS construction cost data for AFO facilities is provided in Table 1.

Based on the data shown in Table 1, the lowest cost VTS design for a beef feedlot is a gravity flow VTA. These systems averaged $42 per head with a range of $22 to $68 per head. The feedlots ranged in size from 120 to 700 head of cattle. Compared to the other two systems, the sloped or sloped and level VTA is the simplest system to design and construct using gravity as the primary power source which results in a lower overall cost.

Table 1. Vegetated treatment system construction costs for 13 animal feeding operations located throughout Nebraska, Minnesota, and South Dakota in 2009 inflation adjusted dollars.

AFO < 1,000 Head								
VTS Type	Location	Number Of Head	VTA Area, ha	Year	Engineering Cost[1]	Construction Cost	Total Cost 2009 Dollars	Dollars Per Head
Sloped or sloped and level VTA	NE	359	1.5	2005	$ 1,800	$ 8,000	$ 11,173	$ 31
Sloped or sloped and level VTA	NE	290	1.0	2006	$ 3,300	$ 8,597	$ 13,118	$ 45
Sloped or sloped and level VTA	NE	700	2.9	2006	$ 2,250	$ 11,488	$ 15,148	$ 22
Sloped or sloped and level VTA	NE	450	1.2	2007	$ 2,650	$ 12,190	$ 15,851	$ 35
Sloped or sloped and level VTA	NE	120	0.2	2007	$ 2,950	$ 2,391	$ 5,704	$ 48
Sloped or sloped and level VTA	SD	450	10.2	2005	$ 3,600	$ 23,390	$ 30,770	$ 68
Pump sloped VTA	NE	285	2.0	2006	$ 2,600	$ 22,131	$ 27,271	$ 96
Pump sloped VTA	NE	780	2.0	2009	$ 3,500	$ 29,875	$ 33,375	$ 43
Pump sloped VTA	SD	665	3.8	2006	$ 2,350[2]	$ 36,687	$ 43,046	$ 65
Sprinkler VTS	NE	210	0.9	2009	$ 3,200	$ 15,453	$ 18,653	$ 89
Sprinkler VTS	NE	800	3.0	2009	$ 4,400	$ 46,265	$ 50,665	$ 63
Sprinkler VTS	NE	450	1.9	2007	$ 3,600	$ 35,115	$ 41,351	$ 92
Sprinkler VTS	NE	720	3.4	2009	$ 4,400	$ 71,795	$ 76,195	$ 106

[1]Estimated design cost based on $50 per hour

[2]Estimated Design cost based on graduate student rates of $23 per hour and producer rates of $30 per hour instead of $50 per hour

The pump sloped VTA systems average $68 per head with a range of $43 to $96 per head. These facilities ranged from 285 to 780 head of cattle. The pump sloped VTA costs on average an additional $26 more per head than a sloped and level VTA system. Major factors affecting the overall cost of a pumping system depend on the pumping distance from the SSB to the VTA and the number of cattle utilizing the system. The cost per head decreases with more cattle because the cost is spread over a larger population.

The most expensive VTS system to construct is a sprinkler system due to the need for purchasing a pump and irrigation equipment. These four systems average $87 per head and range from feedlots containing 210 to 800 head of cattle. Three of the four sites used a towable sprinkler distribution system and the other used a solid set system. These sprinkler VTSs costs twice as much as a gravity flow VTS to construct.

Within each category, the lowest system cost per animal corresponded with the largest number of animals but the highest cost was not necessarily associated with the smallest number of animals. The overall cost of a VTS depends on several site specific design variables such as the amount of earthwork, the type of pump and sprinkler system, and the pumping distance from the SSB to the VTA. These variables are the main factors affecting the various overall costs per head between the VTS facilities.

The concentrated animal feeding operation VTSs were split into three categories: sloped or sloped and level VTA, pump sloped VTA, and a VIB-VTA system. The sloped or sloped and level VTA uses gravity to transport the effluent through the system while the Nebraska site contains a pump to transport effluent to the top of the VTA. Therefore this system contains extra construction costs compared to the sloped or sloped and level VTA systems. Additional costs associated with a VIB-VTA system included a pump and the design/construction costs for an extra basin (the VIB). The construction costs associated with eight CAFOs is provided in table 2. The average construction cost for a gravity flow system is $71 per head and approximately $77 per head for a VIB-VTA system. The VIB-VTA system has a slightly higher cost per head for two reasons: installation of tile lines in the VIB, and purchasing a pump to transport infiltrated effluent from the VIB to the VTA. The pump sloped VTA site showed a larger cost per head compared to a VIB-VTA system. Effluent at this site is transported a longer distance from the SSB to the top of the VTA due to the layout of the site. An additional return pipe connecting the VTA to the SSB sump collects ponded effluent in the VTA and returns it back into the system. The additional piping and trenching costs associated with this type of system could be the primary factor for this higher cost per head. The South Dakota site produced largest VTS cost per head at $104. Explanations for this high value are potentially due to having the largest earthwork cost compared to all the other sites since the VTA is located the farthest away from the feedlot. A long earthen channel was designed to transport SSB effluent to the VTA.

Table 2. Vegetated treatment system construction costs for eight confined feeding operations in 2009 inflation adjusted dollars.

CAFO > 1,000 Head								
VTS Type	Location	Number Of Head	VTA Area, ha	Year	Engineering Cost [1]	Construction Cost	Total Cost 2009 Dollars	Dollars Per Head
Sloped or sloped and level VTA	IA	1500	2.1	2005	$ 22,522	$ 56,359	$ 89,931	$ 60
Sloped or sloped and level VTA	IA	3400	5.4	2005	$ 39,379	$ 193,071	$ 265,013	$ 78
Sloped or sloped and level VTA	IA	2300	4.0	2007	$ 32,002	$ 62,489	$ 100,925	$ 44
Sloped or sloped and level VTA	IA	5500	18.4	2006	$ 179,507	$ 163,367	$ 378,089	$ 69
Sloped or sloped and level VTA	SD	2000	6.4	2009	$ 27,181	$ 173,769	$ 208,687	$ 104
VIB-VTA system	IA	4000	1.5	2005	$ 29,411	$ 231,625	$ 297,603	$ 74
VIB-VTA system	IA	2500	0.5	2005	$ 21,822	$ 152,548	$ 198,796	$ 80
Pump Sloped VTA	NE	1200	4.5	2007	$ 32,500[2]	$ 83,614	$ 124,021	$ 103

[1] Represents actual engineering design costs

[2] Estimated design cost based on $50 per hour

Based on economic analysis data from Lawrence (2006) that have been updated to 2009 inflation adjusted dollars, an estimated containment basin system (Table 3) designed for a 1,500 head beef operation will cost approximately $158 per head and a 750 head operation is $195 per head. The construction cost on a per head basis decreases as the cattle numbers increase since the cost is spread over a larger cattle population. The general trend shown in this paper suggests an increase in animal numbers will produce a lower overall cost per head since the extra design regulations are already accounted for in the system. Gross and Henry (2007) reported an estimated cost of $44 per head for an earthen pond designed for a facility containing less than 400 head. This value excludes engineering and irrigation costs. The 750 head containment basin system reported earlier, costs $66 dollars per head (Lawrence et al. 2006) excluding engineering and irrigation costs. This value does, however, include a settling basin and detention basin.

Table 3. Estimated construction costs for a containment basin system consisting of a SSB, detention basin, and irrigation system adjusted for inflation in 2009 dollars.

Containment Basin Systems						
		750 Head		1500 Head		5000 Head
Engineering Costs	$	55,135	$	55,135	$	55,135
Construction Costs	$	49,622	$	99,243	$	330,811
Irrigation System	$	41,351	$	82,703	$	110,270
Total	**$**	**146,108**	**$**	**237,081**	**$**	**496,217**
$ per head	**$**	**195**	**$**	**158**	**$**	**99**

Source: Lawrence et al., 2006

Vegetative treatment systems designed for CAFOs cost less to construct per head than a traditional containment basin. If all eight of the reported VTSs are averaged regardless of type, the total CAFO VTS cost is approximately $77 per head. This value is considerably less than a containment basin constructed for a 1,500 to 5,000 head feedlot at $158 and $99 per head respectively. AFOs show similar results with a total system average of $62 per head (regardless of type) and an estimated 750 head containment system costing $195 per head.

In order to compare the construction cost of VTSs with monoslope barns, open feedlots with containment basins, and hoop structures, a cost estimate needs to be added to the VTS to account for the area occupied by the cattle. This cost addition is necessary since monoslope and hoop structure facilities confine cattle in the same area as the solid manure. In order to get an estimate of the costs associated with the construction of a new earthen feedlot, the VTS cost per head was added to the feedlot cost per head from the Beef Feedlot Systems Manual adjusted for inflation to 2009 dollars. After adjusting for inflation, a 750 head open feedlot (earthen) without any manure management system costs $197 per head while a 1,500 and 5,000 head feedlot costs $190 and $187 per head, respectively (Table 4). The accuracy of this calculation depends how close the interested feedlot is to the number of cattle reported for each feedlot size in the Beef Feedlot Systems Manual. For instance, if the 720 head VTS sprinkler system costs $106 per head, an additional feedlot cost of $197 per head would yield a total system cost of $303 per head.

Table 4. Earthen feedlot construction costs adjusted for inflation in 2009 dollars.

Earthen Lot With Windbreak			
Facilities and Equipment	750 Head	1500 Head	5000 Head
Building	$ -	$ -	$ -
Concrete	$ 76,087	$ 148,865	$ 496,217
Feed Bunks	$ 12,405	$ 24,811	$ 82,703
Fencing	$ 41,351	$ 74,432	$ 234,325
Site Preparation	$ 8,270	$ 16,541	$ 55,135
Windbreaks	$ 9,924	$ 19,849	$ 66,162
Building engineering cost	$ -	$ -	$ -
Total System Cost	**$ 148,038**	**$ 284,498**	**$ 934,541**
Total System Cost per head	**$ 197**	**$ 190**	**$ 187**

Source: Lawrence et al., 2006

Based on economic analysis data from Lawrence (2006) that have been updated to 2009 inflation adjusted dollars, concrete monoslope facilities cost $627, $621, and $615 per head for a 750, 1,500, and 5,000 head operations respectively (Table 5). Monoslope barns are the most expensive form of cattle feeding operations in both the AFO and CAFO categories. The total system cost for a CAFO is slightly lower than an AFO facility due to the cost being spread over a larger number of cattle.

Table 5. Concrete monoslope barn construction costs adjusted for inflation in 2009 dollars.

Monoslope Barn			
Facilities and Equipment	750 Head	1500 Head	5000 Head
Building	$ 248,108	$ 496,217	$ 1,654,055
Concrete	$ 196,833	$ 387,049	$ 1,279,136
Feed Bunks	$ 12,405	$ 24,811	$ 82,703
Fencing	$ 11,578	$ 16,541	$ 44,108
Site Preparation	$ 1,654	$ 3,308	$ 11,027
Windbreaks	$ -	$ -	$ -
Building engineering cost	$ -	$ 3,308	$ 3,308
Total System Cost	**$ 470,579**	**$ 931,233**	**$ 3,074,338**
Total System Cost per head	**$ 627**	**$ 621**	**$ 615**

Source: Lawrence et al., 2006

Beef Hoop structures cost approximately $395 per head in inflation adjusted 2009 dollars based on assumptions for a hoop structure as described in the system descriptions (Honeyman et al., 2008). The cost estimate reported above assumes flooring constructed primarily of limestone screenings with a small concrete pad located in front of the feed bunk and a manure scrape alley extending the length of the barn. This system was designed for approximately 4.6 square meters (50 square feet) of floor space per head (Honeyman et al., 2008).

Conclusion

The animal feeding operation VTS with the lowest cost per head to construct is a sloped or a sloped and level VTA ($42 per head avg.) followed by the pump sloped VTA ($68 per head avg.) and the sprinkler VTS ($87 per head avg.). The major factors affecting the overall price of these systems depends on the amount of earthwork, type of pump and sprinkler system, and pumping distance from the SSB to the VTA. Systems which use gravity to transport effluent through the VTS are generally lower cost to construct per head. Within each category, the lowest system cost per head corresponds with the largest animal numbers, but the highest cost was not necessarily associated with the smallest number of animals.

The least expensive VTS design for a CAFO facility is a sloped or sloped and level VTA ($71 per head avg.) followed by a VIB-VTA system ($77 per head avg.) The six dollar per head increase for a VIB-VTA system is primarily due to the addition of a pump and the design/construction costs associated for an extra basin (VIB).

Vegetative treatment systems designed for CAFOs cost on average $77 per head and range from $44 to $104 per head depending on the type of VTS system while an estimated containment basin costs $99 to $158 per head depending on the number of animals. A VTS system designed for an AFO facility costs on average $62 per head ranging from $22 to $106 per head while an estimated containment system for a 750 head facility costs $195 per head. In both cases the VTS is the lowest cost option compared to a containment system.

Monoslope barns are reported to be approximately $627 per head for a 750 head AFO and $621 per head for a 1,500 head CAFO facility (Lawrence et al., 2006) and are the most expensive system to construct for a beef manure system. Hoop structures are the next highest cost per head and can be built for approximately $395 per head (Honeyman et al., 2008). Though more expensive to construct per head, these systems handle only solid manure and are not required to handle feedlot runoff since the cattle are confined indoors.

References

Christopherson, S., D. Schmidt, K. Janni and J. Zhu. 2003. Evaluation of Treatment Options for Dairy Parlor and Milk House Wastewater. ASABE Technical Paper Number 034121.

Connor, M.L., 1993. Evaluation of biotech housing for feeder pigs. *Manitoba Swine Update* 5 (3): 1-2.

Financial Trend Forecaster. 2003-2009. Inflation- Historical. Bureau of Labor Statistics. Available at: http://inflationdata.com/inflation/inflation_Rate/historicalinflation.aspx. Accessed 20 March 2009.

Gross, J. and C. G. Henry. 2007. A “Sprinkler” Vegetative Treatment System “VTS”. In Proceedings of the International Symposium on Air Quality and Waste Management for Agriculture. September 16-19, 2007 Omni Interlock Resort Broomfield, Colorado.

Honeyman, M. S. 2005. Extensive bedded indoor and outdoor pig production systems in USA: Current trends and effects on animal care and product quality. *Livestock Production Science* 94: 15-24

Honeyman, M. S., J. D. Harmon, S. C. Shouse, W. D. Busby, D. L. Maxell. 2008. Feasibility of Bedded Hoop Barns for Market Beef Cattle in Iowa: Cattle Performance, Bedding Use, and Environment. *Applied Engineering in Agriculture* 24(2): 251-256.

Lawrence, J., S. Souse, W. Edwards, D. Loy, J. Lally, and R. Martin. 2006. Beef feedlot systems manual. Pm-1867. Ames, Iowa: Iowa Beef Center, Iowa State Univ.

[MWPS] MidWest Plan Service. 1993. Livestock Waste Facilities Handbook. MWPS-18, 3rd edition. Ames, Iowa: MidWest Plan Service

[MWPS-18] MideWest Plan Service. 2001. Manure Storages: Manure Management Systems Series. MWPS-18, Sec 2. Ames, Iowa: MidWest Plan Service.

Shouse, S., M. Honeyman, and J. Harmon. 2004. Hoop Barns for Beef Cattle. AED 50. Ames, Iowa: MidWest Plan Service, Iowa State Univ.

US EPA. 2008. Federal Register. Vol. 73, No. 225. Washington, D.C.

Winkler, F. 1989. Sprinkler Application of Milkhouse Waste to a Sod Filter Area. Dairy Manure Management: Proceedings of the Dairy Manure Management Symposium. Syracuse, New York, February, 1989. Northeast Regional Agricultural Engineering Service. NRAES-31.

Woodbury B.L., J.A. Nienaber, R.A. Eigenberg. 2005. Effectiveness of a passive feedlot runoff control system using a vegetative treatment area for nitrogen control. Applied Engineering in Agriculture 21(4):581-588.

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