SAND LADEN MANURE STORAGE AND TRANSFER

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INTRODUCTION

As sand bedding has gained popularity in New York State, farms have continued to struggle with how to convey and store the mixture of manure and sand. Sand Laden Manure poses challenges throughout the transfer and storage chain. Sand settles in inconvenient locations while at the same time staying suspended in locations designed to promote settling. The unique characteristics of Sand Laden Manure have posed many problems and learning opportunities for producers throughout New York State. Over the past fifteen years sand laden manure handling systems in New York have developed through a combination of trial and error and incorporation and adaptation of ideas and concepts obtained by researching designs found on farms in other states.

BACKGROUND

Throughout the mid 1980's there were many manure transfer systems in New York installed that utilized gravity to transfer material from inside of the barn to an earthen structure immediately adjacent to the barn. These gravity transfer structures were usually installed utilizing a 30" HDPE transfer pipe with an approximately 3% slope and outlet to the bottom of a manure storage located close to the barn. The slopes on the pipes were designed based upon the angle of repose of manure and relied on head pressure to force material into the storage. The systems worked reasonably well with organic bedding as long as excessive amounts of bedding material were not used or were kept out of the transfer system.

As sand began to gain popularity as a bedding product in New York through the early and mid 1990's it quickly became apparent that these previously installed transfer systems were not designed to handle the new mixture of sand and manure. As the farms converted to sand bedding and continued to utilize their existing conveyance and storage system, the transfer systems quickly plugged with sand, some in as little as two to three weeks. With below the ground conveyance systems plugged, many farms converted to a system where they directly scraped into their earthen manure storage(s). These earthen structures were not designed to have manure pushed down their slopes leading to excessive cases of erosion. In addition, before sand was utilized as bedding material in New York, farms rarely needed the ability to get into their structures to excavate and haul built up material out of their storage. With the conveyance issue solved by a direct push system sand and manure build up in long term storage(s) quickly became the next problem. Depending upon the particle size of the sand utilized, sand and manure settled together, gradually reducing the available capacity of the structures unless removed on a regular basis. Farms then had to skim manure from the top of the structure and excavate the sand and manure from the structure and attempt

to land apply the mixture. The excavated material frequently had dirt and rocks from the storage floor mixed in, making it impossible to use traditional spreading equipment.

I have been involved in working with clients who are implementing Sand Laden Manure handling systems since the late 1990's. By this time most farms utilizing sand bedding had gone away from conveyance with underground pipes and were direct scraping into storages. Some farms had improved the pushoff areas as well as the bottom of their storages for removal of solids by adding concrete. Farms were beginning to experiment with multiple celled manure storages in hopes of promoting settling and segregate the sand from the liquid portion of the manure. These systems were marginal at best, often constructed with earthen cells that were difficult to clean and settled sand was not removed frequently enough, reducing the effectiveness of the settling cells. Between the limited capacity of these cells when clean out was not performed frequently and the mucus in manure that bonds the sand to organic material, farms struggled to remove 40% of the sand in the first cell.

In order to promote increased sand settling and ease conveyance struggles, farms began to experiment with below barn concrete structures that were installed with ramps to enter and clean the structures. Due to financial and space constraints, these structures only held a small volume of waste which still has to be transferred to a long term (higher capacity) storage. These systems allowed farms to push the manure straight into the storage without having to turn manure or deal with an outside push off; however these systems pose great danger to the person that is operating the skid steer or loader utilized to remove material from the structure, with the potential for hazardous gas build up internal to the structure. These below barn structures can trap noxious gases that can cause illness or even death. Many farms have emptied these storages multiple times with no incident, creating a false sense of security. It is important that consultants continue to stress to clients how dangerous these facilities are and supply alternatives that meet their needs.

SAND LADEN MANURE CONVEYANCE

Direct scrape systems seem to have worked relatively well on dairies with 400 cows or less, the farm is generally able to scrape manure directly to a long-term, central manure storage. If these storages are designed appropriately, allowing for frequent clean out with large equipment, farms of this size seem to be able to rather easily manage pumping liquids off of the structure and then loading and hauling built up sand. As the farm size increases, so does the required frequency of sand removal from the system, making the handling system more arduous and forcing farms to continue to look for alternatives.

With the topography in New York we are constantly looking for ways to utilize and take advantage of gravity to transfer manure. With sand laden manure this is always a challenge; traditional gravity transfer lines with sand laden manure have proven to be ineffective. Over the past ten years farms in New York have begun to adopt flush barns and flush flumes to transfer manure. The mixing of manure with large volumes of

flowing water allows for the movement of sand laden manure reliably to a treatment/storage area. The addition of flowing water degrades the mucus attachment of the manure to the sand and creates the potential to incorporate a gravity separation system.

Flush barns have been used in a limited capacity due to the cold winter weather. Whether real or perceived, there is a concern that these barns will be slippery for a significant period during the winter months. In the past four years I have been involved with the installation of three different flush facilities, all of which have functioned well, with only a few days each year where the farm has to find an alternative way to remove manure from the barn. This is not an uncommon issue to face in our climate and we attempt to design all facilities with an alternate cleaning plan when cold weather prevents utilization of the primary gravity system. Because all of these facilities are bedded with sand, the alleys are very forgiving; even with a 5% slope on one of the farm's walkways we have seen little issue with slipperiness due to cold weather. The largest challenge with flush systems seems to be that the flush barn alleys must be designed as conveyance structures; the flow rate and distribution systems are vital to ensuring that the alleys work to transfer material out of the barn and to the storage system. Some of the initial flush barns were installed with flow rates in the 1500-2000 gallon per minute range, while research has shown that flush flow rates along the scrape alley should be between 6500 and 8000 gallons per minute for a typical alley width of 10-12 feet. This flow rate helps maintain a minimum cross sectional velocity of 8 feet per second, which is necessary to suspend and transfer the sand laden manure. We have utilized both pre-manufactured flush valves and custom made manifolds to accomplish this. The custom made manifolds distribute flow better at the start of the alleys; however in general both do a satisfactory job of cleaning if appropriate velocities are achieved. All farms report having to scrape built up sand from behind the stall bed curb a minimum of once per week. Collection of the flush water at the end of the alleys also has proven to be challenging. Collecting 7500 gallons per minute of flush water from a 10' to 14' wide cow alley and funneling it into an 18 to 30" HDPE transfer pipe has certainly been a learning experience. Some of the first systems collected the material in a concrete hopper and outlet to a gravity transfer pipe. This led to settling of sand in the concrete hoppers and reduction of flow rates, leading to plugging of the transfer lines. Newer systems were constructed utilizing smooth bore HDPE lines with slots cut in the top, many of these lines were installed with little fall from the alley floor. With little fall, flush water backed into the alley causing settling, or in some cases overflowed the collection pipes and exited the barns. After several installations it has become apparent that there should be approximately four feet of fall from the alley floor to the invert of the collection pipe to allow for head losses generated in the transition. Continuous smooth bore HDPE pipe with slots cut in the top seem to currently be the most reliable systems, if the pipes are well supported at the top to prevent collapse. The current flush systems work reliably and also help cut down on building maintenance due to damage caused by scrape equipment and overzealous employees.

In an attempt to utilize the benefits of water to convey sand laden manure while allowing the farm the flexibility of a manual scrape system, farms in New York have

begun to adopt flush flumes. Flush flumes utilize an HDPE transfer pipe with flowing water to collect sand laden manure and convey it to the storage/treatment area. Flush flumes work well in a retrofit situation allowing the farm to continue using their current cleaning system. On one of the farms that we worked with to install a flush flume, the farm had an existing 800 cow barn with a center collection auger and did not want to disrupt cattle traffic to install a collection channel. We designed a manhole (see photo 1) at the end of the auger to carry manure down to the flush flume. With the slow rate of material exiting the auger and the 2500 gallon per minute flow rate maintained within the flume, the system has worked flawlessly for three years.

Photo 1. Auger depositing to a flush flume.

The flush flume systems that we have installed to date have been very forgiving and posed few growing pains. All of the systems have been installed at slopes between 1 and 1.75%, with flow rates ranging from 1500 to 2500 gallons per minute. Just as with the flush barn alleys, the design flow rate within the collection pipe must generate velocities of around 8 feet per second.

GRAVITY SEPARATION

Just as with conveyance issues, gravity separation in New York has evolved over the past ten to fifteen years. Many farms visited facilities across the nation and appreciated the simplicity of their gravity separation systems. The first gravity separation systems that I was involved with were a variation on the hog slat systems that are popular on flush dairies in the midwest and southwest. These systems accept manure into a three sided structure with a fourth wall constructed of hog slats. Solids build up against the hog slates and the system filters out sands and solids while allowing the liquid portion of the manure to continue to a long term storage. These facilities are generally constructed of concrete for ease of cleaning and have proven to be very effective. A variation of this system was developed by Southern Minnesota Agricultural Engineering Services. The structure was designed to have a manure depth of only 5 feet and utilized screen towers located near the center of an earthen structure with a concrete floor. Manure could be scraped directly into the structure and the towers would allow the liquids to drain to a long term storage.

Photo 2. Screen Towers

The mixture of sand and solids that accumulated still had to be loaded out of the structure and land applied. Two of these systems were installed in New York on 400 cow dairies. The facilities worked marginally when the farms had 400 cows. As the facilities expanded they quickly became difficult to manage and both systems have since been replaced.

As farms continued to travel and search for systems that they felt would work well with limited mechanical components they began to come across sand lanes in the upper midwest and southern Pennsylvania. These were appealing because they required little mechanical equipment and provided the opportunity to reuse the sand that was settled out. The sand lanes that farms had seen were utilized on both flush and flush flume systems, and there was a consensus that these climates were close enough to New York that we could make sand lanes work here. Unlike many of the sand lane facilities that were visited, the ones in New York would all be retrofits to existing facilities. This poses some unique challenges for these systems. The area required for gravity separation is large and many of these facilities had limited space. In addition, the systems that the farms were visiting had large amounts of secondary settling and storage ponds, with supply water for the flumes and flush alleys pulled from the last stage of the storage structures. Most of the dairies in New York that were considering these systems only had long term storage for about six months with their traditional scrape systems. The additional water that is required to be kept within the systems for flush supply created challenges with storage capacity and CAFO regulations. In an attempt to reduce the size and number of cells needed to produce acceptable flush water many farms opted to incorporate mechanical solid separation as a part of their overall system.

In order to ensure that sand lanes function to settle out sand and keep manure solids entrained, the flow rates in these systems need to be around 1 foot per second. This can be adjusted by slope and width of the sand lane. To allow for ease of cleaning, it is advisable to keep the minimum width of the sand lane at a minimum of 12 feet and adjust the slope to achieve the desired flow depth and velocity. Most commonly the sand lanes that were visited had a narrow access point on the side for cleaning. After working with the farms and consulting Jake Martin, a layout specialist from Florida, all of our New York farms decided that access throughout the entire length of the sand lane was their preference.

CASE STUDIES

Case 1 – 400 Cow Scrape Dairy With Flush Barn Addition – Wyoming County NY

Design

In 2006 we began design work on the first of several sand lanes that we have been involved with. This system was planned for one of the facilities that had an original tower separation system and was building a new 1000 stall barn that would be bedded with sand and flushed. The project involved the installation of an 18” flush flume line

that would double as a flush collection line for the new barn. Due to site constraints the new barn was designed to slope to the end of each pen which necessitated the installation of two separate collection points. The new building was designed with commercially available 15" flush valves to supply the flush water and flush towers up in elevation approximately 15' from the barn. This layout required that the collection line turn several times on the way to the space that was available and designated for the sand lane. All lines were installed at a minimum 1.25% slope and all turns were completed utilizing manholes with vertical drops of at least 1'. The collection line at the end of the new barn presented the greatest elevation challenge. This line was installed only 2' in elevation below the alley in the barn.

The sand lane was installed adjacent to the abandoned tower structure. The concrete floor of the tower structure could then be utilized to pile sand after removal from the sand lane, saving the farm approximately $125,000 by avoiding the installation of a sand stacking area. This stacking area allowed the sand to continue to drain and discharged this runoff to the farm's long term storage through the piping already installed at the screen towers. The sand lane design was difficult in that we had to account for several different flow rates entering the lane, ranging from 7500 gallons per minute for the wider cow alley flushes to as little as 2500 gallons per minute for the flume outlet. The decision was made to design the sand lane for the largest flow rate and see how the lower flow rates reacted; this approach dictated a 20' wide sand lane. In addition, the farm installed a settling basin directly off the end of their sand lane, allowing for some sand to settle. The basin is also the source of flume water for this facility. The location of the farms long term storages are several hundred feet from the barns and down in elevation approximately 15 feet. Installation of the flume pump within this structure allowed for the use of a reasonably priced pump as well as reducing the amount of 12" supply line by fifty percent.

This farm has a very limited footprint at their facility and did not have room to install the number of cells and settling basins necessary to remove solids passively; instead they chose to install a mechanical solid separator in an attempt to preserve their flush water quality. Manure is taken from the settling basin at the end of the sand lane, run through an inclined screen separator and discharged to the long term storage system, including additional long term settling basins. Understanding that water quality was the key to the successful operation of any sand separation system, the farm installed an additional 2 million gallon storage to act as an supplemental settling basin to use in conjunction with a converted 1.5 million gallon storage. From these two basins water is pumped off of the top to the farms 7 million gallon storage structure where water is drawn for use in refilling the flush towers.

Operational Evaluation

This system has functioned adequately for the farm. As operations began there were five main areas of concern where we paid particular attention to the results obtained. The first concern was the flush supply system; we were concerned about the performance of the manufactured pop up valves in providing a high enough flow rate

and adequate distribution for cleaning. With the increased head available from the elevated flush tanks the largest problem that was faced at startup was blowing the tops off of the flush valves. Some simple field welded steel plates and a decrease in water level in the flush tanks solved this issue. The valves do an adequate job of spreading out the flow and the farm pulls accumulated sand and manure away from the stall curb on a schedule similar to that of other dairies.

Photo 3. Completed Sand Lane

The next area of concern was the collection of flush water. This was the first installation where we realized that the depth of the collection pipe needed to be greater. With only two feet between the floor alley and the bottom of the pipe the farm frequently over flowed the collection channel. With assistance from their local steel fabrication shop they have since installed a hood system that ensures the flow is directed to the pipe (photo 4 and 5). This system does slow the water slightly as it approaches the collection trench; however there has been no issue with sand settling in the alley.

The third area of concern for this installation was the functionality of the manholes as turning structures with as little as 1' of drop. This quickly became a non-issue on this installation. With the slopes into and out of the manholes adequate and the angle between the inlet and outlet pipes no more than 45 degrees the flows are not restricted enough to cause settling or backup.

The fourth area of concern was the width of the sand lane and how it would handle the varied flows that it was to receive. The lane seems to work fine with these varied flow rates, even though the 2500 gallon per minute flow rate results in flows much less

than 1 foot per second the farm has not experienced excessive amounts of organic matter in their settled sand.

The final area of concern was the availability of space for settling basins and the attempt to utilize a solids separator to provide clean enough water. As with all sand removal systems this is an issue that causes problems from time to time. In addition, the water cycle necessitates additional storage to achieve a six month capacity. To meet these needs the farm installed a large satellite storage structure in 2009.
The farm has made a significant modification to the structure. As indicated the farm is located in Wyoming County, and particularly in the southwest corner of the county, which receives a large amount of lake effect snow. After working with the system through one winter the farm decided that to continue operation it was important for them to install a roof over the sand lane (see photo 6). The large volume of snow and ice buildup impeded the day to day cleaning and maintenance of the sand lane and took a large area to dispose of the “dirty” snow within the sand stacking area.

Photos 4. and 5. Two different views of the hood system installed

Photo 6. Roofed sand lane

Case 2 – 600 Cow Scrape Dairy With Flush Flume Barn Addition – Genesee County NY

Design

In 2008 a farm that we had worked with on the design of a new 600 cow facility several years earlier contacted us to work on a new flush flume and sand lane for the original facility as well as a new 600 cow barn. The farm bedded with sand and pumped to an earthen storage. The manure transfer system had worked well for them; however they had significant issues with sand build up in their manure storage as well as having issues with equipment failures during spreading operations. The farm's main objective was to continue to bed with sand and achieve a level of sand removal that reduced the amount of material in their manure storage system while also improving equipment operation and reducing wear during spreading operations. The farm wanted to install the sand lane, but was not interested in solid separation at the time, feeling that their existing two celled manure storage would allow for clean enough flush flume water to remove sand. At inception, the goal of the system was not to reuse sand beddingThe farm had a limited budget and wanted to install only the sand lane and then remove sand from the area. No provisions were made for a concrete sand stacking area.

A 24" flush flume was designed and installed at a minimum 1.25% slope from the existing milking facility through the new barn to the sand lane. The system was designed to allow for the farm to pump manure from their existing barn into the end of the flume. Similar to case 1, the lane was installed with a "beach" configuration to the side, allowing access throughout (Photo 8). Also similar to case 1, this system was designed with the flume supply pump placed in the sand lane reception pit (Photo 7). In this situation the sand lane was located downslope from all of the farm's manure storage structures. By placing the flume supply pump in the sand lane reception pit, it is virtually impossible to overflow the system.

Photo 7. and 8. Sand lane and adjacent "beach"

Operational Evaluation

This system came on line in the winter of 2008-2009. During the installation of the system the farm decided that they would attempt to recover sand for bedding purposes. Temporary stacking areas were designated and the farm continues to work to receive funding to install permanent sand stacking areas.

As time has progressed at this facility water quality has become a significant challenge. With no mechanical solids separation the quality of the flume water has made separation of quality sand difficult. A significant amount of sand is settled in the sand lane; however for this material to be utilized for bedding the farm must stack and rotate it for a significant amount of time in order for the organic material to break down and decompose.

The amount of sand reaching the farm's long term storage has been significantly reduced with the addition of this sand lane; however to make a more consistent bedding product additional solids separation would be beneficial. The farm has considered this enhancement, but after reviewing several other sand lanes in the area, the farm feels that the increase in sand quality would not offset the equipment investment required and the additional operational costs of a solids separation system.

CONCLUSION

Over the last ten years New York State farmers have learned a significant amount about the transfer and storage of sand laden manure. As with all manure systems on farms there is no one size fits all solutions. Pre-manufactured flush supply valves have continued to improve and we have also continued to improve the collection systems.

One of the biggest lessons learned in New York is the importance of the passive settling that occurs in the multistage storage systems of the midwest sand settling systems. We have had difficulty replicating these systems in New York, with many dairies having limited footprints or soils that are not suitable for earthen storages. The limited long term storage capacities have made consistent water quality a challenge. Overall the systems work to remove sand and reduce loads in the farms long term storage.