

A REVIEW OF MECHANIZED IRRIGATION PERFORMANCE FOR AGRICULTURAL WASTEWATER REUSE PROJECTS

Jacob L LaRue, P.E.
Application Engineer
Valley, Nebraska
Voice: (402) 359-6041 Fax: (402) 359-2045
jlarue@valmont.com

Summary:

This paper will focus on a discussion of considerations and then some wastewater reuse projects which have failed, required significant changes to be successful or have succeeded. An analysis will be presented of what leads to success and to failure of mechanized irrigation wastewater reuse projects both in the short and long run. From the analysis a list of parameters will be discussed which are considered critical to a project's performance. Only agricultural projects will be included in the discussion but many of the same drivers apply to industrial and municipal wastewater reuse projects.

Introduction:

Formerly on 'traditional' Midwest farms from the homestead days through the 1960's there typically were a variety of livestock maintained – some for support of the farm family and some for market. In most cases what livestock waste accumulated was handled primarily 'dry' or as a very thick slurry. At different times of year the waste was applied to the fields with little to no regard for impact to ground or surface water or matching nutrient loading from the waste to nutrient use by the crop. Numbers of animals per farm were relatively small and land fairly abundant. With the introduction of the Clean Water Act in the early 1970's and other legislative action, combined with dramatic changes in the number of head of livestock per farm have lead us to a very different situation. Today more and more the waste water producer does not own the land or sufficient land and must depend on working with neighboring farms to environmentally properly 'dispose' of their wastewater stream

Land application of wastewater with mechanical move irrigation equipment – both center pivot and linear has been successfully used for many years. Since the early 1980's the equipment and techniques for irrigating with fresh water have changed dramatically and many of these changes have been incorporated into mechanized equipment used for land application (Gilley, 1983). While these changes have brought significant improvements, also in today's world we must take into account other issues and particularly public perception of land application systems. Mechanical move irrigation equipment has been used for land application of waste water for reuse from municipal, industrial and

agricultural sources. Mechanized irrigation, due to its characteristics, is considered to have advantages with regards to applying waste water for reuse, particularly from a lagoon with large amounts of water to handle. Some of these characteristics include limited labor input required, application uniformity, ease in handling large volumes of effluent and particularly the ability to apply to actively growing crops with minimal negative impact to the crop. For our discussion we will focus on center pivots. Pivots can also apply during periods of adverse climatic conditions which may prevent or prove challenging to conventional waste handling techniques requiring tractors and other equipment to move through the field.. Some concerns have been expressed include “Land application of wastes may be imposing in some locations, potentially dangerous conditions relative to environmental quality”. (Hegde 1997). Many projects choices are dictated by more than just the equipment to be used. Also critically important is the project meets public scrutiny. Some land application projects are very successful for many years and others are abandoned or shut down after a relatively short time (Valmont Industries, 1988).

Discussion:

In many cases the livestock operation producing the meat or milk has very little interest in crop production. So they are looking for somewhere to go with their waste. So what could be better than having a source of water and plant nutrients right next to your corn fields? Many livestock operations today produce large volumes of nitrogen and water. For example a 2,000 head dairy using flushing may produce in excess of 1000 acre inches of ‘water’ and 250,000 pounds of nitrogen. Just considering the nitrogen, this has a potential value of \$ 45,000 if it can be used to replace the purchase of commercial nitrogen fertilizers. And on the flip side what could be better than having somewhere to go with all of the waste you are producing – potentially saving you significant capital investment and operating cost each year. .

So as a farmer near a facility what could possibly go wrong with agreeing to take waste water from a dairy, hog or beef operation or as a waste producer in sending it to an irrigator?

The answer is just about anything or everything!

Let us consider some specific potential issues.

Permitting –

This in itself may be a challenge. Both partners must agree on nutrient management plan and crops need to match nutrient loading for the land area. The farmer may be pushed to change his cropping plan by adding winter forage which may work well as long as the livestock operation is willing to buy but if not creates marketing challenges for the farmer.

Design –

To get everyone to agree on the same design is commonly a major issue -

Waste producer wants:

- Fast delivery of large volumes
- May need to eliminate large volumes early in the season and/ or late
- May have chunks and trash

Irrigator wants:

- Even volume over season
- Really only wants effluent when crop needs it
- Wants sprinkler package with good uniformity

Construction –

Construction cycle may interfere with crop production while installing pipelines and mechanical move irrigation equipment.

Operation –

Waste producer wants:

- Delivery effluent when they want
- May deliver more 'objects' than anticipated

Irrigator wants:

- Take effluent when they want
- No need to clean nozzles

The only thing they both agree on is they do not want any problems with neighbors and minimal labor required.

Let's now focus on some specific projects and their performance. A review of the original choices considered, concerns, project developed, challenges and benefits will be considered.

- 1) Project for farrowing operation which was hydraulically challenged.
 - a. Choices considered were direct injection or center pivots
 - i. Area needed for land application - 125 acres
 - b. Concerns with using center pivot
 - i. Maintenance
 - c. Project developed with center pivots in 2001
 - i. Project expanded in 2003 with center pivots
 - ii. Project expanded in 2004 with center pivots
 - iii. Hog operation paid to install the pump, pipe and center pivot.
 - d. Hog operation pays operating costs for the pumping
 - e. Major challenge
 - i. Crop management
 - ii. Potential for getting pivots stuck

- f. Major benefit
 - i. Crop production
 - ii. Ability to apply during growing season

Due to previous problems with being able to get into the fields to apply with a direct injection, center pivots were considered the preferred solution. A farmer was identified early on and the design was developed to meet the hog and farm operations. Getting stuck was a problem and early pivots commonly were not operated in complete circles due to wet spots. Have added flotation options to specific drive units which as minimized the problem. Livestock producer continued to identify possible farms for expansion and did a good job of explaining the benefits.

Hog operation – happy Irrigator – mostly happy

- 2) Project for integrated hog production which was nutrient limited.
 - a. Choices considered were direct injection or center pivots
 - i. Area needed for land application - 195 acres
 - b. Concerns with using center pivot
 - i. Odor
 - ii. Maintenance
 - c. Project developed with direct injection during 2000
 - d. Major challenge
 - i. Inability to apply during growing season
 - ii. Inability to apply early in the season when the fields were wet

The hog operation was convinced center pivots would have the potential for too many odor issues. They did not want to consider some of the advanced design sprinkler packages available. Their vision was limited to impact sprinklers on top of the pipe. In addition little effort was put into identifying a crop producer who might be interested in participating with a center pivot.

Hog operation – ??? Land owners - ???

- 3) Project for large dairy.
 - a. Choices considered were direct injection or center pivots
 - i. Area needed for land application - 325 acres
 - b. Concerns with using center pivot
 - i. Handling of sand (bedding in the barns)
 - ii. Neighbors wanted drops on pivot due to perception of odor
 - c. Project developed with center pivots during 2004 using existing pivots near the barns. The dairy installed the pump station and piping to the pivots at their expense.

- d. Operating cost for pumping is paid by the dairy.
- e. Major challenge
 - i. Civil engineering design team (no agricultural experience)
 - ii. Plugging sprinkler packages
 - iii. Delivery of effluent early in the spring

The dairy operation was convinced center pivots would have the potential to make things easy and keep their costs low. They (dairy operators) did not complete the installation to the original design to remove sand and solids so many problems with sprinkler nozzles plugging plus wanted to pump when the farmer was trying to plant. Farmer wanted to maintain good uniformity as was on loamy sand soils but due to narrow spacing of drops and small nozzle sizes has plugging problems. The last time the participants met was not a happy experience! Additional designs are being considered to resolve the issues.

Dairy – not happy Irrigator – not happy

- 4) Project for large beef feedlot which was hydraulically challenged.
 - a. Choices considered were traveling guns or center pivots
 - i. Area needed for land application - 260 acres
 - b. Concerns with using center pivot
 - i. Capital investment
 - ii. Too much water at certain times
 - c. Project developed with center pivots during 2002 by piping to existing pivot irrigators at feedlots cost.
 - d. Feedlot pays pumping costs.
 - e. Major challenge
 - i. No even flow of effluent – problems shifting between wastewater and freshwater
 - ii. Too much water early in the season and after storm events

This situation uses the lagoons to control runoff from the pens. The irrigator did not understand the effluent would primarily only be available after storm events and over winter. The nutrient management plan made it appear there was equal distribution over the season. Then even if there was water to be pumped as long as the lagoons were not near capacity, the feedlot does not want to spend the money for energy to pump and hope evaporation will take care of their problem. The farmer becomes the last resort and does not have any dependable source of water.

Feedlot – happy Irrigator – not happy

Conclusions:

Land application using mechanical move irrigation equipment has proven very beneficial to many reuse projects and can be cost effective over the life of the project. One of the keys to successful projects is an integrated approach to the design combining hardware, agronomic principles, management and neighbors together with the wastewater producer.

An analysis of the projects above would indicate the key parameters to be:

- Land application system should fit with the existing management and/or treatment processes.
- Sufficient land must be available for the expected nutrient and hydraulic load with some allowance for the future.
- Early identification of a potential farmer
- Design must be sensitive to the local concerns about odor, impact on visual landscape and other possible concerns.
- Projects must be reviewed periodically to ensure operation is meeting the design basis and the participants' needs.
- Continuing education must be kept up for consulting engineering firm's personnel so they understand the equipment, the concepts and agronomics of a land application water reuse system.

Key design considerations for the center pivots would be:

- Ability to apply very small depths to help manage lagoons
 - High speed pivot operation
- Control and remote monitoring
 - Packages such as Field Sentry, Pivot Alert, Tracker and others
 - Control panels with sensor packages such as wind, rain and others
- Close attention to sprinkler packages
 - Space as wide as possible to use larger nozzles
 - Use of regulators or flow control nozzles
 - Determine impact if no regulators used
 - Review options available from sprinkler manufacturers
- Use of flotation technology
 - Three wheel drives
 - Tracks on drive units

References:

Gilley, James R., 1983, Suitability of Reduced Pressure Center Pivots, Journal of Irrigation and Drainage Engineering, Vol 110, No. 1,

Hegde, Poornima and Kanwar, R.S., 1997 Impact of Manure Application on Groundwater Quality, 1997 International Summer Mtg. of ASAE, Paper 97-2144, Minneapolis Minnesota

Valmont Industries Inc., Livestock Waste Management through Center Pivots, Wastewater Intelligence volume 1, AD10182 1988

Personal communication with a number of waste water projects.