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Economic Considerations for Beef Manure Management Systems

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Manure can be a valuable resource in a crop production system. Manure contains the macronutrients nitrogen (N), phosphorus (P), and potassium (K) and also contains numerous micronutrients. The nutrient value of manure for crop production depends on the site-specific reserve of plant available soil nutrients, the nutrient concentrations in manure, and the nutrient demands of the crop. In many areas of Missouri, soil levels of P and most micronutrients are already at adequate levels. In some soils, K is also adequate for crop production. Where soil has adequate levels of P, K, and micronutrients, there is little or no economic value associated with these elements in applied manure. Nitrogen is always needed for production of nonleguminous crops (e.g., corn, small grains and grass pasture), and when correctly managed, the N in manure is valuable. For legumes (e.g., alfalfa and soybeans) the N in manure is of little economic value because these crops are able to convert N in the air to plant-available N.

However, when manure is applied to legumes, these plants can make use of the plant-available N instead of producing their own N. Thus, application to legumes can be an environmentally benign way to make use of manure N. The value of the nutrients in manure also depends on the value of alternative sources, mostly commercial fertilizers.

Manure management systems

Most of the beef manure produced in Missouri is dropped on pastures. The purpose of this guide is to compare the economics of three systems for collecting, storing, and transporting beef manure from confined feeding operations and applying it to the land. The three systems are solid manure systems, slurry systems (with injection into the soil) and lagoon systems in which the effluent is applied using a traveling gun (and not incorporated). Value will only be based on the N, P and K added to the soil from the application of manure and no value assigned to other benefits of adding manure, such as increased organic matter.

If the added N, P and K are needed for crop production, they have value. If the nutrients are not needed, they have no value. Each landowner or operator will have to consider the soil tests and the manure nutrient tests to determine the value of the N, P and K in the manure for each field being considered. There are two main driving forces at work when manure use is considered. One is "on farm" profitability, and the other is the negative "downstream" effects. At times, economic and environmental quality goals are competing.

Manure management systems commonly used in Missouri are the solid, slurry (liquid tank) and lagoon. Solid systems have been the traditional way to handle feedlot manure. A common practice is to scrape lots with a box scraper and load manure spreaders with a front-end loader.

Slurry systems, sometimes used for feeding cattle on slatted floors over pits in a barn, allow the maximum recovery of the manure nutrients for crop production. Slurry (liquid tank) systems are often used for livestock when a lagoon is not economical or feasible because of unfavorable soil types or geological considerations. Operations may switch from a solid system to a slurry or lagoon system to reduce labor, to improve water quality and to fix other problems. To be practical, each of these systems must minimize the amount of excess (runoff) water being transported to the field by tank wagons.

Lagoon systems are favored by large livestock operations because labor and investment costs are minimized and a flushing system can be used to collect and transport waste to the lagoon. Flush systems can be used in a confinement barn. In beef units, flushing under slotted floors, through 3- to 4-feet-wide open gutters, and in flumes spaced 12 to 14 feet apart, has been used. These systems normally use an irrigation system with pump, pipe and traveling gun to transport and spread the waste. Hose-fed, tractor-mounted injectors are becoming more common in Missouri, usually operated by custom applicators. These applicators can be equipped for variable-rate, site-specific application using GPS and flow meters.

Economic data

Slurry (liquid tank) and lagoon systems were studied statewide in Missouri several years ago because they were the most likely alternatives to upgrade dairy manure operations. Data were used to project waste management system costs associated with dairy operations ranging in size from 100 to 1,000 cows. Because the solid system is best suited to herds of less than 100 cows, it was not analyzed. An economic analysis based on the data collected was published in MU publication MP666, Waste Management Systems for Dairy Herds. No such study has been conducted for beef operations.

Ray Massey, an MU Commercial Agriculture Program agricultural economist, has developed a computer program for estimating the cost of land application of manure with dry spreaders or liquid tank wagons. The program, Manure Distribution Cost Analyzer, is a Microsoft Excel spreadsheet and is available at *http://agebb.missouri.edu* under Farm Management. A spreadsheet titled Fertilizer Value of Manure Analyzer, is also downloadable from same Web site.

Systems to be considered

This publication presents information for three sizes of beef feeding operations with average animal weights of 1,000 pounds, as follows: 150 head, 300 head and 600 head using lagoon, slurry and solid manure systems.

Lagoon-gutter flush system

Lagoon size is based on a 365-day storage capacity with 100 percent of the manure going into the lagoon. Land required for spreading the effluent is based on 195 pounds of nitrogen per acre for corn production with 165 lb/acre from manure and 30 lb/acre from the previous soybean crop.

The lagoon system is assumed to hire a custom irrigation system at $70/hour. Other components are assumed to be owned. Major expenditures include the cost of a slatted floor and shallow flush pits for a beef-feeding confinement barn and constructing the lagoon. The estimated costs include a clay lagoon seal compacted by a sheepsfoot roller. Other equipment includes the water storage tanks for flushing gutters and the electric pump and pipe needed to recycle water from the lagoon to the flush tanks.

The irrigation system includes a traveling gun irrigator that will distribute 1 acre-inch (27,154 gallons) of effluent per hour (or about 450 gallons/minute (gpm)). A custom operator provides everything except "equipment check labor." The livestock operation is responsible for properly operating the equipment.

Slurry (liquid storage tank/pit) system

The slurry system is assumed to include a 12-foot deep pit with approximately 180-day storage capacity under a slatted floor in a confinement barn. The equipment cost includes an open-impeller, centrifugal chopper pump used to agitate the slurry in the tank while pumping from storage to tank wagon(s). The tank wagon size varies with herd size; a 4,200-gallon tank wagon pulled by a 190-horsepower tractor for 150 head, a 12,000-gallon tank wagon pulled by a 325 hp tractor for 300 head, and two 12,000-gallon tank wagons pulled by 325 hp tractors for 600 head (to permit waste distribution within a 10-day period during the 180-day storage period). The tank wagons are equipped with injectors to maximize the use of plant nutrients and to minimize runoff and odor problems.

Labor required for loading, hauling and spreading the manure assumes the tractor operator for each tank wagon used to distribute the manure onto the fields will also operate the tractor powering the agitator pump to fill the tank wagon.

Solid manure handling system

The solid system includes a tractor-drawn box scraper for maintaining lot surfaces, a farm tractor with front-end loader for loading a solid manure spreader and a tractor with operator to haul manure to the field(s) for land application. The lot areas are assumed to be sized at 250 sq ft/head, and the total area with runoff draining to the holding pond is 400 sq ft/head. The holding pond is sized for 365-day storage capacity, and land application of the holding pond effluent is by a custom traveling-gun irrigator.

Fertilizer nutrient equivalent value

Manure applied to the land is assumed to have an equivalent fertilizer nutrient value for the replaced commercial fertilizer or for the increased production of plant growth, which is harvested or used by animals.

Fertilizer nutrient availability is shown in Tables 13, 20 and 26; nitrogen availability is based on data in Tables 14 and 15. For ammonia nitrogen availability, a factor of 0.6 is used for the unincorporated manure applied by the solids spreaders and by irrigation; a factor of 0.95 is used for slurry manure injected by the tank wagon(s).

Comparison of systems

The investment per animal for the lagoon and slurry systems is roughly equivalent when compared with the investment for the solid handling system, as shown in Table 1 (these data are from Tables 6, 7 and 8).

Likewise, the net annual costs per animal for the lagoon and slurry systems are relatively close to each other when compared with the cost per animal for the solid handling system, as shown in Table 2. (These data are also from Tables 6, 7 and 8.) The net annual cost per animal accounts for the fertilizer equivalent value of the plant nutrients in the manure if it is applied to the land and fully used for crop production in lieu of purchased fertilizer.

Table 3 shows the minimum required acres for land application for the three systems based on nitrogen as

the limiting nutrient. (These data are from Tables 13, 20 and 26.) The lagoon system requires considerably less acres than the other two systems.

Table 4 compares annual plant-available nutrients (N, P and K) for the three systems. Less nitrogen is available from the lagoon system because of oxidation, denitrification and dilution. The values for the slurry system are about three to four times greater than the values for the lagoon system. This can be an advantage for lagoon systems if nearby land available for manure disposal is limited. However, there may be a considerable expenditure for disposing of accumulated sludge when the lagoon is closed. The values for the solid system are slightly greater than the values for the lagoon system. Assumed values of the fertilizer nutrients are as follows:

Assumed value of fertilizer nutrients

Element	Cents/lb
Nitrogen	30
Phosphate	20
Potash	15

Table 5 shows that the cost for pumping a lagoon with owned equipment may be much greater than hiring a custom operator for small operations. However, if custom operators are not available when the lagoon must be pumped, owning equipment may be necessary.

Table 14 illustrates the advantage of prompt incorporation of manure to minimize losses of ammonia-N; 80 percent can be lost in a week without incorporation. In the case of irrigated lagoon effluent, incorporation occurs if the soil is dry enough for the liquid to soak in and the application rate does not exceed the soil infiltration rate.

Table 15 provides data on the availability of N from the organic portion of applied manure. About 50 percent may become available in the year of application, the reminder becoming available at a declining rate over the next few years.

For annual fixed costs and annual operating costs, see Tables 9, 10, 11 and 12 for the lagoon system, Tables 16, 17, 18 and 19 for the liquid manure tank system, and Tables 21, 22, 23, 24 and 25 for the solids system. Tables 27, 28 and 29 provide data and an example for calculating fixed and operating costs for a traveling-gun irrigator.

See page 11 for examples based on typical soil test data.

In Missouri, a confined animal feeding operation (CAFO) with 1,000 or more animal units (for beef, 1,000 or more beef feeders or slaughter animals) is required to obtain an operating permit from the Missouri Department of Natural Resources (DNR). CAFOs with 300 to 999 animal units are encouraged to obtain a letter of approval from DNR for their animal manure management plans. This may cause some operations to upgrade their manure management system. Cost-sharing assistance may be available from the EQIP program administered by the Natural Resources Conservation Service (NRCS). Contact your local NRCS office for details on the EQIP program.

Conclusions

The solids system has much lower initial investment per animal and much lower net cost per animal than either the lagoon or the slurry system.

Even though manure from slurry (liquid tank) systems is more concentrated and valuable than the manure from lagoon systems, the net cost per animal for a slurry system is similar to that for a lagoon system for the three herd sizes considered in this publication.

The slurry system requires a plant filter area about three to four times larger than that for a lagoon system. This can be a major consideration for operations with limited acreage. The solid system requires slightly more land-application area than the lagoon system.

Large feedlot operations with more than 600 animals may benefit from purchasing a traveling-gun irrigator rather than relying on a custom operator charging $70 per hour (see Tables 27, 28 and 29). However, lack of available labor and management may make hiring a custom irrigation system a better choice, even for the largest of operations.

Tables

Table 1. Investment per animal for three manure systems.

System	Herd size		
	150	300	600
Solid system with dirt lot & holding pond	$186	$120	$107
Lagoon system, barn, flushed under slats	$795	$636	$555
Slurry system, barn, deep pit under slats	$980	$892	$836

Table 2. Net annual cost per animal for three manure systems.

System	Herd size		
	150	300	600
Solid system with dirt lot & holding pond	$34	$23	$21
Lagoon system, barn, flushed under slats	$96	$71	$59
Slurry system, barn, deep pit under slats	$112	$99	$89

Table 3. Minimum acres required for land application based on nitrogen for three manure systems.

System	Herd size		
	150	300	600
Solid system with dirt lot & holding pond	24	49	98
Lagoon system, barn, flushed under slats	15	30	59
Slurry system, barn, deep pit under slats	57	115	229

Table 4. Comparison of annual plant-available nutrient values for the three systems.

System	Herd size		
	150	300	600
Nitrogen from solids @$.30/lb	$1,210	$2,416	$4,828
Nitrogen from slurry	2,840	5,679	11,358
Nitrogen from lagoon	732	1,463	2,927
P_2O_5 from solids @$0.20/lb	$798	$1,596	$3,192
P_2O_5 from slurry	1,568	3,135	6,270
P_2O_5 from lagoon	599	1,197	2,394
K_2O from solids @$0.15/lb	$1,164	$2,316	$4,614
K_2O from slurry	1,689	3,377	6,755
K_2O from lagoon	577	1,154	2,309

Table 5. Cost per acre-inch for custom lagoon pumping.

System	Herd size		
	150	300	600
Pumping costs for owned equipment purchased used			
Acre inches pumped annually	11.1	19.8	36.4
Custom lagoon pumping cost	$105	$93	$86
Owned lagoon pumping cost	$432	$277	$190
Custom pumping and irrigation from the lagoon system			
1.Estimated acre-inches to pump annually	11.1	19.8	36.4
2. Custom pumping charge/hour	$70	$70	$70
3. Annual lagoon pumping costs (line 1 x line 2) plus $300 setup charge	$1,077	$1,686	$2,848
4. Check labor hours/year	11	20	36
5. Annual labor costs (line 4 x $8/hour)	$88	$160	$288
6. Total operating costs (line 3 + line 5)	$1,165	$1,846	$3,136
7. Cost per acre-inch (line 14 ÷ line 1) or per hour operation	$104.95	$93.23	$86.15

Table 6. Summary of lagoon system costs.

	Herd size		
	150	300	600
1. Average investment per animal ($)	795	636	555
2. Annual operating costs ($) (from Table 12, line 10)	1,357	2,229	3,775
3. Annual fixed costs ($) (from Table 11, line 9)	15,000	23,000	39,000
4. Total annual costs ($) (line 2 + line 3)	16,357	25,229	42,775
5. Annual costs per animal ($)	109	84	71
6. Value of manure ($) (from Table 13, line 12)	1,907	3,815	7,629
7. Net annual cost ($) (line 4 – line 6)	14,450	21,414	35,146
8. Net annual cost per animal ($)	96	71	59

Note: Value of manure assumes all contained nutrients are needed and used for crop production in lieu of commercial fertilizer.

Table 7. Summary of slurry manure (tank) system annual costs.

	Herd size		
	150	300	600
1. Average investment per animal ($)	980	892	836
2. Annual operating costs ($) (from Table 19, line 10)	4,750	8,643	15,540
3. Annual fixed costs ($) (from Table 18, line 7)	18,117	33,269	62,383
4. Total annual costs ($) (line 2 + line 3)	22,867	41,912	77,923
5. Annual costs per animal ($)	152	140	130
6. Value of manure ($) (from Table 20, line 10)	6,096	12,191	24,383
7. Net annual cost ($) (line 4 – line 6)	16,771	29,721	53,540
8. Net annual cost per animal ($)	112	99	89

Note: Value of manure assumes all contained nutrients are needed and used for crop production in lieu of commercial fertilizer.

Table 8. Summary of solid manure system annual costs.

	Herd size		
	150	300	600
1. Average investment per animal ($)	186	120	107
2. Annual operating costs ($) (from Table 24, line 14)	1,608	3,485	7,437
3. Annual cost to have custom irrigator land-apply holding pond effluent (from Table 25)	2,484	4,512	8,568
4. Annual fixed costs ($) (from Table 23, line 5)	4,152	5,125	9,174
5. Total annual costs ($) (line 2 + line 3 + line 4)	8,244	13,122	25,179
6. Annual costs per animal ($)	55	44	42
7. Value of manure ($) (from Table 26, line 12)	3,171	6,327	12,634
8. Net annual cost ($) (line 4 – line 6)	5,073	6,795	12,545
9. Net annual cost per animal ($)	34	23	21

Note: Value of manure assumes all contained nutrients are needed and used for crop production in lieu of commercial fertilizer.

Table 9. Lagoon system investment.

	Herd size (1,000 lb animals)		
	150	300	600
Lagoon	$13,000	$24,000	$43,000
Fencing ($1.00/ft)	1,200	1,400	1,700
Total - Lagoon & fence	$14,200	$25,400	$44,700
Flush pit under slats	58,000	103,000	194,000
Slats, concrete	14,000	28,000	56,000
Total - Flush pit & slats	$72,000	$131,000	$250,000
Storage tanks/gates (to flush pit)	23,000	24,000	26,000
Recycling pump and pipe	6,000	6,000	7,000
Total - Tanks, gates, pump & pipe	$29,000	$30,000	$33,000
Consultation	4,000	4,500	5,500
Total investment	$119,200	$190,900	$333,200
Average investment per animal	$794.67	$636.33	$555.33

Note: Assume square lagoons @15 ft deep with 365 days storage, estimated cost at $2.00 per cut yard.

Table 10. Lagoon system: Annual fixed costs (% of new cost).

	Lagoon and fence	Equipment	Consultation
Years useful life	20	10	
Fixed costs as percent of new cost			
Depreciation	5.0	9.0[1]	5.0
Interest	4.0[2]	4.0[2]	4.0
Repairs and maintenance	1.5	1.5	
Taxes	0.8[3]	1.0[3]	
Insurance		1.0	
Total percent	11.3	16.5	9.0

Notes:
[1] Allows for 10 percent salvage.
[2] Annual interest charge is 4 percent of original investment (equivalent to investment x 50 percent x 8 percent APR.)
[3] Tax assessment varies based on value added to the property. A lagoon established on a suitable site in an area where unfavorable geological conditions predominate will add more value to the property than one established in an area with many favorable sites.

NOTE: Apparent minor errors in tables are due to spreadsheet rounding.

Table 11. Lagoon system: Total annual fixed costs.

	Herd size (1,000 lb animals)		
	150	300	600
1. Lagoon & fence (investment)[1]	$14,200	$25,400	$44,700
2. Flush pit & slats (investment)[1]	$72,000	$131,000	$250,000
3. Tanks, gates, pump & pipe (investment)[1]	$29,000	$30,000	$33,000
4. Consultation[1]	$4,000	$4,500	$5,500
5. Lagoon & fence (ln 1 x 11.3%)[2]	$1,605	$2,870	$5,051
6. Flush pit & slats (ln 2 x 11.3%)[2]	$8,136	$14,803	$28,250
7. Tanks, gates, pump & pipe (ln 3 x 16.5%)[2]	$4,785	$4,950	$5,445
8. Consultation (ln 4 x 9%)[2]	$360	$405	$495
9. Total annual fixed costs (ln 5 + ln 6 + ln 7 + ln 8)	$14,886	$23,028	$39,241
10. Annual cost per animal	$99.24	$76.76	$65.40

Notes:
Assume square lagoons @ 15 ft deep with 365 days storage,estimated cost at $2.00 per cut yard.
[1] Transferred from Table 9.
[2] Transferred from Table 10.

Table12. Lagoon system: Annual operating costs.

	Herd size		
	150	300	600
Operating recycle pump			
1. Size electric pump (hp)	1.5	3	5
2. Annual pumping time (5 hrs daily x 365 days)	1,825	1,825	1,825
3. Cost/hour (1kw x hp x $.07/kw)	$0.11	$0.21	$0.35
4. Annual pumping costs (line 2 x line 3)	$192	$383	$639
Irrigation lagoon annual pumping cost			
5. Estimated acre-inches to pump annually (from lagoon design)	11.1	19.8	36.4
6. Custom pumping charge/hour[1]	$70	$70	$70
7. Annual lagoon pumping costs (line 5 x line 6) + $300 setup	$1,077	$1,686	$2,848
8. Check labor hours/year[2]	11	20	36
9. Annual labor costs (line 8 x $8/hour)	$88	$160	$288
10. Total operating costs (line 4 + line 7 + line 9)	$1,357	$2,229	$3,775

Notes:
[1] Assume a traveling gun pumps 500 gallons per minute, which allows pumping 1 acre-inch per hour.
[2] Check labor required to inspect the irrigation system periodically to determine if the traveling gun and equipment are operating adequately. Assume 1 hour per hour of irrigator operation.

Table 13. Lagoon system: Value of manure to plant production.

	Herd size		
	150	300	600
Nutrients produced (lb/yr)[1]			
1. Ammonia nitrogen	3,600	7,200	14,400
2. Organic nitrogen	450	900	1800
3. P_2O_5 (phosphate)[2]	3,150	6,300	12,600
4. K_2O (potash)[2]	4,050	8,100	16,200
Pounds of fertilizer nutrient equivalent available			
5. Ammonia nitrogen (line 1 x 60%)[3]	2,160	4,320	8,640
6. Organic nitrogen (line 2 x 62%)[3]	279	558	1116
7. P_2O_5 (line 3 x 95%)[3]	2,993	5,985	11,970
8. K_2O (line 4 x 95%)[3]	3,848	7,695	15,390
Value of fertilizer equivalents			
9. Nitrogen (ln 5 + ln 6) x $0.30/lb)	$732	$1,463	$2,927
10. Phosphate (line 7 x $0.20/lb)	$599	$1,197	$2,394
11. Potash (line 8 x $0.15/lb)	$577	$1,154	$2,309
12. Total value of fertilizer equivalent	$1,907	$3,815	$7,629
13. Minimum no. acres to irrigate[4]	14.8	29.6	59.1
14. Value of fertilizer equivalent/ acre (line 12 ÷ line 13)[5]	$129	$129	$129

Notes:
[1] Average analysis of lagoon waste.
[2] P x 2.29 = P_2O_5 ; K x 1.21 = K_2O
[3] Average percent available to plant.
[4] Application of 165 pounds of available nitrogen per acre for corn
[5] Value of manure assumes all contained nutrients are needed and used for crop production in lieu of commercial fertilizer.

The assumed value of the fertilizer nutrients is as follows: nitrogen @ $0.30/lb, phosphate @ $0.20/lb, and potash @ $0.15/lb.

Table 14. Manure ammonia-nitrogen loss by days until worked into the soil.

Days until incorporation	Ammonia-N available for crops (%)
0–2	80
2–4	60
4–7	40
more than 7	20

Table 15. Manure organic nitrogen available by year.

Manure applied	Organic N available during year (%)
current year	40–60
1 year ago	10
2 years ago	5
3 years ago	5

Table 16. Slurry (liquid manure pit/tanker) system: Investment.

	Herd size (1,000 lb animals)		
	150	300	600
1. Manure pit (under slats)[1]	$85,000	$150,000	$280,000
2. Slats (concrete)	$14,000	$28,000	$56,000
3. Agitating and loading pump	$10,000	$11,000	$11,000
4. Tank wagon with injectors[2]	$35,000	$75,000	$150,000
5. Consultation	$3,000	$3,500	$4,500
6. Total investment	$147,000	$267,500	$501,500
7. Average investment per animal	$980	$892	$836
8. Estimated hours/year to land apply[3]	50	67	74

Notes:
[1] Assumes 12 ft deep excavation 8 feet beyond walls all around at bottom at a cost of $2 per cut yard including backfilling. Excavation to have sides sloped at 2:1 for workers' safety.
[2] Assumes a 4,200 gallon tanker pulled by a 190 hp tractor for 150 head; a 12,000 gallon tanker pulled by a 325 hp tractor for 300 head; and two 12,000 gallon tankers each pulled by a 325 hp tractor for 600 head.
[3] Assumes 8,000 gallons applied per acre for 165 lbs of N to be available for corn. Assumes 0.5 mile haul for 150 head; 0.75 mile haul for 300 head and 1 mile haul for 600 head.

Table 17. Slurry (liquid manure pit) system: Annual fixed costs (% of new cost).

	Lagoon and fence	Equipment	Consultation
Years useful life	20	10	20
Fixed costs as percent of new cost			
Depreciation	5.0	9.0[1]	5.0
Interest	4.0[2]	4.0[2]	4.0
Repairs and maintenance	0.5	2.5	
Taxes	0.8[3]	1.0	
Insurance		0.5	
Total percent	10.3	17.0	9.0

Notes:
[1] Allows for 10 percent salvage.
[2] Annual interest charge is 4 percent of original investment (equivalent to investment x 50 percent x 8 percent APR.)
[3] Tax assessment varies based on value added to the property.

Table 18. Slurry (liquid manure pit) system: Total annual fixed costs.

	Herd size		
	150	300	600
1. Deep pit & slotted floor (from Table 16, line 1 + line 2)	$99,000	$178,000	$336,000
2. Equipment, initial investment[1]	$45,000	$86,000	$161,000
3. Consultation[2]	$3,000	$3,500	$4,500
4. Pit & floor (line 1 x 10.3%)[3]	$10,197	$18,334	$34,608
5. Equipment, annual costs (line 2 x 17%)[3]	$7,650	$14,620	$27,370
6. Consultation (line 3 x 9%)[3]	$270	$315	$405
7. Total annual fixed costs (line 4 + line 5 + line 6)	$18,117	$33,269	$62,383
8. Total annual fixed costs per animal	$121	$111	$104

Notes:
[1] From Table 16, line 3 + line 4.
[2] Transferred from Table 16.
[3] Transferred from Table 17.

Table 19. Slurry (liquid manure pit) system: Annual operating costs.

	Herd size		
	150	300	600
Power supply, hours use annually			
1. Agitation/pump tractor[1]	50	67	74
2. Tank wagon tractor(s) hrs/yr[2]	50	67	74
Power costs			
3. Agitation/pump tractor, hp	135	170	170
4. Agitation pump tractor operating costs per hour[3]	$37	$48	$48
5. Agitation pump tractor operating costs per year	$1,850	$3,216	$3,552
6. Tank wagon tractor(s), hp	190	325	325
7. Tank wagon tractor(s) operating costs per hour[4]	$49	$72	$144
8. Tank wagon tractor(s) operating costs per year (line 2 x line 7)[3]	$2,450	$4,824	$10,656
Labor costs			
9. Tractor operators (one for 150 & 300 head, two for 600 head) x $9/hr)[5]	$450	$603	$1,332
10. Total operating costs (line 5 + line 8 + line 9)	$4,750	$8,643	$15,540
11. Total operating costs per animal	$32	$29	$26

Notes:
[1] Based on same hours as spreading to keep agitated.
[2] Hauling time per load by herd size (minutes): 150 animals — 27; 300 — 52; 600 — 57.
[3] Based on "2002 Doane's Machinery Custom Rates Guide" plus estimated fuel cost.
[4] Cost for 600 head is for operating two 325 hp tractors.
[5] Assumes that the tanker-tractor operator(s) operates the agitator/pump and its tractor.

Table 20. Slurry (manure tank) system: Value of manure to plant production.

	Herd size (1,000 lb animals)		
	150	300	600
Nutrients produced (lb/yr)			
1. Ammonia nitrogen	3,600	7,200	14,400
2. Organic nitrogen	9,750	19,500	39,000
3. P_2O_5 (phosphate)[1]	8,250	16,500	33,000
4. K_2O (potash)[1]	11,850	23,700	47,400
Fertilizer nutrient equivalent (lb/yr)			
5. Ammonia nitrogen (line 1 x 95%)[2]	3,420	6,840	13,680
6. Organic nitrogen (line 2 x 62%)[3]	6,045	12,090	24,180
Value of fertilizer equivalents			
7. Nitrogen (line 5 + line 6) x $0.30/lb)	$2,840	$5,679	$11,358
8. Phosphate (line 3 x 0.95%[4] x $0.20/lb)	1,568	3,135	6,270
9. Potash (line 4 x 0.95%[4] x $0.15/lb)	1,689	3,377	6,755
10. Total value of fertilizer equivalent	$6,096	$12,191	$24,383
11. Minimum no. acres to apply slurry[5]	57	115	229
12. Value of fertilizer equivalent per acre (line 10 ÷ line 11)[6]	$106	$106	$106

Notes:
[1] P x 2.29 = P_2O_5; K x 1.21 = K_2O
[2] Assumes immediate incorporation with tank-wagon injection.
[3] Assumes same amount of manure applied to fields each year.
[4] Average percent available to plant.
[5] Based on 165 pounds of nitrogen per acre for corn.
[6] Value of manure assumes all contained nutrients are needed and used for crop production in lieu of commercial fertilizer.
The assumed value of the fertilizer nutrients is as follows: nitrogen@30 cents/lb; phosphate @20 cents/lb; potash @15 cents/lb.

Table 21. Solid-manure, dirt-lot system: Investment.

	Herd size (1,000 lb animals)		
	150	300	600
1. Holding pond (without separation) ($)	8,000	14,000	25,000
2. Fence ($)	950	1,100	1,350
3. Pond & fence (ln 1 + ln 2) ($)	8,950	15,100	26,350
4. Box scraper ($)	3,000	3,000	4,000
5. Front-end loader ($)	6,000	6,000	9,000
6. Spreader[1] ($)	10,000	12,000	25,000
7. Equipment ($) (line 4 + line 5 + line 6)	19,000	21,000	38,000
8. Total investment ($) (line 3 + line 7)	27,950	36,100	64,350
9. Average investment per animal ($)	$186	$120	107
10. Estimated hrs/yr to land apply[2]	21	44	79

Notes:
[1] Assumes 300 bu (6 ton) spreader and 100 hp MFWD tractor for 0.5 mile haul, 400 bu (8 ton) spreader and 130 hp MFWD tractor for 0.75 mile haul, and 636 bu (12 ton) spreader and 185 hp MFWD tractor for 1mile haul for 150 head, 300 head, and 600 head, respectively.
[2] Assumes 2 tons of solid manure per head per year.

Table 22. Solid (dirt lot) manure system: Annual fixed costs as a percent of new cost.

	Holding pond & fence	Equipment[1]
Years useful life	20	10
Fixed costs as percent of new cost		
Depreciation	5	9
Interest[2]	4	4
Repairs and maintenance	0.5	2.5
Taxes	0.8	1
Insurance		0.5
Total percent	10.3	17

Notes:
[1]Allows for 10 percent salvage.
[2]Annual interest charge is 4 percent of original investment (equivalent to investment x 50 percent x 8 percent APR.)

Table 23. Solid (dirt lot) manure system: Total annual fixed costs.

	Herd size		
	150	300	600
1. Holding pond & fence[1]	$8,950	$15,100	$26,350
2. Equipment, initial investment[2]	$19,000	$21,000	$38,000
3. Holding pond & fence (line 1 x 10.3%)[3]	$922	$1,555	$2,714
4. Equipment, annual costs (line 2 x 17%)[3]	$3,230	$3,570	$6,460
5. Total annual fixed costs (line 3 + line 4)	$4,152	$5,125	$9,174
6. Total annual fixed costs per animal	$28	$17	$15

Notes:
[1]From Table 21, line 3.
[2]From Table 21, line 7.
[3]Transferred from Table 22.

Table 24. Solid (dirt lot) manure system: Annual operating costs.

	Herd size		
	150	300	600
Power supply, hours use annually			
1. Scraper tractor, hrs/year[1]	13	26	52
2. Loader tractor, hrs/year[2]	8	15	25
3. Spreader tractor, hrs/year[3]	21	44	79
Power costs			
4. Scraper tractor, hp	105	105	105
5. Scraper tractor operating costs per hour[4]	31	31	31
6. Scraper tractor operating costs per year (line 1 x line 5)	403	806	1612
7. Loader tractor, hp	105	105	105
8. Loader tractor operating costs per hour[4]	31	31	31
9. Loader tractor operating costs per year (line 2 x line 8)	248	465	775
10. Spreader tractor, hp	100	130	185
11. Spreader tractor operating costs per hour[4]	31	36	49
12. Spreader tractor operating costs per year (ln 3 x ln 11)	$651	$1,584	$3,871
Labor costs			
13. Tractor operators @ $9/hr)[5]	$306	$630	$1,179
Total operating costs			
14. Total operating costs (line 6 + line 9 + line 12 + line 13)	$1,608	$3,485	$7,437
15. Total operating costs per animal	$11	$12	$12

Notes:
[1] Based on 15 minutes per week per 150-head lot.
[2] Estimated loading time per load by herd size (minutes): 150 animals - 10 min.; 300 - 12min.; 600 - 15 min.
[3] Hauling time per load by herd size (minutes): 150 animals - 25 min.; 300 - 35 min.; 600 - 47 min.
[4] Based on "2002 Doane's Machinery Custom Rates Guide" plus estimated fuel cost @ $1.30/gal.
[5] Assumes the spreader tractor operator operates the loader tractor.

Table 25. Holding pond pumping costs (solids system): Annual operating costs.

	Herd size		
	150	300	600
1. Estimated acre-inches to pump annually (from holding pond design)	28	54	106
2. Custom pumping charge/hr[1]	$70	$70	$70
3. Annual lagoon pumping costs (line 1 x line 2) + $300 setup	$2,260	$4,080	$7,720
4. Check labor hours/year[2]	28	54	106
5. Annual labor costs (line 4 x $8/hour)	$224	$432	$848
6. Total operating costs (line 3 + line 5)	$2,484	$4,512	$8,568

Notes:
[1] Assume a traveling-gun pumps 500 gallons per minute, which allows pumping one acre-inch per hour.
[2] Check labor required to inspect the irrigation system periodically to determine if the traveling gun and equipment are operating adequately. Assume one hour per hour of irrigator operation.

Table 26A. Solid manure system: Value of solid manure to plant production.

	Herd size (1,000 lb animals)		
	150	300	600
Nutrients produced (lb/yr)			
1. Ammonia nitrogen	2,100	4,200	8,400
2. Organic nitrogen	4,200	8,400	16,800
3. P_2O_5 (phosphate)	4,200	8,400	16,800
4. K_2O (potash)	6,900	13,800	27,600
Fertilizer nutrient equivalent (lb/yr)			
5. Ammonia nitrogen (line 1 x 60)[1]	1,260	2,520	5,040
6. Organic nitrogen (line 2 x 62%)[2]	2,604	5,208	10,416
Value of fertilizer equivalents			
7. Nitrogen (line 5 + line 6) x $0.30/lb)	1,159	2,318	4,637
8. Phosphate (line 3 x 0.95%[3] x $0.20/lb)	798	1,596	3,192
9. Potash (line 4 x 0.95%[3] x $0.15/lb)	$983	$1,967	$3,933
10. Total value of fertilizer equivalent	2,940	5,881	11,762
11. Minimum no. acres to apply solid manure.[4]	23	47	94
12. Value of fertilizer equivalent per acre (line 10 ÷ line 11)	126	126	126

Notes:
[1] Assumes no incorporation.
[2] Assumes same amount spread on same fields each year.
[3] Average percent available to plant.
[4] 165 pounds of nitrogen per acre from manure.
[5] Value of manure assumes all contained nutrients are needed and used for crop production in lieu of commercial fertilizer.
P x 2.29 = P_2O_5; K x 1.21 = K_2O
The assumed value of the fertilizer nutrients is as follows: Nitrogen @ 30 cents/lb; phosphate @ 20 cents/lb; potash @ 15 cents/lb.

Table 26B. Solid manure system: Value of holding pond effluent manure to plant production.

	Herd size (1,000 lb animals)		
	150	300	600
Nutrients produced (lb/yr)			
1. Ammonia nitrogen	253	488	954
2. Organic nitrogen	28	54	106
3. P_2O_5 (phosphate)	0	0	0
4. K_2O (potash)	1,268	2,446	4,779
Fertilizer nutrient equivalent (lb/yr)			
5. Ammonia nitrogen (line 1 x 60%)[1]	152	293	572
6. Organic nitrogen (line 2 x 62%)[2]	17	33	66
Value of fertilizer equivalents			
7. Nitrogen (line 5 + line 6) x $0.30/lb)	$51	$98	$191
8. Phosphate (line 3 x 0.95%[3] x $0.20/lb)	0	0	0
9. Potash (line 4 x 0.95%[3] x $0.15/lb)	$181	$349	$681
10. Total value of fertilizer equivalent	$231	$446	$872
11. Minimum no. acres to apply solid manure[4]	1	2	4
12. Value of fertilizer equivalent per acre (line 10 ÷ line 11)	$226	$226	$226

Notes:
[1] Assumes no incorporation.
[2] Assumes same amount spread on same fields each year.
[3] Average percent available to plant.
[4] 165 pounds of nitrogen per acre from manure in effluent.
[5] Value of manure assumes all contained nutrients are needed and used for crop production in lieu of commercial fertilizer.
P x 2.29 = P_2O_5; K x 1.21 = K_2O
The assumed value of the fertilizer nutrients is as follows: Nitrogen @ 30 cents/lb; phosphate @20 cents/lb; potash @15 cents/lb.

Table 27. Annual fixed costs expressed as percent of initial cost of irrigation system.

	Acre-inches lagoon waste pumped annually	
	50 to 175	175 to 300
Years useful life	15	10
Depreciation	6.0%	9.0%
Interest	4.0	4.0
Repairs and maintenance	7.0	10.0
Taxes	1.5	1.5
Total fixed costs	18.5%	24.5%

Note: Based on used equipment with above average maintenance and care.

Table 28. Traveling gun system: Annual fixed costs.

		Acre-inches lagoon waste pumped annually			
		50 to 175		175 to 300	
	Initial cost	%	Annual fixed costs	%	Annual fixed costs
1. Traveling gun[1]	$10,000	18.5	$1,850	24.5	$2,450
2. PTO pump, 500 gpm[1]	$3,000	18.5	$555	24.5	$735
3. Agitation pump[2]	$3,500	18.5	$648	24.5	$858
4. Aluminum pipe[1]	$4,200	18.5	$777		
	$8,400			24.5	$2,058
5. Total annual fixed cost			$3,830		$6,101

Notes:
[1] Workable used equipment.
[2] Not needed if you have a solids separator.

Table 29. Annual ownership and operating costs for a used traveling gun for lagoon system.

	Herd size (1,000 lb animals)		
	150	300	600
Annual operating costs			
1. Acre-inches of effluent[1]	11.1	19.8	36.4
2. Agitation pump time (hr)[2]	11.1	19.8	36.4
3. Minimum acres spread over[3]	14.8	29.6	59.1
4. No. times system set up[4]	2	3	6
5. Set up time (hr)[5]	16	24	48
Power costs			
6. Irrigation pump (line 1 x $27/hr 80 hp, includes fuel)[7]	$300	$535	$983
7. Agitation pump (line 2 x $30.67/hr 100 hp)[7]	340	607	1116
8. Laying pipe (line 5 x 25%[6] x $27/hr)[7]	108	162	324
Labor costs			
9. Check labor hrs[8] (from line 1)	11.1	19.8	36.4
10. Total labor hrs (line 5 + line 9)	27.1	43.8	84.4
11. Total labor costs (line 10 x $8/hr)	$217	$350	$675
12. Total annual operating costs (add lines 6, 7, 8 and 11)	$965	$1,654	$3,098
13. Total annual fixed costs (Table 28, line 5)	$3,830	$3,830	$3,830
14. Total annual costs (line 12 + line 13)	$4,795	$5,484	$6,928
15. Cost per acre-inch (line 14 ÷ line 1) or per hour operation	432	277	190

Notes:
[1] Transferred from Table 12, line 5; also irrigation operating hours.
[2] Agitator hours equal to pumping hours.
[3] Transferred from Table 13, line 13.
[4] One setup per 10 acres.
[5] Eight hours labor per set up.
[6] Assume tractor operates 25 percent of time required to lay pipe.
[7] Tractor power cost taken from "Doane's Machinery Custom Rates Guide, 2002."
[8] Check labor is used to check the irrigation system periodically to determine if the system is operating adequately. Assume continuous monitoring during land application.

Examples using typical soil tests

Example 1: Determine the value of the three types of manure for a corn-soybean rotation with the following soil test recommendations: For 150 bu/acre corn: 195 lb N, zero P_2O_5 and 60 lb K_2O. For 40 bu/acre soybeans: zero N, zero P_2O_5 and 75 lb K_2O (soil test results were 116 [very high] for phosphorus, 280 for potassium, and 2.9 for organic matter).

The last crop was soybeans, so we can take credit for 30 lb N from the soybeans and apply 165 lb of N for corn.

Using all the slurry manure from 150 head (see Table 20), the available N is 3,420 + 6,045 = 9,465 lb of N; the available P_2O_5 is 8,250 lb x 0.95 = 7,838 lb; and the available K_2O is 11,850 lb x 0.95 = 11,258 lb. With 9,465 lb of available N, we can apply 165 lb of N to 57 acres. Using all the manure will also apply 8,250 lb of P_2O_5 and 11,850 lb of K_2O (see Table 20). For the 57 acres of corn, the soil test calls for zero P_2O_5 and 3,420 lb K_2O. No return should be expected from the 8,250 lb of P_2O_5. To have 3,420 lb of K_2O available, we must apply 3,600 lb at 0.95 percent availability. Adding the value of 9,465 lb of N @ $0.30/lb = $2,840 to the value of 3,420 lb of K_2O @ $0.15/lb = $513, the total value is $3,353. If all the P_2O_5 and K_2O applied had been needed, the value would have been $6,096 (see Table 20).

For soybeans and applying the solid manure at a rate to supply 75 lb of K_2O per acre, the 11,258 lb of available K_2O will fertilize 11,258/75 = 150 acres of soybeans. Since the soil test did not call for any N or P_2O_5, the only value to be credited to the manure is for 11,258 lb of available K_2O @ $0.15 = $1,689 (see Table 20).

Caution: Since the soil test P is very high, any addition of manure increases the risk of downstream pollution from phosphorous and may not be allowed under developing regulations.

Example 2: Determine the value of the three types of manure for a continuous fescue hay rotation with the following soil test recommendations: For 2 tons/acre of fescue hay: 80 lb N, 70 lb P_2O_5 and 110 lb K_2O (the soil test P1 test was 7, potassium was 108, and organic matter was 2.2).

Assume the slurry application will be surface applied with no incorporation and reduce the availability of ammonia nitrogen by using a factor of 0.6 instead of the 0.95 used for injection. This reduces the available N from 9,465 lb of N in Example 1 to 8,205 lb of N.

Base the slurry manure application on N and observe the results. From Example 1, find 7,838 lb of P_2O_5; and 11,258 lb of K_2O are available. The 8,205 lb of N @ 80 lb/acre will fertilize 102.6 acres. Applying the 7,838 lb of P_2O_5 to 102.6 acres will be a rate of 76.4 lb/acre, 6.4 lb/acre above the recommended rate. Applying the 11,258 lb of K_2O to 102.6 acres will be a rate of 109.7 lb/acre, 0.3 lb/acre less than the recommended rate.

Basing the application rate on P would result in application to 112 acres at a rate of 70 lb/acre, an N application rate of 73.3 lb/acre, and a K_2O application rate of 100.5 lb/acre.

Example 1 Table. Value of manure nutrients used by 150 bu/acre corn (based on soil test).

	Herd size (1,000 lb animals)		
	150	**300**	**600**
Gross value of excreted manure	$12,542	$25,084	$50,168
Value of lagoon N @ 165 lb/acre	$732	$1,463	$2,927
Application acres	**15.0**	**30.0**	**59.0**
Value of P_2O_5 used by corn	0	0	0
Value of K_2O used by corn	$135	$270	$531
Value of lagoon nutrients used	$867	$1,733	$3,458
Value of slurry N @ 165 lb/acre	$2,840	$5,679	$11,358
Application acres	**57**	**115**	**229**
Value of P_2O_5 used by corn	0	0	0
Value of K_2O used by corn	$513	$1,035	$2,061
Value of slurry nutrients used	$3,353	$6,714	$13,419
Value of solid N @ 165 lb/acre	$1,210	$2,318	$4,636
Application acres	**24**	**49**	**98**
Value of P_2O_5 used by corn	0	0	0
Value of K_2O used by corn	$216	$441	$882
Value of solid nutrients used	$1,426	$2,759	$5,518

Example 2 Table. Value of manure nutrients used by 2 tons/acre fescue hay (based on soil test).

	Herd size (1,000 lb animals)		
	150	**300**	**600**
Gross value of excreted manure	$12,542	$25,084	$50,168
Value of lagoon N @ 80 lb/acre	$732	$1,463	$2,927
Application acres	**30.5**	**61.0**	**122.0**
Value of P_2O_5 used by fescue	$427	$854	$1,708
Value of K_2O used by fescue	$503	$1,007	$2,013
Value of lagoon nutrients used	$1,662	$3,324	$6,648
Value of slurry N @ 80 lb/acre	$2,462	$4,923	$9,846
Application acres	**102.6**	**205.1**	**410.3**
Value of P_2O_5 used by fescue	$1,436	$2,872	$5,744
Value of K_2O used by fescue	$1,692	$3,385	$6,769
Value of slurry nutrients used	$5,590	$11,179	$22,359
Value of solid N @ 80 lb/acre	$1,210	$2,420	$4,840
Application acres	**50.4**	**100.8**	**201.7**
Value of P_2O_5 used by fescue	$706	$1,412	$2,823
Value of K_2O used by fescue	$832	$1,664	$3,327
Value of solid nutrients used	$2,747	$5,495	$10,990

For further information

USDA-Natural Resources Conservation Service. 1992. *Agricultural Waste Management Field Handbook*, Part 651. USDA-NRCS, Washington, D.C.

Available from Extension Publications
1-800-292-0969

MU publications

EQ 201 *Reduce Environmental Problems with Proper Land Application of Animal Manure*
EQ 202 *Land Application Considerations for Animal Manure*
EQ 382 *Sizing Soil-Plant Filters for Conservative Manure Management*
EQ 383 *Land Application Equipment for Livestock and Poultry Manure Management*
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MWPS-6 *Beef Housing and Equipment Handbook*
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