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EC 77-720

# SELECTING DAIRY MANURE HANDLING SYSTEMS

## Introduction

A good manure handling system makes best use of land, labor, and capital. It also uses manure's value as a fertilizer and soil conditioner while avoiding pollution and nuisance problems. Before selecting a manure handling system, make these two decisions:

- Will you haul manure daily or store it before spreading?
- Will you handle manure as solids or liquids?

Then choose the collection, storage, and hauling units that fit your needs.

## Handling Methods

### Daily Hauling and Spreading

#### Advantages

- Hauling labor is distributed throughout the year.
- There is no accumulation of manure.
- Odor is minimized.
- Facilities cost less.

#### Disadvantages

- Manure must be hauled every day and in all kinds of weather.
- Crop cover, rain, or snow cover can interrupt spreading.
- Excessive runoff from sloping ground can reduce fertilizer value and cause water pollution.
- Wear on tractors and equipment increases in cold weather.
- Use bedding, which may be scarce or expensive, or liquid-tight spreaders to save the urine.

### Storing and Spreading

#### Advantages

- Annual labor requirements can be reduced.
- Spreading can be delayed to avoid other field operations, bad weather, or poor field conditions.

#### Disadvantages

- Storage facilities are costly.
- Equipment for loading and unloading storages is needed.
- Odors and flies may be a problem.
- Poorly located storages can be unsightly.
- Extra agitation time and special equipment may be required for some storages.

## Solid vs. Liquid

### Storing and Handling as a Solid

Stack solid manure with elevators, throwers, large piston pumps or tractor loaders. Use bedding to absorb liquids and to make the manure handle as a solid.

Storages for solid manure can be:

- Open ground space
- All-weather base such as crushed limestone
- Concrete base with post and plank sidewalls
- Concrete base with concrete sidewalls, Fig 1
- Concrete base with low dikes can hold "semi-solid" manure from free stall barns. Use a picket dam or other method to drain off precipitation.
- Covered bunker

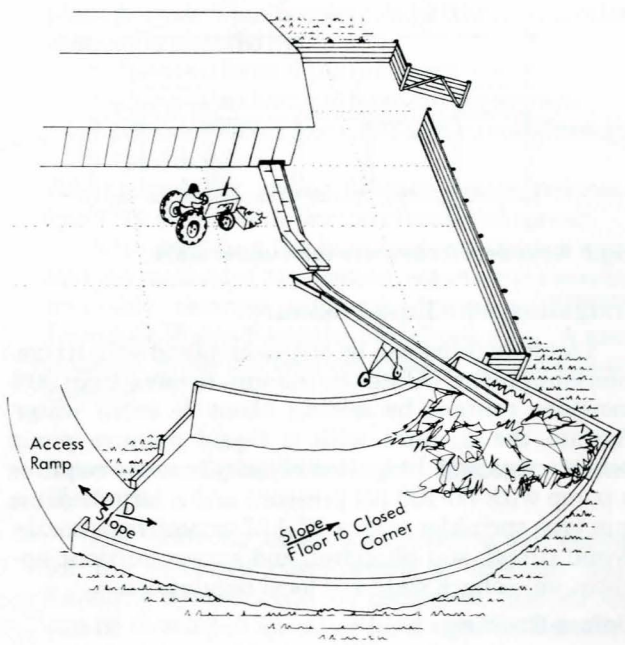


**Fig. 1 Solid manure storage; barn cleaner to moveable stack.**

Solid manure storages usually cost less than most liquid systems and are easily adapted to stall barn operations.

Use a front end loader with forks and/or a bucket to empty the storage into manure spreader. "Semi-solid" manure requires a liquid tight spreader and a large "snow" bucket loader.

### Storing and Handling as a Liquid

Storages for liquid manure can be:

- Below ground reinforced concrete tanks, Fig 2
- Earth storage basins; excavated or cut and fill earth sides; see types of storages in Fig 3
- Above ground storage tanks (silos); 25'-72' diameter, 10'-20' high; stave or cast concrete, or coated steel, Fig 4

Liquid manure storages are loaded with:

- Tractor scraper
- Mechanical scraper
- Slotted floor
- Liquid manure pump
- Large piston pump



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Stored liquid manure requires specialized equipment for agitating and pumping, hauling, and spreading. Odors can be a problem during agitation and spreading.

Take special precautions when using a liquid manure system. Avoid agitating and pumping problems by minimizing bedding and keeping foreign material and frozen manure out of the storage. Guard openings into the storages to keep livestock and people out. Rain, ice, and snow entering a storage reduce the storage volume.

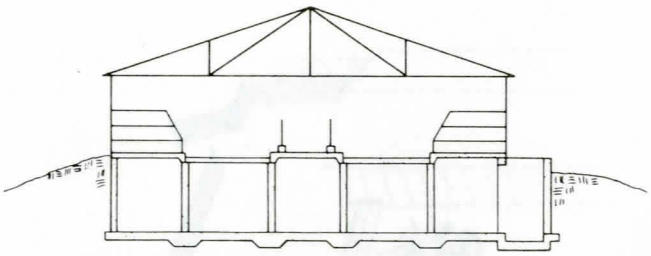


**Fig 2. Reinforced concrete tank under slats.**

## Irrigating with liquid manure

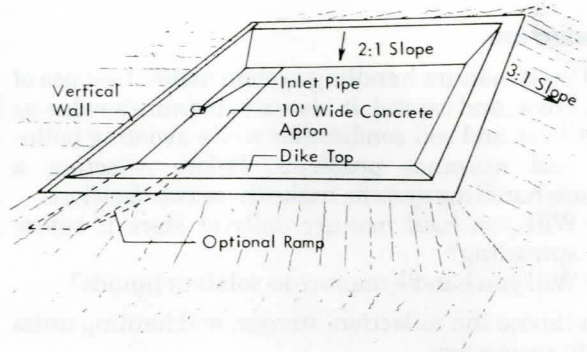
Liquid manure can be put on cropland with irrigation equipment. Dilute the manure to more than 90% moisture content by adding about ⅓ extra water. Agitate the manure with a liquid manure pump before irrigating. Irrigation of dairy manure requires a pump with 80-100 psi pressure and a large volume gun type sprinkler with a ¾"-1¼" smooth bore nozzle. Avoid runoff, soil plugging, and excess nutrient application—check state and local regulations.

## Before Building

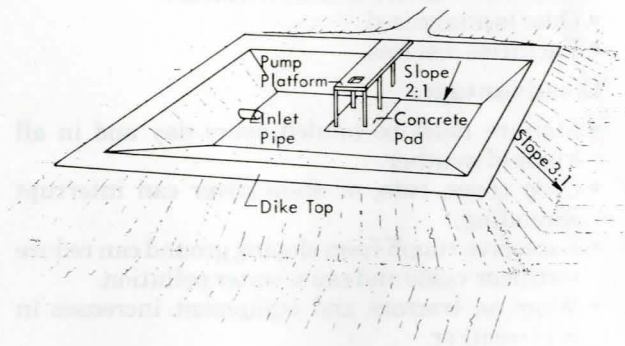
Before building any component of a waste management system, check with local and state regulatory agencies. Special requirements may have to be met and some type of cost sharing may be available. Design storages to keep livestock and people out. Construct storages for easy loading and emptying. Storages must be large enough to hold manure produced during periods when spreading is undesirable; storage for 1 year provides more management flexibility. Spreading may be restricted by weather and ground conditions (winter and spring) or crop conditions (summer and fall).

Consider the following factors when deciding where to locate a storage:

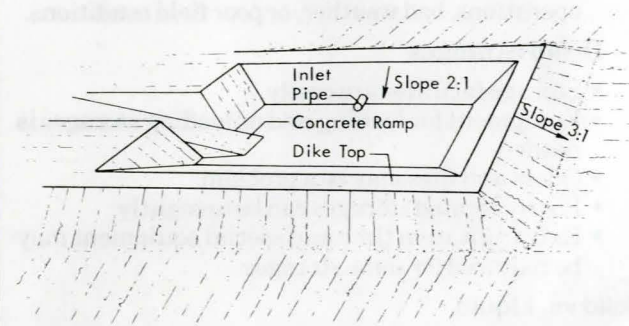
- the sources and location of *all* manure or wastewater
- distance to wells
- potential for pollution of nearby lakes or streams and groundwater
- prevailing winds
- distance and direction to the farm home and neighbors
- drainage
- access to the storage for loading, unloading and hauling
- cattle should not have access to the storage




**3a. Vertical reinforced concrete wall.**
Agitate and pump with a conventional liquid manure pump along the wall.




**3b. Dock or pier for agitating and pumping with a conventional liquid manure pump from the platform.**




**3c. Concrete apron for access.**
Agitate and pump with a tractor-mounted liquid manure pump that is backed down the ramp.

**Fig 3. Liquid manure storage basins.**
Some soils require less bank slope than shown; check with your local SCS office.

# Comparative Costs of Dairy Waste Systems
# 1977 Data from Wisconsin

## 50-Cow Stanchion Barn

### Stacking manure

| | Investment | DIRI[a] Factor | Hours | Hourly Rate | Annual Cost |
|---|---|---|---|---|---|
| Manure platform[i] | $ 3,000 | .14 | -- | -- | $ 420 |
| Barn cleaner | 3,200 | .20 | -- | -- | 640 |
| Stacker | 3,000 | .20 | -- | -- | 600 |
| Manure spreader, 150 cu ft | 2,100 | .20 | -- | -- | 420 |
| Manure loader | 1,400 | .20 | -- | -- | 280 |
| Tractor loading, 70 hp | -- | -- | 70 | $6.00 | 420 |
| Tractor hauling, 50 hp | -- | -- | 70 | 4.50 | 315 |
| Labor haul and spread | -- | -- | 70 | 4.50[e] | 315 |
| Labor daily cleaning | -- | -- | 140 | 3.00 | 420 |
| Total | $12,700 | | | | $3,830 |
| Bedding, 50 ton @ $50/ton[j] | | | | | 2,500 |
| | | | Total with bedding | | $6,330 |

### Daily hauling

| | | | | | |
|---|---|---|---|---|---|
| Barn cleaner | $ 3,200 | .20 | -- | -- | $ 640 |
| Manure spreader, 150 cu ft | 2,100 | .22[b] | -- | -- | 462 |
| Tractor, 50 hp | -- | -- | 365[h] | $4.50 | 1,643 |
| Labor daily | -- | -- | 365 | 3.00 | 1,095 |
| Total | $ 5,300 | | | | $3,840 |
| Bedding, 50 ton[j] | | | | | 2,500 |
| | | | Total with bedding | | $6,340 |

### Liquid manure storage basin

| | | | | | |
|---|---|---|---|---|---|
| Basin[d,i,m] | $ 4,400 | .14 | -- | -- | $ 616 |
| Barn cleaner | 3,200 | .20 | -- | -- | 640 |
| Mats and grates | 4,000 | .14 | -- | -- | 560 |
| Large piston pump | 6,000 | .20 | -- | -- | 1,200 |
| Load out pump | 3,000 | .22 | -- | -- | 660 |
| Spreader tank, 1500 gal | 3,500 | .20 | -- | -- | 700 |
| Tractor pumping, 70 hp | -- | -- | 90[f] | $6.00 | 540 |
| Tractor hauling, 100 hp | -- | -- | 70[m] | 8.50[c] | 595 |
| Labor haul and spread | -- | -- | 80[f,m] | 4.50 | 360 |
| Labor daily cleaning | -- | -- | 140 | 3.00 | 420 |
| Total | $24,100 | | | | $6,291 |
| Bedding, 25 ton[j] | | | | | 1,250 |
| | | | Total with bedding | | $7,541 |

### Liquid manure storage tank

| | | | | | |
|---|---|---|---|---|---|
| Storage tank[d,i] | $16,300 | .14 | -- | -- | $2,282 |
| Barn cleaner | 3,200 | .20 | -- | -- | 640 |
| Cow mats and grates | 4,000 | .14 | -- | -- | 560 |
| Spreader tank wagon, 1500 gal | 3,500 | .20 | -- | -- | 700 |
| Load out pump | 3,000 | .22 | -- | -- | 660 |
| Tractor pumping, 70 hp | -- | -- | 80[f] | $6.00 | 480 |
| Tractor hauling, 100 hp | -- | -- | 60 | 8.50[c] | 510 |
| Labor haul and spread | -- | -- | 70[f] | 4.50[e] | 315 |
| Labor daily cleaning | -- | -- | 140 | 3.00 | 420 |
| Total | $30,000 | | | | $6,567 |
| Bedding, 25 ton[j] | | | | | 1,250 |
| | | | Total with bedding | | $7,817 |

## 100-Cow Free Stall Barn

### Semi-solid storage, tractor scraper

| | Investment | DIRI[a] Factor | Hours | Hourly Rate | Annual Cost |
|---|---|---|---|---|---|
| Manure storage, picket dam[i] | $ 8,800 | .14 | -- | -- | $1,232 |
| Tractor scraper, 30 hp | 5,200 | .20 | -- | -- | 1,040 |
| Stacker | 4,800 | .20 | -- | -- | 960 |
| Spreader, tank flail 1400 gal | 4,500 | .20 | -- | -- | 900 |
| Manure loader | 1,400 | .20 | -- | -- | 280 |
| Tractor loading, 70 hp | -- | -- | 125 | $6.00 | 750 |
| Tractor hauling 100 hp | -- | -- | 125 | 8.50 | 1,063 |
| Labor haul and spread | -- | -- | 125 | 4.50[e] | 563 |
| Labor daily cleaning | -- | -- | 300[n] | 3.00 | 900 |
| Total | $24,700 | | | | $7,688 |
| Bedding, 50 ton[j] | | | | | 2,500 |
| | | | Total with bedding | | $10,188 |

### Daily hauling, tractor scraper

| | | | | | |
|---|---|---|---|---|---|
| Ramp, push off | $ 1,100 | .14 | -- | -- | $ 154 |
| Tractor scraper, 30 hp | 5,200 | .20 | -- | -- | 1,040 |
| Spreader, tank flail 1400 gal | 4,500 | .22[b] | -- | -- | 990 |
| Tractor hauling, 100 hp | -- | -- | 440[h] | $8.50 | 3,740 |
| Labor daily cleaning | -- | -- | 300[n] | 3.00 | 900 |
| Labor daily hauling | -- | -- | 440 | 3.00 | 1,320 |
| Total | $10,800 | | | | $8,144 |
| Bedding, 50 ton[j] | | | | | 2,500 |
| | | | Total with bedding | | $10,644 |

### Liquid manure storage basin, alley scraper

| | | | | | |
|---|---|---|---|---|---|
| Basin[d,i,m] | $ 7,100 | .14 | -- | -- | $ 994 |
| Alley cleaner | 6,000 | .20 | -- | -- | 1,200 |
| Cross conveyor | 2,300 | .20 | -- | -- | 460 |
| Large piston pump | 6,000 | .20 | -- | -- | 1,200 |
| Load out pump | 3,000 | .22 | -- | -- | 660 |
| Spreader tank, 2300 gal | 5,000 | .20 | -- | -- | 1,000 |
| Tractor pumping, 70 hp | -- | -- | 105[f] | $6.00 | 630 |
| Tractor hauling, 100 hp | -- | -- | 85[m] | 8.50[c] | 723 |
| Labor haul and spread | -- | -- | 95[f,m] | 4.50[e] | 428 |
| Labor daily cleaning | -- | -- | 170[n] | 3.00 | 510 |
| Electrical energy[k] | -- | -- | -- | -- | 250 |
| Total | $29,400 | | | | $8,055 |
| Bedding, 50 ton[j] | | | | | 2,500 |
| | | | Total with bedding | | $10,555 |

### Liquid manure with slotted floor over tank

| | | | | | |
|---|---|---|---|---|---|
| Storage tank, with slotted floor[d,i] | $32,600 | .14 | -- | -- | $4,564 |
| Load out pump | 3,000 | .22 | -- | -- | 660 |
| Spreader tank wagon, 2300 gal | 5,000 | .20 | -- | -- | 1,000 |
| Tractor pumping, 70 hp | -- | -- | 90[f] | $6.00 | 540 |
| Tractor hauling, 100 hp | -- | -- | 70 | 8.50[c] | 595 |
| Labor haul and spread | -- | -- | 80[f] | 4.50[e] | 360 |
| Labor daily cleaning | -- | -- | 120[n] | 3.00 | 360 |
| Ventilation[g] | -- | -- | -- | -- | 200 |
| Total | $40,600 | | | | $8,279 |
| Bedding, 50 ton[j] | | | | | 2,500 |
| | | | Total with bedding | | $10,779 |

### Liquid manure storage silo

| | | | | | |
|---|---|---|---|---|---|
| Silo, 45 x 15[d,i,m] | $14,500 | .14 | -- | -- | $2,030 |
| Barn cleaner | 3,200 | .20 | -- | -- | 640 |
| Mats and grates | 4,000 | .14 | -- | -- | 560 |
| Large piston pump | 6,000 | .20 | -- | -- | 1,200 |
| Load out pump | 3,000 | .22 | -- | -- | 660 |
| Spreader tank, 1500 gal | 3,500 | .20 | -- | -- | 700 |
| Tractor pumping, 70 hp | -- | -- | 85[f] | $6.00 | 510 |
| Tractor hauling, 100 hp | -- | -- | 70[m] | 8.50 | 595 |
| Labor haul and spread | -- | -- | 80[f,m] | 4.50[e] | 360 |
| Labor daily cleaning | -- | -- | 140 | 3.00 | 420 |
| Total | $34,200 | | | | $7,675 |
| Bedding, 25 ton[j] | | | | | 1,250 |
| | | | | Total with bedding | $8,925 |

[a] DIRI = Depreciation, interest, repairs, insurance—and taxes where applicable.

[b] Manure spreaders used daily wear out faster.

[c] Larger tractor is used for a 1500 and 2300 gallon tank.

[d] Tank capacity for 180 days is based on the number of cows, 2 cu ft/cow/day, 85% useable and 70¢/cu ft.

[e] Labor cost increases slightly due to busy season competition.

[f] Includes agitation.

[g] Estimated increase in annual cost due to added ventilation required.

[h] Includes time to start tractor, hitch to spreader, load, travel to and from fields, unloading, unhitching, and parking tractor.

[i] To modify this item for other storage periods, divide this cost by 180 days and multiply by the desired number. Thus, for 150 days, multiply by 0.83; for 120 days, multiply by 0.66; for 90 days, multiply by 0.5.

[j] Assumes 1 ton of bedding/cow/year in stanchion barns and ½ ton/cow/year in free stall systems and stanchion barns with cow mats.

[k] The electricity cost for the systems with an alley cleaner, cross conveyor, and piston pump is included as a separate item. Most all of the systems have some electrical energy cost for operating equipment, but in many cases it is not significant amount.

[l] Mainline plus two laterals—40 min sets.

[m] Volume handled is increased by about 20% to account for additional water from water added at pumping and rainfall.

[n] Volume handled increased by about 10% to account for water added at pumping.

### Liquid manure storage basin, irrigation spreading twice yearly, alley scraper

| | | | | | |
|---|---|---|---|---|---|
| Basin[d,i,m] | $ 7,100 | .14 | -- | -- | $ 994 |
| Alley cleaner | 6,000 | .20 | -- | -- | 1,200 |
| Cross conveyor | 2,300 | .20 | -- | -- | 460 |
| Large piston pump | 6,000 | .20 | -- | -- | 1,200 |
| Agitation pump | 3,000 | .22 | -- | -- | 660 |
| Irrigation pump, 250 gpm | 2,750 | .22 | -- | -- | 605 |
| Pipe for 40 - 80 acres | 7,800 | .20 | -- | -- | 1,560 |
| Tractor agitating and pumping, 70 hp | -- | -- | 60[f] | $6.00 | 360 |
| Tractor moving pipe, 70 hp | -- | -- | 54 | 6.00 | 324 |
| Labor moving pipe, agitation | -- | -- | 54 | 4.50 | 243 |
| Labor daily cleaning | -- | -- | 170[n] | 3.00 | 510 |
| Electrical energy[k] | -- | -- | -- | -- | 250 |
| Total | $34,950 | | | | $8,366 |
| Bedding, 50 ton[j] | | | | | 2,500 |
| | | | | Total with bedding | $10,866 |

### Liquid manure storage tank, tractor scraper

| | | | | | |
|---|---|---|---|---|---|
| Storage tank[d,i] | $32,600 | .14 | -- | -- | $4,564 |
| Tractor and scraper | 5,200 | .20 | -- | -- | 1,040 |
| Load out pump | 3,000 | .22 | -- | -- | 660 |
| Spreader tank, 2300 gal | 5,000 | .20 | -- | -- | 1,000 |
| Tractor pumping, 70 hp | -- | -- | 90[f] | $6.00 | 540 |
| Tractor hauling, 100 hp | -- | -- | 70 | 8.50[c] | 595 |
| Labor haul and spread | -- | -- | 80[f] | 4.50[e] | 360 |
| Labor daily cleaning | -- | -- | 300[n] | 3.00 | 900 |
| Total | $45,800 | | | | $9,659 |
| Bedding, 50 ton[j] | | | | | 2,500 |
| | | | | Total with bedding | $12,159 |

### Liquid manure storage silo, alley scraper

| | | | | | |
|---|---|---|---|---|---|
| Silo, 60 x 15[d,i,m] | $21,600 | .14 | -- | -- | $3,024 |
| Alley cleaner | 6,000 | .20 | -- | -- | 1,200 |
| Cross conveyor | 2,300 | .20 | -- | -- | 460 |
| Large piston pump | 6,000 | .20 | -- | -- | 1,200 |
| Load out pump | 3,000 | .22 | -- | -- | 660 |
| Spreader tank, 2300 gal | 5,000 | .20 | -- | -- | 1,000 |
| Tractor pumping, 70 hp | -- | -- | 95[f] | $6.00 | 570 |
| Tractor hauling, 100 hp | -- | -- | 85[m] | 8.50 | 723 |
| Labor haul and spread | -- | -- | 95[f,m] | 4.50[e] | 428 |
| Labor daily cleaning | -- | -- | 170[n] | 3.00 | 510 |
| Electrical energy[k] | -- | -- | -- | -- | 250 |
| Total | $43,900 | | | | $10,025 |
| Bedding, 50 ton[j] | | | | | 2,500 |
| | | | | Total with bedding | $12,525 |

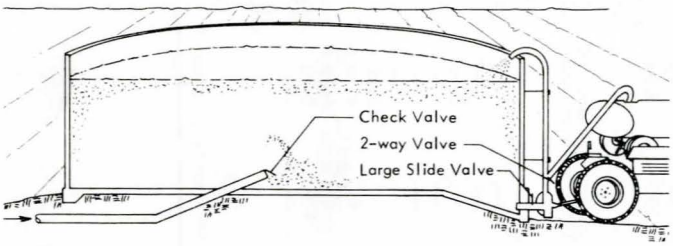



**Fig. 4. Above ground liquid manure storage.**
Use a large piston manure pump to load. Agitate and pump with a side-mounted liquid manure pump.

## Value of Cattle Manure

Decomposing manure releases nutrients for plant growth, and the organic matter improves tilth and water holding capacity.

Dairy cattle manure—feces and urine—ranges in consistency from a wet solid to a semi-solid. The housing system affects the physical state of the manure. The amount and type of bedding, if any, affects both the manure moisture content and the fertilizer value. Moisture content is also related to the type of storage.

As manure breaks down biologically, ammonia (a form of nitrogen) is released and lost to the air. Therefore, the longer manure remains in the housing area or storage before spreading, or on the soil surface after spreading, the greater the potential nitrogen loss.

Immediately incorporate—plow, disc, or cultivate—the manure into the soil to save much of the nutrients and prevent loss by runoff. Up to 25% of the nitrogen can be lost to the air in the first 24 hours after spreading stored manure if it is not incorporated.

A 1000 lb dairy cow produces about 82 lb/day (1.32 cu ft/day or 9.9 gal/day) of urine and feces at about 87% moisture content. A 1400 lb cow produces about 115 lb/day (1.85 cu ft/day or 13.9 gal/day). Fresh dairy manure weighs about 62 lb/cu ft. Table 1 gives the approximate chemical nutrients in 1 ton of fresh manure. Manure also contains many trace elements used by various crops. Use absorbent bedding, tight storages, and liquid-tight manure spreaders to conserve large amounts of nitrogen and potassium in urine.

**Table 1. Approximate nutrient value of fresh dairy manure.**
To convert $P_2O_5$ to elemental P, multiply by 0.44.
To convert $K_2O$ to elemental K, multiply by 0.83.

| Nutrient | Feces + | Urine = | Total |
|---|---|---|---|
| | Lb/ton | | |
| Nitrogen, N | 5 | 5 | 10 |
| Phosphate, $P_2O_5$ | 4.75 | 0.25 | 5 |
| Potash, $K_2O$ | 1.5 | 8.5 | 10 |

The nutrients in Table 1 are not all available for plant growth. The commercial fertilizer equivalent of manure is affected by:

- chemical form of the nutrients
- changes in chemical form during storage
- physical losses from spillage, runoff, leaching or volatilization.

Adding bedding and/or dilution water reduces the quantity of nutrients per ton of material spread.

After selecting the handling and storage systems and the method of application, estimate the amount of available manure nutrients by using MWPS-18, Livestock Waste Facilities Handbook. Note: A manure analysis gives the best estimate of manure nutrient content.

## Economic Comparison of Manure Handling Systems

The following tables give relative cost estimates for the principal cost factors so different manure handling systems can be compared. Similar tables can be developed for other herd sizes by substituting appropriate cost factors. The estimates are based on 1977 costs. Do not use estimates as actual costs.

Note the liquid manure tank cost is based on contractor labor rather than farm labor and that the tank size allows 180 days of usable storage with an allowance of 85% useable space. The 180 days of storage —about 6 months—may be required by some regulatory agencies and usually allows spreading on fields free of snow and dry enough for heavy equipment.

The tractor investment is not included in the total investment but hourly charges for the use of the tractor are included. The footnotes for the tables are on page 5 .

**Table 2. Value of Available Nutrients per Ton of Dairy Cattle Manure.**

| Nitrogen | Lbs/ton x | Estimated* cost/lb = | Estimated value/ton | Your farm Cost | Your farm Value/ton |
|---|---|---|---|---|---|
| Nitrogen | 4.0 | 16¢ | $ .64 | _____ | _____ |
| Phosphate | 2.7 | 20¢ | .54 | _____ | _____ |
| Potash | 6.7 | 10¢ | .67 | _____ | _____ |
| | | | $1.85 | | |

*1977 estimates

**Summary comparison of investment of annual cost of manure handling alternatives.**

## 50-Cow Stanchion Barn

| System | Investment* | Annual Cost: Without Bedding | Annual Cost: Add Bedding | Annual Cost: Total With Bedding |
|---|---|---|---|---|
| Stacking | $12,700 | $3,830 | $2,500 | $6,330 |
| Daily hauling | 5,300 | 3,840 | 2,500 | 6,340 |
| Liquid basin storage | 24,100 | 6,291 | 1,250 | 7,541 |
| Liquid tank storage | 30,000 | 6,567 | 1,250 | 7,817 |
| Liquid silo storage | 34,200 | 7,675 | 1,250 | 8,925 |

## 100-Cow Free Stall Barn

| System | Investment* | Annual Cost: Without Bedding | Annual Cost: Add Bedding | Annual Cost: Total With Bedding |
|---|---|---|---|---|
| Semi-solid storage, tractor scraper | $24,700 | $ 7,688 | $2,500 | $10,188 |
| Daily hauling, tractor scraper | 10,800 | 8,144 | 2,500 | 10,644 |
| Liquid basin storage, alley scraper | 29,400 | 8,055 | 2,500 | 10,555 |
| Liquid slotted floor | 40,600 | 8,279 | 2,500 | 10,779 |
| Liquid basin, irrigation, alley scraper | 34,950 | 8,366 | 2,500 | 10,866 |
| Liquid tank, tractor scraper | 45,800 | 9,659 | 2,500 | 12,159 |
| Liquid silo storage, alley scraper | 43,900 | 10,025 | 2,500 | 12,525 |

*Investment in tractors not included here, but is included in the hourly charges for use of tractor.

*Major credit for this publication goes to O. I. Berge, T. J. Brevik, L. A. Brooks, M. F. Brugger, E. G. Bruns, R. E. Graves, L. R. Massie and D. J. Meyer, Agricultural Engineers at the University of Wisconsin.*

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