MANURE STORAGE AND HANDLING

THIS CHAPTER EXPLORES:

the principles of manure storage and handling

alternatives to manure storage

types of manure storage systems

sizing and safety requirements of manure storage designs

best management practices.

Your manure storage system has impressive "reach" when you consider all its implications concerning:

timing and scheduling of application

- manure cannot be applied year-round
- storage capacity will directly affect when and how often manure needs to be applied
- net nutrient loss from leaching is reduced in properly stored and applied manure

quantity of manure

- net nutrient loss from leaching is reduced when manure is properly stored and applied

potential for groundwater contamination

- systems that store all contaminated liquids from the farmstead area – including silo effluent, milking-centre and housing-facility washwater, and yard and manure runoff – will reduce the risk of surface water or groundwater contamination

odours and loss of other gases

- storage conditions can reduce odour levels and the rate of release of manure gases to the atmosphere
- release of manure gases, particularly ammonia, affects the nitrogen content of the manure (and its value as a fertilizer)

potential for manure treatment and innovative technology trials

- solid manure systems are more compatible with composting treatments
- technologies such as energy co-generation, i.e., anaerobic digesters, and solid-liquid separation are intended for liquid manure systems or combination liquid/solid systems.

Manure piled behind the barn is NOT manure storage.

Manure can be treated to reduce storage volume requirements and to create useful end-products such as compost or energy.

Manure can be composted instead of stored as raw manure.

ALTERNATIVES TO PERMANENT LONG-TERM STORAGE ON YOUR FARM

Permanent manure storage is not the only legitimate way to manage manure materials. Here are three other approaches:

- **temporary in-field storage – solid manure may be stored for up to several months in-field provided certain site and management conditions are met**
- **manure treatment – e.g., solid manure can be composted to reduce overall volume and create a more biologically stable product (NB: although storage is part of treatment systems)**
- **manure removal by a manure broker (e.g., solid sheep manure for commercial composting).**

All temporary storage systems should be developed in ways that minimize nutrient loss.

To view current, legally correct compliance information for the Nutrient Management Act, look up: http://www.omafra.gov.on.ca/english/agops/index.html

HOW STORAGE AND HANDLING SYSTEMS AFFECT NUTRIENT MANAGEMENT PLANS

The selection and use of your manure storage and handling system will directly affect the development and implementation of your nutrient management plan.

A roofed storage system can reduce or eliminate the need to manage liquids.

SYSTEM FEATURE	IMPLICATIONS FOR YOUR NUTRIENT MANAGEMENT PLAN
FORM OF MANURE – SOLID OR LIQUID (OR BOTH)	• in many cases, unroofed liquid systems require larger volumes for storage • application rates for liquid manure are limited by soil type and are affected by the amount of nutrients lost during storage and handling • nutrient loss and residual content: solid manure will lose more nitrogen in the form of nitrous oxide than liquid manure, and liquid will lose more ammonia-N than will stored solid manure ○ nitrates, potassium and phosphorous can be lost with unmanaged runoff from solid manure stacks • in liquid manure storages, some N will be lost to the atmosphere ○ other forms of nutrients will not be lost unless there's a spill or leak in the system • application opportunities are fewer with solid systems, in most cases • options needed to reduce environmental risks: field runoff from winter spreading of solid manure, tile effluent from liquid applications • separation distances from sensitive areas are generally greater for liquid manure
MANURE SOURCE	• poultry manure nutrient levels are higher than swine and dairy manure • swine and dairy manure contains more washwater than poultry • manure nutrient content will affect application rates
MANURE VOLUME	• 240–250 days of storage is ideal to avoid spreading on frozen ground in Ontario • large volumes will require more acres for application (unless very dilute, or where multiple applications to the same land base are possible) • large volumes will require more opportunities for application and/or equipment capable of handling larger volumes per day • diversion of clean water or roofing the storage facility will help reduce volume stored • a roofing system for solid manure handling systems will reduce or eliminate the need for a secondary liquid storage system to handle runoff
STORAGE SITES – TEMPORARY AND/ OR PERMANENT	• use of temporary manure storage sites are limited to a certain length of time (120–300 days) • manure stored at temporary sites should be used on that farm unit for crop production • NB: temporary storage is not a BMP – it's recommended that you use a permanent storage that eliminates or contains all runoff
CROP ROTATION	• crop choice and sequence will affect crop needs, timing and application rates • cropping and tillage systems will affect the application methods and opportunities (e.g., sidedressing or early fall application can affect storage size)

A solid storage with a separate runoff system will contain all liquids – but will require two means of application.

DEFINING A MANURE STORAGE AND HANDLING MANAGEMENT SYSTEM

A management system for manure must take into account the following factors:

- **volumes of waste material or manure produced**
- **collection system (how the manure is collected from animals)**
- **transfer to storage facility (elevator or stacker, pump, etc.)**
- **approved storage structures, including roofed or concrete storage structures, runoff storages**
- **handling (transfer from storage location to application site)**
- **application scheduling and technology.**

COMMON HANDLING SYSTEMS

Livestock manure is handled and stored in a solid or liquid form. Manure form depends on the type of livestock manure and what's added – the amount of dilution water plus the type and volume of bedding used.

Most livestock operations in Ontario use either solid or liquid systems. Regardless of which system you have, it's critical that **all** liquids are managed. Clean water and eavestrough water should be diverted away from the barn or manure storage structure.

With the exception of poultry farms, larger livestock operations commonly use liquid manure systems. Washwater and milking centre washwater are often added to the manure storage facility.

Contaminated water such as yard runoff should be stored and managed separately. That's why some solid systems have separate liquid storage facilities.

CHOOSING A SYSTEM – WHY CONSIDER LIQUID?

When you think of manure storage and handling systems for beef operations, you normally think of solid manure systems. But should this always be the case?

Consider a large, unroofed feedlot that uses minimal bedding and needs to improve yard runoff management and manure storage. Without bedding and proper storage, a liquid manure system may be better suited to handle all the manure and yard runoff. This runoff can be land-applied to supply additional nutrients to growing crops.

SYSTEM	PROS	CONS
SOLID MANURE	• less expensive if currently in solid system • less odour • more application options • less concern regarding direct runoff or leaching	• manure runoff is not managed • yard runoff is not managed • more bedding needed • more labour required
LIQUID MANURE	• all liquids are managed • yard runoff can be contained • less labour	• more expensive system • more odours than with solid • higher risk for runoff and spills

Manure stacker and stable cleaners work well for tie-stall operations, when used in combination with a runoff tank.

SOLID MANURE HANDLING SYSTEMS IN ONTARIO

COLLECTION SYSTEM	TRANSFER SYSTEM TO STORAGE	COMMON STORAGE SYSTEM	APPLICATION SYSTEM	PROS + / CONS –	CAPITAL COSTS
BEDDED PACK with LOADER (e.g., beef, open-concept barn)	not required	bedded pack	box spreader	+ low labour until cleanout – runoff storage may be required if yard used – rodents/flies	low – combined with livestock housing
FRONT-END LOADER (e.g., broiler barn)	front-end loader, box spreader, hydraulic dump trailer or truck	roofed solid storage or open manure storage with a runoff storage facility	box spreader or hopper spreader	+ uses existing equipment – runoff storage facility may be required	moderate for roofed storage system – costs vary with choice of runoff system
STABLE CLEANER (e.g., tie-stall dairy barn)	stacker, front-end loader, or ram/ piston/air pump	roofed solid storage structure, or open manure storage structure and runoff storage facility	box spreader or hopper spreader	+ uses existing equipment + livestock don't have to be moved – runoff storage facility may be required – labour-intensive – stacker freezes/cannot handle wet manure	moderate to high for roofed storage system – costs vary with choice of runoff storage and transfer system

High-trajectory irrigation guns are not suitable replacements for insufficient storage volumes.

Concrete storages can be sized to hold all sources of contaminant liquids.

Earthen storages – with proper siting, site characterization and design – can be effective storages for liquid manure, runoff and washwaters.

LIQUID MANURE HANDLING SYSTEMS					
COLLECTION SYSTEM	**TRANSFER SYSTEM TO STORAGE**	**COMMON STORAGE SYSTEM**	**APPLICATION SYSTEM**	**PROS + / CONS –**	**CAPITAL COSTS**
TRACTOR SCRAPER (e.g., free-stall dairy)	liquid pump or gravity transfer	open or covered concrete, earthen, or steel	tanker, low-trajectory irrigation or drag hose	+ uses existing equipment – wear on concrete floors	moderate
MECHANICAL SCRAPER (e.g., layer barn)	direct to tank, cross auger, hydraulic/ mechanical/air pump, or gravity transfer	open or covered concrete, earthen, or steel	tanker, low-trajectory irrigation, or drag hose	– cannot irrigate gutter-scraped layer manure	moderate
ALLEY SCRAPERS (e.g., free-stall dairy)	direct to tank, liquid pump, or gravity transfer	open or covered concrete, earthen, or steel	tanker, low-trajectory irrigation, or drag hose	+ automatic manure removal – less bedding needed	moderate to high
GUTTERS – STOP-AND-FLOW, and CONTINUOUS GRAVITY-FLOW (swine)	liquid pump or gravity transfer	open or covered concrete, earthen, or steel	tanker, low-trajectory irrigation, or drag hose	– requires more management	moderate
SLATTED FLOOR (e.g., free-stall dairy, swine)	direct to tank below	in-barn concrete – storage below	tanker, low-trajectory irrigation, or drag hose	+ labour-efficient – manure gases and safety concerns	high to very high
SLATTED FLOOR / FLOW GUTTER BELOW (e.g., swine)	liquid pump or gravity transfer	open or covered concrete, earthen, or steel	tanker, low-trajectory irrigation, or drag hose	+ labour-efficient – requires good management	high to very high
FLUSHED ALLEYS (e.g., free-stall dairy)	liquid pump or gravity transfer	open or covered concrete, earthen, or steel	tanker, low-trajectory irrigation, or drag hose	+ labour-efficient – in-barn odours – possible difficulties in cold weather – new technology	moderate

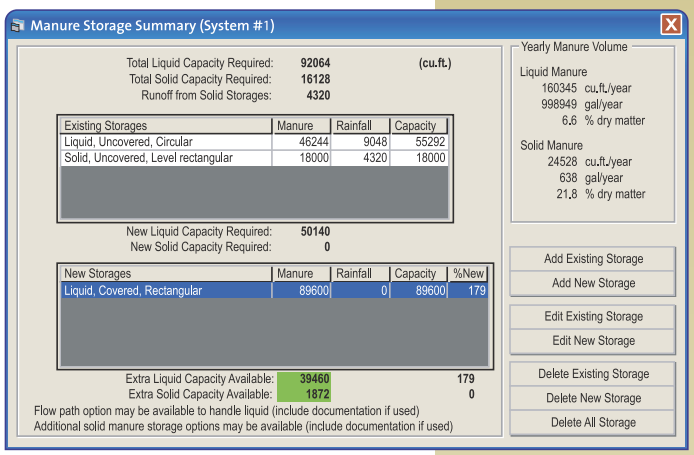
A manure storage system design that considers both manure production volumes and suitable times for cropland application simplifies the task of developing an effective NMP.

SIZING STORAGE SYSTEMS

To size a manure storage system properly, estimate the volumes of manure and washwater produced. Key factors to consider are as follows:

- ▶ type, size, age and numbers of livestock
- ▶ amount and type of bedding used
- ▶ volume of other washwaters generated, such as milking centre washwater, sanitation washwater, silage seepage
- ▶ volume of other inputs, such as roof water, yard runoff water, direct rain or snowfall, that can enter the storage system.

Menu-driven software named MSTOR, part of the NMAN software program, is available to assist in the sizing of manure storage facilities.

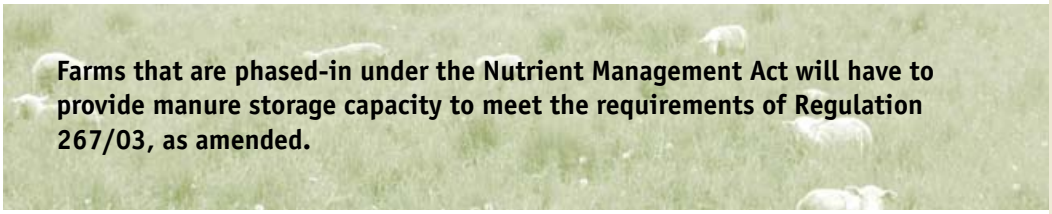


The MSTOR program has been developed to help properly size washwater storages.

DO YOU NEED MORE STORAGE CAPACITY?

Typically, storages are sized for a minimum of 240 days. But there are cases where having more than the minimum is justified, such as:

- ▶ you're spreading on land with a high Nitrogen Index (e.g., sandy, shallow to bedrock, etc.) – where you can only spread once a year (e.g., spring) – see page 89 for more information
- ▶ you're spreading on land with a high risk of compaction (e.g., poorly drained loamy soils – Parkhill loam)
- ▶ you're spreading on land with high runoff potential (e.g., steeply sloping clay soils such as Huron Clay Loams, Smithville Clays, Brantford Silty Clay Loams)
- ▶ you require more flexibility when scheduling the timing of manure applications
- ▶ you're planning for future expansion or systems change.



Farms that are phased-in under the Nutrient Management Act will have to provide manure storage capacity to meet the requirements of Regulation 267/03, as amended.

COLLECTION AND TRANSFER SYSTEMS FOR SOLID MANURE

FRONT-END LOADER

A tractor equipped with a front-end loader is an effective way of removing manure from livestock housed on a bedded pack. The manure can be loaded directly into a manure spreader, or moved to long-term storage.

TRACTOR SCRAPER

Tractors or loaders with rear-mounted scraper blades can be used to clean feed alleys and yard areas, as needed. This system is labour-intensive and requires removal of livestock during cleaning. Without precautions, it can wear concrete floors, creating a risk to livestock footing. To minimize this risk, concrete floors can be grooved. Rubber or wood can be attached to the edges of scraper blades to reduce wear on the concrete.

GUTTER CLEANERS

Gutter cleaners are commonly used in tie-stall dairy operations. Tie-stalls should be sized to accommodate cow size and for proper collection of manure. Stalls that are too short or too long will result in manure missing the gutter or dirty stalls. Electric trainers are helpful to keep the cows clean.

Bedding keepers and gutter grates reduce the amount of straw required, although they're not essential for the proper operation of the manure system. Bedding keepers can be constructed from 25–50 mm (1–2 in.) pipe or purchased commercially. Grates work best with softer manure. Manure that is drier will not fall through the grate into the gutter.

HIGHRISE (CAGES OVER A DEEP PIT)

For poultry operations, highrise barns provide long-term storage for dry manure in the storey below the bird level. No mechanical equipment is needed to transfer manure to a separate storage structure. Manure is air-dried as it accumulates in the storage structure. Fans in the storage area are used to circulate the air over the manure. The fans are spaced 24 metres (80 ft) apart, directing their flow to one side of the barn length and returning on the other side.

In-barn storage is sufficient for highrise broiler operations.

The manure has a high moisture content during hot, humid weather, due to poor drying conditions and increased water consumption by the birds. In extreme cases, the manure is so moist that the development of cone-shaped manure piles on the barn floor doesn't take place, increasing odours and flies.

To keep the manure dry, use the following construction measures:

- ▶ storage completely above the original grade
- ▶ footings protected by fill
- ▶ concrete floor.

Salt content of the water and feedstuffs should not exceed dietary requirements.

MANURE BELT

Belts are located under layer cages or slatted floor and act as conveyors, moving manure to the end of the barn for collection.

In poultry layer-cage systems, a plastic belt is located under each tier (row) of cages. In order to produce dry, stackable and relatively odour-free manure, air-flow must be directed across the manure belt to promote rapid drying. The barn ventilation system must be designed to accommodate the increased humidity from this moisture. The manure is sent to a cross-conveyor and onto a covered solid manure storage.

For optimal handling and minimal odour, good ventilation is key.

STORING AND HANDLING SAND-LADEN DAIRY MANURE

Sand provides greater cushioning and surface drainage than other materials to enhance stall use and cow cleanliness. Many veterinarians recommend sand bedding to reduce mastitis risk, but the benefits must be weighed against difficulties experienced when handling sand-laden manure.

CHALLENGES

Composition

- sand is dense, adding considerable weight to the manure mixture
- sand doesn't absorb moisture
- compared to raw dairy manure, a sand-laden manure system must handle, on average, 43% more material by weight and 18% greater total volume

Handling

- increased weight – the increased density can have especially serious implications for equipment used to haul sand-laden manure
  - while a gallon of raw manure or manure with organic bedding weighs about 8 lbs, sand-laden manure can easily weigh 10 lbs, or more, per gallon
- very abrasive material that can cause wear of moving parts and even surfaces

Undiluted vs. Diluted

Undiluted – sand-laden manure is best handled with a tire scraper or bucket loader

Diluted – handling characteristics of sand-laden manure and the performance of selected handling systems are greatly affected by dilution, in the following ways:

- excess water can quickly settle out sand from freshly loaded manure
- sand can build up and develop a large mass of solids similar to those seen when top-loading frozen or dry manure, making it difficult to load more manure into the storage
- settled sand and manure solids can build up to 2 ft on the bottom of liquid manure storages – this requires an intricate balance of dilution, agitation and pumping to handle
- often farmers and custom operators replace pump bearings on an annual basis
- agitation of sand-laden manure in storage must take place below the surface
- sand walls form when sand is propelled horizontally

STORAGE REQUIREMENTS FOR DILUTED SAND-LADEN MANURE

- alternative loading access is generally desirable for other storage loading options in the event that sand builds up and blocks the intended path of manure into the storage
- a concrete floor is highly recommended for the manure pit in any sand-laden manure storage
  - pour a level floor or gently slope the floor (normally no more than 1–2%) to direct the flow of liquids toward a sump or pumping area, and away from any areas where solids are to collect and drain
  - a flat surface prevents undesired ponding
- access ramp, concrete bottom and buckwalls are distinct features of sand-laden manure storages
  - this allows convenient removal of solids that may otherwise build up over time – the ramp provides access for a front-end loader and spreader

HANDLING STRATEGIES FOR DILUTED SAND-LADEN MANURE

Skim off water and haul solids – skim the liquid off the top of the storage and haul the remainder out as solid material. In long-term storage, liquids are typically removed two or three times a year while the bulk of the solids is hauled out each fall.

Stir-and-pump approach – uses agitation to mix solids into the liquid and the resulting manure slurry is pumped for application. Washwaters are used to dilute the manure when it becomes too thick to agitate and pump. The remaining sand-laden material is stirred by driving a tractor-loader or payloader around in the storage.

Fully agitate and pump out slurry – this method won't work due to an inability to properly agitate solids off the bottom of the storage. Also, solids quickly settle once agitation is reduced or stopped

Transfer methods

Tractor scraper – works best

Mechanical conveyor – extensive damage to all moving parts

Positive displacement pumps – wear is accelerated by abrasive action of sands

Gravity-flow cross-channels – require more elevation for gravity to work

HANDLING AND APPLICATION METHODS FOR UNDILUTED SAND-LADEN MANURE

Front-end loader – not efficient

Auger – special augers for sand-laden manure are effective with undiluted manure

V-spreader – suitable for undiluted sand manure

Box-spreader – less suitable, hard-to-contain liquids and easy to overload spreader

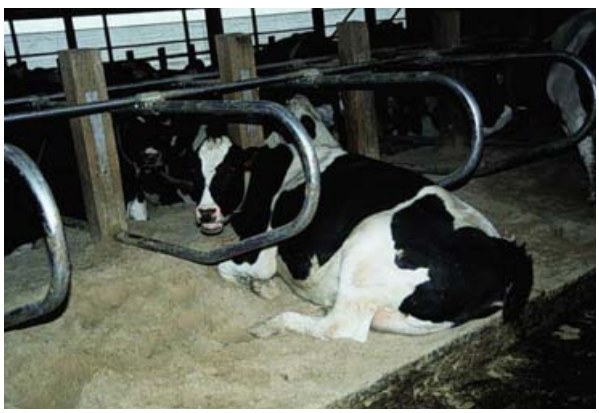
HANDLING AND APPLICATION METHODS FOR DILUTED SAND-LADEN MANURE

Tank methods – will work if baffles are replaced with simpler structure and if heavy-duty tires and suspension systems are used

Irrigation equipment – unsuitable for sand-laden diluted manure

Toolbar injection – reasonably compatible

Information on managing sand-laden manure is expanding rapidly. Before you make any planning decision, talk to someone knowledgeable (e.g., provincial agricultural engineer or dairy specialist) to get the latest information.



Sand-laden dairy manure poses unique challenges for manure handling.

Augers have been developed for sand-laden manure.

SOLID MANURE STORAGE SYSTEMS

There are several options for the storage of solid manure:

- in-barn manure pack
- roofed storage
- solid storage with separate runoff storage system.

SPECIAL FEATURES OF SOLID MANURE STORAGES

FEATURE	MANURE PACK BARN	ROOFED STORAGE	OPEN STORAGE WITH SEPARATE LIQUID RUNOFF
SIZE OF STORAGE	• floor area large enough for all livestock and poultry • headroom to allow 1–1.2 m (3–4 ft) depth of manure pack above floor	• floor area large enough to store all manure produced at depth of 1.8–2.5 m (6–8 ft) depth	• pad area large enough to store all manure produced at 1.2–2.5 m (4–8 ft) depth above the walled pad • runoff storage sized to hold liquid runoff plus any contaminated runoff from yards, washwater and milking centre
CONTROL OF CONTAMINATED LIQUIDS	• does not handle external sources of contaminated water effectively	• does not handle external sources of contaminated water effectively	• runoff from stacked manure and any other contaminated water collected and stored as a liquid in runoff storage
EASE OF EXPANSION	• can be expanded if space available; demolition of concrete walls required	• can be expanded if space available; demolition of concrete walls required	• both pad and runoff storage can be expanded; demolition of concrete walls and safety fence required
CONSTRUCTION	• concrete floor and partial sidewalls plus standard woodframe construction	• concrete floor and partial sidewalls plus standard woodframe construction • open walls and ridge for ventilation	• concrete pad plus walls for solids; earthen or concrete for liquids
COST OF CONSTRUCTION	• cost-effective since one building used to house livestock and store manure • extra storage for contaminated water needed	• higher cost as separate building • a separate liquid storage may be needed	• cost-effective system since all manure and contaminated water can be stored
PRODUCTION OF ODOURS	• odours confined to building	• odours confined to building	• odours may be present from open liquid storage runoff
SAFETY OF PEOPLE AND LIVESTOCK	• minimal safety problems related to storage		• runoff storage must include all safety measures as in a liquid storage – including safety fence and lockable gates

ROOFED RECTANGULAR STORAGE

Advantages

- no liquid storage component
- only solid manure handling equipment is required
- manure volume doesn't include precipitation and the manure may partially dry with time
- moderate cost

Disadvantages

- may be difficult to keep manure solid
  - high levels of bedding may be required
  - cannot add liquids such as milking centre washwater or runoff from paved areas

Roofed rectangular storages are more commonly used in dairy, beef and poultry operations.

OPEN RECTANGULAR STORAGE WITH SEPARATE LIQUID RUNOFF STORAGE

Advantages

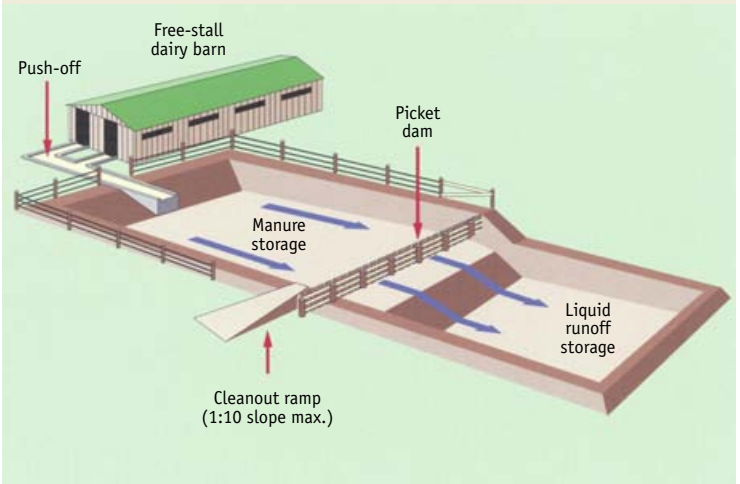
- high volumes of bedding can be handled in this system
- can cost less if an earthen liquid storage is used
- can handle liquids, such as milking centre washwater

Disadvantages

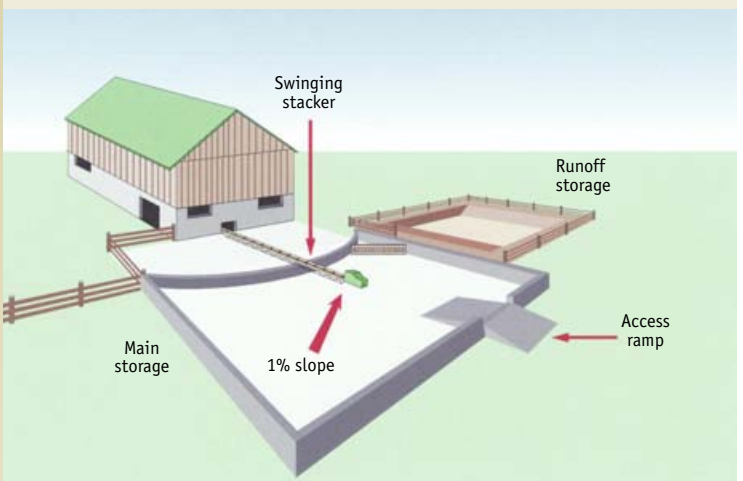
- two manure handling systems are required
- can be expensive if concrete liquid storages are used

Solid manure systems with separate liquid runoff storages can handle large volumes of bedding and liquids.

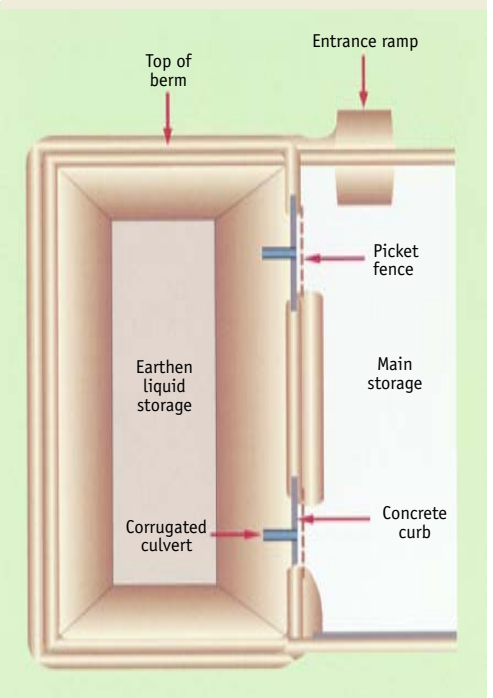
DAIRY FREE-STALL



DAIRY TIE-STALL



LARGE BEEF FEEDLOT



Open rectangular storage with separate storage for liquid runoff is a system used in dairy, beef, poultry and swine operations. The liquid storage may include any of the liquid manure options discussed previously. Solid storage can be sized using a level surface or a cone-shaped surface, depending on how manure is loaded into storage.

COLLECTION AND TRANSFER SYSTEMS FOR LIQUID MANURE

CONTINUOUS GRAVITY-FLOW GUTTERS

Continuous gravity-flow gutters consist of a flat, level gutter with a lip at the outlet. The lip is important in retaining liquids in the gutter, allowing the solids to flow or float along the gutter. Manure in a continuous-flow gutter must be prevented from becoming too dry. The gutter flow must be level along its length and flat across its width.

Continuous gravity-flow gutter systems are used successfully in tie-stall barns with grated gutters, and also under slatted-floor transfer gutters in free-stall barns. Their success depends greatly on bedding management. Excessive use of bedding will result in a buildup of solids. Parlour and milking centre washwater may be discharged into the upper end of the gutter to provide additional water.

Continuous-flow gutters work best with minimal bedding.

SLATTED FLOORS

By the action of animals' feet, manure is forced through the slats to a storage structure below. The slat design must not hurt the animals' feet, and must allow the manure to enter the storage structure freely.

Long-straw bedding will not move through the slats and should not be used. It may be necessary to add washwater to the manure under the slats for proper agitation.

Explosive, noxious, and deadly gases may be released when manure under the slats is agitated prior to manure removal. Since livestock may be in the barn during this process, the barn must be well-ventilated. If the barn is naturally ventilated, ensure you have adequate ventilation during agitation and pumping of manure.

Partially slatted floor areas may be used with a continuous-flow gutter underneath to collect and transport the manure to a separate, long-term storage.

Manure is transferred to an in-barn storage by the action of animals' hooves.

RACEWAY OR CIRCULATORY SYSTEMS (ONE TYPE OF SLATTED-FLOOR SYSTEM)

Raceway systems consist of two or more interconnected channels that lead back to one circulation or agitation point.

These systems consist of two or more interconnected channels that lead back to one circulation or agitation point. The channel walls commonly support the slats above. Raceway manure systems are agitated with a propeller-type agitator, forcing manure around the raceway until it completes the circuit. This breaks up crust, and dislodges solids that have settled to the bottom.

Be careful when agitating manure in this type of system. When pumping begins, the manure should circulate immediately. Otherwise, a blockage may develop, causing the manure level to rise and lift the slats. Since the slats provide lateral support for the dividing wall, when the support is removed, the wall can move, leading to a structural failure. As a result, the slats and livestock may fall into the storage area below.

The manure storage should be fully agitated when the storage tank is about half-full and then again when full. Start the agitator at a very low speed and pump out enough to lower the level so that it can be safely agitated. Start slowly and increase speed as manure starts to circulate around the track. Be careful that a blockage does not develop.

ALLEY SCRAPERS

Free-stall dairy barns often use a chain- or cable-driven alley scraper. They usually have one blade per alley and shuttle back and forth periodically. Blades fold back or are raised on the return stroke.

The cable- and chain-driven scrapers work in pairs, so while one scraper is cleaning one alley, another is on the return part of its cycle. Both alleys must be the same length. A hydraulic motor drives a second type of scraper. It can operate single scrapers, with different lengths of alleys. Cows are able to step over the slow-moving scraper blade. The collected manure may drop directly into long-term storage or into a transfer pump or gravity-transfer system.

Mechanical alley scrapers have the advantage of providing automatic, mechanized removal of manure. Frequent cleaning results in less bedding being used and cleaner cows. Maintenance and repair costs may be high because of the severe conditions that they operate in. During cold weather, alley scrapers may need to run more frequently to prevent manure from freezing to the alley floors. Over time, they can cause wear, making the floor slippery.

One advantage of alley scrapers is that they can keep cows clean with minimal bedding.

TRACTOR SCRAPERS

Free-stall alleys can also be cleaned with a tractor and front-end loader or rear-mounted scraper blade. Alleys are scraped when the cows are out of the barn and being milked. The tractor-scraping system is more labour-intensive and requires cattle to be relocated during cleaning. Cattle may be dirtier since the barn may not be scraped as often as in automated systems.

Adding a wood or rubber edge on the scraper blade can reduce wear.

Another problem is wear on the concrete floor. After several years of scraping, the concrete may become slippery, and cattle may be in danger of falling. Grooving or grinding the concrete surface will improve traction.

Using a wood or rubber edge on the scraper blade will reduce the polishing effect. Some operators use scraper blades made from large used tires. The tires are cut in half and split down the centre to form the scraper.

FLUSH MANURE

Free-stall barns can be cleaned with a flush-manure system. In a flush system, a large volume of water flows down a sloped alley and carries manure to an outside storage. Flushing can be used in free-stall alleys, holding areas, and milking parlours.

Typically, 546 litres/day (120 gal/day) per 454 kg (1000 lb) of cow is needed for adequate manure flushing. Flush with at least 1350 litres/m (90 gal/ft) of alley width. All flush water should be released in 10–20 seconds. Actual flush water volumes and the frequency of flushing are management decisions and will be based on experience with the overall system. The solids must be separated from the flush water to be most effective. Consider using a liquid-solid separator or multi-stage earthen storages for separation.

If the barn temperature is below freezing, a flushing system may require additional protection or an alternative manure handling system may need to be used.

For several reasons, including high odour levels, flush systems are currently not being installed on typical dairy barns in Ontario.

Washwaters can be reused to reduce the large volume of water required to make flush systems work effectively.

LIQUID MANURE STORAGE SYSTEMS

SPECIAL FEATURES OF LIQUID MANURE STORAGES

FEATURE	EARTHEN	OPEN CONCRETE OR STEEL	COVERED CONCRETE
SIZE OF STORAGE	• must also store rainwater and snow that falls into it • must be larger than covered storages as they collect more snow and rain because of sloped walls	• must also store rainwater and snow that falls into it • must be larger than covered storages	• sized only for manure and manure-contaminated liquids to be stored
HEIGHT OF STORAGE ABOVEGROUND	• in-ground, or partially in-ground	• in-ground, aboveground or partially in-ground	• totally in-ground if top reinforced for heavy loads • minimum .6 m (2 ft) aboveground warning signs installed if top is not designed for heavy loads
EASE OF EXPANSION	• possible to excavate larger area at low cost if area is available	• difficult to expand – often requires building a complete new storage	• requires additional storage
CONSTRUCTION	• plastic or clay lined • proper soil type and construction required to ensure proper sealing	• reinforced concrete or glass-lined steel (aboveground only)	• usually reinforced concrete • covers of reinforced concrete or wood frame/metal roofing • cover must be constructed of reinforced concrete capable of withstanding heavy vehicle loading if less than 0.6 m (2 ft) aboveground and not properly signed
COST OF CONSTRUCTION	• lower initial costs may be offset by higher maintenance and manure application costs	• approximately half the cost of same tank with reinforced concrete top	• can be twice the cost of similar open concrete storage – concrete covers are expensive
PRODUCTION OF ODOURS	• persistent odours more evident at a distance than for covered storage • floating crust (dairy cattle manure) reduces odour	• persistent odours more evident at a distance than for covered storage • floating crust (dairy cattle manure) reduces odour	• covers reduce odours during storage period, but strong odours produced during agitation, removal and spreading
SAFETY OF PEOPLE AND LIVESTOCK	• must be properly fenced • all access points must have proper safety signs	• must be properly fenced (or tank wall must extend) to minimum of 1.5 m (5 ft) aboveground • all access points must have proper safety signs	• access opening covers must be locked and secured with safety chain • cover must be constructed of reinforced concrete if less than .6 m (2 ft) aboveground • all access points must have proper safety signs and all staff and family fully aware of the dangers

COVERED RECTANGULAR

- cover must be made of reinforced concrete
- commonly used for swine, dairy and beef
- often barn is built directly over the storage structure

Advantages

- helps to control odour
- walls are used as foundation for barn
- keeps precipitation out of storage structure

Disadvantages

- potential manure gas hazard if barn located over storage structure
- difficult to agitate
- higher cost – especially if the top must carry vehicles

Covered liquid manure storages emit fewer odours.

COVERED CIRCULAR STORAGE

- commonly used for swine
- covered storages are no longer common – occasionally you see floating covers or air-inflated covers

Advantages

- helps to control odour
- easy to agitate

Disadvantages

- higher cost – especially if the top needs to support vehicles
- not easy to expand

Floating covers can be effective alternatives for circular storages.

OPEN CIRCULAR STORAGE

Open circular storages can be used on most soil types and conditions.

- commonly used in swine, dairy, and layer-hen operations
- available in concrete and steel

Advantages

- lower cost than a covered system
- structurally adequate without a top
- usable on most soil types
- easy to agitate
- can be retrofitted with a cover

Disadvantages

- provides limited odour control
- difficult to expand
- precipitation adds to volume

OPEN EARTHEN STORAGE

Although less expensive than concrete storage, open earthen storages require a thorough site investigation and may require liners to protect ground-water from contamination.

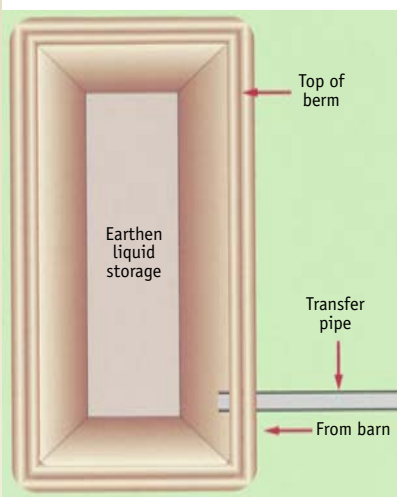
- commonly used for swine, dairy and layer

Advantages

- lower initial capital cost

Disadvantages

- poor odour control due to large surface area
- high volume of precipitation entering large surface area due to sloping sides
- installation requirements dependent on soil type – most conditions require a liner
- liners require considerable maintenance



Earthen storage

PERMANENT STORAGE SITES

The manure storage systems we've outlined should follow the requirements for permanent manure storages as set out by the Nutrient Management Act and its associated regulation and protocols. These requirements ensure that manure storage facilities won't create a risk to surface water and groundwater.

New or expanding permanent manure storage facilities should be designed and inspected by a professional engineer.

GENERAL SITING RECOMMENDATIONS FOR A PERMANENT MANURE STORAGE FACILITY

- not be located within a regional or 1 in 100-year flood line unless a permit for the facility is issued under section 28 of the Conservation Authorities Act
- at least a 50-metre (164 ft) flow path to the nearest surface water (unless it's an artificial facility intended to collect runoff)
- type and depth of soil material to meet requirements of the type of storage facility (e.g., earthen, concrete)
- located at least 15 metres (49 ft) from a drilled well, 100 metres (328 ft) from a well supplying water to a municipal water system and at least 30 metres (98 ft) from any other type of well
- Minimum Distance Separation II distances between the manure storage facility and neighbouring land uses (e.g. residence, school)

When permanent manure storage sites are taken out of operation, they should be decommissioned. This involves disposing of any manure left in the facility.

Decommissioning

As the owner of a manure storage structure, you should ensure the facility is in good repair and in safe working condition. When permanent manure storage sites are taken out of operation, they should be decommissioned by disposing of any manure left in the facility. The site should then be rehabilitated.

When rehabilitating a decommissioned nutrient storage facility:

1. fill the hole with layers of clean soil or fill material with similar infiltration rate of the surrounding soil
2. crown topsoil to allow for settlement
3. establish vegetation
4. prevent water from accumulating on the area.

To view current, legally correct compliance information for the Nutrient Management Act, look up: http://www.omafra.gov.on.ca/english/agops/index.html

DESIGN AND CONSTRUCTION CHECKLIST

Construction of a New Manure Storage or Expansion of an Existing Storage

✓ a professional engineer to design the structure, monitoring and nutrient transfer system for liquid system

✓ a professional engineer to supervise construction and ensure that the structure is built according to the design

✓ facility designed to minimize leakage and corrosion and be structurally sound

✓ a professional engineer to follow construction procedures and standards that comply with NMA Regulation 267/03, as amended

Professional engineers should be hired to supervise the construction of new liquid manure storages.

Concrete Quality

✓ to construct a permanent nutrient storage facility, where concrete is required, the concrete must meet the specifications as outlined in NMA Regulation 267/03, as amended

LINERS

✓ where liners are proposed or required, the synthetic liners must follow the standards in NMA Regulation 267/03, as amended

✓ all liners must be continuous under the floor and must extend up the wall to ground-surface level

✓ compacted soil liners must follow the standards as outlined in NMA Regulation 267/03, as amended

Synthetic liners must be anchored or bonded to the facility. Any discontinuity or perforations must be repaired according to the engineer's instructions.

To view current, legally correct compliance information for the Nutrient Management Act, look up: http://www.omafra.gov.on.ca/english/agops/index.html.

For regulated farms, the maximum time that a temporary storage site should be used is determined by using the table in Regulation 267/03, as amended. Complete the table in this reference to determine the maximum number of days of temporary storage.

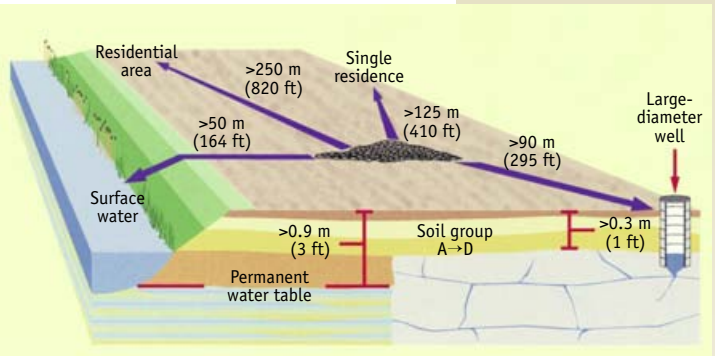
TEMPORARY STORAGE SITES

Temporary in-field manure storage sites are used for solid manure. The amount of manure stored at the temporary site should not exceed the quantity needed for crop production on that farm unit, as outlined in the nutrient management plan.

When determining the location of a temporary manure storage site, the site should have the following features:

- slope less than 3%
- Hydrological Soil Group A–D; not AA, soil with a rapid infiltration rate
- not located in a regional or 1 in 100-year flood line
- at least 0.3 metre (1 ft) of soil above the bedrock and at least 0.9 metre (3 ft) of unsaturated soil above the permanent water table
- a flow path that is at least 50 metres (164 ft) from the nearest surface water and is located at least 0.3 metre (1 ft) above bedrock
- at least 45 metres (148 ft) from a drilled well having a depth of at least 6 metres (20 ft) and a watertight casing extending to a depth of at least 6 metres below ground level, 90 metres (295 ft) from any other well except a municipal well and at least 100 metres (330 ft) from a municipal well
- at least 125 metres (410 ft) from a single residence and 250 metres (820 ft) from a residential area if it is NOT used for storing dewatered municipal sewage bio-solids
- at least 200 metres (656 ft) from a single residence and 450 metres (1,476 yds) from a residential area for dewatered municipal sewage biosolids.

Keep records of the location and dates of pile establishment, turning and removal.



Temporary manure storage sites must be selected carefully to reduce the risk of contaminating ground and surface water.