Chapter 3. MANAGING MANURE STORAGE AND COLLECTION AREAS

This chapter discusses design and management of manure storage facilities and manure collection areas, which are areas like barns and pens from which manure is collected before storage.
The following aspects are addressed:

- environmental risks associated with site selection
- design considerations for manure storages
- loading and emptying
- maintenance and monitoring
- odour management options
- fly control
- decommissioning

Manure is collected and stored so it can be applied to the land at times that are compatible with weather conditions and cropping practices. Manure nutrients can be best utilized when spread near or during the growing season of the crop. Storage of manure allows producers to efficiently utilize their manure but poses challenges in developing and maintaining appropriate storage systems.

The main goals associated with collecting and storing manure include:

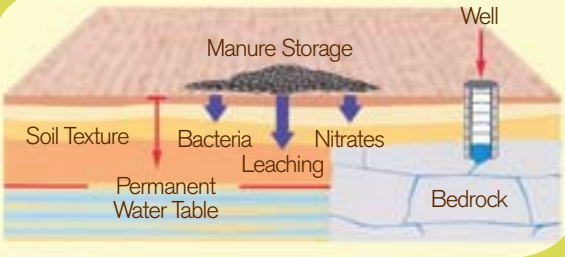
- protecting groundwater
- protecting surface water
- minimizing odours

NEW AND EXPANDING CONFINED FEEDING OPERATIONS need to meet permitting requirements, including manure storage requirements, as set out in the *Agricultural Operation Practices Act* (AOPA). As well if there is a change to an existing manure storage, the Natural Resources Conservation Board (NCRB) staff should be contacted to ensure that all necessary permits are in place.

3.1 SITE CONSIDERATIONS

To protect groundwater and surface water, the site or location of manure collection and storage areas must be managed by taking into account the natural characteristics of the area. Understanding the inherent risks of your site is the first step to managing it appropriately.

A livestock operation and manure storage located on a site with a deep groundwater resource, clay soils, and moderate slopes, and which is far away from sensitive areas poses a low environmental risk, so there are fewer restrictions for management and development of the site. Conversely, a similar facility on a site with coarse-textured soil over a shallow groundwater resource would be at a higher risk of groundwater contamination, so site development and management would require a larger investment of time and money.



Manure and manure nutrients can leach to groundwater on sites with coarse-textured soils, shallow depths to bedrock, and/or shallow groundwater resource.

3.1.1 Groundwater Contamination Risks

Groundwater quality is degraded when inadequately filtered water carries contaminants downward through the soil to the groundwater. If contaminants reach a groundwater aquifer, all water wells drawing water from that aquifer are at risk. Soil texture, geological formation and depth to groundwater significantly affect the degree of risk. General factors affecting the risk of contamination are outlined in Table 3.1.

Soil Texture

Soil texture is the relative coarseness or fineness of soil particles. It is the most important determining factor in the ease and speed with which water and contaminants can move through soil to groundwater.

Coarse-textured soils such as gravels and sands have large pore spaces between the soil particles. This allows water to quickly percolate downward to groundwater.

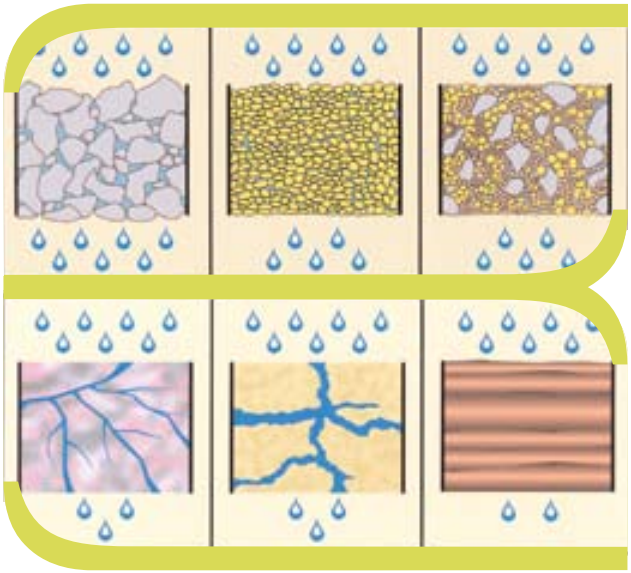
Fine-textured soils, such as clays and clay loams, bind compounds and provide better natural protection for groundwater. In these soils, the movement of water and contaminants through the soil is very slow. They act as a natural filter and allow for biological and chemical breakdown of contaminants before they reach groundwater.

Soil texture can be assessed using hand-texturing methods or with laboratory particle-size analyses to describe the relative fineness or coarseness of the soil particles. Soil maps are not as accurate as soil sampling but can provide an indication of the soil texture at the site.

Geological Formation

The geological formation under the surface varies greatly throughout the province. As a result the vulnerability of our groundwater resources to contamination is also variable.

Coarse-textured soils may require concrete, compacted clay or synthetic liner in order to prevent groundwater contamination.



Water moves slowly through uncracked clay soils and very quickly through gravelly and sandy soils.

A general understanding of the geological setting of your operation can be obtained through various published sources. These include soil data, water well reports, and geological maps.

Table 3.1 Factors Affecting the Vulnerability of Groundwater to Contamination

Factor	Explanation
Type of Soil above the Shallowest Water Table	Coarse-textured soils and soils with large cracks increase the risk of movement of water into the aquifer.
Depth to the Shallowest Water Table	Shallower water tables are more vulnerable.
Topography	Steep slopes increase water movement to low-lying areas, which have a greater chance of being directly connected to water tables.
Depth to Bedrock	Shallower bedrock can increase the risk of contamination. The upper surface of the bedrock is often highly fractured and conductive, and increases groundwater movement. It also acts as a conduit and moves water horizontally.

Depth to Groundwater

Filtering and treatment of contaminated water by natural processes primarily take place in soil above the water table in the unsaturated soil zone. In a naturally occurring, high water table, water and contaminants have little time to move through unsaturated soil before reaching shallow groundwater resources.

Water table depths can fluctuate significantly, depending on the season. Depending on the site, the depth to the water table can be assessed by:

- digging a hole in June or September and observing the depth to free water in the hole,
- using soil colour features and the soil drainage method to assess drainage class – usually done by soil specialists and engineers,
- referring to a local soil map to assess drainage class (e.g. the map will identify any areas of imperfect or poor drainage).

Site-Specific Assessment

A site-specific groundwater assessment will need to be conducted before the construction or expansion of a manure storage facility to determine the degree of groundwater sensitivity to contamination and the most appropriate measures to protect groundwater quality at the site.

These site-specific assessments and the design of any groundwater monitoring programs should be conducted by professionals with a specialized knowledge of geology and hydrogeology (the study of groundwater).

3.1.2 Surface Water Contamination Risks

Surface water can be found in various forms within a livestock operation. These include permanent water bodies such as creeks, dugouts, ponds, lakes, and sloughs as well as intermittent channels and ponds resulting from snowmelt and rainfall runoff. Surface water flow can provide a path to allow contaminants from the operation to flow into these water bodies.

To effectively reduce the potential risk, the goals to managing water pathways should include controlling the movement of water and providing an opportunity for manured water to be treated before flowing into a significant water pathway. The following factors that affect water pathways should be considered when developing action plans to reduce surface water contamination risks:

- Spring snowmelt presents a great risk of surface water contamination because the soil is still frozen and water infiltration is limited;
- Infiltration of water is slower in fine-textured soils (clay), increasing the amount of runoff from these soils which increases the risk of surface water contamination;
- Infiltration of water is faster in coarse-textured soils (sand), reducing the amount of runoff from these soils which decreases the risk of surface water contamination;

- Long and steep slopes increase the speed at which water will travel, reducing water infiltration rates and capture of contaminants;
- Packed soils and paved surfaces, as found in farmsteads, reduce infiltration and increase surface water runoff; and
- Permanent vegetation cover within the pathway will slow down water and can in turn capture both dissolved contaminants and soil particles with contaminants. Depending on the contaminant, this may be a form of treatment and reduce the risk to surface water.

For more information on managing surface water refer to Chapter 8.

3.1.3 Odour Risks

To varying degrees all livestock operations emit manure odours. In Alberta 26% of the nuisance complaints regarding agriculture concern odours (based on number of operations receiving complaints through the NRCB). Odour that is continuous and at excessive levels is atypical of normal farming practices.

Addressing odour issues is an important component of siting livestock facilities and manure storages. An odour problem that may arise at a site can potentially attract attention to other environmental problems – real or perceived. Proactive manure odour control measures will help ward off other neighbourly conflicts.

Table 3.2 Odour Reduction Options for Livestock Sites and Facilities

Technique	Considerations
Siting	• Where possible, choose the facility's location so that prevailing winds don't blow towards neighbours' homes. • Use existing or constructed windbreaks (trees or hilly areas) to direct wind and odours. • Consider the location of surrounding livestock operations and neighbouring residences.
Building Design and Maintenance	• Choose room designs, equipment and flooring that are easy to clean and require minimal amounts of water. • Design solid floors in livestock facilities so they slope towards gutters to ensure good drainage. • Keep facilities clean (e.g. regularly remove manure, wet feed, feed spillage and other products that could produce odour).
Corral/pen Design and Maintenance	• Design pens/corrals with slopes for good drainage; keep corral surfaces hard, smooth and free of loose manure; regularly fill in low-lying spots and potholes to reduce standing water. • Design settling channels and basins for easy machinery access for solids removal in all weather conditions. • Reduce feed spillage and clean up spills (e.g. adjust feeder design and/or reduce the level of feed in feeders).
Landscaping	• Keep storages out of main view. • Design with berms and side slopes to reduce visibility and manage air flow. • Plant trees to act as a visual barrier and provide considerable air movement and increase air dilution (but ensure earthen walls are unaffected by tree roots). Airflow is decreased within the existing trees on site and airflow and turbulence are increased around the site, which can increase dispersion. • Landscape the site to aid in keeping the site all-weather accessible and well drained.

3.2 MANURE STORAGE DESIGN CONSIDERATIONS

The design of your manure storage will be specific to your operation. The factors that you will have to consider include:

- amount of manure produced – depends on animal types and numbers
- type of manure – solid, liquid, semi-solid
- plans for land application – frequency and timing to meet your needs

3.2.1 Storage Capacity

Storage capacity should allow for operators to have timely application of manure. Applying manure on frozen or snow-covered ground increases the risk of runoff and the loss of valuable nutrients. Having adequate storage capacity allows operators to have flexibility in their application timing and reduces the cost of future expansion of manure storages.

Storage capacity takes into consideration the following factors:

- type of livestock
- number of livestock
- amount and type of bedding used
- volume of other wastewater such as milking centre washwaters, sanitation washwater and silage seepage, that are to be stored
- volume of other inputs such as roof water, runon water, rainfall and snowfall that can enter the storage system

Sources of information available to determine your storage capacity include:

- The AOPA Manure Characteristics and Land Base Code provides manure production volumes based on livestock species and type. The numbers are estimated volumes of manure production that also take into account bedding and wastewater.
- The dugout/lagoon calculator can be used to determine the actual size of your existing lagoon.
- Chapter 4.1 in the Nutrient Management Planning Guide explains how to calculate your manure inventory.
- Confined Feeding Operation (CFO) Extension Specialists can assist you.

All these can be found at www.agriculture.alberta.ca/aopa.

3.2.2 Manure Storage Systems

Operations will have solid, liquid or both types of manure storage. Solid manure storages are typically associated with beef production, some dairy, poultry and some hog operations. They can include feedlot pens, barns, and outside storage areas.

Liquid manure storages are typically associated with hog and some dairy operations. They can include

IT IS RECOMMENDED THAT MANURE STORAGE SIZE be large enough to allow operators to have flexibility in land application timing and frequency. New and expanding operations need to have at least nine months of storage as regulated in AOPA.

GEOTECHNICAL INVESTIGATION A geotechnical investigation is required to determine the geological characteristics below a proposed manure storage. The purpose of the investigation is to determine the naturally occurring soil and geologic conditions. The preliminary investigation will review existing information to decide if further physical investigation is warranted. The physical investigation would include the drilling of boreholes to study the subsurface. As well a hydraulic conductivity test would be conducted to determine the flow of water in the subsurface.

earthen manure storages, slurry storages, lined manure storages and concrete in-barn storages.

Several design options are available to protect groundwater and surface water. They include:

- natural clay liner
- compacted clay liner
- concrete liner
- synthetic liner
- steel for liquid manure storages
- temporary storage for solid manure

Natural Clay Liner

- This option depends on the geology of your site. Some parts of the province provide natural protection to groundwater as a result of naturally occurring clay layers between the manure storage and the groundwater resource.
- A geotechnical investigation will be required to ensure that the naturally occurring protective layer is adequate.
- Control of runon and runoff will have to be developed for the site. For more information read Chapter 8.
- Construction of a natural clay liner is simply landscaping the site for the use, either a feedlot floor or earthen manure storage.

Compacted Clay Liner

- Compacted clay liners are used when a naturally occurring protective layer below the storage does not exist but there is sufficient clay in the area that can be compacted to create a protective layer.
- A geotechnical investigation will be required to ensure that there is sufficient clay in the area and may initially demonstrate the lack of a naturally occurring protective layer.
- Control of runon and runoff will have to be developed for the site. For more information read chapter 8.
- Construction costs will include the proper development of a compacted clay liner.

Concrete or Steel Storage

- Geotechnical investigation is done to ensure that the soil conditions below the storage are stable enough to support a concrete or steel structure.
- Side walls can be incorporated into the design of a concrete pad to manage surface water flow onto the pad.
- Concrete storages will need proper seals between slabs to ensure no leaking, and be constructed with materials that can withstand the salt content of manure.

Temporary Solid Manure Storage

- Solid manure can be temporarily stored in areas that meet requirements for setbacks to common bodies of water; these requirements are set out in AOPA. Temporary storages can only be used once every three years for a maximum of seven months.

3.2.3 Loading and Emptying of Liquid Storages

Odours are released when liquid manure storages are loaded or emptied. During loading, the added manure can disturb the stored manure, causing gases trapped in the stored manure to be released. During emptying, liquid manure is agitated to obtain a consistent slurry of liquids and solids that will flow during loading or pump-out. The agitation and pumping release odorous gases.

To reduce odour when loading manure into a storage, discharge the new material beneath the surface of the existing stored manure. The discharge point should be in the bottom quarter of the storage. This technique is called bottom loading. It limits the disturbance of gases trapped in the manure. In addition, use a low discharge flow rate to prevent vigorous agitation of the manure.

New or improved manure storage facilities must be constructed so that the structure through which the primary cell is filled is located within the bottom quarter of the facility.

Be aware that several of the gases released by disturbed manure can be fatal. Several deaths have occurred in Alberta because of a lack of training and personal protection equipment while working with stored manure. For more information on the risk associated with manure gases, see Manure Application Safety in Chapter 7 on page 73.

CHOOSING A MILKHOUSE WASTEWATER HANDLING SYSTEM

Option	Considerations
Option 1: Add washwater to a liquid manure storage system.	• Pump to a properly designed liquid manure storage or feedyard runoff catchment. • Size storage to hold the additional wastewater.
Option 2: Store washwater in a separate storage system.	• Use properly designed concrete or earthen storage. • Size to store at least nine months of wastewater production. • Open storages release odours; reducing milk contents will reduce odours.
Option 3: Use a sediment tank and vegetative filter strip.	• If soil is too shallow, or has a high water table, choose another option. • Minimize manure and milk content in wastewater. • Reduce volumes by using water conservation techniques. • Use properly designed two-compartment “septic” tank with pump-out. • Use distribution header on discharge to spread effluent over larger area; alternate discharge location several times per year.
Option 4: Use lime flocculator treatment with treatment trench.	• Feed pre-rinse washwater to calves (reduce milk content). • Add 1.4 kg of lime to 1500 litres of wastewater, mix for 20 minutes and let settle for two hours (lime flocculates milk and soap solids, which then settle). • Pump clear water on top into disposal field system (treatment trench). • Flush bottom layer of wastewater (approx. 114 litres) into solid or semi-solid manure system.

3.3 MANAGEMENT PRACTICES FOR MANURE STORAGE

3.3.1 Maintenance and Monitoring

Visual Monitoring
There are several visual indicators of storage problems:

- Volume levels are not as expected.
- Wave damage to the liner.
- Erosion where manure enters into or is pumped from the storage.
- Cracking or slumping of the liner.
- Seepage, soft spots or slumping on the outside of the berm, or several feet out from the berm, that indicates leakage. Any leakage or slumping is a serious problem that requires immediate attention.
- Evidence of rodents. Rodent burrows can damage the liner and walls of the manure storage.
- Vegetation (tree and shrub roots). The roots of trees and shrubs growing in or near the storage can penetrate the liner and create leaks. Remove trees and other plants that start to grow in the manure storage. Trees, if planted, should be located with their mature root zone well beyond the storage.

Although most research regarding leakage from earthen manure storage structures has shown minimal problems, there may be some site-specific cases where more than visual monitoring is warranted.

Signage and Fencing
Hazardous areas such as storage structures, dugouts and water basins should be fenced/secured to prevent curious humans/unauthorized persons and animals from entering. A clearly visible sign should be erected at the entrance warning of the nature and danger of the facility.

Mowing
Keep weeds and grass mowed to promote a positive image, reduce flies and rodents, and reduce the potential for liner damage.

Sampling/Monitoring Wells
Sampling wells can be installed to regularly monitor water quality in the vicinity of the manure storage. Regular monitoring can be used to verify that the manure storage practices are protecting the environment, and can also act as an early warning that a change or repair is needed. A qualified engineer or hydrogeologist should design the monitoring well system and analyze the water quality data. After installation, the wells must be sampled to determine background conditions. Take samples at least twice per year for the first two years. After that, sampling once per year should be sufficient. Operations with a Natural Resources Conservation Board (NRCB) Permit will have conditions within their permit. Information is available from CFO Extension Specialists that provide direction to voluntary monitoring programs.

3.3.2 Odour

Table 3.3 lists BMPs to control odours from storages. Operators will have to make management decisions based on these practices and practices for odour control when applying manure. Technology and management practices can help alleviate odour-related issues; however the most effective and economical practice is to maintain good relations with your neighbours.

Table 3.3 BMPs to Control Odours from Manure Storages

Technique	Liquid Storage Considerations	Solid Storage Considerations
Natural Covers	• Reduce surface area exposure to ambient air. • Act as a filter on odour. • Depending on feed ration, manure storages can form a natural crust providing odour control.	• Does not apply.
Synthetic Covers	• Add cost but allow for capture of gases. • Reduce volume of liquid to be spread. • Challenges with agitation before spreading.	• Reduce water content of manure (by reducing rain water) and encourage aerobic conditions. • No runoff to handle.
Roofs	• Reduce surface area exposure to ambient air. • Can be a high capital cost. • Reduce water content of manure and encourage aerobic conditions. • Don't have to deal with precipitation.	
Biofilters	• Exhaust from barns or storages is blown through a porous bed of organic material (such as peat, straw, compost, etc.) that is kept moist. Naturally occurring microbes colonize the material and decompose odour compounds. • The systems require proper design and management to perform well and prevent ventilation problems. • Costly option and requires intensive management	
Chemical/Bio Additives	• Approach with caution – more failures than successes.	
Liquid/Solid Separation	• Done often in conjunction with other treatment. • Provides more options for further handling and management of manure.	• Collect liquid runoff from solid systems to encourage aerobic conditions.
Aeration	• Preferably done in conjunction with liquid/solid separation. • Has high energy demands.	• Has high energy demands. • Can have short-circuiting of air flow through pile.
Composting	• Need a very large carbon supply (e.g. straw) liquid to solid.	• Increased area and equipment required. • Need to manage leachate.
Anaerobic Digestion	• Costly to install and maintain, but revenue from energy generated may offset costs.	• Can mix solid manure with liquid manure for use in the digester.
Bottom Loading of Liquid Storages	• Discharge the new material beneath the surface of the manure. • The discharge point of the primary cell should be within the bottom quarter of the facility.	• Not applicable.

FOR MORE INFORMATION

regarding fly monitoring and control options, refer to A Guide for the Control of Flies in Alberta Confined Feeding Operations, available from www.agriculture.alberta.ca or by calling the ARD Publications Office at 1-800-292-5697.

3.3.3 Fly Control

Fly control is important due to the risk of disease transfer through flies, food safety concerns and the risk of nuisance complaints from neighbours. Because of the enclosed, controlled environment of barns, fly control can be a year-round process. Though complaints from neighbours mainly occur in the summer months, operators should be concerned about the fly population actively living in barns over the winter and the number of pupae overwintering from last summer's population. Both will contribute to the population that begins the next summer season. A larger initial population in the spring may result in greater fly problems earlier in the summer.

Producers can prevent fly outbreaks by implementing a fly management program that includes monitoring the population and a regular cleaning schedule of areas typical of fly breeding habitat. Fly populations involve four lifecycle stages (egg, larva, pupa, adult). Therefore, control methods should be conducted regularly, preferably weekly, to effectively disrupt the fly lifecycle and prevent fly outbreaks. If or when insecticides are used, animals should be removed from the area prior to application and all label instructions strictly followed. Remember, these chemicals will only affect the adult portion of the fly population and control of the population will only be short-term. Removal of fly breeding habitat is the key to effectively reducing fly populations.

Having a written fly management plan and communicating with your neighbours about the actions you are taking to reduce fly populations on your operation will help avoid potential nuisance complaints. Taking a proactive approach to fly control is your best defence.

The following checklist is a tool for you to use in monitoring fly populations and in routine maintenance of key fly breeding habitats on your operation:

- Identify sites where flies are breeding on your operation.
- Use a weekly clean-up and maintenance checklist to ensure the effective control of fly populations on your operation.

Remember to keep records to confirm the actions you have taken to control fly populations on your operation.

3.4 TEMPORARY SHUTDOWN AND DECOMMISSIONING OF A MANURE STORAGE

CFO operators considering either a temporary operating suspension or a permanent shutdown of their CFO should contact ARD CFO Extension Specialists or NRCB staff to discuss options for their individual situation.