5.0 LAND APPLICATION OF MANURE

Manure – A Sustainable Resource

Spreading manure on land is a highly desirable method of recycling a natural, organic by-product of poultry production. Land application of manure has many benefits:

- it is readily available on poultry operations with minimal energy input;
- many poultry operations are surrounded by large areas of productive agricultural land that can benefit from its use;
- land application can significantly decrease crop production costs (fertilizer) by providing plant nutrients; and
- poultry manure acts as a valuable soil amendment when properly managed by adding organic matter which improves soil tilth, structure, aeration, water holding and warming properties (organic matter affects soil color), reduces soil stickiness and helps to control soil erosion.

Poultry manure is an excellent fertilizer given its high nitrogen concentration and poses an environmental risk only when mismanaged. Too much of a good thing, however, can lead to problems such as damage to crops or the risk of pollution. Soil assay tests must be carried out before manure spreading is undertaken to ensure the nutrients applied meet only the soil requirements for beneficial use. Once these results are known, there are two main strategies for manure use on land: maximum nutrient efficiency or maximum application rates. (Source: Best Management Practices: A Manure Nutrient Management Program, Ohio State University Extension, Department of Horticulture and Crop Science.)

If maximum nutrient efficiency is the goal, rates of application need to be based on the nutrient present at the highest level in terms of the crop needs. In many cases, this is phosphorous. Manure must be applied at a rate which will meet the crop requirements for phosphorous. Additional nitrogen and potassium can be supplied with commercial fertilizers. This strategy is least likely to cause undesirable environmental effects and makes the most efficient use of all nutrients in the manure.

The other strategy for utilizing manure on cropland is to determine a rate of application which will satisfy the crop's requirement for nitrogen without causing environmental problems. This strategy maximizes the rate of applications, making less efficient use of phosphorous and potassium than the first strategy outlined above. It is important to note that a manure application strategy based on crop nitrogen requirements will lead to an accumulation of potassium in the long term, especially with repeated applications. Excessive soil test levels of potassium can result in surface water quality problems.

The goals of every poultry producer must be to:

- minimize the nuisance created by spreading manure;

- maximize the utilization of the manure nutrients by crops; and

- minimize the risk of polluting surface waters and groundwater.

One of the easiest ways of achieving these goals is to incorporate the manure into the soil if at all possible. Every possible effort must be made to incorporate manure into soil within 48 hours of application. If incorporation is not feasible, such as on perennial forage crops, then apply manure under favourable weather conditions, when possible.

Some poultry operations do not have an adequate land base to dispose of the manure that they generate. In these cases, it is the farmer's responsibility to identify other producers with an adequate land base who are willing to accept responsibility for the volume of manure being generated.

Increasing amounts of inorganic fertilizers (chemical fertilizers that are either mixed or manufactured) are also being used in the production of horticulture crops in Newfoundland and Labrador. The benefits of using inorganic fertilizers include consistent analysis and ease of handling. You must ensure that elements found in commercial fertilizers do not accumulate in the soil to high concentration levels. Base the amount of inorganic fertilizer used in your operation on soil analysis and follow recommendations for fertilizer use.

Application of other natural fertilizers such as fish offal, kelp, crab shells and similar materials is regulated under the Waste Disposal Act and subject to the approval and conditions of the Government Services Centre. These are sometimes added to the soil as a conditioner and can cause odour problems. Marine products must be turned into the soil within 24 hours unless the Government Services Centre is satisfied that the remoteness of the site will not likely result in conflicts. The soil or crop specialists with the Agrifoods Branch can provide advice on the use of natural fertilizers and compost.

Manure as a Fertilizer

When considering manure as a fertilizer the important characteristics are:

- nitrogen content;
- phosphorous content;
- potassium (potash) content and minerals such as sulphur;
- micro-organisms; and
- organic matter content.

Nitrogen, phosphorous and potassium are the three main nutrients found in manure and used for plant growth.

(a) Nitrogen

Nitrogen promotes rapid vegetative growth and gives plants their healthy green colour. To maximize the fertilizer value, manure must be stored and handled to reduce nitrogen losses. This is important since nitrogen in manure exists in two forms:

- the largest portion is contained in the complex molecules of digested feed and is known as organic nitrogen; and

- ammonium nitrogen and nitrate nitrogen (the general assumption for Newfoundland and Labrador is that ammonium nitrogen equals 50% of total N and nitrate nitrogen equals 5% of total N).

Organic nitrogen is not available for use by plants until it mineralizes to the nitrate form, the same form as the nitrogen in some commercial fertilizers. The rate of mineralization will depend on the composition of the manure, soil type, temperature and moisture content. Generally, 30 to 50% of the nitrogen will be mineralized during the first cropping season with the balance mineralized during the next three years.

Nitrate-nitrogen is dissolved in water and can move away from the root zone in the soil. This process is known as leaching. When manure is handled and spread on land, some of the nitrogen in the manure that exists as ammonia gas will be released to the atmosphere. It is important to minimize the time of exposure by incorporating the manure into the soil as quickly as possible. Most nitrogen losses occur within the first 24 hours after the manure is spread due to volatilization.

Nitrogen can be conserved by using the following practices:

- transfer the manure from the barn to storage as often as possible, especially during the summer;

- use transfer systems such as bottom loading storages that minimize contact between the manure and the air;

- use storage facilities with a minimum of exposed surface area, or cover the manure storage to reduce contact with air;

- when spreading manure, minimize the time of exposure by incorporating the manure into the soil as quickly as possible; and

- limit the application rate to avoid ponding.

Typical nitrogen losses for various methods of spreading are listed in Appendix E.

(b) Phosphorous

Phosphorous stimulates early growth and root formation, hastens maturity, promotes seed production and makes plants hardy. The phosphorous in manure exists in both the organic and inorganic forms, but unlike nitrogen, phosphorous is not released to the air. As with nitrogen, the inorganic form is readily available to be used by plants, but the organic form is not available until the phosphorous is mineralized. Phosphorous is not removed from the root zone unless very high levels build up in the soil. Most

phosphorous loss is due to soil erosion.

(c) Potassium (Potash) and Minerals such as Sulphur

Potassium improves the plant's ability to resist disease and cold and aids in the production of carbohydrates (energy producing organic compounds). Potassium is especially important for stem strength in grasses. Sulphur is needed in small amounts and is essential for protein production.

Manure potassium, chiefly present in the urine, is equivalent to fertilizer potassium and is available for plant growth in the year it is applied. It accumulates in the soil which is generally desirable because it supplies the plant needs. Like phosphorous, however, potassium can accumulate to excessive levels and have detrimental effects on plant growth.

(d) Micro-organisms

Although manure contains large numbers of micro-organisms, very few can carry diseases to people. The micro-organisms that carry or cause diseases are known as pathogens. The easiest transfer of pathogens from animals to people is through direct contact. The potential for disease transmission is very low since pathogens are rapidly destroyed by drying and exposure to sunlight. Proper preparation of food including the use of clean water further minimizes the likelihood of contaminating food.

(e) Organic Matter

Repeated long-term application of manure at reasonable rates will add organic matter to the soil thereby improving soil tilth, structure, aeration, water holding properties and reduction of susceptibility to soil erosion.

When fields are cropped, a portion of the organic matter is removed from the field. The use of commercial inorganic fertilizers does not replenish the lost organic material. Depending on the soil type, a steady depletion of soil organic matter can result in a soil structure that is more susceptible to erosion and one which requires high levels of fertilizer to maintain adequate levels of fertility.

For more information on organic matter see the document, *Farm Practice Guidelines for Horticultural Producers in Newfoundland and Labrador*.

Prevent Pollution

A portion of the nutrients in poultry feed is not used by the bird and is excreted in the manure. The

nutrient content of poultry manure depends upon the bird age, the feed type and the manure management system.

The composition of the manure can vary with the following factors:

(1) **Animal Age** – Manure contents are the products remaining after digestion. Animals that are growing will utilize some nutrients more efficiently than mature animals.

(2) **Feed Type** – If the feed is in a form that does not permit the animal to digest all of the nutrients, the undigested nutrients will be excreted in the manure. Similarly, if a ration is unbalanced, the animal will not be able to use all of the nutrients and excess nutrients will be excreted.

(3) **Manure Management System** – Depending on how the manure is stored and spread on land, some of the nutrients may be lost. The amount of straw or shavings added as bedding will change the manure properties. Some common types of organic bedding materials are straw, sawdust, sand, shredded news prints, composted manure solids, rice hulls, etc. Sand drains well and unlike organic bedding does not provide a conducive environment for micro-organism proliferation. Sand, however, is incompatible with gravity flow or slatted floor manure systems as it tends to settle down in storage and clogs pipes.

The methods of handling, storing and spreading manure also affect the final nutrient content. Nutrients such as nitrogen, phosphorous and potassium not used by the animal are returned to the soil where they are used by the crop. However, when proper management is not used in spreading manure, erosion, runoff and leaching may transfer the nutrients away from the soil and into water sources, causing pollution.

Water Pollution

Pursuant to Section 10(2) (a) of the Environment Act, SN 1995, C. E-13.1, no person shall place, deposit, discharge or allow to remain within a protected water supply area any material of any kind that might impair the quality of the water. You must exercise great care when handling and applying pesticides, fertilizers or manure in water supplies.

There are a number of serious effects when water is polluted by manure:

- water quality is affected (turbidity, colour, suspended solids, nitrate or ammonia, phosphorous, potassium and pathogens);

- the organic material in the manure will decompose and consume the dissolved oxygen in the water, possibly resulting in the death of fish;

- settled solids and nitrogen compounds can kill aquatic life forms;

- nutrients in the manure may increase the growth of aquatic plants that can disrupt

the ecosystem of the water body;

- bacteria and viruses may be introduced, increasing the potential for spreading diseases; and

- excessive nitrates in drinking water can create a health hazard for humans (especially in young children) and reduce the performance of poultry.

You must ensure that manure storages are secure and that land spreading is performed at proper rates so that water sources are not polluted (see Table 5, 6 and 7).

Soil Pollution

Over-application of manure to soils can result in the build up of nutrients in the soil. When the nutrient concentrations become too high, nutrients such as nitrate-nitrogen can move through the soil to groundwater. A prolonged over-application of manure can lead to an imbalance in the soil chemistry which will result in reduced crop yields. High concentrations of manure are toxic to plants. After one year's manure application, grasses, root crops or some type of flora must be planted to take up the nutrients applied to the soil.

Minimize soil compacting by not driving repeatedly over the area of the field with heavy tanks of manure.

5.1 SEASONAL CONSIDERATIONS

The timing of manure spreading throughout the year is important. Manure will gradually decompose in the soil zone. As decomposition occurs, nutrients from the manure become available for use by the plant. These nutrients, however, also become susceptible to losses through leaching or runoff depending on the time of the year, weather and soil conditions.

(1) *Spring* may be the best time to apply manure, since the crop will be able to use the nutrients as they become available. Soil compacting can be a problem in spring, however, since the land is often not dry enough to handle the heavy wheel loads involved with certain types of spreading methods.

(2) *Fall* application will usually result in the loss of more nutrients than spring application if the manure is not incorporated into the soil. However, fall application usually results in more time available for spreading. In addition, the soil is often quite firm and if compaction does occur, winter freezing and thawing can reduce the damage.

(3) *Summer* application is suitable for pastures, forage crops and summer fallow. Additional care must be exercised when applying manure to summer fallow since these fields usually release enough nitrate nitrogen during the summer to meet the next year's crop demands. Nitrates are more prone to leaching from light-textured soils. Rather than summer-fallowing these soils, producers must consider

establishing a green manure crop which can utilize the nitrates.

(4) Spreading of manure on snow covered or frozen land is not permitted. Spreading in the winter increases the potential of runoff to water courses. Concurrently, the nutrient loss is high and would have few benefits to the soil.

5.2 DISTANCE TO SURFACE WATER AND WELLS

It is important to consider the slope of the land and the absence of buffer areas to reduce runoff when spreading manure. As the slope increases, so does the chance that manure may run off. On steeply sloping land (greater than 15%), extra caution must be used when applying manure. It is recommended that the spreading be supervised at all times to ensure that runoff is not occurring. Sloping land must be maintained with a reasonable amount of crop cover to provide additional protection against erosion.

A buffer area is necessary to absorb the runoff and prevent it from traveling down a slope, thereby reducing the risk of runoff entering surface waters. The effectiveness of a buffer depends on factors such as land use conditions, vegetation and slope. Good judgment must be used in all cases to ensure runoff cannot enter water sources.

Private Water Supplies

A general guideline for spreading manure is to not spread on land situated less than 75 metres (250 ft) from the source of supply of water used for drinking purposes when the draining of the land is towards the water supply. Consequently, a buffer of less than 75 metres (250 ft) may be acceptable depending on the topography of the area. (Public Health Regulations, 1991.)

Public Water Supplies

Draft guidelines for agricultural operations and associated activities such as manure spreading within protected water supplies do not permit development, within the buffer zones as follows:

- intake pond/lake: a minimum of 150 metres (500 ft);
- river intake: a minimum of 150 metres (500 ft) for a distance of 1 kilometre (0.62 miles) upstream and 100 metres (328 ft) downstream;
- main river channel: a minimum of 75 metres (250 ft);
- major tributaries/lakes/ponds: a minimum of 50 metres (160 ft); and
- other water bodies: including wetlands (bogs and fens) a minimum of 30 metres (100 ft) along and around water bodies.

Buffer zones may be broadened or imposed around sensitive areas such as steep or unstable slopes, bogs, marshes or any other areas as deemed necessary by the Department of Environment. For further interpretation of these guidelines contact the

Land Management Specialist, Agrifoods Branch or the Water Resources Officer, Department of Environment.

To protect watercourses (non-water supply), manure must not be spread: (Under review. These distances are measured on the horizontal.)

- within a distance of 15 metres (50 ft) plus 1.5 times the percentage of the slope; and

- on newly cleared land within 30 metres (100 ft) of a watercourse.

Manure may only be spread on land between 15 and 30 metres (50 and 100 ft) of a watercourse if there is a naturally vegetated buffer within 0 to 15 metres (50 ft) of the water course.

Salmon Rivers

Buffer requirements may be greater along salmon rivers. The Environmental Assessment Act requires all development within 200 metres (660 ft) of a salmon river to be registered under the Act. Farmers must consult with the Department of Environment if contemplating expansion within 200 metres (660 ft) of a salmon river.

5.3 SENSITIVE GROUNDWATER AREAS

Both soil and groundwater conditions* can be sensitive to agricultural practices which involve the application of either inorganic or organic (manure) fertilizers. Summer-fallowing is another agricultural practice that has the potential to influence surface and groundwater quality. The degree of sensitivity depends on:

- the type and depth of the overburden above an aquifer; and

- the type of vegetation at the soil surface.

* Sensitive groundwater conditions include areas where the groundwater is used for drinking water (wells) and a) the groundwater is close to the surface, or b) where the soil is very permeable and the groundwater is close to the surface, or c) where shallow bedrock occurs.

In order to prevent groundwater pollution during manure spreading, you must be careful to consider the following practices

- care should be taken when spreading manure where the water table in shallow aquifers is near the ground surface;

- care should be taken when spreading manure in areas where very permeable soils such as coarse sand or gravel and sand are found at the surface and the water table is close to the surface;

- do not spread manure where the overburden above an aquifer is very shallow; and

- care should be taken when spreading manure in areas where shallow bedrock occurs.

Nutrients applied to the soil surface may leach rapidly downward beyond crop rooting depths and eventually reach the aquifer. Since areas with the above noted characteristics tend to be well drained, crop vegetation is often relatively sparse and plant uptake of nutrients is low.

Where such sensitive groundwater conditions exist, manure applications must be avoided or manure must be applied at greatly reduced rates from those recommended in Section 5.4, Application Rate. Consult a professional Agrologist for site specific recommendations in these sensitive areas before applying manure.

5.4 APPLICATION RATE

Nitrogen is usually the nutrient that limits manure application rate. The rate of application will ultimately be determined by:

- the rate at which the nutrients are used by the crop; and

- the reserves of nitrogen in the soil.

(1) Soil and manure testing is important. The application rate is often based on estimated soil and manure nutrient levels which may result in inaccuracies. These inaccuracies may lead to application rates lower or higher than required. The fertility of a field can be determined by soil testing. Ideally the manure must be tested since its nutrient content can vary depending on how the manure has been handled. The application rate can be calculated from this information, together with knowledge of the method of application, timing and soil conditions. Proper soil and manure sampling procedures are shown in Appendix G.

(2) Do not over-apply manure. A moderate over-application will not immediately lead to pollution problems or crop damage, especially in dryland conditions. With excessive application rates, nitrogen and phosphorous will generally accumulate in the soil and this accumulation can be detected through subsequent soil fertility tests. If an accumulation occurs, the rate of application must be reduced accordingly. Recording the manure spreading time and rate on each field is one way to avoid long-term over-application and ensures accurate records if needed.

Tables 5, 6, and 7 provide general rates and schedules of manure applications for various crops, soil types and manure sources.

TABLE 5
Rate and Schedule of Manure Application in Tonnes/Hectare
(crops over 60% legume & a sandy loam soil type)

	Early Spring			1st Cut			2nd Cut			Total		
	S	SL	L	S	SL	L	S	SL	L	S	SL	L
L1	3	4	5							3	4	5
B	4	5	6							4	5	6
T	3	4	5							3	4	5

TABLE 6
Rate and Schedule of Manure Application in Tonnes/Hectare
(crops 30-60% legume and a sandy loam soil type)

	Early Spring			1st Cut			2nd Cut			Total		
	S	SL	L	S	SL	L	S	SL	L	S	SL	L
L1	8	11	14	8	10	13	1.5	2	3	17.5	23	29
B	8	11	14	8	10	13	1.5	2	3	17.5	23	29
T	8	11	14	8	10	13	1.5	2	3	17.5	23	29

TABLE 7
Rate and Schedule of Manure Application in Tonnes/Hectare
(crops over 70% grass and a sandy loam soil type)

	Early Spring			1st Cut			2nd Cut			Total		
	S	SL	L	S	SL	L	S	SL	L	S	SL	L
L1	15	20	25	15	20	25	1.5	2	2.5	33	42	52
B	15	20	25	15	20	25	1.5	2	2.5	33	42	52
T	15	20	25	15	20	25	1.5	2	2.5	33	42	52

(1) Legend:
L1 Layer
B Broiler
T Turkey

Headers:

S Solid manure (tonnes), with 25% moisture content removal base from excretion.
SL Slurry manure (tonnes), (raw manure equivalent as excreted).
L Liquid manure (tonnes), with 25% dilution water by volume. To convert tonnes of liquid manure into Imperial gallons, multiply by 211; US gallons, multiply by 250.
Source: Newfoundland and Labrador Department of Forest Resources and Agrifoods.

5.5 LOSSES DURING STORAGE AND APPLICATION

The nutrient content of manure (particularly nitrogen) declines during collection, storage and disposal/application. This is due to ammonia volatilization, as well as leaching and surface runoff of all soluble forms of nutrients (particularly nitrate). Proper management is important to:

- reduce nitrogen losses;
- maximize the nutrient value of the manure; and
- minimize the potential for soil and water pollution.

Suggested management techniques include:

- using proper facilities for storage and handling (a summary of typical nitrogen losses from various storage and application systems is presented in Appendix E); and
- applying manure to cool, moist soil in fall or early spring and incorporating it immediately when feasible. Fields in perennial forage (hay) are not plowed for the sole purpose of manure spreading.

5.6 SOIL AND CROP IMPLICATIONS

The soil characteristics of the field where manure will be spread must be known. On sandy soils, time the spreading of manure to maximize use of the nutrients by the crop. Limit the application to avoid ponding. Manure must not be applied to soil that has a moisture content greater than its field capacity.* The soil is at field capacity if free water is visible when a handful of soil is squeezed.

The yield potential and nitrogen requirement is considerably higher on heavier textured soils than on well-drained sandy soils. In addition, the risk of groundwater pollution by the leaching of nitrates is greater on lighter textured soils than on clays. Therefore, the allowable manure application rate is higher on heavier textured soils. The Atlantic Provinces have high rainfalls and milder winters. In these areas, extensive nitrate leaching can occur after harvest to freeze-up, during extended mid-winter thaws and again in the spring. Please note, though, groundwater nitrate problems are not widespread in Newfoundland and have generally been confined to local sites within sensitive groundwater areas. In some areas manure or inorganic fertilizers have been applied at excessive rates.

* Field capacity is the maximum amount of water the soil can handle without any water seeping out.

A practical way to determine if there is problem with nitrate nitrogen is to test groundwater (preferably a well) for nitrates.

There is considerable variation in the amount of nitrogen required by different crops. Forage crops such as alfalfa can utilize much more nitrogen than annual cereal crops. Alfalfa is a deep-rooted plant capable of withdrawing nitrates that may have leached out of the soils near the surface. High levels of nitrogen in the soil also presents a problem and therefore, soil testing is important to accurately assess plant requirements.

5.7 ACCEPTABLE APPLICATION RATE

Over-application of manure can lead to the following problems:

- negative effect on crops such as excessive vegetative growth, lodging, and/or delayed maturity; and

- an accumulation of salt in the soil from some manures (periodic soil tests can monitor these situations and indicate if management adjustments are necessary).

A Method of Determining Manure Application Rates for Specific Crops

A method for calculating manure application rates is provided in Appendix H. This method uses information on the manure's composition, soil information and the nutrient needs of the crop in question to determine annual application rates and additional fertilizer requirements.

At the start of a series of annual applications to a field, 30 to 40 kg/ha (25 to 35 lb/acre) additional nitrogen fertilizer may be needed to achieve yield potentials. The reason is that not all of the manure nitrogen is available in the year of application. The nitrogen not available will be a source of residual nitrogen for crops in succeeding years.

Fields receiving annual applications of manure should be tested annually. The samples should be taken at approximately 15 cm (6 in) depth and analyzed for nitrogen, phosphorous and potassium (shallow soils in some areas of the province do not contain this much soil cover).

Consulting with a soils or crop specialist is also useful for unusual site-specific conditions (see Section 10, Sources of Information).

A Method to Determine Minimum Land Area Needed for Manure Applications

Do not to apply manure at too high a rate, particularly on coarse-textured sand and sandy loam soils which constitute about 95% of all soils in the province (see Appendix C to determine the recommended minimum land area needed for your manure). Deep rooted crops such as alfalfa, peas and vetch must be included in the crop rotation to retrieve any nitrates that may have leached down into the soil profile.

Often the costs of handling and applying manure are high, making it non competitive on a pound-per-pound nutrient basis with commercial mineral fertilizers. However, proper periodic applications can result in substantial long-term improvements in the physical characteristics of the soil.

Field Application for Odour Control

Manure spreading is the most common cause of nuisance odour. There are many factors that contribute to the production of odours during application. Good management practices are the best method of minimizing the possibility of complaints.

Minimize Odour

Public Relations

Neighbours are less likely to complain if they understand the problem of the odour control and why manure spreading is a critical component of farming. Neighbours will be more tolerant if they can see a genuine effort is being made to minimize odours. Some specific points to consider are:

- keep the barnyard, manure storage as neat and clean as possible;
- maintain good communications with neighbours. If possible inform your neighbours of your intentions to spread;
- keep transport equipment clean and well maintained to ensure that manure is not deposited on the road; and
- if possible, avoid transporting manure on public roads during periods of high traffic. In some areas, high traffic exists no matter the time of day. However, even in these cases, peak traffic usually occurs early in the morning and late afternoon/early evening, Monday to Friday. It is noted there are other types of slow moving traffic, such as front end loaders and other construction equipment.

Note: Poultry producers can draw one important insight from the subjective nature of odour responses. Odours from the operations of respected neighbours trusted friends and value community supporters are dramatically less objectionable than that of any evasive irresponsible individual. There clearly is a reward for the responsible community member who is appreciated by a neighbour. The reward - fewer complaints.

Weather Conditions

Weather conditions influence the intensity and duration of farm odours. Consider the following factors when deciding when to spread manure;

- **!** manure spread in cool or cold weather will create less odour than manure spread in warm weather;
- **!** wind will help dilute the odours by increased mixing in the air;
- **!** on calm, humid days, rapid drying of the manure and dilution of the odours will not occur;
- **!** if possible, avoid fields a short distance upwind of neighbours during sensitive weather conditions;

Note: The close proximity of forage lands to some urban areas in the Province (such as St. John's) makes it difficult to adopt minimum separation distances to residential properties or residential areas.

- do not exceed recommended rates of application for your soil type. Generally, the period when odours are strongest is during the first 12 to 48 hours after spreading depending on temperature and weather conditions. But, with very heavy applications, odours could last up to 10 days. When spreading liquid manure in sensitive areas, apply it as thin as possible (approximately 50 m^3/ha or 5 mm thick) to maximize absorption into the soil, to enhance drying and to maintain an aerobic environment;

- keep the discharge height of the slurry as low as possible. The higher the trajectory of discharge the greater the release of odours. Listed below are discharge methods in order from least to most effective for odour control:

  – Large gun irrigation,
  – Low trajectory irrigation,
  – Top discharge tanker,
  – Bottom discharge tanker,
  – Dribble bars or booms,
  – Pump and fill tankers release less odours than vacuum filled tankers;

- if possible, incorporate manure into the soil as soon as possible after application. Tilling reduces the release of odours. If applicable, cultivation of manure directly into the soil is an excellent method of odour control. The forage land in the St. John's area is only cultivated every few years, hence it will be seldom practical to incorporate manures in such areas; and

- particle size or droplet size of applied manure influences odour release. Small droplets have more surface area and tend to drift more. This allows for more odourous gases to be released quickly.