2.10 VEHICLE SPREADING

Vehicle spreading involves pump-spraying farm dairy effluent, drawn from a storage facility (i.e. large sump, holding pond or oxidation ponds) from the rear of a vehicle onto the land. The vehicle spreader applies the effluent up and down the paddocks in strips, until the application site is completely covered, and the storage facility is sufficiently drained.

Vehicle spreading is a permitted activity under many Regional Councils' plans providing certain conditions are met such as nitrogen loading (check with your Regional Council for requirements). It is popular with many farmers as effluent can be applied to any part of the farm, including undulating country, and is not restricted to the same area at each application.

Furthermore, vehicle spreaders can apply effluent of a higher level of solids than is possible with spray application systems.

When a tank is used, a trailer with a 7000 litre tank may require up to a 100 hp tractor. Unfortunately, **tractors used to tow the tank are often required for other farm work.**

Soil compaction is a common problem with vehicle spreading, especially around paddock gateways where exposure to the heavy vehicle is frequent.

Vehicles weigh up to 1 tonne and commonly carry up to 7000 litres (i.e. 7 tonnes) of effluent. The number of trips into a single paddock can be substantial (i.e. up to 20 loads per hectare), so races and gateways receive excessive heavy traffic.

When farmers using vehicle spreaders are forced to apply effluent when it is too wet, owing to lack of storage capacity, **damage occurs to the grass sward and to the topsoil** because of deep wheel tracks and ponding in depressions. This can affect the ability of soils to take up water (i.e. infiltration) and cause drainage problems.

However, a 'do-it-yourself' application with hired equipment may not be as good, and application will typically take farmers, who have other work commitments, four times as long.

2.10.1 Application depths and rates

It is critical that the vehicle spreader has the ability to apply a **small application of effluent per pass (mm)** to avoid nitrogen overloading and leaching. Nutrient analysis and a nutrient budget will help to assess appropriate application rates.

The required hydraulic loading is dependent on the soil type. To achieve the best response from the application of effluent it is better to apply several light applications rather than all the effluent at one time (i.e. down to 15 mm). It is also better to apply the effluent slowly to avoid runoff (i.e. down to 10 mm per hour).

For recommendations for various soil types refer to 2.4.2 Recommended applications for common soils and 2.4.3 Planning the periods of application.

The application depth per pass and **application rate** can be calculated using the following formulae:

$$\text{Application depth (mm)} = \frac{\text{Volume of tank (m}^3\text{) x 1,000}}{\text{Wetted width (m) x Distance travelled (m)}}$$

$$\text{Application rate (mm per hour)} = \frac{\text{Application depth (mm)}}{\text{Time tank takes to empty (hour)}}$$

The **required travel distance** of the vehicle spreader (to obtain the correct application) can be calculated using the following formula:

$$\text{Required travel distance (m)} = \frac{\text{Volume of tank (m}^3\text{) x 1,000}}{\text{Wetted width (m) x Required application (mm)}}$$

2.10.2 Vehicle spreading systems

There are two vehicle spreading systems currently used world-wide. The **method traditionally used in New Zealand** involves pumping effluent from the storage facility into a tanker and transporting it to the application site (refer to Figure 2.10-1).

The alternative **umbilical system**, not used in New Zealand because it has proven uneconomical, involves piping the effluent from the storage facility to the vehicle spreader at the application site.

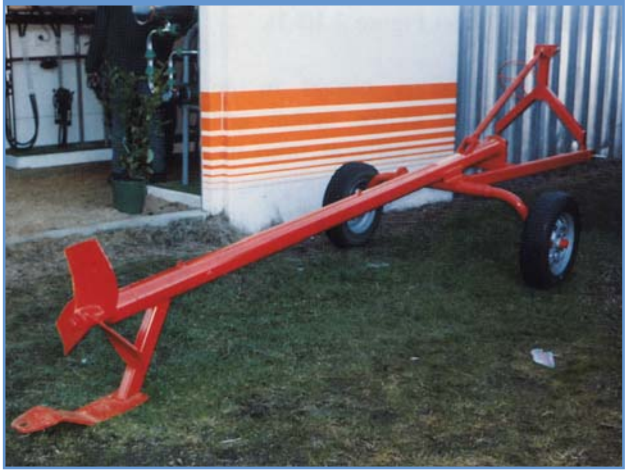
With vehicle spreading, **it is essential that the correct receiving area is calculated** before effluent application (check with your Regional Council for requirements).

FIGURE 2.10-1

A VEHICLE SPREADING TANK AND TRACTOR

FIGURE 2.10-2

POND STIRRER



The effluent must be stirred, to mix the various layers into a liquid slurry, before removing it from storage.

Stirrers are commercially available, and consist of a spinning arm or heavy propeller driven by the PTO (refer to Figure 2.10-2).

When stirring ponds, take care backing the tractor close to where the ground slopes away. If the tractor slopes back too far, lubricating oil in the tractor engine will fall away from the front crank bearing, damaging the engine.

Stirrers also place a considerable pull force on tractors. Ensure that the tractor is adequately braked into position, so that it cannot be pulled toward the pond.

2.10.2.1 Effluent collection

Effluent collection can be carried out in one of two ways:

- overflow from the storage facility can be gravity fed through a pipe, leading to a collection point for the tanker
- the tanker can be backed close to the storage facility, and effluent drawn into it by a PTO-driven pump and suction delivery hose.

In both situations, the delivery pipe should have a strainer to prevent solid material from entering, wearing and damaging the vehicle spreader's pumping system. The store should be arranged so that the contents can be easily emptied for spreading without spilling them.

Where effluent is drawn into the tanker by a PTO-driven pump, **self-filling mechanisms** can aid the filling of the tank by saving the operator from having to handle slurry pipes. Tank filling is made safer as operators are kept away from the storage facility and PTO-driven pump.

Self-filling mechanisms consist of **a suction pipe on the tanker being coupled to a stand pipe, suspended on a frame** (refer to Figure 2.10-3).

The stand pipe is placed in an accessible point to the tanker and where it can draw effluent from the storage facility. The suction pipe is swung into position, aligned and clamped by a hydraulic ram into the cone shaped fitting on the end of the stand pipe. The operator can then open the filling valve and set the pump to vacuum.

A flexible rubber skirt provides a tight seal once the vacuum pump starts running.

Alternatively, **a hydraulically operated filling pipe can dip into the storage pond.** Difficulty may arise if the fencing around the pond needs to be dismantled for the tanker to get close enough for filling, so include a suitably designed gate in the fence line.

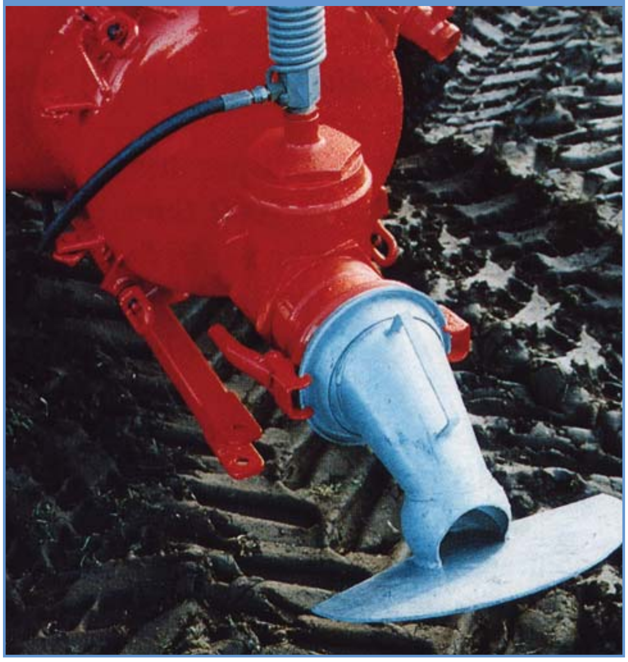
Self-filling mechanisms are commercially available and can be supplied as a kit to fit existing tankers.

FIGURE 2.10-3

STAND PIPE AND SELF-FILLING MECHANISM

FIGURE 2.10-4

TANK OUTLET AND SPLASH PLATE



2.10.2.2 Effluent application

Vehicle spreaders pump the effluent from the rear of the tank onto land in one of three ways:

- **onto a splash plate** which deflects the liquid into a spray pattern (refer to Figure 2.10- 4)
- **via a 'big gun' that has 'swivel control'.** The swivel is controlled from the tractor cab
- **through a trailing applicator** consisting of a folding boom with lie-flat hose drop pipes. The pipes distribute the effluent directly on to the pasture in bands. This method creates no spray drift and less odour problems than the splash plate system.

In most cases, effluent is applied in strips, with a spread roughly similar to that of the vehicle's wheel base (i.e. 2 m to 3 m). The vehicle spreader runs up and down the paddocks until the complete application site is covered.

With the 'big gun' the vehicle spreader can run up and down raceways, applying the effluent over the race fences and onto the pasture.

The land can be worked prior to effluent application. Working the land can prevent surface ponding on flat land or effluent runoff from sloping land.

Simple spiked rollers, which encourage rapid effluent infiltration by breaking up the soil surface, are commercially available and can also be hired. The roller attaches behind the spraying tanker and uses its weight to puncture the soil with hollow spikes. Spiked rollers are particularly useful where a shallow surface pan has developed, or undulating country is being treated.

The time involved in vehicle spreading effluent is typically **20 hours for every 1,000,000 litres.** The time can be reduced with larger tankers and experienced contractors.

Late spring, for silage and hay paddocks, and mid-summer, to combat dry weather, are the best seasons for vehicle spreading.

2.10.2.3 Costs of vehicle spreading

The cost of using a vehicle spreading system depends on whether equipment and machinery are purchased or hired, and whether contractors are used.

When purchasing equipment and machinery, the capital outlay for a vehicle spreading system ranges between $21,000 and $40,000 (refer to Table 2.10-1) depending on what equipment can be hired and what is eventually purchased.

TABLE 2.10-1

ESTIMATED COST OF VEHICLE SPREADING EQUIPMENT			
Equipment and machinery		**Cost ($)**	**Notes**
Vehicle spreader			Includes the tank, hydraulic brakes and PTO driven pump
	5000 litre tank	17,000 – 20,000	Requires a 70 hp tractor
or	7000 litre tank	20,000 – 25,000	Requires a 90 hp to 100 hp tractor
Pond stirrer		3,900	Necessary to mix in solid and liquid fractions before spreading
Self-filling device		3,500	Optional tank filling system
Spiked roller		7,500	Optional soil conditioner to ensure effluent infiltration
TOTAL CAPITAL COST: Between $21,000 and $40,000			

2.10.2.4 Contractors

Contractors using vehicle spreaders generally charge by the hour for cleaning out ponds and spreading effluent onto the land, from the time of arriving at, to the time of leaving from the farm gate. Although this may encourage the contractor to stretch out the job, correct coverage is ensured and the quality of the application should be excellent.

Charges range up to **$80 per hour.** A usual working pace is eight tank loads an hour each carrying 5000 litres to 7000 litres (i.e. 50,000 litres per hour per $80). Therefore, a typical contracting charge will be **$1600 for every 1,000,000 litres** of applied effluent. Some contractors are able to supply two spreaders operating together. This significantly reduces the contractor's charge while on the hourly rate.

The annual cost of having a contractor clean out **holding ponds** and apply the effluent to the land will generally be **spread over two or three visits** by the contractor over the drier seasons.

Contractors must take responsibility for the correct application of effluent on to the land in compliance with Regional Council standards. Therefore, contractors should guarantee a good job. However, farmers or farm employees can still be held liable, especially if they are aware that the contractor is not operating to the required standard. Farmers have a responsibility to ensure the contractor is aware of Regional Council rules and specific consent requirements.

2.10.2.5 Equipment hire

Vehicle spreading equipment can be hired in some areas. Standard costs are up to **$180 per day for hire plus fuel.** A day generally refers to 24 hours.

The speed and quality of the job are dependent on the experience of individual farmer operators and the time available for doing the work. A 'do-it-yourself' application with hired equipment may not be as good as the job done by an experienced contractor, and application will typically take farmers, who have other work commitments, four times as long.

The probable time will be **four days for every 1,000,000 litres** applied to land. Therefore, a typical hire cost is **$900 for every 1,000,000 litres** of applied effluent plus farm labour costs.

2.11 BORDER DYKES

Border dyke systems use slightly sloping land and gravity to transmit the farm dairy effluent from a point of discharge to the application site by flooding the land surface.

An advantage of land flooding is that **the foliage is not contaminated by the effluent.** It is palatable to stock almost immediately following treatment.

Land flooding has a lower running cost than a spray application system, since the soil conveys the effluent. However, **extensive earthworks are involved** in land levelling and establishing border dykes to allow successful effluent reticulation.

To operate effectively, **a land flooding system requires a large volume of liquid to be applied at one time.** Hence, land flooding has been successfully used with municipality and food processing effluent, which is largely water that is relatively low in solids.

The system is used for dairy effluent in some regions where border dyke irrigation systems are in place. This is because the effluent can be diluted with irrigation water within the irrigation system already in operation.

However, Regional Councils and farmers do not favour land flooding or border dyke systems and these are being phased out for the following reasons:

- due to a lack of flow control, **applied effluent is easily lost to surface runoff and to percolation below the root zone,** polluting groundwater and surface water
- the free-draining soil necessary for the system to work **allows most of the effluent to filter into the soil very close to the point of discharge** without reaching the bottom of the application area, resulting in uneven application. This can be likened to a point discharge and can result in a breach of Regional Council regulations
- **highly permeable and highly impermeable soils are difficult to flood evenly,** and so are unsuitable for land flooding
- ditches and ridges **reduce the area that can receive the effluent.** The land contour also encourages concentration of rainwater in hollows during the wet seasons and creates subsequent drainage problems, and presents difficulties in harvesting crops grown on land that has been flooded
- weed growth in channels and drains is increased. With this and the build-up of solids on the channel floor, **regular clearing and maintenance is required.**

Wild flooding (i.e. outside a border dyke system) should not be used to apply effluent to land.

FIGURE 2.11-1

EFFLUENT DELIVERY FROM A FEEDER DITCH

2.12 PROCESSING OPTIONS PRIOR TO LAND APPLICATION

Solids separation or anaerobic digestion are pre-processing options that require extra facilities or equipment but can be useful, especially for effluents with high solids and nutrient content (e.g. slurry from feed pads).

A storage pond acts as a system for settling out solids from liquid in situations where effluent is stored prior to land irrigation. However, solids must then be periodically removed from the pond and also applied to land. The liquid effluent may still contain sufficient solids to block up irrigator nozzles. Alternatively, a means to separate solids can be employed so that only liquid effluent passes into storage ponds or irrigation systems.

These methods have the advantages of:

- **Causing less blockages in equipment. This is particularly beneficial for sprinklers with smaller nozzles (e.g. 'pod'-type systems).**
- **Providing more dilute effluent with low solids that can be pumped over a greater distance for irrigation.**
- **Possibly reducing the amount of land required for irrigation because of the lower nutrient concentration in liquid effluent (provided soil conditions are suitable for the liquid loading and K levels are low enough in the liquid effluent).**
- **Creating other useful products. Solids separation provides a solid fertiliser** with high organic matter and nutrient value that can be incorporated into cropping land or paddocks at re-grassing. **Anaerobic digestion provides biogas (methane)** that can be used as a power source.

2.12.1 Gravity systems

The simplest system for removing liquid from solids is separation via gravity.

The appropriate means to do this depends on the liquid content of the effluent, slurry or sludge. Slurry scraped from the farm dairy or feed pad can be placed in a storage bunker or a 'weeping wall' type structure, and the liquid allowed to drain out. Alternatively, ramp systems can be devised where manure from the pad is scraped to the top and left to drain and dry out. Where effluent has been removed by washing down, solids can settle out in drying beds with a 'weeping wall' outlet that allows liquid to escape and be fed or pumped into a storage pond for irrigation.

It is essential that any solids are stored on a properly sealed and contained site, and that liquid is not allowed to drain into the soil where it could pollute groundwater. Instead, liquids must be directed into a sealed treatment pond or stored before land application.

Storage facilities should be sited at least 45 m from the farm dairy.

All storage facilities must be designed and constructed to stand up to the load of the stored material and safely contain it.

'Herd Homes' also use gravity followed by evaporation to leave a bunker manure or semi-dried solids product. In these facilities, effluent deposited on the floor drops through concrete slats into bunkers. It becomes partially or wholly dehydrated over time in the warm conditions created by the 'greenhouse' type roof of the Herd Home structure. Where Herd Homes are used for only a limited period over winter, the effluent in the bunkers will tend to dry out completely over summer months. However, where stock are using the facility year-round and shade cloth is placed on the roof for summer cooling, manure in the bunkers is reduced to a 'dung pat' consistency but not fully dried. In either case, the bunkers are emptied periodically with machinery and the solids or sludge are applied to land using a 'muck spreader' (refer to 2.8.2 Sludge spreading).

Solids that have been separated by gravity can have high nutrient concentrations and a nutrient analysis and nutrient budget should be used to assess land application rates. Where dehydration has occurred, K is likely to be particularly high in relation to N, and so K may be the limiting factor in determining land application rates. Refer to 4.2.2 Effluent content to see the typical nutrient content figures for feed pad and Herd Home effluent. K can also be high in post-separation liquids (refer to 2.12.2.1 Content of separated solids and liquid).

2.12.1.1 Storage facilities for feed pad slurry

A typical system to receive scrapings from a feed pad has a reception store next to the pad (refer to Figure 2.12-1). A grid covers the reception store floor or walls to allow liquid through, and/or the floor is sloped so that liquids can drain away to the effluent treatment system. Effluent solids and long fibres such as hay are retained.

The base and walls of storage facilities should be impermeable to contain liquids and to prevent groundwater getting in if below the ground. General design considerations for such storage facilities are as follows:

- above-ground storage is the most practical and is necessary where there is a high seasonal water table
- animal wastes are corrosive. Therefore, all materials which they contact, whether timber, concrete or steel, should have their surfaces treated
- a polyethylene cover or complete roof will prevent rain entering the store
- a series of stores will allow one store to be filled and left to drain while another is being filled
- drainage outlets are required to allow liquid to be collected during sludge drying
- a suitable access area, able to support loaders and spreaders should surround the store
- the facility should be as close as possible to the feed pad so that the sludge can be scraped across the floor and to the store. However storage areas must be 45m from the farm dairy.

FIGURE 2.12-1

RECEPTION STORE FOR FEED PAD SCRAPINGS

Photo provided by Bob Longhurst, AgResearch

If yard levels will allow, it is desirable to fill the storage facility from above. Otherwise, a loading ramp will be needed. These should have:

- an incline of no more than 1 m in 8 m to prevent wheel-slip in damp floor conditions
- a restraining rail to prevent the vehicle from driving off the ramp
- the ramp width matching the scraper blade width.

The size of the store needed is calculated from the volume of effluent (related to duration of use) and the volume of soft bedding (for a stand-off pad). The volume of effluent likely to be deposited on a feed pad can be calculated from figures given in 4.2 Volume and characteristics of effluent. Add to these the volume of any bedding material that may be scraped into the solids store.

Storage bunker design for sludge and semi-solids

Walls of storage bunkers should be constructed on three sides with an entrance at the bottom end. The walls may be of concrete or timber construction, with sturdy retaining walls enclosing and retaining the sludge and semi-solids (refer to Figure 2.12-2).

Concrete walls can be of reinforced concrete or concrete block. If using timber, have rolled steel joists (RSJ's) set into a substantial concrete foundation and set timber panelling onto them.

The compound walls may be up to 2 m high and the sludge and semi-solids can be stored to a higher level than this. Walls must be strong enough to contain the waste and resist the weight of vehicles pushing against them. A concrete pad strong enough to withstand the weight of fully laden vehicles should slope towards the open end. Vehicles can then drive into the facility to load and off-load. The concrete floor should have a minimum fall of 1 m in 100 m towards drainage outlets.

Liquid effluent will drain from the sludge and semi-solids. Construct a grated channel lying across the entrance to collect liquid runoff. For very wide compounds lay a further drain down the centre with the concrete floor sloping to the channel. Channels should be wide enough to allow clearing with a shovel and have a fall of 1 m in 100 m. The runoff can then drain into facilities storing other liquid effluent and be treated or applied to land.

Weeping-wall stores for sludge or slurry

Weeping-wall sludge stores are normally built above ground on a concrete base (refer to Figure 2.12-3). Excess liquid drains through narrow slots in the walls, is collected in a channel, and is carried to the liquid effluent facility.

The weeping-wall store is particularly suitable for wastes containing a lot of fibre (e.g. wastes from feed pads or wintering pads). The contents of the store gradually dry out, so the removable side panels can be safely taken out to access the solids for spreading on to land (usually in late summer).

The walls are typically 2 m high and the sludge is stored at least 300 mm lower than this. The design of the weeping-wall store is similar to that of the concrete or timber banked compound - precast concrete panelling or RSJs set into a concrete foundation and supporting timber panelling. The differences in the weeping-wall store are as follows:

- the compound is fully enclosed by four walls. Some panels are easily removable to empty the contents. These removable panels should be opposite the filling point
- the panelling is spaced with horizontal or vertical gaps to allow excess liquid effluent to drain away. Pre-cast concrete panels should have slots down them, or the horizontal timber panelling can be spaced at these widths. The spacing of these slots depends on the fibre and solids content of the material being stored. For thick and fibrous effluent, gaps may be 25-35 mm. For more liquid slurries, gaps may be as little as 5-10 mm. There must be enough fibre within the scrapings so that manure slurry does not run out through the slots. Building the wall with adjustable slots will give flexibility for different fibre content
- the concrete pad extends outside the walls to collect runoff from the weeping walls and carry it to a liquid effluent storage facility.

A drainage channel should completely surround the store to collect all runoff. Channels should be wide enough to allow clearing with a shovel and be installed with a fall of 1 m in 100 m.

2.12.1.2 Solids settling beds for wash-down effluent

Where effluent is more liquid (i.e. from a surface that has been washed down rather than scraped), a weeping wall structure can still be used for initial settling of solids before transferring liquids to a holding pond for irrigation. In this case, the settling bed may be dug into the ground and a weeping wall outlet created at one end (refer to Figure 2.12-4). Slots in the weeping wall will generally be set to give 5 mm gaps. The structure must be lined and designed to withstand the load of the liquid (consult an engineer for advice).

FIGURE 2.12-2

STORAGE COMPOUND FOR DRYING FEED PAD SLURRY

Photo provided by Bob Longhurst, AgResearch

FIGURE 2.12-3

WEEPING WALL STORAGE FOR FEED PAD SLURRY

Photo provided by John Scandrett

FIGURE 2.12-4

WEEPING WALL SETTLING BED FOR DAIRY EFFLUENT

Photo provided by John Scandrett

2.12.2 Mechanical solids separation

Mechanical solids separation methods can achieve high rates of solids removal from both farm dairy and feed pad effluent. The effluent is typically pumped from the sump to the solids separator, which removes and stockpiles the solids product for later land application. The liquid is held in a storage facility for irrigation.

Mechanical separation is ideal for feed pad effluent that contains high fibre content, which could otherwise lead to pond in-filling and/or blockages and wear of irrigation equipment. It is generally suited to large operations, which can generate 30-40 m^3 of waste a day. Removing solids greatly reduces the volume of effluent for storage and makes it more manageable. It also removes a proportion of the N (within the solid material). Therefore the liquid fraction can be irrigated over a smaller area, as long as K levels and hydraulic loading of the soil permit (refer to 2.12.2.1 Content of separated solids and liquid). This is also useful for feed pad effluent, which can have four times the N concentration of farm dairy effluent.

The two types of mechanical solids separators most commonly used in New Zealand are:

- Screw press separators – the effluent is forced under pressure through one or more layers of fine mesh screens to separate the solids and liquids. Screw press separators are normally built on raised platforms over concrete pads so that solids (15-25% DM) can pile up below for easy removal (refer to Figure 2.12-5).
- Belt presses (pressure separators) – these are continuously fed dewatering systems that use chemical conditioning, gravity drainage and mechanically applied pressure to dewater the manure. These belt-pressed solids come out at between 30-50% DM (refer to Figure 2.12-6).

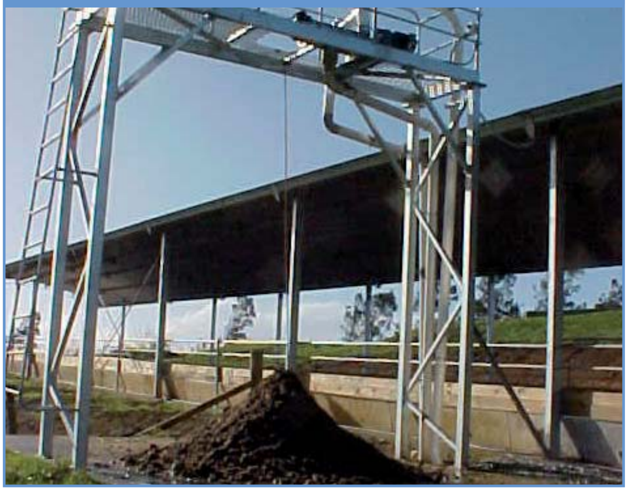
Prices for mechanical separators range from **$15,000 to $45,000.**

FIGURE 2.12-5

FAN SCREW PRESS SEPARATOR ON OVERHEAD STAND

FIGURE 2.12-6

PRESSURE SEPARATOR ON OVERHEAD STAND



Photos provided by Bob Longhurst, AgResearch

When planning for a mechanical solids separation system, consider the following:

- **Sufficient storage facilities are still required for effluent prior to separation**
- **All handling equipment should be placed so that if any effluent is spilt it will flow back to the farm dairy sump**
- **There should be plenty of storage space for separated solids and liquids** so that the farmer is not forced to immediately apply effluent to land when it is undesirable
- **The separated solids should be covered** to prevent rainwater infiltrating and creating liquid effluent again
- **Land area and machinery are required** for land application of solids in addition to liquid effluent. Solids should be applied to land in compliance with Regional Council rules
- **Mechanical separators have to be regularly inspected and maintained.**

2.12.2.1 Content of separated solids and liquid

Mechanical solids separation can typically reduce an effluent with a concentration of 3-7% solids to a liquid of 0.2% solids and significantly lower nutrient concentrations. The resultant solids fraction is approximately 21% solids and has higher nutrient concentrations (refer to Table 2.12-1).

TABLE 2.12-1

TYPICAL SOLIDS AND NUTRIENT CONCENTRATIONS (%) OF VARIOUS EFFLUENTS

Effluent	Volume	Solids	N	P	K
Pre-separation	100	3.6	0.120	0.020	0.080
Post-separation solids	6	21	0.360	0.065	0.120
Post-separation liquid	94	0.2	0.020	0.003	0.025

Land area for effluent application is largely governed by nutrient concentrations (N or K). Removing solids means that the liquid feed pad effluent can be applied to a smaller area of land while still meeting N loading requirements (refer to 4.3.2.2 Land area for feed pad effluent). However, the ratio of N to K changes as solids are separated out, since K is largely in soluble forms and remains in the liquid fraction, while a portion of the N is in solid form (particulate or organic N) and is separated out in the solid fraction. In working out land areas for application, the K content of the liquid should be carefully considered as well as the N content, as K loading may be the critical factor for irrigating post-separation liquid effluent. The solids product can be N-rich and this needs to be taken into account when applying to land. As both N and K levels can be variable in both solid and liquid fractions, a nutrient analysis and nutrient budget should be carried out to determine application rates accurately.

Hydraulic loading (the capacity of the soil to absorb moisture) also needs to be considered if land application of liquid effluent is planned over a reduced area (refer to 2.4.2 Recommended applications for common soils).

2.12.3 Anaerobic digestion

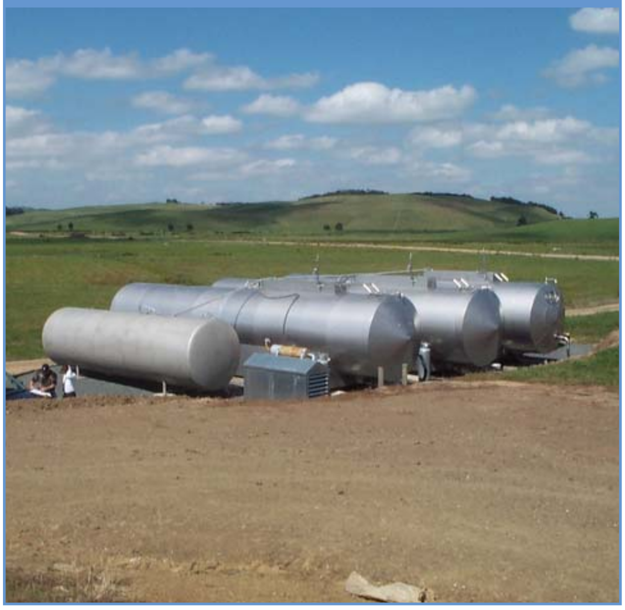
In anaerobic digestion, effluent from a holding pond is stirred into a slurry and usually mixed with water before being pumped into the digester facility. A number of separate digestion tanks are typically used, taking 40 days to digest effluent (refer to Figure 2.12-7 Methane digesters). **The end products are energy and a post-digestion effluent.**

Plug-flow digesters are a lower cost technology being specifically designed for New Zealand dairy farms. A plug-flow digester is a trench, (typically this could be 3 m deep by 3 m wide by 20 m long) which is either constructed of concrete or dug into the ground and lined with a heavy plastic liner. It is a 'constant volume digester', where manure feeding in at one end displaces an equal amount of digested effluent at the other end. The effluent spends around 20 days in the digester. **A solids concentration of more than 8% is required,** so this digester is appropriate for effluent slurry that has been scraped, rather than washed, from the farm dairy or feed pad. There is no mixing in the plug-flow digester but effluent is pre-mixed in a tank before entering the digester to achieve the correct solids content. There is no requirement to clean out the plug flow digester, or to filter the liquid after digestion, as solids are removed in the digestion process.

A digester tank system with the capacity for 1000 cows costs around $135,000 and is cost-effective only for large herds where effluent is collected from intensive feed pad or wintering systems. **A plug-flow trench system can be built for around $20,000** (suitable for slurry or scraped effluent only). There are also safety issues to be aware of with digesters as the gases produced are explosive and toxic.

FIGURE 2.12-7

METHANE DIGESTER



2.12.3.1 Post-digestion products

Anaerobic digestion is not yet common in New Zealand, so the typical content of the post-digestion effluent has not yet been established. One analysis showed a 5% solids content and nutrient concentrations of 0.11% N, 0.04% P and 0.135% K. Digestion removes solids by breaking down carbon material, but it does not remove N and K. Therefore, the post-digest liquid is not as low in nutrients as liquid from mechanical solids separation where particulate N is removed. A nutrient analysis and nutrient budget are recommended to ensure appropriate land area for irrigating the post-digestion liquid.

Significant energy can be generated by anaerobic digestion. One day's effluent collected from the farm dairy and feed pad from a 1000 cow herd can produce enough methane to generate 3-phase power at 22-25kW for seven hours, or 170kWh (worth about $27). This is a substantial contribution to overall power costs.

If effluent is left to decompose anaerobically outside (e.g. in an effluent pond), methane will be released into the atmosphere. However, capturing the methane and burning it as fuel is an alternative that will generate 'carbon-neutral' energy for the farm. (Pond covers can also be used over a normal anaerobic pond to capture the gas being given off).

The methane from anaerobic digestion can be used directly for gas heating or refrigeration, or it can be converted to electricity with a generator. If a retrofitted petrol or diesel engine is used, typically there will be a 30% efficiency of conversion to electricity with a further 40-60% of the energy converted to heat. This heat can then be harvested by drawing the hot water from the engine's cooling system and by fitting a heat exchanger to the exhaust of the generator. The resulting hot water can be circulated either through pipes inside the digester or via a water jacket around it to warm the chamber, speeding up the digestion rate and reducing the size of digester required to process the effluent.

2.12.4 Other methods

Emerging technologies for separating solids include perforated geotextile tubes developed for housed animals. Farmers are also constantly innovating and developing practical designs for storing effluent and separating solids. Research into options that are currently available and those systems proving useful is recommended at the design stage.

2.13 LAND APPLICATION REGULATIONS

Farm dairy effluent is applied to land with an application system, and in such a way, that is compatible with the:

- **infiltration rate of the soil**
- **ability of the pasture to utilise nutrients such as N, P, K and S**
- **ability of the environment to deal with the effluent.**

The system is designed around these limitations.

Furthermore, in view of these limiting factors, **Regional Councils** and the **New Zealand Food Safety Authority in conjunction with the Dairy Industry** have regulations governing the design of land application systems and how effluent is to be applied.

2.13.1 Food safety and dairy industry requirements

New Zealand Food Safety Authority rules, developed in conjunction with the Dairy Industry, are primarily focused on human and animal health. Apart from containing beneficial nutrients, effluent may contain transmissible animal diseases.

The health and hygiene practices on the farm and within the farm dairy are closely monitored by overseas markets and have a considerable effect on the marketability of dairy products. Hence, the Dairy Industry works closely with the NZ Food Safety Authority to develop hygiene regulations that must be followed to help promote the industry to overseas consumers.

2.13.1.1 Human and animal health

Consideration should be given to any harmful components in applied effluent and possible detrimental effects from using the effluent as fertiliser. Effluent can contain a wide variety of disease-causing micro-organisms including **bacteria, viruses, cysts**, and **eggs and larvae of parasites** (e.g. hookworm, roundworm and tapeworm).

The survival of various disease-causing micro-organisms during effluent storage and treatment can be summarised as below:

- the majority of intestinal **bacteria** die off very quickly in the pastoral environment, and are the most fragile of the four groups of disease-causing micro-organisms. Their numbers are greatly reduced by sunlight and drying but will survive longer if lodged in cracked or split plant surfaces as there they are protected from the prevailing environment. Bacteria will persist longer in the soil than on crops and pasture
- generally **viruses** do not survive well in an exposed environment as they are deactivated by exposure to sunlight and drying conditions. Spray application will shock viruses and increase their die-off considerably. Viruses on crops have similar survival times to bacteria, and may persist in the soil for several weeks or months
- **cysts** persist for only a matter of hours on crops and pasture. Of all the disease-causing micro-organisms, cysts are the most susceptible to drying and elevated temperatures. They can survive for longer periods in the soil and in water
- in contrast to bacteria and viruses, **eggs and larvae of parasites,** once applied to land, are stable in the soil environment and may remain viable for a long time.

Disease-causing micro-organisms present in effluent originate mainly from stock and so **the levels of micro-organisms reflect the current state of health of the herd.** Therefore, with **good husbandry practices**, effluent originating from dairy cows should be free of major diseases if applied correctly. With suitable s**tock withholding periods prior to grazing** (i.e. at least 10 days) no health problems should occur.

A withholding period allows maximum exposure to sunlight, which will kill most disease-causing micro-organisms and provide the opportunity for the effluent fertiliser to be washed into the soil by moisture.

2.13.1.2 Specific diseases acquired from animals via effluent

Leptospirosis: Farmers usually acquire the disease from the urine of animals infected with Leptospira bacteria. Working in drains may also expose farmers to leptospiral organisms, via contact with contaminated soil.

Campylobacter and Salmonella infections: Farmers can acquire these bacteria by eating contaminated food and drinking contaminated water.

All these diseases and others can be prevented by observing the following principles:

- **eliminate the disease-causing organisms from the animals.** Vaccination of animals using the correct vaccination schedule is imperative. Occupational Safety and Health legislation requires farmers to vaccinate stock against transmissible animal diseases (e.g. leptospirosis)
- **avoid contact with potentially contaminated effluent or wear protective boots and gloves** when work necessitates contact with the effluent
- **provide for adequate drainage**
- **thoroughly wash hands** following contact with effluent
- **thoroughly wash crops,** prior to human consumption, that have been grown on soils treated with effluent
- **avoid consumption of unchlorinated water** and **protect drinking water from contamination** by effluent.

A problem with **worms** in stock could also occur. This is most likely with a heavily stocked herd with a high percentage of younger cows.

Calf paddocks should not be treated with effluent as calves have not developed immune responses to the degree of older animals and are more susceptible to infection.

2.13.1.3 Food safety, dairy industry and health regulations

Food Safety regulations for the dairy industry (i.e. the Farm Dairy Code of Practice NZCP1) require that **large storage sumps** (i.e. those sumps where the effluent is not immediately pumped or gravity fed into ponds) **are not to be located within 10 m of the farm dairy** (i.e. milking area, milk receiving area and milk storage area). Effluent **may not be disposed of within 45 m of the farm dairy.** This includes ponds, treatment ditches and places where effluent is applied to land.

Occupational Safety and Health regulations require stock to be vaccinated against harmful animal and human diseases (e.g. leptospirosis).

When developing Regional Plans, Regional Councils obtain input from health authorities and the Health Act (1956) is considered.

Health considerations must also be considered when applying effluent sludge onto land (refer to 2.8 Land application of sludge).

2.13.2 Regional Council requirements

Effluent can place pressure on the environment if it reaches groundwater or surface waterways. The nutrients in effluent can stimulate algal growth in waterways and the concentrated ammonia in effluent can be toxic to aquatic life. The biological oxygen demand produced as the effluent is broken down in the aquatic system may also degrade the waterway's habitat value.

Nitrate or faecal pathogens in drinking water are considered a health risk.

Care must be taken to ensure both surface and ground water supplies are protected, by allowing appropriate buffer zones and managing application rates carefully.

Effluent loading rates are also important. Application of effluent at rates that can be utilised by the pasture or crop pose least threat to groundwater or surface water. This is why N loadings are either required or recommended by most Regional Councils, commonly at 150-200 kg/ha/yr (check with your Regional Council for requirements).

Application at higher rates will result in larger leaching losses and consequently higher nitrate concentrations in groundwater.

Soils most prone to leaching of N, and also K and S, are the high permeability soils including peats, pumices, sands and ash soils (refer to 2.4.2 Recommended applications for common soils). The following points regarding the leaching of nitrates following effluent application to land should be noted:

- **leaching losses can be high from soils ploughed, subjected to effluent application and then left fallow over an extended period as there is no plant uptake.** This is a particular problem with winter fallow when rainfall is high
- **leaching losses are generally lower with pasture cut for hay and silage**
- **higher leaching losses occur with vegetable cropping than with pasture systems**
- **with all crops, leaching loss depends on the application rate relative to plant requirement and soil conditions. The latter is affected by rainfall and drainage conditions.**

When determining solid fertiliser requirements in addition to the effluent, care should be taken and a nutrient budget prepared to avoid wasteage and water quality problems. Some Regional Councils have rules limiting the use of fertiliser-N on land already receiving applications of effluent (check with your Regional Council for requirements).

There is unlikely to be a need for N fertiliser to be applied to soils that receive effluent. A nutrient budget can help to assess this.

2.13.2.1 Regional Council regulations regarding effluent applied to land

Each Regional Council has different rules for the application of effluent onto land. Regional Councils may also have different rules between catchments within the same region therefore check with the Regional Council for the relevant rules. Table 2.13-1 outlines what the activity in each region is classified as. A permitted activity has certain conditions that must be met but does not require a resource consent, whereas a controlled, discretionary, restricted discretionary or non-complying activity all require a consent before the activity can commence. For more information on the different classifications of activities refer to section 5.3.1 What is a Regional Plan. However, if the conditions of the activity cannot be met then the classification is likely to be more restrictive. For example if the conditions of a permitted activity rule cannot be met then it is likely to be classified as a controlled or discretionary activity and therefore a consent would be required.

Table 2.13-1 is a summary and should not be used for legal purposes. To obtain the information in full, request the Regional Plan(s) pertaining to soils, water and air quality from the Regional Council. The classifications of these activities are current (January, 2006) and may be subject to change by the Regional Councils.

TABLE 2.13-1

ACTIVITY CLASSIFICATIONS FOR THE DISCHARGE OF FARM DAIRY EFFLUENT ONTO OR INTO LAND	
Regional Council or Unitary Authority	**Type of activity**
Northland Regional Council	Permitted
Auckland Regional Council	Permitted
Environment Waikato	Permitted
Environment BOP	Discretionary
Gisborne District Council	Discretionary
Hawke's Bay Regional Council	Controlled Discretionary (if located in sensitive catchments as identified in Rule 15)
Taranaki Regional Council	Controlled
Horizons	Controlled
Greater Wellington	Controlled
Marlborough District Council	Permitted (if located within the Marlborough Sounds Resource Management Plan) Controlled if under the Wairau/Awatere Resource Management Plan
Nelson City Council	Permitted
Tasman District Council	Permitted
Canterbury Regional Council	Controlled
West Coast Regional Council	Permitted
Otago Regional Council	Permitted
Environment Southland	Permitted (less than 50 cows) Controlled (more than 50 but less than 600 cows) Discretionary (over 600 cows)

Conditions that Regional Councils may place on permitted activities or resource consent will generally include a mixture of the following:

- **adequate storage.** Some Regional Councils may set a minimum level e.g. 2000L or 2 days' storage. Storage facilities should be sized appropriately to ensure that they never overflow (refer to 3.5.8 Holding pond design). This is to avoid the situation where farmers are forced to empty storage areas onto land that is already saturated, creating risk of ponding or surface runoff
- **provision for system failure.** There may be a requirement for a contingency plan so that there are no accidental discharges of effluent and no need to apply effluent to saturated soils
- **setback distances for effluent application.** Some Regional Councils have minimum setback distances for effluent application e.g. 20m from waterways
- **setback distances for storage facilities.** There may be minimum setback restrictions for holding facilities from property boundaries or waterways
- **maximum N loading rates to protect surface or groundwater.** N loadings are either required or recommended by most Regional Councils, commonly at 150-200 kg/ha/yr. Application of effluent at rates that can be utilised by the pasture or crop pose least threat to groundwater or surface water. Application at higher rates will result in larger leaching losses and consequently higher nitrate concentrations in groundwater
- **use of fertiliser-N.** Some Regional Councils have rules limiting the use of fertiliser-N on land already receiving applications of effluent (check with your Regional Council for requirements). They may also require a nutrient budget to be carried out for the whole farm and/or the areas of the farm that receive farm dairy effluent

- **avoiding runoff or ponding of effluent.** If effluent is applied directly to waterways, or reaches a waterway through surface runoff or subsurface drains, the water may become contaminated and unsuitable for swimming or drinking, or aquatic life
- **maximum application rate.** The speed at which animal waste can be applied
- **air quality and odour.** Effluent must be applied to land in such a way that it does not cause a nuisance to the public or endanger human health. For more information on minimising odour refer to 2.5.7 Application management
- **minimum return period.** The time that should expire before animal waste is reapplied to the same land
- **maximum application depth.** The amount of animal waste that can be applied at any one time
- **stormwater diversion.** The diversion of clean water (e.g. rainwater) away from the effluent treatment system
- **sealing of storage facilities.** Most Regional Councils require any effluent storage facilities to be sealed so that effluent does not leach out and increase nutrient levels in groundwater
- **monitoring requirements.** Regional Councils may require environmental monitoring of groundwater and/or surface water at certain times
- **consent duration.** It is up to the Regional Council to determine the duration of the consent.
- **documentation of compliance.** Regional Councils may require information to be recorded in order to show how compliance is met. For example recording the areas where the effluent is being irrigated in order to show that the maximum Nitrogen loading rate is not being exceeded.

There may also be other conditions that Regional Councils place on permitted activities or resource consents.