Section E:

Appendices

Section E:
Appendices

22.1 Appendix A: Feedpads in Declared Special WaterSupply Catchment Areas

22.1.1 Special Water Supply Catchment Areas

Water supply catchments are of particular value to the community and are sensitive to disturbance of the catchment or pollution of the water. The special value of certain catchments has been recognised in the provision for their Declaration as Special Areas under the Catchment and Land Protection Act 1994 (previously proclaimed as Water Supply Catchments). In addition, there are a number of reticulated water systems drawing potable water from streams for which no catchment has been declared. Separation distances from such streams or channels will be calculated as if they were in a special catchment area.

The potential impact of feedpads on the whole water supply catchment (surface and sub-surface waters) requires consideration in terms of both the probability of any escape of nutrients or contaminants, and the consequences of such an escape into the water system. The likely consequences of such an escape are the dominant considerations. Thus, prevention by the selection of a site outside a Special Water Supply Catchment is a more effective strategy than rehabilitation.

Advice is available on Declared Special Water Supply Catchment Area boundaries from local water authorities and the Department of Natural Resources and Environment (DNRE). The Department is also able to provide (for a nominal fee) a Certificate as to whether or not a specific parcel of land is in a Declared Special Water Supply Catchment Area.

The Minister for Agriculture will accept this Certificate as conclusive proof that a proposal does not fall within a Declared Special Water Supply Catchment Area.

22.1.2 Developing a Feedpad in a Special Water Supply Catchment Area

The State Environment Protection Policy (Waters of Victoria) highlights the need for careful consideration of any proposal for a feedpad in a Special Water Supply Catchment Area.

Critical considerations in assessing such proposals will be:

1. The size and shape/topography of the catchment (small, long and narrow, or steeply sloping catchments will substantially restrict the options in the selection of a satisfactory site for a feedpad, irrespective of the design or the intensity of management);
2. The nature of the land, including climate (the ability of land to retain nutrients and not lose them in runoff or through leaching is dependent upon a range of factors and the interaction of those factors);
3. The degree of treatment of water currently applied (untreated supplies are more vulnerable to contamination; detention is a form of treatment);
4. The current nutrient status of the water resource (some water resources are already enriched by nutrients and have less capability to absorb additional nutrients without adverse effects on established uses and users); and
5. The use of the water resource (domestic consumption is more sensitive to deterioration of quality than are irrigation or power generation uses; waters from virtually all Special Water Supply Catchment Areas are used for domestic consumption although the proportion varies).

Persons seeking to develop feedpads in Special Water Supply Catchment Areas and water supply catchments should recognise that they will be required to provide a detailed technical assessment of the site and the proposed development in addition to the standard performance requirements in these Guidelines. They should also satisfy the approval authorities that they can adhere to strict management and monitoring requirements.

22.1.3 Requirements for Feedpads in Special Water Supply Catchment Areas

A detailed environmental appraisal should include the following matters in addition to the requirements in these Guidelines and any other matters specified by the relevant water authorities, EPA, DNRE and planning agencies:

- Detailed topographic assessment including survey data to confirm contours;
- Detailed soil assessment, including depth, permeability, physical and chemical analyses;
- Surface and groundwater hydrology, including location, depth and quality of groundwater/watertable;
- Existing vegetation, including native vegetation subject to Native Vegetation Retention controls;
- Design calculations for all earthworks, drains and structures; and
- Detail of the waste re-use system, including nutrient, water and salt balances for all areas of land to be used for re-use of the wastes.

All designs will be required to cope with a 1:100 year rainfall event.

Minimum separation distances for feedpads or land application of wastes are:

- 800m of full level of a water storage used for supply of potable water, or the off-take or bore for supply of potable water;
- 200m from a watercourse in a declared catchment, or from a watercourse supplying potable water.

It will be required that the feedpad is maintained at a high standard.

Some catchments have been excluded from any form of feedpad development. These include the;

- Upper Delatite Catchment (Mansfield) - in the Municipality of Delatite
- Upper Goulburn (part) (refers to the environs of Lake Eildon) - in the Municipalities of Delatite and Murindindi
- Running Creek - in the Municipality of Delatite
- Nine Mile Creek (Longwood) - in the Municipality of Strathbogie
- Honeysuckle Creek (Violet Town)- in the Municipality of Strathbogie

Information regarding the boundaries of these catchments may be obtained from local water authorities or the Department of Natural Resources and Environment.

22.2 Appendix B: Anomalous Sized Feedpads

22.2.1 Dairy Feedpads of Less than 50 Head

Dairy feedpads of less than 50 head, which meet the following requirements, and have lodged a completed proposal with the responsible authority that demonstrates the requirements hereunder have been met, are deemed to be as-of-right for planning purposes. Where any of the following requirements cannot be met, the feedpad should be assessed in accordance with the requirements of these Guidelines.

Approved Measures for Feedpads of Less Than 50 Head.

- The feedpad is sited outside a Declared Special Water Supply Catchment Area.
- The feedpad is sited on land that is above the 1 in 100 year defined flood level. Where such information is not available, the site is outside an area known to be subject to flooding.
- No part of the feedpad is closer than 300m to a house on an adjoining property.
- Minimum set back of 200m from a watercourse, groundwater recharge area, bore or spring.
- Minimum set back of 800m from the full level of a water storage used for the supply of potable water, or the take off or bore for the supply of potable water.
- Minimum setback of 200m from any road.
- The stocking intensity does not exceed 1 DCU (refer to Appendix E) per square metre.
- The pad surface is impervious and well drained.
- Wastes are prevented from flowing toward any watercourse by mounds or levies, unless traversing a prepared dispersal area.
- Fresh runoff water is prevented from running onto the feedpad area by mounds or levies.
- Liquid wastes are dispersed by spreader banks or contour furrows or drainage levies where required to ensure adequate dispersion.
- The area for liquid waste dispersal is not less than 2 hectares.
- The area for solid waste application to land is not less than 1 hectare for every 5 DCU (refer to Appendix E) on the feedpad. Wastes are to be incorporated into a vegetation production system.
- An area of not less than 2.5m around the drinking tough is kept substantially free of manure and dressed with crushed rock or concrete.
- An area of not less than 2.5m around the feed trough is kept substantially free of manure and dressed with crushed rock or concrete.
- The pad surface is cleaned at least annually.
- The feedpad is operated in a manner to keep the surface in a generally dry condition and to avoid the development of wet areas on the pad.
- The feedpad is operated in a manner to keep feed and water troughs in a clean condition.
- The feedpad is maintained so as to prevent the propagation of weeds and the breeding and spread of vermin and flies.
- If any of these requirements are not met, the feedpad is assessed under the Guidelines as for a feedpad of more then 50 head.

22.2.2 Dairy Feedpads of more than 5,000 Head

Dairy feedpads of more than 5,000 head will need to get a works approval from the EPA. Contact should be made with DNRE to discuss additional requirements and an Environmental Improvement Plan will need to be developed.

22.3 Appendix C: Types of Feedpads

For the purpose of these Guidelines, the term 'feedpad' will incorporate not only the pad, but also the associated dairy supplementary feeding system incorporating all of the factors relating to the use of the feedpad including feed, feed storage, laneways, waste removal/storage/reuse and the management of the system. To delineate between the many various types of feedpads, a list of the different types of pads referred to in these Guidelines follows.

Four different feedpad types have been defined based on the material the feedpad is constructed of, and the exposure of the feedpad to the elements which influenced odour generation rates.

- Dirt Pad (DP) – Open area not formed or with formed dirt pad – minimal feed troughs
- Paved Pad (PP) – Open pad formed of impervious material with distinct feed troughs/areas
- Roofed Pad (RP) – Formed pad with ventilated roof and distinct roofed feed troughs/areas
- Enclosed Pad (EP) – fully enclosed shed

Where a feedpad does not specifically fit one of these cateogries the less sophisticated type should be adopted.

Different forms of these types of feedpads include:

- **Dirt Pad (DP)**
  - crushed rock
  - limestone
  - screenings
  - compacted clay

- **Paved Pad (PP)**
  - reinforced concrete
  - brick
  - cement stabilised clay
  - geosynthetic

- **Roofed Pad (RP)**
  - meshcloth
  - partial roof
  - full roof

- **Enclosed Pad (EP)** - fully enclosed shed with:
  - concrete floor
  - dirt floor
  - bedding

22.4 Appendix D: - Cattle Feedlots (Beef) - Definition

The definition of a cattle feedlot, as stated in the Victorian Code for Cattle Feedlots (DAEM 1995) is as follows:

"Land on which cattle are restrained by pens or enclosures for the purposes of intensive feeding and includes any structure, work or area:

(a) in which such cattle are handled, fed, loaded and unloaded;

(b) where the animal wastes from the feedlot are accumulated or treated pending removal or disposal;

(c) where the animal wastes from the feedlot are treated, placed or dispersed on land. (NB: This does not include land that does not form part of the land on which the feedlot pens and associated works are located.);

(d) in which facilities for feeding such cattle are maintained and the feed for such cattle is stored; or

(e) set aside for the purpose of landscaping and planting of vegetation.

It does not include any area in which cattle are penned or enclosed for:

(a) grazing; or

(b) hand feeding prior to 12 weeks of age or for weaning, or for the provision of subsistence rations due to fodder shortage, abnormal seasonal conditions or other like events; or

(c) the provision of supplementary rations for cattle which have daily access to pasture."

22.5 Appendix E:
- Comparing Feedpads - Dairy Cattle Units

To be consistent with other codes, animal loading needs to be considered and to do this a unit termed a 'Dairy Cattle Unit' (DCU) has been employed. The number of DCU's is used to help determine buffer distances, masses of manure and nutrient loadings.

A DCU is similar to the Standard Cattle Units (SCU) used in the feedlot code and is based on:

- The number of dairy cows' on the feedpad
- The average weight of dairy cows on the feedpad
- The duration the dairy cows' are located on the pad

Cow numbers-
The number of dairy cows' on the feedpad is simply the number of head including calves (e.g. 500 cows).
Weight

As manure and urine production are a function of live-weight, the average weight of the cows using the feedpad should be take into consideration and this will naturally vary with cow age and breed.

A standard weight of 550 kg has been adopted and for cases where the average weight varies from this, the number of cows on the feedpad needs to be adjusted using the Weight Conversion Factors in Table 3 below. Simply multiply the number of cows on the feedpad by the appropriate Weight Conversion Factor corresponding to the average weight of the cows.

For example - 500 cows with an average weight of 600kg would be calculated as 500 x 1.06 and would equal 530 cows.

Duration on Pad

Table 3; *Weight Conversion Factors.*

Average Weight of Cows	Conversion Factor
300 kg	0.70
350 kg	0.76
400 kg	0.82
450 kg	0.88
500 kg	0.94
550 kg	1.00
600 kg	1.06
650 kg	1.12
700 kg	1.18
750 kg	1.24

In conjunction with the number of cows and the average weight of the cows, the amount of time the cows spend on the pad must also be considered. This figure will be the number of hours a day the cows spend on the feedpad. In most cases the amount of time the cows spend on the pad will vary depending on the stage of lactation, weather conditions and the ratio of supplementary feed to pasture.

For planning purposes it will be essential to adopt peak loading conditions and therefore the maximum duration that the cows are on the feedpad should be adopted. However, to account for the occasional exceptional incident such as an unusually heavy rainfall period, the average duration on the feedpad in the peak use month should be taken.
For example, if the cows are on the feedpad for 2 hours a day for most of the year, 3 hours a day in June and July and in these peak months when conditions are very wet (e.g. after a heavy rainfall event) the cows will most likely spend 12 hours on the pad, the average for one of these peak months should be used. In this case the peak monthly average duration on the pad would be 3 hours a day for 28 days and 12 hours a day for 2 days giving a peak monthly average of 3.6 hours.

Calculating DCU
The fraction of the day the cows spend on the pad is multiplied by the number of cows after average cow weight has been considered (see above). For example, if the 530 cows considered above occupy the feedpad for a peak monthly average of 3.6 hours a day, the number of DCU's for the feedpad is:

$$3.6/24 \times 530 = 80 \text{ DCU}$$

22.6 Appendix F
- Definition of a Waterway

The term ‘waterway’ means:

(a) a river, creek, stream or water course; or

(b) a natural channel in which water regularly flows, whether or not the flow is continuous (passive and action flow paths); or

(c) a channel formed wholly or partly by the alteration or relocation of a waterway as described in a) or b); or

(d) a lake, lagoon, swamp or marsh being;

(i) a natural collection of water (other than water collected and contained in a private dam or a natural depression on private land) into or through or out of which a current that forms the whole or part of the flow of a river, creek, stream or watercourse passes, whether or not the flow is continuous; or

(ii) a collection of water (other than water collected and contained in a private dam or a natural depression on private land) that the Governor in Council declares under section 4 (1) of the water act 1989 to be a lake, lagoon, swamp or marsh; or

(e) land on which, as a result of works constructed on a waterway as described in a), b) or c), water collects regularly, whether or not the collection is continuous; or

(f) land which is regularly covered by water from a waterway as described in a), b), c), d) or e), but does not include any artificial channel or work which diverts water away from such a waterway; or

(g) if any land described in f) forms part of a slope rising from the waterway to a definite lip, the land up to that lip.

It should be noted that G-MW is the responsible Authority for the determination of a Waterway and should be contacted accordingly.

It should also be noted that the definition of a Waterway may change with the Farm Dams Review Bill which is currently under debate in Parliament.

22.7 Appendix G: - Acts, Policies and Regulations

There are a number of acts, policies and regulations that should be adhered to when designing and implementing a feedpad. These are listed below, along with the relevant authority in brackets.

1. Works Approval
   (for operations over 5,000 head)(EPA)
   Very large feedpads of greater than 5,000 head will have additional requirements to those outlined in these guidelines and in these cases reference should be made to Appendix B.
2. Environment Protection Act 1970 (EPA)
3. Dairy Shed Act (Food Victoria)
4. State Environment Protection Policy (SEPP) – Waters of Victoria (EPA)
5. SEPP – Groundwaters of Victoria (EPA)
6. SEPP – Air - Air Quality Management (EPA)
7. SEPP – Air - Ambient Air Quality (EPA)
8. Noise Guidelines (EPA)
9. Health Act
10. National Environment Protection Measures (EPA)
11. Flora and Fauna Guarantee Act 1988
12. Archaeological and Aboriginal Relics Act 1972
13. Environment Effects Act 1978
14. Manure Management Guidelines (VDIA)
15. Runoff From Agricultural Land
16. Environment Protection and Biodiversity Conservation Act, 1999
    Under this last Act, actions that are likely to have a significant impact on matters of national environmental significance need approval from the Commonwealth Government in addition to any approval which might be required by the State Government or Council. An action includes a project, development, undertaking, activity, or series of activities undertaken by a person, a company, a local council, a Catchment Management Authority, State or Federal Government.

There are six matters of national environmental significance in this Act:

- World heritage properties
- RAMSAR wetlands of international significance (for example Barmah Forest)
- Nationally threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- Nuclear actions

The person proposing to take an action, which may have a significant impact on a matter of National Environmental Significance, should refer the proposed action to the Commonwealth Environment Minister.

The penalties under the Act are severe and include a civil penalty of up to $5.5 million, and a criminal penalty of up to 7 years imprisonment.

An example of an action which has been determined as needing approval under the Act is a 40 head rotary dairy and effluent ponds adjacent to a RAMSAR Listed Wetland.

22.8 Appendix H:
- Determining Buffer Distances

22.8.1 Stocking Intensity Factor – S1

Using field trial relationships between odour generation rates and stocking density for various feedlot categories (defined by pad moisture content), and with model-predicted odour levels at impact locations (calibrated using the observed odour impact at some existing feedlots), values of the impact of stocking intensity on odour generation have been developed.

This level of detail is not available for feedpads so assumptions must be made. Moisture content and the rate of decomposition of manure are major factors influencing odour production. While a manure pack is not commonly associated with a dairy feedpad, manure is generated on the facility and often stored nearby.

It should be noted that this information is derived from the feedlot practice and the results presented should therefore be recognized as "indicative only".

It is a recommendation of the dairy effluent strategy that an effluent pond should not be situated within 300 metres of a neighbouring residence. Therefore, in cases where a feedpad buffer distance is less than 300m, this default figure of 300m applies.

The S1 factor for each class of feedpad will vary with the minimum stocking intensity proposed and is determined from Table 4.

Note: the stocking intensity is considered as the pad area available per DCU (refer to Appendix E) and the DCU calculation takes into account the live weight of the stock.

***Table 4;** S1 Factor for a range of stocking densities and cleaning systems.*

	Type of Cleaning System		Stocking Density m^2 per DCU		
			10	**15**	**20**
Dirt Pad (DP)	Scraped Only	Weekly	33	32	31
		Monthly	36	35	34
		Annually	39	38	37
Paved Pad (PP)	Scraped Only	Weekly	31	29	27
		Monthly	34	33	32
		Annually	37	36	35
	Flood Washed	Daily	23	22	21
		Weekly	26	25	24
Roofed Pad (RP)	Scraped Only	Weekly	29	27	25
		Monthly	32	31	30
		Annually	35	34	33
	Flood Washed	Daily	20	19	18
		Weekly	23	22	21
Enclosed Pad (EP)	Scraped Only	Weekly	27	25	23
		Monthly	30	29	28
		Annually	33	32	31
	Flood Washed	Daily	17	16	15
		Weekly	20	19	18

22.8.2 Separation Distances and Receptor Factor – S2

The separation distances to impact locations and receptors are usually the key factors that limit the number of DCUs that may be accommodated on a particular site.

The critical separation distances should be assessed for each receptor applicable to a particular site to determine if the proposed loading will adversely impact on the receptor. In each case it is the closest part of any development, zoning or adopted strategy or structure plan which should be used, not necessarily that portion of the site specifically associated with odour generation or reception.

The impact location may be a neighbour's house, a small town or a large town that may be affected by odour generated from the supplementary feeding system, feedpad structure or waste management facilities serving the structure. The S2 factor will vary depending on the receptor type and is determined according to Table 5.

Table 5; *S2 Factor for a range of receptor types.*

Receptor Type	S2 Value
Large towns > 2000 persons	5
Towns > 100 persons	4
Small towns > 20 persons	3
Rural Residential Zone or rural residential development with 5 or more houses or house sites*	3
Three or four (3 or 4) houses or house sites* within a single radius of 250m	2
Two (2) houses or house sites* within a distance of 250m of each other	1.5
Isolated house, house site or a site for a dwelling on land greater than 2 ha in area where the furthest dwelling site from the Feedpad is used to establish the separation distance	1
Public areas – high usage** e.g. national parks and recreation areas	3
Public areas – high usage** e.g. schools and similar high usage non-residential institutional uses	2
Public areas – low usage** e.g. state forest, isolated public halls, mechanics institute, rural cemeteries and similar low frequency uses	0.1

* *Note: "Rural residential" and "house site" means land used or capable of being used under the relevant planning controls for a residence and having an area of 2 hectares or less.*

** *Note: The values indicated for public uses apply to areas subject to occasional or less frequent use outside towns. Higher values are appropriate for public areas used frequently or sensitive in nature such as schools, and frequently used halls and recreation areas. Lesser values are appropriate for less frequently used facilities. In many cases the appropriate value will need to be determined in conjunction with staff of the Department of Natural Resources and Environment and the local planning authority having regard to the characteristics of the use.For the situation where a receptor has the potential to be impacted on by a number of feedpads the example diagrams provided*

For the situation where a receptor has the potential to be impacted on by a number of feedpads the example diagram provided in Figure 30 indicate acceptable and unacceptable layouts

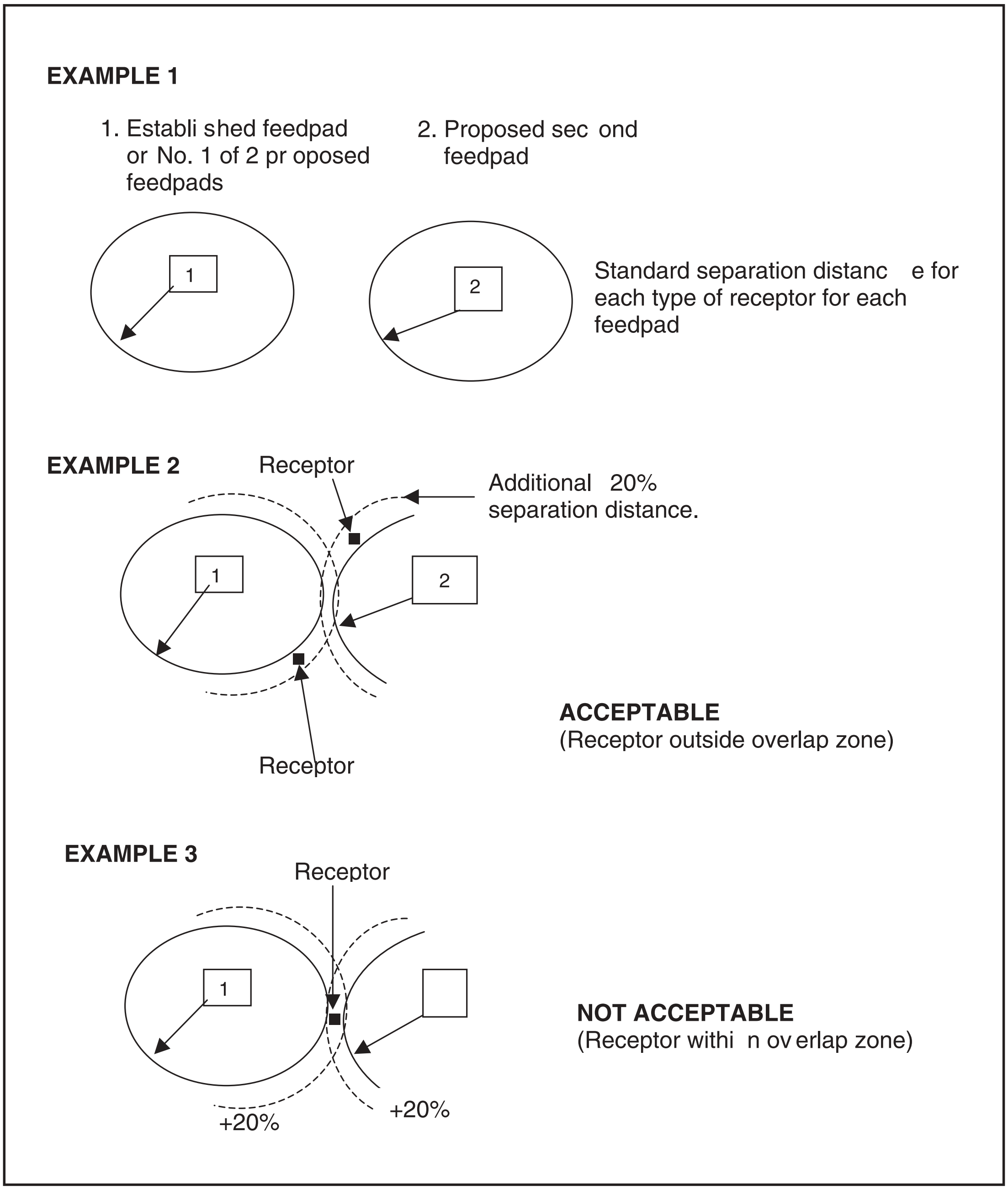


Figure 30; *Acceptable layouts for receptors impacted on by more than one feedpad*

22.8.3 Terrain Factor - S3

The S3 terrain factor will vary depending on topography and is determined according to Table 6.

Topographical features of the selected site may increase the odour impact under certain circumstances. During the early evening or night time under low wind speed conditions, population centers located in a valley at a lower elevation than a feedpad may be subject to higher odour concentrations as a result of down-valley wind or the occurrence of low-level inversions. Unless site specific information has been gathered under conditions dominated by low wind speeds, the value for the S3 Factor given in Table 6 will apply.

The proposed reduction in separation distance for receptors located at a higher elevation through the use of lower values for S3 is a combination of a number of factors including; upslope winds occurring during daylight hours and the tendency for winds to pass around hills (see Figure 31).

For much of the Goulburn Broken Catchment the prevailing wind direction rather than topography will be the principal governing factor on impact.

Table 6; *Topography for odour impact and the S3 Factor*

		Value
(a)	High relief at (> 10% upslope from site)	0.7
(b)	Low relief (> 5% down slope from site)	1.2
(c)	Valley drainage zone	2.0
	Flat (< 1% slope)	1.0
(d)	Areas subject to catabatic drift	1.5

(a) High relief is regarded as upslope terrain or a hill that projects above the 10% rising grade line from the feedpad. Thus the receptor location will be either uphill from the feedpad or be behind a significant obstruction.

(b) Low relief is regarded as terrain which is generally below the 5% falling grade line from the feedpad. Thus the receptor will be downhill from the feedpad.

(c) A valley drainage zone has low relief topography (as above) with significant confining sidewalls.

(d) Receptors located down slope from the feedpad which are subject to potential impact from the movement of odour-laden air during late afternoon or evening as the cool air mass moves down slope.

High Relief

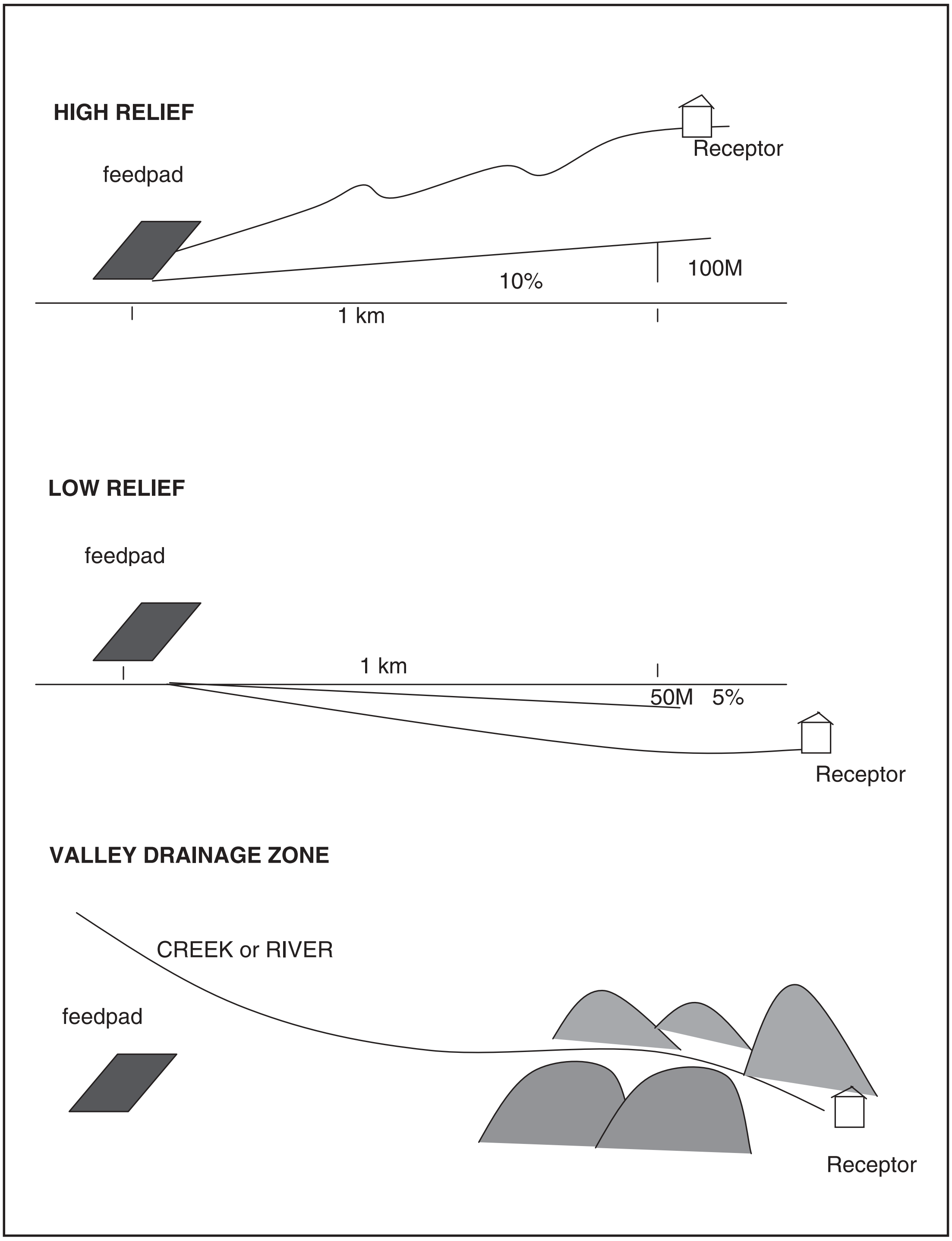


Figure 31; *Odour impacts and topographical features*

22.8.4 Vegetation Factor – S4

The S4 Factor will vary depending on vegetation density and is determined according to Table 7.

Upper story and lower story tree cover should not provide shade for confined stock but act as a buffer promoting odour dispersion. The congregation of stock in shaded areas results in the formation of wet patches and a subsequent increase in odour generation potential. The values suggested for S4 given in Table 7 for tree covered areas should be used with care and a number of provisions should qualify an approval given on this basis.For example, no permanent concession is allowed for tree cover not controlled by the occupier, except permanent state forest which is not subject to logging. No concession is given for an intention to plant a barrier, and, if an occupier fails to maintain a stipulated barrier, then a reduction in the allowed number of cattle follows. However, operators are encouraged to maintain and plant an upper story and lower story vegetation cover buffer zone in order to improve visual amenity, odour dispersion, dust control and noise attenuation.

Table 7; *Vegetation density and S4 Factor*

Vegetation	Value
No tree cover	1.0
Light tree cover	0.9
Heavy tree cover	0.7

Note: *Proponents and assessing officers should recognise that, if tree cover relied on in the initial calculation of stock numbers disappears during the life of the feedpad, this will require a change in the number of stock allowed at that time.*

To qualify for light tree cover, vegetation should be of dense upper and lower story and not less than 250 metres in width or, if little lower story vegetation, of greater than 500 metres in width.

To qualify as heavy tree cover vegetation should be dense upper and lower story of not less than 250 metres in width or if little lower story vegetation, of not less than 1.5 kilometres in width.

Intermediate values should be interpolated for intermediate vegetation conditions.
The distances specified above are based on a feedlot of 5000 head rather than a feedpad and a proportionately lesser amount of vegetation may be required for smaller feedpads.

This matter will need to be assessed for each case in consultation with staff of the Department of Natural Resources and Environment and the responsible Authority.

22.8.5 Example Buffer Distance Calculation

To help determine buffer distances, the feedpad loading needs to be determined. In this example we have 500 cows with an average weight of 600 kg and they occupy the feedpad for a maximum of 3 hours per day.

This loading or DCU calculation requires:

- The number of dairy cows' on the feedpad = 500
- The average weight of dairy cows on the feedpad = 600 kg
- The duration the diary cows' are located on the pad = 3 hrs

The number of DCU's is then calculated by multiplying the number of cows, by a weight conversion factor (Table 3 in Appendix E) multiplied by the fraction of the day that the cows occupy the pad.

500 x 1.06 x (3/24) = 66.25 DCU

Example - Buffer Factors

Stocking Intensity Factor – S1
The feedpad is a dirt pad cleaned annually and covers 1,000 m^2 and this equates to $15m^2$/DCU for the 66.25 DCU. The S1 Factor is then determined from Table 4 in Appendix H which indicates an S1 Factor of 38.

Separation Distances and Receptor Factor – S2
The nearest receptor to the feedpad is a single residence located 400 m away. This type of receptor is designated an S2 Factor of 1 from Table 5 in Appendix H.

Terrain Factor - S3
The topography of the site is flat and is therefore designated an S3 Factor of 1 based on Table 6 in Appendix H.

Vegetation Factor – S4
The areas surrounding the feedpad are classified as having no tree cover and would therefore be designated an S4 Factor of 1 based on Table 7 in Appendix H.

Example Buffer Distance Calculations
The required data to calculate the buffer distance is as follows:

DCU	=	66.25
S1 Factor	=	38
S1 Factor	=	1
S1 Factor	=	1
S1 Factor	=	1

Composite S Factors
= S1 x S2 x S3 x S4 = 38

Distance
= S x $\sqrt{DCU}$ = 309.3 m

The feedpad should be located more than 310m from the nearest receptor, the single residence.

Note: *It is a recommendation that a feedpad be located at least 300m from any off site dwelling and therefore this default value applies if the buffer distance calculation is lower than 300m.*

22.8. 6 Fixed Buffer Distances

In addition to the above calcuated buffer distances, the following Fixed Buffer Distances are minimum recommended distances. In cases where the calculated buffer distances are less than these Fixed Buffer Distances, it is recommended that these Fixed Buffer Distances be used.

Minimum distance from land application of liquid waste to:

- Site Boundary	20 m
- Public Area	100 m
- Waterway, bore or spring	100 m
- Off site residence	200 m
- Flood prone land (1:100 yr flood level)	200 m

Minimum distance from solid waste spreading areas to:

- Site Boundary	20 m
- Public Area	100 m
- Waterway, bore or spring	100 m
- Off site residence	200 m
- Flood prone land (1:100 yr flood level)	200 m

Minimum distance from feedpad or pond servicing a feepad to:

- Site Boundary	50 m
- Waterway, bore or spring	200 m
- Off site residence	300 m
- Flood prone land (1:100 yr flood level)	200 m

22.9 Appendix I:
- Odour Dispersion Modeling

In cases where it is not appropriate, or as an alternative to the buffer distances calculated in Appendix H, proponents may wish to undertake odour dispersion modeling to demonstrate satisfactory performance for a proposed feedpad.

At site specific locations where odour is apparent EPA dispersion models can be employed to:

- assess the impact of increasing stocking rate
- assess the impact of vegetated buffers
- apply collected data to similar situations reflecting similar terrain and weather conditions

For proposed feedpads with no site-specific meteorological data, the following atmospheric and site conditions have been assumed in deriving recommendations for typical situations:

- Wind direction - towards receptor
- Wind speed - 1m/s
- Stability category - F
- Mixing height - 500m
- Terrain - flat, open

Where there is an existing feedpad in close proximity or it is proposed to develop two feedpads on one site, separation distances should be determined having regard to each feedpad and the combined effect of the two feedpads. Where two feedpads are proposed in close proximity, modeling is used to demonstrate adequate separation distances from receptors.

22.10 Appendix J: Rainfall Runoff & Liquid Waste Volume Calculations

All of the liquid waste from the feedpad should be accounted for when designing the feedpad drainage system and associated storage volume. Rainfall runoff and flood washing system water needs to be considered as does the storage volume required for liquid wastes that are to be reused as irrigation and need to be stored over the winter period when irrigation is not feasible (for the latter refer to Appendix K). Any other sources of water that will be entering the feedpad drainage system should also be included. Rainfall runoff calculations are required for the feedpad (be this the pad surface or the roof if not diverted) and the associated feedpad works area (laneways, feed storage area, loafing areas etc.) for a 1 in 20 year 24 hour storm event using Australian Rainfall and Runoff Data.

22.10.1 Rainfall Runoff

The volume required for a feedpad storage for retaining the runoff from a 1 in 20 year 24 hour storm event can be calculated as follows:

$$Q = [(Af + Ab) \times (Rf \times Ro)] \times Fs + (As \times Rf) / 1000$$

Where;

Q	=	volume (m^3)
Af	=	Area of actual pad (m^2)
Ab	=	Balance of catchment area (m^2)
Rf	=	80% of the 1 in 20 years 24 hour rainfall event
Ro	=	Runoff coefficient for a dirt pad > 600 mm per annum = 0.40 501 - 600 mm = 0.35 400 - 500 mm = 0.30 < 400 mm = 0.25
	=	Runoff coefficient for a concrete Pad* = 0.6-0.8
	=	Runoff coefficient for a roofed pad = 0.9
Fs	=	Safety Factor of 1.25
As	=	Area of storage (m^2)

** The runoff coefficient for a concrete pad asssumes the presence of indentations and absorbent material on the surface and the actual coefficient used between this range should reflect the degree of indentations and absorbent material present.*

An example is provided where the area of the actual pad is 0.52 ha, areas surrounding the pad including a loafing area, yards and laneway total 0.46 ha and the feed storage area covers 0.91 ha.

The feedpad is a dirt pad and is in a 400 - 500 mm per annum rainfall area and therefore has a runoff coefficient of 0.3. The proposed storage will cover an area of 40m by 40 m or 1,600m^2.

Figure 32 shows a map (from Australian Rainfall and Runoff Data) that provides the 24 hour rainfall 20 year recurrence interval for Victoria in mm. From this map an interpolated value of 90 mm is attained.

We therefore end up with the following data;

Q	=	volume (m^3)
Af	=	5,200 m^2
Ab	=	13,700 m^2
Rf	=	80% of the 90 mm = 72 mm
Ro	=	0.30
Fs	=	1.25
As	=	1,600 m^2

The calculation is then;

$$Q = [[(5{,}200 + 13{,}700) \times (72 \times 0.3) \times 1.25] + (1{,}600 \times 72)] / 1000$$

$$Q = [[18{,}900 \times 21.6 \times 1.25] + 115{,}200] / 1000$$

$$Q = 510{,}300 / 1000 = 510.3 \text{ m}^3$$

Therefore 510 m^3 or 0.51 ML is required to accommodate the rainfall runoff from the feedpad and the associated feedpad works area.

22.10.2 Flood Washing System

The volume of water used by a flood washing system is generally known or can be relatively easily calculated. If the flood washing system uses fresh water this amount needs to be accounted for. In this example case we will have a flood washing system using a volume of 30,000 litres of fresh water per day.

No additional volume is added for the manure collected as it is expected that this will be off set by evaporation from the storages and during the flood washing. The flood washing system volume then needs to be totaled for the period when wastes need to be stored (see winter storage) and in this case this period is 8 months.

The calculation is then;

30,000 x (30 x 8) / 1,000,000 = 7.2 ML

Therefore the storage needs to accommodate the 7.2 ML of liquid generated by the flood wash system over winter.

For flood washing systems recycling water no figure for flood washing volumes needs to be considered.

22.10.3 Winter Storage

The storage of liquid wastes prior to reuse should be considered and this volume can be substantial where wastes are reused as

irrigation and need to be stored over winter while irrigation is not feasible.

Where this is the case, reference should be made to the Rainfall and Evapotranspiration graphs in Appendix K. From Appendix K we calculate for our example case that rainfall exceeds evapotranspiration for 8 months over winter and therefore wastewater cannot be reused and needs to be stored over this period.

To calculate the rainfall runoff from the feedpad and feedpad works area over this period, the default figure used is 20% of the runoff from a 1 in 20 year 24 hour storm event per month.

The calculation is therefore;

8 x 0.2 x 0.51 = 0.82 ML

22.10.4 Total Volume

Rainfall Runoff	=	0.51 ML
Flood Washing System	=	7.2 ML
Winter Storage	=	0.82 ML

Total Effluent Storage
Required = <u>8.53 ML</u>

If the feedpad was not flood washed or was flood washed using recycled water, the required volume would be reduced
significantly to 1.33 ML.

22.10.5 Alternative Method

Alternatively, DNRE has a Dairy Shed Effluent Pond Sizing Manual that could be utilised.

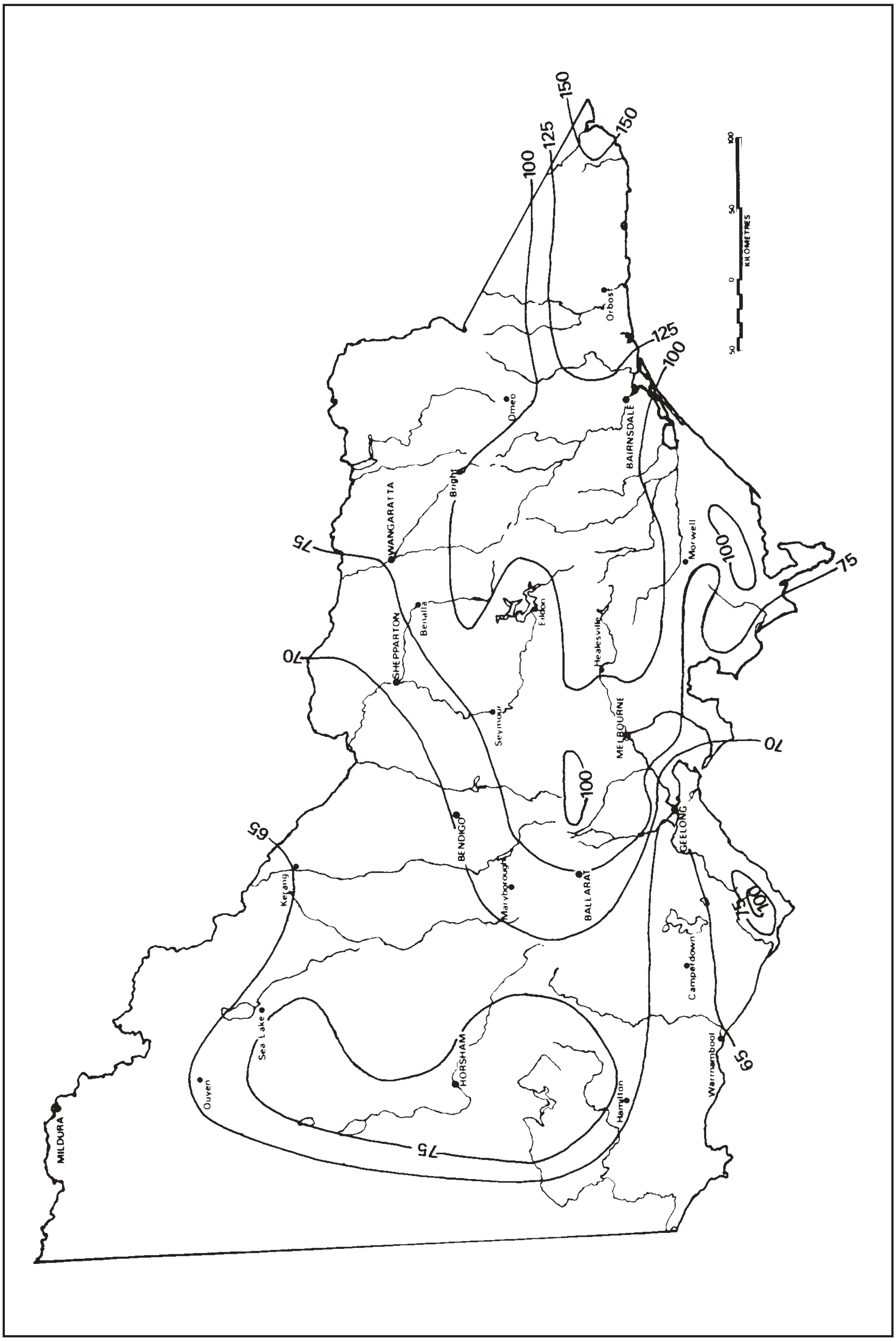


Figure 32: *Australian rainfall and runoff data rainfall intensity map for Victoria for 24 hour rainfall 20 year recurrence interval. From this map an interpolated value of 90 mm is attained.*

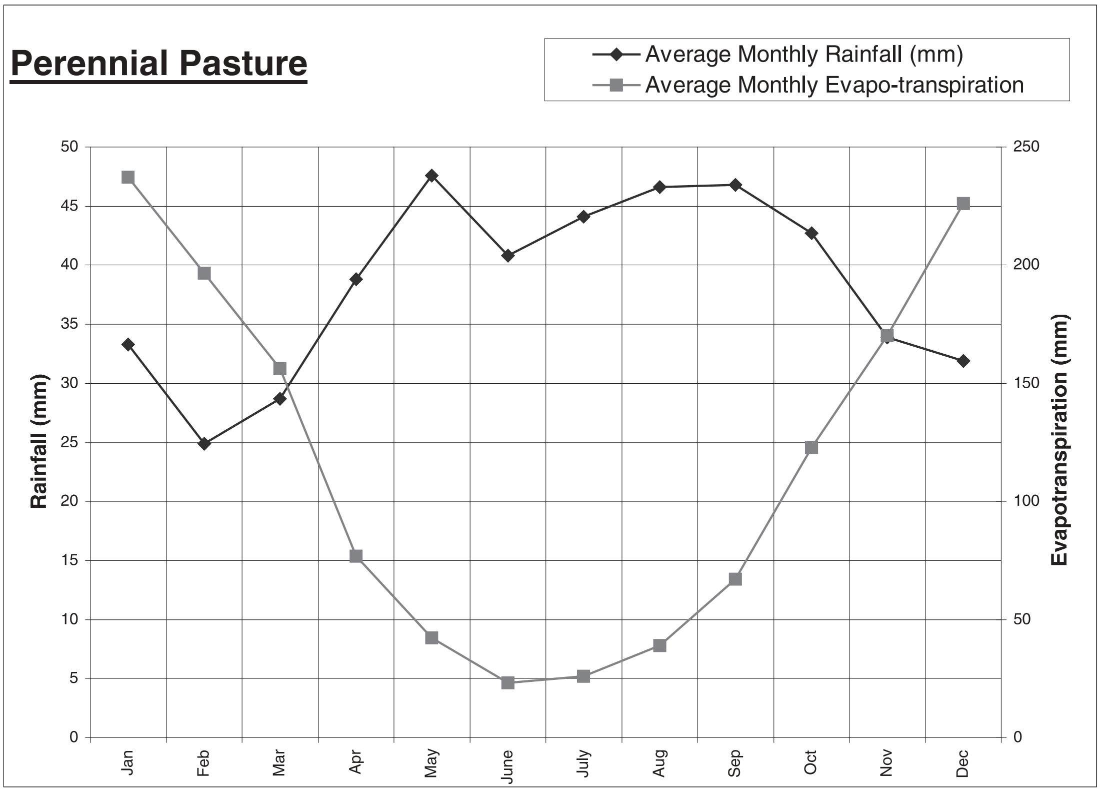
22.11 Appendix K : Rainfall & Evapotranspiration Graphs for Storage Volumes

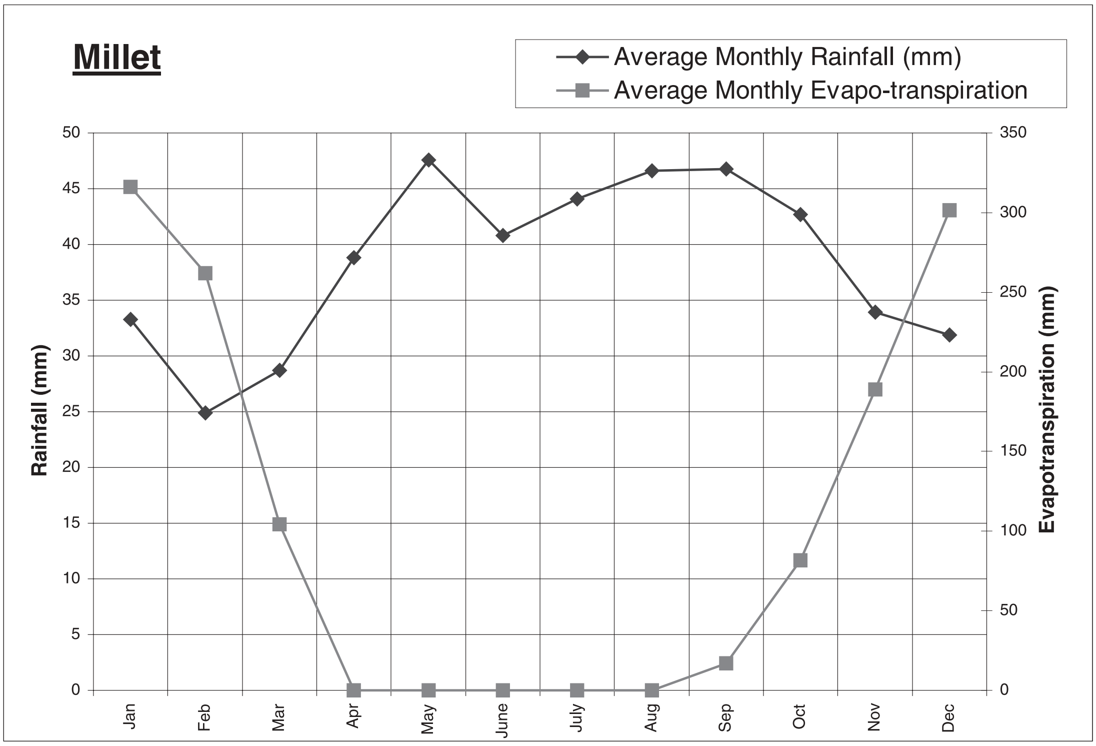
The storage of liquid wastes prior to reuse should be considered and this volume can be substantial where wastes are reused as irrigation and need to be stored over winter while irrigation is not feasible. Where this is the case, reference should be made to the following Rainfall and Evapotranspiration graphs depending on the crop utilising the water.

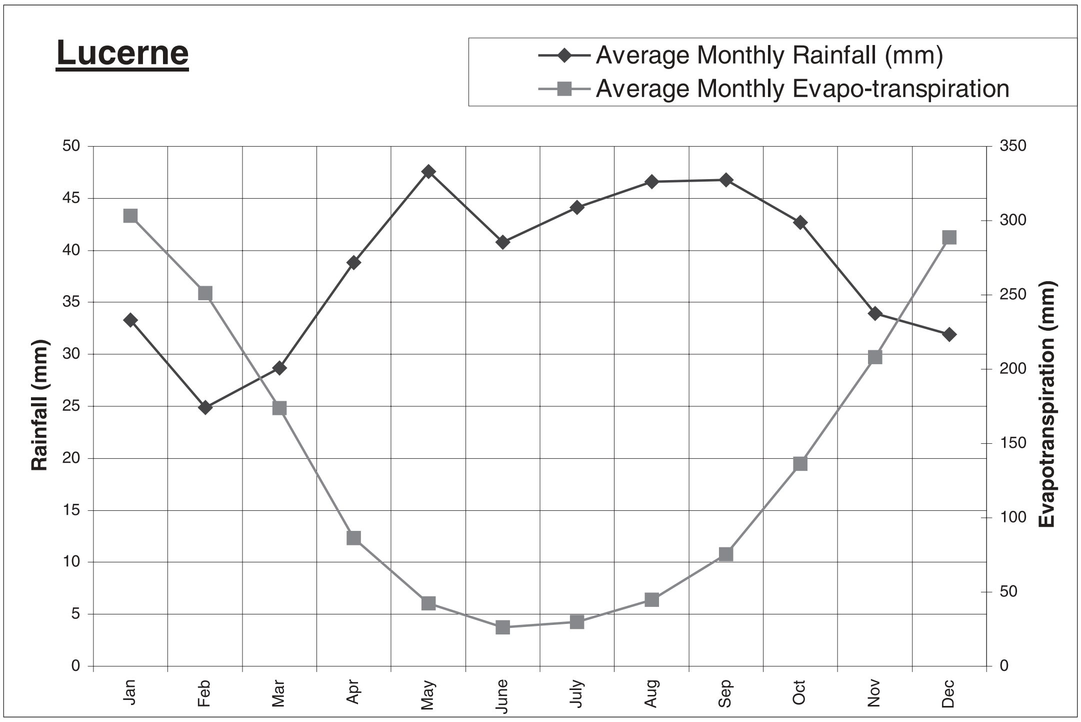
These graphs provide an indication of the periods when rainfall exceeds evapo-transpiration and therefore crops will not be using water and wastewater will need to be stored.

The graphs are indicative only as they are for the central Goulburn Valley region and allowances will need to made for those areas where rainfall and/or evaporation varies from these medium examples.

To provide for different types of crops, graphs are supplied for perennial pasture, lucerne and millet. To provide an example of the method used to determine the amount of water a crop will potentially use, an irrigation water budget is also supplied.




Millet
Average Monthly Rainfall (mm)
Average Monthly Evapo-transpiration
Rainfall (mm)
Evapotranspiration (mm)
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150
200
250
300
350
Jan
Feb
Mar
Apr
May
June
July
Aug
Sep
Oct
Nov
Dec


Lucerne
Average Monthly Rainfall (mm)
Average Monthly Evapo-transpiration
Rainfall (mm)
Evapotranspiration (mm)
0
5
10
15
20
25
30
35
40
45
50
0
50
100
150
200
250
300
350
Jan
Feb
Mar
Apr
May
June
July
Aug
Sep
Oct
Nov
Dec

Pasture at Tatura		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average monthly rainfall (mm) from	Tatura	34	31	35	36	49	45	49	48	45	49	39	33	493
Mean Daily Evaporation (mm) from	Tatura	7.2	6.6	4.7	2.8	1.5	1	1	1.6	2.6	4	5.5	6.9	
Reference Crop Evapotranspiration (mm)	Tatura	223.2	18-4.8	145-.7	84.0	46.5	30.0	31.0	49.6	78.0	124.0	165.0	213.9	1376
Crop Co-efficient for	pasture	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.8	0.9	0.9	0.9	
Monthly Evapotranspiration (mm)		201	166	124	63	35	21	22	35	59	105	140	193	1163
Differential (evapotranspiration - rainfall) (mm)		167	136	89	27	-14	-24	-28	-14	14	57	101	159	750
Differential accounting for 20% system inefficiencies (mm)		200	163	107	33	-17	-29	-33	-16	17	68	122	191	900
Cummulative irrigation requirements (mm)		598	760	867	900	Application limited (cold & wet)				17	85	206	397	
Land use practices		Irrigation				Rainfall supplies water requirements				Irrigation				

Irrigation Application Rate – Average Year – Theoretically = 7.50 ML/ha
Irrrigation Application Rate – Average Year = 9.00 ML/ha

22.12 Appendix L: - Solid Waste & Nutrient Generation/Budgeting

22.12.1 Solid Manure Generation

The amount of solid manure generated from the herd is bases on the default values of a 500 kg dairy cow fed on harvested feed produces:

Raw manure	-	40 kg/cow/day
Solids	-	4.2 kg/cow/day

This daily production then needs to be adjusted for the proportionate weight of cows. For example a 600kg cow would produce:

Raw manure	-	48 kg/cow/day
Solids	-	5.04 kg/cow/day

The daily production then needs to be adjusted for the apportionment of time. For example if the 600 kg cows spent 2 hours on the pad a day the solid manure generated would be:

Raw manure	-	4 kg/cow/day
Solids	-	0.42 kg/cow/day

If there were 500 cows occupying the pad for 365 days of the year, this equates to the following amounts of manure being generated:

730 tonnes of raw manure per annum
77 tonnes of solids per annum.

22.12.2 Nutrient Generation

If the farm nutrient generation was as follow:

Default figures for production of nutrients of dairy cattle for a 500 kg animal:
N = 0.225 kg/day
P = 0.047 kg/day
K = 0.145 kg/day

Based on 600 kg animals the values would be
N = 0.270 kg/day
P = 0.056 kg/day
K = 0.174 kg/day

Based on the apportionment of time where the cows spend 4.5 hours on the pad the values would be:

N = 0.05 kg/day
P = 0.011 kg/day
K = 0.033 kg/day

If there were 500 cows occupying the pad for 4.5 hours for 365 days of the year, the total nutrients produced per annum would equate to:
N = 9,125 kg of N
P = 2,008 kg of P
K = 6,023 kg of K

The Nutrient Budget would then be based on a typical dairy pasture producing 10t of dry matter/ha, which would use the following nutrients:

For the nutrient uptake of other crops refer to Appendix M.

N Removal (kg/ha/yr.)	P Removal (kg/ha/yr.)	K Removal (kg/ha/yr.)
400	40	200

Therefore based on the nutrient generation of the feedpad, the following areas will be required to reuse the liquid and solid wastes generated:
N = 9,125 = 22.8 ha
P = 2,008 = 50.2 ha
K = 6,023 = 30.1 ha

Therefore the liquid and solid wastes should be spread over 50 ha of pasture to allow for the reuse of all the nutrients and especially the phosphorus.

For more detailed information on nutrient loading and removal rates on dairy farms, reference can be made to the Target 10 "NutriMatch" worksheet available from DNRE.

22.13 Appendix M: - Crop Nutrient uptake and Production Requirements

Crop (Yield/ha)	Salt Tolerance	Response to Waterlogging	Response to Water Stress	N Removal (kg/ha/yr.)	P Removal (kg/ha/yr.)	K Removal (kg/ha/yr.)	Seedbed Preparation	Management Requirements	Limitations
Barley ($3.5m^3$)	Moderate	Low	Reduced yield	168	27	140	Good soil structure	Nutrient, weed and disease management	Winter crop
Lucerne Hay (7.5 t)	Moderate (seedlings not tolerant)	Low. Good drainage is essential	Drought tolerant. Low yield	209 Dependant on fertiliser practice	19	141	Fine, level, weed free	Requires extra care at establishment and for timing of grazing or cutting	Legume crop
Maize - Silage (50 t)	Low	Low	Poor drought tolerance. Loss of production	165	65	206	Good soil structure, fine, moist seedbed	High level of irrigation and nutrient management	Requires specialised sowing and harvesting equipment
Millet (9 t)	Moderate	Moderate	Poor drought tolerance. Dramatic loss of production	280	45	186	Not essential	High level of irrigation and nutrient management	Volatile grain and hay market. Hay of poor quality
Oats ($3.5m^3$)	Moderate	Moderate	Reduced yield	168	27	140	Good soil structure	Nutrient, weed and disease management	Winter crop
Perennial Pasture for hay (15 t)	High	High	Able to survive but loss of production	150	18	80	Not essential	Requires extra care at establishment	Hay of poor quality
Perennial Ryegrass (15 t)	High	High	Able to survive but loss of production	200-250	25-40	200	Not essential	Requires extra care at establishment	Hay of poor quality
Wheat (2.8 t)	Moderate	Moderate	Reduced yield	208	27	150	Good soil structure	Nutrient, weed and disease management	Winter crop
Sorghum - Grain (9 t)	Moderate	Moderate	Higher tolerance to drought than maize or millet. Potential for prussic acid poisoning if plants stressed early	280	45	186	Good soil structure, fine, moist seedbed	High level of irrigation and nutrient management. Prevention of prussic acid poisoning	Does not perform as well as millet and maize during cool periods
Sunflowers	Low	Low. Good drainage is essential	Poor drought tolerance. Dramatic loss of production	15-30	4-8	50	Good soil structure, fine, moist seedbed	High level of irrigation, nutrient and disease management	Requires specialised sowing and harvesting equipment
Triticale (2.8 t)	Moderate	Moderate	Reduced yield	168	27	140	Good soil structure	Nutrient, weed and disease management	Winter crop
Dairying 10tDM/ha	Clover - low Ryegrass - high	Moderate	Reduced production	400	40	200	Not essential	High level of irrigation & grazing management	Requires dairying infrastructure & herd
Viticulture	Moderate	High	High	32	11	45	Deep ripping	Specialist management skills required	Need infrastructure and an available market

22.14 Appendix N:
- Nutrient Cycling

22.14.1 Nitrogen In Manure And Wastewater

The nitrogen cycle is quite complex and is subject to ongoing research. Nitrogen in the soil consists of inorganic and organic forms. The organic fraction is usually larger and contains compounds differing in biode-gradability. At any time, most of the nitrogen is immobilized as organic nitrogen in animal and plant material and is therefore not available for plant growth, leaching or gaseous loss. Through the process of mineralisation, microorganisms oxidize organic nitrogen to inorganic forms that can be utilized by plants.

Plants absorb inorganic nitrogen primarily as nitrate or ammonium, and fertilizer, manure or organic material is usually added to the existing nitrogen in the soil, especially when the rate of conversion of organic and inorganic nitrogen in the soil is insufficient for desired plant growth. Legumes are also grown to help improve soil nitrogen level through microbial processes.

Some nitrogen can be lost as gas or leachate from the soil before it can be assimilated by plants. The principal losses occur through denitrification, ammonia volatilization and leaching of nitrate. Denitrification is the microbial reduction of nitrate to nitrogen oxides or nitrogen gas, which returns to the atmosphere. The denitrification process provides a means of reducing the nitrogen content of waste without terrestrial or aquatic pollution although gaseous losses are recognised as contributing to the greenhouse effect.

Ammonia does not occur in large quantities in the soil. However, when wastewater, fertilizers, manure or organic materials are applied to the soil surface, free ammonia is released to the atmosphere. Over 50% of the nitrogen deposited as faeces or urine by animals can be lost in this manner. The fate of this ammonia is largely unknown, but is probably dissolved in rainfall and is returned to land or water surfaces. Nitrate nitrogen which, being soluble, is readily removed by water flowing over or leaching through the soil is recognized as a significant pollutant. This nitrate may contaminate both ground-water and surface water resources. Losses of organic nitrogen can be controlled by the utilization of sound soil conservation practices such as minimum tillage and direct drilling and the maintenance of a healthy soil biota.

Nitrogen occurring in rainfall or fog drip is mainly in the nitrate and ammonia forms and is readily available to plants. In a temperate climate, about 5 kg of inorganic nitrogen annually falls on a hectare of land.

Where excess nitrogen in animal faeces and urine is implicated in pollution problems, more effective nitrogen management may be needed. The amount of nutrient removal from agricultural wastes in land application is variable and hard to predict. Loss rates are assumed but rarely measured.

Of the recognised methods of nitrogen reduction, only nitrification-denitrification appears feasible as a prospective method with current animal production operations and wastewater management projects. Controlled ammonia desorption from wastewater sludges and manure is technically possible. However, it requires a degree of pH control or aeration that is unlikely to be achieved or maintained in conventional waste management systems. Some amount of uncontrolled ammonia desorption will however result from waste storage treatment, handling and application to the land.

The actual amount of nitrogen exhausted in collection, storage treatment and land application processes is dependent on solid separation, the degree of aeration or agitation, the time of storage and handling, and the pH of the slurry or mixture. A reasonable estimate is that between 10 % and 50 % of the nitrogen, which can be converted to ammonia, is lost from the wastes under conventional management systems.

A high degree of nitrogen control may not be necessary in wastewater treatment facilities when the effluent is applied to land. The control that is necessary will be related to the level of conservation or atmospheric loss that is desired. To provide a degree of nitrogen control by nitrification and denitrification, it is necessary to understand the processes which transform nitrogen in wastes from one form to another. It is also vital to understand that the principle of conservation of mass dictates that nitrogen cannot be "lost" it is simply converted from one form to another. In addition, gaseous losses may not be desirable from the perspective of the "Greenhouse Effect".

Nitrification and denitrification processes are reasonably well understood. Nitrification can be defined as the biological conversion of nitrogen in inorganic or organic compounds from a reduced to a more oxidized state. In the field of water pollution control, nitrification is generally referred to as a microbial process in which ammonium ions are oxidized initially to nitrite and then to nitrate.

Nitrogen in fresh faeces or raw wastewater is essentially in organic form. Microbial manure and wastewater stabilization systems produce a sequence of nitrogen transformations, the first step of which is the ammonification of the organic nitrogen:

$$\text{Organic nitrogen} \xrightarrow[\text{(heterotrophs)}]{\text{ammonification}} NH_3 \underset{\text{hydrolysis}}{\overset{H_20}{\rightleftarrows}} NH_4^+ + OH$$

This step can result in an increase in pH. If the ammonium concentration and pH are sufficiently high, significant ammonia volatilization can occur. Such ammonia losses have been documented with manure and wastewater storage and treatment.

Under aerobic conditions, ammonium nitrogen can be microbially oxidized to nitrate by the autotrophic organisms Nitrosomonas and Nitrobacter. This oxidation of NH_4^+ to NO_3^- is termed nitrification:

Under anaerobic conditions, nitrite and nitrate can be reduced by denitrifying organisms. This process is termed denitrification and may be represented as:

$$NH_4 \xrightarrow{\text{(Nitrosomonas)}} NO_2 \xrightarrow{\text{(Nitrobacter)}} NH_3$$

Reduced organic matter =
NO_3^- $\xrightarrow{\text{bacteria}}$ NO_2^- + Oxidized organic matter

which illustrates the reduction of nitrate to nitrite, and
Reduced organic matter +
NO_2^- $\xrightarrow{\text{bacteria}}$ Oxidized organic matter = N_2

which illustrates the reduction of nitrite to nitrogen gas. During denitrification the pH will increase. The degree of pH change is related to the amount of denitrification and the buffer capacity of wastewater or moisture in manure or sludge.

Wastewaters containing oxidized nitrogen can be denitrified readily if there is an adequate supply of hydrogen donor compounds available. Microbial denitrification takes place under anaerobic conditions where nitrites and nitrates are used as terminal hydrogen acceptors in place of molecular oxygen.

Denitrification is brought about by facultative bacteria such as Pseudomonas, Serratia. Achromobacter, Bacillus and Micrococcus. Of the several genera of nitrifying organisms recorded, only Nitrosomonas and Nitrobacter are generally found in wastewaters and are the principal nitrifying autotrophs associated with aeration. Although nitrification is predominantly autotrophic, bacteria, actinomycetes and fungi can bring about heterotrophic oxidation of nitrogen to nitrite and nitrate.

If it were possible to control nitrification-denitrification processes it would be possible to conserve, reduce or to remove the nitrogen content of the waste, prior to land application. Where stabilization ponds are used, particular where flood washing is used for cleaning surfaces or there is a predictable volumetric and mass loading of waste commitments there is some prospect of designing aerated facilities to encourage conversion to gaseous forms of nitrogen.

22.14.2 Phosphorus In Manure and Wastewater

Phosphorus exists in both organic and inorganic forms in wastewater and manure as well as in soils and aquatic systems. Inorganic phosphorus is the most important form for aquatic and terrestrial plant growth. As plant roots remove phosphorus from the soil solution, phosphorus adsorbed to soil particles enters the soil-water solution to help replenish that removed. The soluble and thus available phosphorus constitutes only a small fraction of the total phosphorus in the soil. Organic phosphorus, converted to the inorganic form by soil borne microorganisms, also acts as a source of supply for soluble phosphorus which is taken up by plants.

The quantity of soluble phosphorus in the soil is determined by soil pH, iron, aluminium, manganese and calcium levels, decomposition of organic matter, and microbial activity. These factors are interrelated because their effects are dependent on the soil environment. In alkaline soils, phosphate from fertilizer, wastewater and manure reacts with exchangeable calcium ions and salts to form only slightly soluble calcium phosphate.

Iron and aluminium phosphates have a minimum solubility near pH 3-4. At higher pH values these phosphates become more soluble. At a pH 6, phosphorus precipitation as calcium compounds begins. The greatest level of phosphate available to plants is when the soil pH is maintained in the range of 6-7.

The removal of phosphorus from the soil is almost entirely due to plant uptake and harvest, with some losses occurring in runoff to waterways and depressions and some minor leaching through soil macropores and biological channels. Gaseous losses of phosphorus do not occur naturally. Some phosphorus however, becomes airborne in dust. In aquatic systems phosphorus deposition occurs leading to fixation in benthic layers and in banks.
Water in contact with soils contains relatively low concentrations of phosphorus. Applications of wastewater, manure and fertilizer to soil can increase the concentration of nitrogen and phosphorus in soil water. Surface runoff from sites in receipt of wastewater, manure and fertilizer will contain higher concentrations of phosphorus than subsurface waters.

The pH-phosphorus solubility relationships are important in the reduction or removal of phosphorus from manure and wastewater, since chemical precipitation can be used to assist this process. The possible alternatives for control of phosphorus in animal wastes or wastewaters are really land application and chemical precipitation. Chemical precipitation is more applicable to liquid wastes that are intended to be discharged to surface waters. The effluent limitations in Victoria do not permit discharge of animal wastes to surface waters or groundwater except due to extreme storms. This no-discharge requirement means that the manure, sludges and wastewater should be applied to land or land filled.

Although land application is acknowledged as the appropriate technique for phosphorus control with animal manure and sludges as well as agricultural industry wastewaters, chemical precipitation of wastewater, particularly that derived from an agro-industrial source, has been practiced.

Results have led to chemical demand relationships, types of sludge production and relative costs of chemical precipitation which can be applied to other animal wastewaters but rarely are.

The chemicals which may be used to precipitate phosphorus are polyelectrolyte lime (calcium carbonate), alum (aluminium sulphate) and ferric salts. Lime reacts with orthophosphate in solution to precipitate hydroxylapatite. When alum is used to remove phosphates, the removal mechanism is by incorporation in a complex with aluminium or by adsorption on aluminium hydroxide floc.Ferric ions and phosphates react to form insoluble ferric phosphate precipitates. Each of the reactions has a specific pH optimum range.

The quantity of chemical to achieve specific phosphorus removals depends upon the characteristics of the manure, sludge or wastewater, such as pH, alkalinity, phosphate concentration and related factors that affect coagulant demand. These factors vary from wastewater to wastewater. Empirical relationships can be used to estimate the type and quantity of chemical coagulant.

The type of coagulant selected will have a significant impact on the magnitude of sludge produced and the availability of phosphorus in the sludge.

Section E: Appendices

State Government Victoria
Department of Natural Resources and Environment

GARDINER FOUNDATION

VICTORIAN NUTRIENT MANAGEMENT PROGRAM

DAIRY RESEARCH AND DEVELOPMENT CORPORATION

Victoria The Place To Be