

# INVESTOR-READY SHEEP FEEDLOT

**A Sheep Industry Business Innovation project  
DAFWA, Western Australia**

**Completed by**

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## 1.0 INTRODUCTION

The Sheep Industry Business Innovation Project aims to develop technical and business information and facilitation of new sheep value chains within Western Australia. The proposed project seeks to determine establishment costs, infrastructure requirements, environmental impact and effluent management assessments and a Benefit:Cost feasibility study for low input, large-scale commercial sheep meat feedlots.

This report focusses on Objective No. 1 of the project eg. design of a 5000 sheep feedlot module, water requirements and manure and effluent disposal.

Note that it is considered that the design principles for a 5000 sheep feedlot module are generally consistent regardless of the size of a proposed sheep feedlot. Where a larger feedlot is proposed then with appropriate local environmental assessment as well as additional feedlot and drainage design the “model” feedlot can be duplicated or expanded to the required feedlot capacity.

In designing the 5000 sheep feedlot consideration has been given to the information and guidelines outlined in a number of key publications including :-

- *National Procedures & Guidelines for Intensive Sheep & Lamb Feeding Systems* (Meat & Livestock Australia, 2011)
- “Feedlotting Lambs” (Agnote DAI/42, 2002)
- “Grain Finishing of Lambs” (Meat & Livestock Australia, 2005).

The proposed feedlot has also been designed considering details in the *National Guidelines for Beef Cattle Feedlots in Aus.* (Meat & Livestock Australia, 2012).

## 2.0 SITE SELECTION

Site selection is a most important planning function for a proposed sheep feedlot to help overcome community issues as well as assist in minimising any adverse environmental impacts. The site should satisfy a number of the preferred feedlot locational criteria including :-

- Temperate climate with average rainfall & high evaporation
- Gently undulating terrain for good drainage
- Good separation from local creeks or rivers
- Sheep feeding areas well above any floodplain
- Absence of shallow groundwater
- Sufficient land available for manure utilisation
- Adequate water supplies
- Suitable soils
- Adequate buffer distance to neighbours and any nearby town
- Abundant grain and fodder supplies

## 3.0 FEEDLOT DESIGN

The feedlot is designed for a capacity of 5000 sheep. Following are a number of key points re the feedlot :-

- Feeding pens will generally hold about 500 sheep and be fifty (50) metres wide by forty (40) metres deep providing 4 metres<sup>2</sup> per sheep.
- Hospital pens for more intensive husbandry and care of any unwell animals to be incorporated into the feedlot.
- It is important that there is minimal pen – to – pen drainage and therefore pen orientation be perpendicular to the contour
- Feeding pens are to be constructed using a mix of materials including steel pipes and strainer assemblies, netting fences and high tensile wires.
- Ideally the site would have a slope gradient of 2 – 4%. -If required cutting, filling and compaction operations would be undertaken to achieve a slope gradient in pens of ~ 2.5%.
- All weather internal farm access roads to the feedlot are essential.
- The feed pens would be regularly cleaned (recommendation quarterly), Manure would be stockpiled into windrows on compacted clay lined pads for composting.

- The development should comply with the feedlot drainage system requirements outlined in the *National Procedures & Guidelines* (MLA, 2011) and the *National Guidelines for Beef Feedlots* (MLA, 2012).
- Rainfall runoff from the pens drains via the sedimentation structures to an effluent evaporation dam. Note that Bureau of Meteorology records indicate that the evaporation is approximately 1800 mm (BOM, 2017).
- Earthen embankments including the effluent catch drains will fully enclose the feedlot forming a “controlled drainage area”.
- A runoff diversion bank and channel is to be constructed upgradient of the feedlot to prevent extraneous run-on water entering the feedlot.
- Run-on water should be discharged to natural drainage pathways.
- Feed and water troughs to be sited on 2.5m concrete aprons to minimise soil pugging and erosion at trough faces

### 3.1 Feed Pen Management

Minimising pen moisture assists with reduced odour production/risk and improved animal performance.

Feedlot drainage design, pen orientation and a 2.5% slope gradient facilitates good pen drainage and drying.

Pen cleaning must be carefully managed so as to cause minimum disturbance of the compacted manure-soil interfacial layer. This layer helps in achieving an effective moisture seal and prevents downward movement of wastes and potential leaching of nutrients to groundwater (Sweeten, Undated).

This zone of low infiltration is composed of bacterial cells, organic matter, degradation products and soil particles and it is this combination that achieves a surface seal and helps protect any susceptible underlying groundwater (Schuman and McCalla, 1975).

### 3.2 Shade and Shelter

Where practical feedlots should consider shade and windbreak and shelter planting using local native species of shrubs and trees to help mitigate the extremes of cold and hot weather.

In addition the following “best management practices” should be considered to help mitigate the effects of extreme heat events including:-

- Regular cleaning of feeding pens to help ensure that the pad is clean and dry and to help in controlling humidity, especially during the hotter summer months
- Install an overflow/waste outflow system to the water troughs to help contain waste water outflow.
- Routinely monitor weather conditions during the critical hotter months of the year, especially following summer rainfall
- Consider modifying ration components during extreme summer heat conditions to help minimise animal heat load eg. possibly introducing highly digestible energy substitutes such as molasses and more easily digested roughages to the ration as well as ensuring adequacy of vitamins and minerals
- More regular feeding of smaller sized fresh feed to help spread the heat load in animals which rises during and after feeding
- Where feasible, feeding to be more oriented to afternoon or early evening to better align heat production peaks with cooler night-time conditions
- Ensure a good supply of clean, cool high quality water to stock at all times including adequate backup supplies in case of emergency situations

#### **4.0 WATER SUPPLY**

To ensure water is available in case of emergency (eg pump failure) a minimum of three (3) days summer supply will be stored on site. These tanks will have a gravity feed option to the feedlot pens. are recommended.

Water troughs will be located away from feed areas. Concrete troughs will be centrally placed within pen division fencelines, providing two (2) water access points per pen. i

#### Sheep Requirements

The 5000 sheep feedlot will require an average of approximately 25 kilolitres of water per day ie. 5 litres per sheep per day (NSW Ag, 2002). A potential maximum water requirement for the feedlot (assuming ~80% feedlot operation & annual throughput of about 26250 sheep) is approx. 7.5 ML per annum.

Feedlot operators will be aware that it is vital that a good clean supply of drinking water is available at all times not only for feedlot productivity but also for the important animal welfare considerations.

If water quality and/or availability are compromised, contingency plans (eg removal of stock from feedlot pens; alternate water supply) must be in place.

## 5.0 SHEEP HUSBANDRY AND FEEDLOT MANAGEMENT

Many factors contribute to the environmental sustainability, success and financial viability of a sheep feedlot including:-

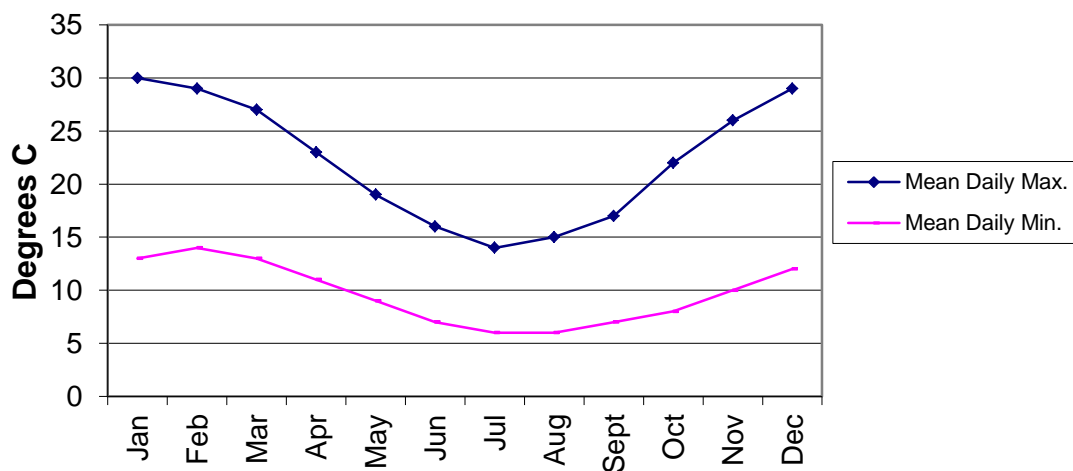
- Environmental considerations eg. planned and executed manure handling and utilisation, regular pen cleaning, effluent management, etc.
- Sheep welfare and management ie. health, husbandry and feeding management
- Financial planning, budgeting and marketing

Due consideration needs to be given to the above at all times.

## 6.0 CLIMATE

For the purposes of designing a “model” feedlot the Katanning – Broomehill locality was chosen. There are a number of reasons including the area being a typical sheep grazing area in south-western WA and the proximity to the nearby Katanning Saleyards and abattoirs.

**Figure 1. Mean Daily Maximum & Minimum Temperatures**



Climate statistics for Katanning has been sourced from the Bureau of Meteorology.

Mean monthly maximum temperatures range between a maximum of 30.1° C in January and 14.7° C in July.

In winter, mean monthly minimum temperatures are as low as 5.9° C in July and 14.1° C in January (Refer to Figure 1).

**Figure 2. Average monthly Rainfall & Evaporation**

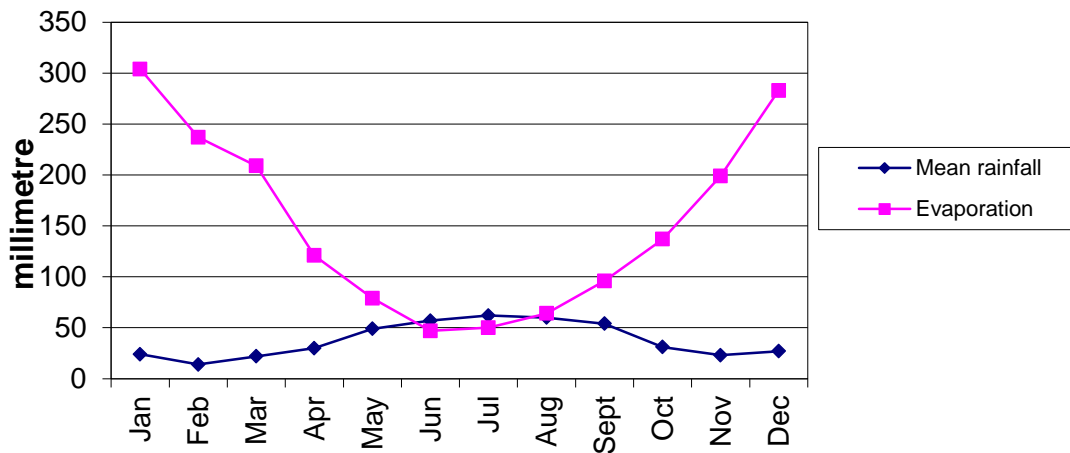


Figure 2. shows the relationship between average annual rainfall and evaporation. The average annual rainfall is recorded as of 455 mm and a winter dominant pattern is evident.

As a consequence of the warm to hot summers evaporation is approximately 1800 mm/year. Note that in this relatively low rainfall region rainfall is similar to evaporation only in the winter months of June to August.

## 7.0 FEEDLOT MANURE & EFFLUENT

### 7.1 Introduction

Sheep feedlot wastes include the manure regularly cleaned from the feeding pens during the year and any rainfall runoff or feedlot effluent.

The manure and effluent contain a variety of valuable nutrients including nitrogen and phosphorus. When sustainably applied to land these nutrients enhance vegetative production and have significant beneficial effects on soils.

Feedlot manure is naturally rich in organic matter and when applied to soils can significantly increase organic matter and carbon content and thereby help to improve soil structure, increase rainfall infiltration into soils and enhance the soils' water holding capacity.

The principles applied in developing the manure and effluent management systems for the model feedlot are:-

- to compost the manure and treat it as a valuable feedlot by-product

- to apply the philosophy of sustainability to the land application of manure
- to design the effluent management system according to the requirements of the *National Procedures and Guidelines for Intensive Sheep & Lamb Feeding Systems* (MLA, 2011)
- to safely dispose of the effluent by evaporation

## 7.2 Feedlot Manure

Many factors contribute to the amount of manure cleaned from the feed pens in a year including the number and size of sheep, ration content, ration digestibility and climate.

The NSW Feedlot Manual (NSW Agriculture, 1997) states that in open feedlots there is considerable loss between the production of fresh manure and removal from feed pens.

These losses arise from evaporation, bio-degradation of volatile solids, as dust and other mechanical factors such as runoff and incorporation into the manure “pad”.

Although sheep manure is considerably drier than cattle manure, under the appropriate conditions these same processes occur.

### Manure Characteristics

The characteristics of feedlot manure have been found to vary widely and are determined by such factors as:-

- weight & class of sheep
- stocking density of pens
- the feedlot ration
- the time between cleaning out of feedlot pens
- rainfall and temperature
- length of time of stockpiling of manure
- whether manure is composted or spread direct from the feedlot

**Table 1. Typical Average Composition of Feedlot Wastes - Sheep**

Parameter	Symbol	Units	Average
Wet Excreta Waste	WW	%lwt/day	3.6
Total Solids	TS	%WW	29.7
Volatile Solids	VS	%TS	84.7
Biochem.O <sub>2</sub> Demand	BOD	%TS	8.8
Nitrogen	N	%TS	4
Phosphorus	P	%TS	1.4
Potassium	K	%TS	2.9

Ref: Taiganides (1977)



Typical average waste product composition of intensively fed sheep is shown in Table 1. Note that the mass of waste products generated are directly proportional to the live weight of the animal.

A comparison of the fresh manure production and characteristics between sheep and cattle is provided in Table 2. One key characteristic is the relatively lower moisture content of sheep manure.

### 7.3 Manure Generated

Little data is available nor specific details regarding manure generation in sheep feedlots in Australia. However, the beef feedlot industry has developed detailed guidelines and specific methodologies for managing solid and liquid wastes.

Calculating the sheep manure generated in a 5000-sheep feedlot is performed by making comparisons to beef feedlots.

**Table 2. Mean Fresh Manure Production and Characteristics per 1000 Kg Live Animal Mass Per Day**

Parameter	Units	Animal Type	
		Beef	Sheep
Total manure	Kg	58	40
Urine	Kg	18	15
Density	Kg/m <sup>3</sup>	1000	1000
Total Solids	Kg	8.5	11
Volatile Solids	Kg	7.2	9.2
Biochemical Oxygen Demand, 5-day	Kg	1.6	1.2
Chemical Oxygen Demand	Kg	7.8	11
PH		7.0	**
Total Kjeldahl Nitrogen	Kg	0.34	0.42
Ammonia Nitrogen	Kg	0.086	**
Total Phosphorus	Kg	0.092	0.087
Orthophosphorus	Kg	0.030	0.032
Potassium	Kg	0.21	0.32
Calcium	Kg	0.14	0.28
Magnesium	Kg	0.049	0.072
Sulfur	Kg	0.045	0.055
Sodium	Kg	0.030	0.078
Chloride	Kg	**	0.089
Iron	G	7.8	8.1
Manganese	G	1.2	1.4

Ref: ASAE Standards 2000

In estimating the manure generated a comparison of the metabolic bodyweight of sheep and cattle is undertaken. This approach can be justified due to the fact

that both species ie. ovine and bovine animals, are ruminants and have comparable metabolism.

Metabolism being the sum of both the physical and chemical changes by which animals process food into simpler compounds to enable the animal to function and includes the generation and exchange of energy.

The *National Guidelines for Beef Cattle Feedlots* (MLA, 2012) defines a Standard Cattle Unit (SCU) as an animal with a live weight on exit from the feedlot of 600 kilograms.

In calculations relating to a sheep feedlot and considering metabolic bodyweight (NDSU, 2005) and information outlined in the *National Procedures and Guidelines for Intensive Sheep & Lamb Feeding Systems* (MLA, 2011), one SCU is calculated to be equivalent to 7.29 sheep weighing approximately 60 kilograms ie. a Standard Sheep Unit (SSU).

The mass of manure generated per year can be calculated for 686 SCU equivalent to 5000 SSU.

Manure generated in a beef feedlot operating year round with similar metabolic body weight as the proposed 5000 sheep feedlot is calculated as follows :-

$$\begin{aligned}\text{Manure Generated} &= L \times C \times D \times U \times 0.0075 \\ &= 500 \times 686 \times 365 \times 0.8 \times 0.0075/1000 \\ &= 751 \text{ tonnes}\end{aligned}$$

Where

- L - median live weight on feed (Kgs)
- C - Feedlot capacity (Sheep:Cattle equivalents)
- D - No. days feedlot operates annually
- U - Av. utilisation capacity
- 0.0075 - Multiplication factor

Also needing to be considered is that sheep manure is much drier than cattle manure and on a weight basis sheep produce approximately two thirds as much manure as cattle (Dowling & Crossley, 2003).

Therefore the assumed sheep manure produced is calculated as follows:-

$$\begin{aligned}\text{Sheep Manure} &= 751 \times 0.666 \\ &= \sim 500 \text{ Tonnes}\end{aligned}$$

#### 7.4 Sustainable Manure Utilisation

Manure cleaned from the feed pens would normally be aerobically composted onsite ie. manure would be placed into stockpiles, regularly turned and processed into a moist and crumbly dark soil-like product.

There is little data in the literature on the composition of sheep manure under dry Australian conditions (Dowling & Crossley, 2003). Most data on animal waste and its characterisation has come from North America and Europe (Kruger, 1997).

However, it is well established that animal manure is high in nutrients such as nitrogen and phosphorus. Published information eg. MWPS, 1993 and MWPS, 2000, generally indicates that there is approximately 1.06% nitrogen and 0.22% phosphorus in fresh manure.

As indicated earlier in open feedlots there are considerable losses between the production of fresh manure and removal or harvesting of manure from feed pens by feedlot operators (NSW Agriculture, 1997).

**Table 3. Estimated Mass of Nutrients in Fresh Manure**

Parameter	% Content <sup>1.</sup>	Nutrients / Tonne Kg	Manure Generated T/year	Nutrient Generated Kg/yr	Losses %	Nutrient Harvested Kg
Nitrogen	1.055	10.55	500	5275.0	50	2638
Phosphorus	0.2175	2.175	500	1087.5	5	1033

Note 1. Ref: ASAE, (1999) MWPS, (1993), MWPS, (2000) & ASAE, (2003)

For example, there is the potential for substantial nitrogen losses from the freshly voided manure arising from microbial activities and nitrification, volatilisation and denitrification and degradation and mineralisation processes.

Based on the published data the losses of nutrients are assumed to be approximately 50% nitrogen and 5% phosphorus and these losses have been factored into the calculations and data shown in Tables 3. & 4.

Generally composted feedlot manure would be spread at sustainable rates onto cropping lands ie. at rates not exceeding the ability of the crop-soil system to utilise the nutrients.

Environmentally sustainable reuse of feedlot by-products dictates that the allowable loading rate to soils generally equates to:-

- the removal of a nutrient in grain and/or vegetative plant matter, and
- storages in the soil profile

It is calculated that there will be approximately 2.64 tonnes and 1 tonnes of nitrogen and phosphorus, respectively, available in the manure harvested from the “model” feedlot.

#### 7.5 Land Area Requirement - Feedlot Manure

For dryland farming operations phosphorus loading rates usually determine the upper limit for manure applications. The loading rate for nitrogen is much higher than phosphorus because of the greater uptake of nitrogen by growing plants.

Another important factor is the slow release of inorganic nitrogen from mineralisation of the organic nitrogen in feedlot manure over time.

Predicting mineralisation is difficult but the industry has generally adopted the semi empirical, semi quantitative mineralisation decay series developed by Pratt *et al* (1973, 1976).

Pratt *et al* measured the rate of release of nitrogen as a function of time eg. for dry feedlot manure with 1.5% N (dry basis) the decay series is 35% mineralisation in the first year, 15% of the un-mineralised residual in the second year, 10% in the third year and 5% of the residual in the fourth and subsequent years.

Soil storage, based on the P sorption capacity of a soil rather than plant uptake, is normal practice and the major sink for phosphorus (Gardiner & Casey, 1995).

**Table 4. Nutrient Utilisation – Area of Winter Cereals**

Parameter	Nutrient Uptake <sup>1</sup> . %	Average Yield (tonnes/ha)	Nutrients Required <sup>2</sup> . (Kgs/ha)	Nutrients Available <sup>3</sup> . (Kgs)	Area Required (hectares)
Nitrogen	1.8	2	36	2638	74
Phosphorus	0.4	2	8	1033	<b>130</b>

- Note
1. Ref: NSW Feedlot Manual (NSW Agriculture, 1997)
  2. Allowing zero P sorption
  3. Refer to Table 3. - Allowance has been made for loss of nutrients eg. volatilisation of N, losses to atmosphere

Table 4. indicates that under the planned manure recycling system approximately 130 hectares of winter cereal crop is required to balance phosphorus applied in feedlot manure with plant uptake.

## 7.6 Feedlot Effluent

Feedlot effluent comprises pen runoff from heavy or prolonged rainfall and the volume of runoff is naturally related to surface conditions and the feedlot area. Design features of the “model” feedlot are as follows:-

- 1 x Module of sheep feeding pens
  - 10 feeding pens 50m x 40m & 2000 metres<sup>2</sup> in area plus hospital pens
  - 500 sheep/pen @ 4 m<sup>2</sup> each
  - Manure composting pads 50m x 50m
  - Total area 3 hectares

Thus the “controlled drainage area” of the feedlot is approximately 3 hectares in area and it is intended that the effluent generated be directed via the drainage system and sedimentation structures to evaporation ponds. The relatively high evaporation rates experienced in the Katanning District (~1800 mm) assists in this disposal method.

It is proposed that when excessive sludge accumulates ie. where pond capacity is reduced by 15%, the sludge will be disposed of to one of the following:-

- Secure landfill as per the requirements of government agencies
- Spread on agricultural land at acceptable rates
- Mixed with manure and spread on land at acceptable rates

Details re the “controlled” drainage system and effluent evaporation system are outlined in the following sections.

## 7.7 Effluent Drains

The feedlot is designed to be a “controlled drainage area” ie. where earthen embankments isolate the feeding pens, prevent runoff from the upslope catchment from entering the feedlot and the effluent drainage and sedimentation system isolate and contain the feedlot.

Refer to the attached Site Layout (Schematic) plan.

### Effluent Catch Drains

The specifications of the effluent catch drains immediately downgradient of the feeding pens are as follows :-

Bank height	-	60 cm
Batter grades	-	1V:6H
Channel base	-	3 m
Depth of flow	-	35 cm
Channel slope	-	0.5 – 0.75%

These drains have greater slope gradient compared to the gradient normally used in earthworks because the velocity of flows needs to be increased to help prevent deposition of entrained manure. It is intended that these drains will be constructed of compacted material to help convey effluent at the faster velocity without scouring or eroding the base of the drain.

### Main Drains to Evaporation Structure

These drains convey the runoff from the sedimentation terrace to the evaporation dam. These too will be constructed of compacted material and be accessible for cleaning equipment. The drain specifications are as follows :-

Bank height	-	60 cm
Channel base	-	4 m
Batter grades	-	1V:4H
Depth of flow	-	35 cm

### Note :-

These drainage works, as well as the following effluent control works are designed to comply with the requirements of the key government agencies and industry guidelines.

## 7.8 Sedimentation System

The purpose of the sedimentation system is to remove settleable solid material from feedlot runoff and prevent it from entering the evaporation ponds. It is proposed that the sedimentation system comprise sedimentation terraces versus a basin or pond.

To optimise feedlot drainage, the settling of solids and to facilitate cleaning the design includes a multi-celled sedimentation terrace. The cells will be joined by throttle weir structures as will the discharge points to the evaporation ponds. These help to reduce flow velocity and thereby promote the settling out of solids.

The structure is located immediately below the feeding pens and incorporated into the effluent drainage system. It will be trafficable ie. including a compacted gravel bed, to facilitate cleaning out of accumulated solids. Removed solids will be incorporated into manure stockpiles prior to being spread on-farm.

Designing sedimentation structures includes calculations of the volume required to achieve significant settling of solids as follows:-

$$V = Q_p \times (l/w) \times z/v$$

where:

V	=	volumetric capacity of sedimentation pond
Q <sub>p</sub>	=	peak inflow rate (m <sup>3</sup> /s), AEP 5%

l/w	=	length to width ratio
z	=	a scaling factor (1 for a terrace)
v	=	maximum flow velocity 0.005 m/s.

Sedimentation systems are designed to handle the peak discharge (Qp) from the catchment with a design AEP of 5%.

So :-

C	=	Coefficient of Runoff (0.8 for feedlots)
Tc	=	Time of Concentration (15 minutes)
I	=	Rainfall Intensity (66 mm/hr)
Qp	=	Peak Discharge (0.5 m <sup>3</sup> /s)

Therefore:

$$V = Qp \times (l/w) \times z/v$$

$$= 0.5 \times 10 \times 1/0.005$$

$$= 1000 \text{ metres}^3$$

The sedimentation terrace to be constructed with the following specifications :-

Bank height	-	1.0 m
Batter grades	-	1V:3H
Crest width	-	2.5 m
Width	-	10 m
Depth	-	1.5 m
Length	-	100 m

As mentioned above it is intended that the discharge from each pond be regulated by throttle weirs at the outlet to the evaporation pond.

## 7.9 Effluent Evaporation Pond

Evaporation ponds are sized based on calculations of the annual water balance and are designed to contain the runoff/effluent from the feedlot site.

Only in extreme rainfall events will the pond discharge treated effluent via a spillway designed to comply with a 1 – 50 year ARI (MLA, 2011)

The system is designed to have ~0.6 metre of freeboard and, as stated above, only in extreme rainfall events will any excessive effluent generated flow via the spillway.

**Table 5. Rainfall and Evaporation**

Month	Mean Monthly Rainfall <sup>1</sup> (mm)	Average Raindays <sup>1</sup>	Mean Monthly Evaporation <sup>2</sup> (mm)
Jan	24	2.0	304
Feb	14	1.3	237
Mar	22	2.9	209
Apr	30	4.4	121
May	49	6.1	79
Jun	57	8.8	47
Jul	62	10.4	50
Aug	60	9.3	64
Sep	54	8.9	96
Oct	31	5.4	137
Nov	23	4.0	199
Dec	27	2.6	283
	<b>453</b>	<b>66.1</b>	<b>1826</b>

- Note 1. Ref. Bureau of Meteorology  
2. Ref. Bureau of Meteorology

### Annual Water Balance

This section includes the determination of the water balance and storage requirements for the evaporation pond. Table 5. shows mean monthly rainfall, average rain days and monthly evaporation for Katanning.

**Table 6. Feedlot Effluent**

Month	Mean Rainfall (mm)	Feedlot Effluent (metres <sup>3</sup> )
Jan	24	360
Feb	14	210
Mar	22	330
Apr	30	450
May	49	735
Jun	57	855
Jul	62	930
Aug	60	900
Sep	54	810
Oct	31	465
Nov	23	345
Dec	27	405
	<b>453</b>	<b>6795</b>

Table 6. indicates effluent generated on a monthly basis for the “model” feedlot assuming a Coefficient of Runoff of 0.5 (MLA, 2012) and average monthly rainfall.

It is proposed that the evaporation pond has the following specifications :-



**Volumetric Capacity ~ 4500 Metres<sup>3</sup>**

Bank height	-	1.0 m
Batter grades	-	1V:3H
Crest width	-	2.5 m
Length	-	100 m
Width	-	50 m
Depth	-	1.2 m
Freeboard	-	0.6 m

The effluent storage demand and cumulative storage requirement are presented in Table 7. In viewing the data on cumulative storage it is important to note that pond has a design depth of ~1.2 metres and the maximum cumulative storage depth in the pond is 510 mm

As indicated above the feedlot will be fully contained by earthen embankments forming the main effluent drains and sedimentation pond and all effluent will be directed to the shallow evaporation pond.

**Table 7. Water Balance**

Month	Mean Rainfall (mm)	Feedlot Effluent (metres <sup>3</sup> )	Effluent to Storage <sup>1</sup> (mm)	Mean Monthly Evap (mm)	Storage Demand (mm)	Cumulative Storage (mm)
Jan	24	360	72	304	-232	0
Feb	14	210	42	237	-195	0
Mar	22	330	66	209	-143	0
Apr	30	450	90	121	-31	0
May	49	735	147	79	68	68
Jun	57	855	171	47	124	192
Jul	62	930	186	50	136	328
Aug	60	900	180	64	116	444
Sep	54	810	162	96	66	<b>510</b>
Oct	31	465	93	137	-44	466
Nov	23	345	69	199	-130	336
Dec	27	405	81	283	-202	134
	<b>453</b>	<b>6795</b>		<b>1826</b>		

1. ~4.5 ML Evaporation Pond

As stated above, only in extreme rainfall events will the excess effluent generated flow via the spillway.

The spillway is proposed to have the following characteristics :-

- level 4 metre wide grass-lined outlet at ground level
- a peak discharge of ~ 0.6 m<sup>3</sup>/s (1-50 year ARI)
- depth of 0.5 metres.

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