

Appendix C. – Clay lining of feedlot pens, pads and drainage system

Preamble

Runoff from the feedlot pad contains organic and mineralised manure constituents that could pose a significant ecological hazard if they were released, uncontrolled, into the environment.

If a groundwater assessment indicates a high potential for contamination of underground water resources because of leaching of nutrients through permeable, underlying soil or rock strata, an impermeable barrier will be needed between the contaminant and the groundwater. This is required if the permeability of underlying soil/rock strata exceeds 0.1mm/day (3.5 cm/year).

This impermeable barrier is generally created using a liner made of compacted clay or other suitable compactable soil materials. Where these materials are not available, a synthetic liner (polymembrane) may be used. Synthetic liners tend to be expensive, require specialist installation and are hard to protect from damage by cattle and cleaning equipment. Clay liners tend to be the most common form employed in feedlot construction, and the following section outlines the characteristics of suitable clay lining material.

Design standard

- Clay liners should have a maximum permeability of 1×10^{-9} m/s (0.1mm/day) for distilled water with 1 m of pressure head.
- Clay liners must be of sufficient depth so that the integrity of the structure is maintained throughout the general working of the feedlot.

Clay liners

Clay liners are commonly used in industry for a range of contaminants including liquid effluent.

For a given soil, permeability is related to soil particle composition, moisture content and level of compaction; and there are limits to the permeability that can be achieved at any level of compaction. *In-situ* and laboratory measurement of permeability is difficult, and relatively inaccurate. Also, some soil types, because of their physical and chemical properties, are impermeable *in-situ*, but fail to meet the design standard when measured in the laboratory.

For these reasons, rather than relying on permeability standards, this section provides guidance on specifications for materials and construction methods to be used for clay lining.

The specifications in Table C.1 provide guidance on the selection of the correct materials for use in the liner. Soils may need to be mixed or engineered to produce a material that meets the specifications.

Table C.1 Specifications for clay liner materials

Soil characteristic	Acceptability criterion	Test method
Percentage fines	More than 25% passing 75 µm sieve	AS 1289 3.6
	More than 15% passing 2 µm sieve	
Liquid Limit	Less than 70	AS 1289 3.1.2
Plasticity Index	More than 15	AS 1289 3.3.1
Emerson class number	5 to 6	AS 1289 3.8.1

Areas to be clay lined within the controlled drainage area include:

- effluent catch drain
- sedimentation system
- holding ponds
- manure stockpile and composting pad
- any area where contaminants are stored or handled.

Because of the formation of a low permeability soil-manure interface layer, clay lining is not generally required on the feedlot pen and yard areas.

Trafficability of clay lined materials

The liner should be trafficable for cattle and equipment. To ensure that the integrity of the liner is maintained, the depth of the liner should be sufficient to ensure that equipment does not damage it during harvesting of manure. The minimum depth recommended for the clay liner is 300 mm after compaction. Periodic repair of the liner will be necessary due to the wear and tear associated with cattle traffic and normal cleaning operations.

The mechanical strength of liners can be tested using the Californian Bearing Ratio (CBR) test, which was developed for measuring the load-bearing capacity of soils used for building roads. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area in both the saturated and dry conditions at a specified compaction. The minimum standard for CBR wet and dry is 20%.

Particular attention should be applied to the load-bearing capability of areas where cleaning or harvesting of dry waste is undertaken, including:

- feedlot pens
- effluent catch drain
- sedimentation system
- manure stockpile and composting pad.

Construction

All areas to be clay lined should be cleared and grubbed, stripped of top soil and prepared to the required levels and gradients by cutting and filling. The surface of the excavated area should also be tined before the clay material is placed to produce a satisfactory bonding surface.

The clay lining material should be placed in layers of 150 mm (± 50 mm). Each layer should be tined, wetted to $\pm 2\%$ of optimum moisture content (AS 1289 5.1.1) and compacted to the required compaction (relative to the maximum dry density, AS 1289 5.4.2) that is needed to achieve the required permeability of 1mm/day.

APPENDIX E STANDARD SPECIFICATION

CATTLE FEEDLOTS



CLAY LINING OF DRAINS, SEDIMENTATION SYSTEMS, HOLDING PONDS AND MANURE STOCKPILE AREAS

Alan Skerman, Senior Environmental Engineer, Intensive Livestock Environmental Management Services

INTRODUCTION

This standard specification is intended to provide guidance and technical direction to licensees, contractors, consultants and project managers involved in the construction of cattle feedlots at sites where groundwater impact assessments have indicated a high potential for contamination of underground and/or surface water resources, because of leaching of nutrients through permeable, underlying soil or rock strata. It outlines this Department's recommended practices for the clay lining of drains, sedimentation systems, holding ponds and manure stockpile areas and provides a set of enforceable, quantitative standards to ensure that consistency is achieved throughout the industry.

This specification is based on established engineering principles and operational experience gained by the industry over several years. However, it may be revised from time to time as new methods are developed and/or as experience dictates. Proposals involving alternative materials and/or construction methods may be submitted to the administering authority for consideration.

1. PERMEABILITY STANDARD

If a groundwater impact assessment indicates a high potential for contamination of underground and/or surface water resources, because of the leaching of nutrients through permeable, underlying soil/rock strata, clay lining of the feedlot complex should be undertaken in accordance with this specification. For the purpose of this specification, it is considered that there is a significant risk of nutrient leaching if the permeability of underlying soil/rock strata exceeds 0.1 mm/day (37 mm/year).

Because in-situ and laboratory measurement of permeability is difficult and relatively inaccurate, rather than relying on permeability standards, this document provides proven standards for materials and methods used for clay lining. By applying these standards, the required permeability should be achieved consistently.

2. AREAS TO BE CLAY LINED

Unless the underlying soil type and geology changes significantly across the feedlot site, each of the following areas of the feedlot complex should be clay lined:

- internal catch drain(s),
- sedimentation system(s),
- holding pond(s) and
- manure stockpile area(s)

Because of the formation of a low permeability soil–manure interface layer, clay lining is not generally required on the pen and yard areas, unless directed by the administering authority.

3. CLAY LINING SURFACE PREPARATION

All surfaces to be clay lined shall be cleared and grubbed, stripped of topsoil and prepared to the required levels and gradients by cutting and filling, as required. This will involve over-excavation (excavation below the design level indicated on the plans) to accommodate the required thickness of clay lining while ensuring that the final design gradients, levels and dimensions are achieved, in accordance with the plans approved by the administering authority.

To produce a satisfactory bonding surface for the placement of subsequent layers, the following operations should be carried out on all areas to be clay lined:

- (i) scarifying or ripping with a tined implement, to a minimum depth of 150 mm,
- (ii) watering to produce the correct moisture content, as specified in Clause 6,
- (iii) compaction in accordance with Clause 7.

4. CLAY LINING MATERIAL

Soils shall be considered suitable for use as clay lining materials, subject to compliance with the following requirements:

The material shall be classified as either CL, CI, CH, SC or GC in accordance with the soil classification system described in Appendix A of AS 1726. Furthermore, it shall conform with the following particle size distribution and plasticity limits:

- (i) Particle Size Distribution:

AS Metric Sieve Size (mm)	Percentage Passing (by dry weight)
75	100
19	70 – 100
2.36	40 – 100
0.075	25 – 90

- (ii) Plasticity Limits on fines fraction, passing 0.425 mm sieve:

Liquid Limit W_L	30 – 60 %
Plasticity Index I_p	> 10 %

Note for explanatory purposes: The material classification symbols CL, CI, CH, SC and GC represent clays having low, intermediate and high plasticity, clayey sands and clayey gravels respectively.

If materials complying with the above plasticity limits are not readily available, clays having liquid limits between 60% and 80% may be used as lining material, provided that the clay lining layer is covered with a layer of compacted gravel (or other approved material), having a minimum thickness of 100 mm, to prevent the clay lining from drying out and cracking.

Topsoil, soils incorporating tree roots or organic matter and any other material which does not compact properly, must not be placed in any of the areas to be clay lined. Wherever non-dispersive materials are available, they are to be used in preference to materials shown to be dispersive using the Emerson test, as described in Method 8.1 of AS 1289.

5. MATERIAL SUITABILITY AND IDENTIFICATION

The visual identification methods described in AS 1726 may be used by suitably qualified and experienced persons, for classifying soils in the field. However, if there is doubt about the suitability of the material, the administering authority may direct the licensee to arrange for laboratory testing, in accordance with the appropriate sections of AS 1289. All such laboratory testing must be carried out by a soils laboratory, accredited by the National Association of Testing Authorities (NATA).

6. CLAY LINING THICKNESS

The minimum required thickness of clay lining depends on the maximum head of effluent in contact with the clay lining and the duration of that contact. The following table outlines minimum lining thicknesses (after compaction), for the different areas of the feedlot, for two maximum head conditions.

Area of Feedlot	Maximum Head Over Clay Lining (m)	Minimum Clay Lining Thickness (mm)
Internal Catch Drains Sedimentation Systems Holding Ponds Manure Stockpile Areas	< 2 m	300
Sedimentation Systems Holding Ponds	> 2 m	450

7. PLACEMENT OF MATERIAL

Clay lining material complying with Clause 4, shall be placed at the correct moisture content as defined in Clause 8, on surfaces prepared in accordance with Clause 3, in progressive, uniform, horizontal layers, not exceeding 200 mm in thickness, prior to compaction.

8. CORRECT MOISTURE CONTENT

Prior to compaction, all material used for lining purposes shall be conditioned to have a moisture content within the range of two (2) percent wet to two (2) percent dry of the optimum moisture content required to produce the maximum dry density when compacted in accordance with Method 5.1.1 of AS 1289.

Note for explanatory purposes: This moisture content is consistent with the requirements for compaction using a sheepsfoot roller to produce maximum impermeability. As a guide, the required moisture content is as wet as can be rolled without clogging a sheepsfoot roller. A preliminary assessment of the required moisture content can be made by rolling a sample of the material between the hands. If it can be rolled to pencil thickness without breaking, it should be satisfactory.

9. COMPACTION

Each layer of material placed in accordance with Clause 7, shall be compacted to produce **either** a field dry density of at least 95% of the standard maximum laboratory dry density determined in accordance with Method 5.4.1 of AS 1289, **or alternatively**, a Hilf density ratio of at least 95% when tested in accordance with Method 5.7.1 of AS 1289.

Note for explanatory purposes: This degree of compaction may generally be achieved by rolling each layer of material, placed at the correct moisture content, with at least eight (8) passes of a sheepsfoot roller of the configuration described in Clause 10 below. As a guide, compaction will generally be sufficient when there is a clearance of 100 mm between the drum of the roller and the compacted material.

10. SHEEPSFOOT ROLLER

The following specifications describe a sheepsfoot roller which is suitable for fulfilling the compaction requirements described in Clause 9:

- (i) The diameter of the drum(s) shall be not less than 1m.
- (ii) The length of each drum(s) shall be approximately 1.2 times the drum diameter.
- (iii) The feet shall extend approximately 175mm radially from the drum and be of the taper-foot type, with a cross-sectional area close to the outer end of not less than 3200mm² and not more than 4500mm².
- (iv) The number of feet shall be such that their total area close to the outer ends shall be between 5% and approximately 8% of the area of the cylinder which would enclose all the feet, *i.e.* a cylinder having a diameter equal to the diameter of the drum plus twice the length of each foot.
- (v) The weight of the roller ballasted, shall be such that the bearing pressure thus obtained shall be not less than 1750 kilopascals, in accordance with the following formula:

$$\text{Bearing Pressure (kPa)} = \frac{\text{Mass (kg)} \times 9.81 \times 1000}{\text{Area of contact of one row of feet (mm}^2\text{)}}$$

Rollers of other types and configurations may be used provided that the required compaction is achieved in accordance with Clause 9.

11. TEST FOR ADEQUATE COMPACTION

The administering authority may direct the licensee to arrange for compaction testing, in accordance with the methods referred to in Clause 9 of this specification, to be carried out on appropriate sections of the works area. Compaction testing is to be performed by suitably qualified and experienced personnel, employed by a soils laboratory accredited by the National Association of Testing Authorities (NATA) for the specified testing method.

Failure of the test results to comply with the compaction requirements described in Clause 9 will result in the licensee being prohibited from stocking the feedlot until appropriate remedial measures are implemented, as directed by the administering authority.

12. EXEMPTION FROM CLAY LINING REQUIREMENTS

The administering authority may exempt a licensee from the requirement to clay line cattle feedlot facilities if the licensee can submit certified test results confirming that the permeability of soils underlying nominated areas of the feedlot does not exceed 0.1 mm/day.

Permeability testing is to be carried in accordance with the methods specified in either Part 6 of BS 1377 (Triaxial Permeability) or Section F7.1 of AS 1289. The test results shall be submitted to the administering authority, following certification by a National Association of Testing Authorities (NATA) accredited soils laboratory.

13. FINAL TRIMMING

Following the completion of compaction, final trimming of all clay lined areas shall be carried out to produce a smooth, uniform surface, in accordance with the design gradients, levels and dimensions shown on the plans, as previously approved by the administering authority.

14. SYNTHETIC LINERS

A licensee may submit to the administering authority, alternate material and installation specifications relating to the use of synthetic lining materials, in lieu of clay lining. Approval of synthetic lining proposals will be subject to assessment by the administering authority.

15. INDEMNITY

The Department of Primary Industries and Officers of that Department shall not be responsible for any costs incurred by either the licensee or his/her contractor, in carrying out any works, as directed by the administering authority, for the purpose of rectifying design and/or construction faults or omissions.