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NSW DEPARTMENT OF
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Leaking farm dams

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Failure to hold water is the most common problem with farm dams. Anxious farmers want the leak sealed and stopped—fast. However, like most business people, they are often short of funds and want the works to be done as cheaply as possible.

When a leak is suspected, all other sources of water loss should be thoroughly checked. Loss through evaporation can be the cause of some hard-to-find 'leaks'. Accidentally leaving a valve open on an outlet pipe can be another cause of apparent leaking. The farm dams that do leak were not planned or built properly; and sometimes it is hard to pinpoint the exact cause of the problem. Often you cannot keep a close eye on all the dam construction works; or the dam may have been constructed by a previous owner.

Common causes of dam leakage are:

- the work of a contractor unfamiliar with farm dam construction
- failure to remove topsoil and vegetation at the embankment site
- use of an unsuitable soil type in the dam wall
- failure to construct a cut-off trench
- poor soil compaction
- failure to backfill exposed rock, gravel or sand in the storage basin
- poor maintenance of the dam.

The right contractor

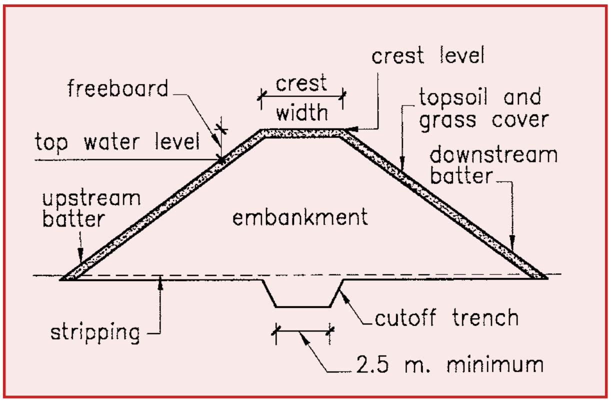
It is worthwhile to choose an earthmoving contractor who has experience and a good work record. Not every contractor has the experience or the ability to build a dam.

Try to find someone who specialises in dam construction. For example, you could ask neighbours who have had dams built if they are happy with the results.

Once you have found a few dam builders, ask them to show you some of their recent work. If possible, talk to the owners of these dams and ask their opinions of the work.

If you choose an experienced dam builder with good references, you can reduce the chance of problems occurring during and after the building of your dam.

Figure 1. A typical cross-section of a dam



Topsoil and vegetation

Topsoil is porous: water runs freely through it. So, before building starts, the area to be covered by the embankment, spillway and excavation should be stripped of all topsoil, roots and vegetation (including trees and stumps). Store the topsoil for completion of the embankment.

Soil type

The soil used to build the embankment must be impermeable, so the embankment can hold water.

Clay soils are usually satisfactory. As a guide, a soil containing enough clay to be impermeable sticks to your fingers when it is damp. However, not all clays are suitable for dam embankments. For example, some clays disperse (break down easily) when wet,

Figure 2. A central clay core

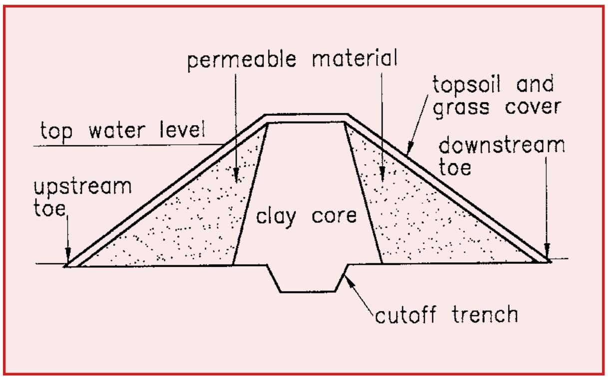


Figure 3. A typical upstream clay core

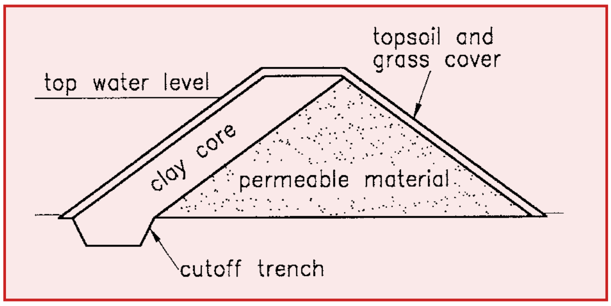
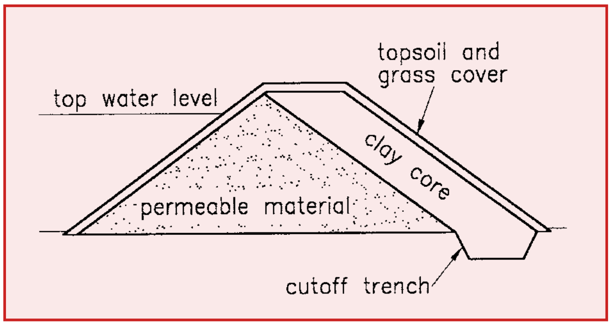


Figure 4. A typical downstream clay core



causing tunnels to form in the embankment, so the soil must be tested to determine its behaviour.

For the tests, samples of the soil must be obtained from the excavation area. The samples can come from auger holes or backhoe trenches. The sampling depth should extend at least to the depth of anticipated excavation. The samples should be tested by someone experienced in assessing soil for dam construction.

A clay core may be required if there is not enough suitable material at the excavation area to build a homogeneous embankment. In these cases, the clay core is used to provide the impermeable barrier; and the balance of the material in the embankment provides the dam with structural stability.

The core can be located between more permeable material or it may be constructed at either the water- or non-water face. Typical arrangements are shown in Figures 2, 3 and 4.

The cut-off trench

With good construction methods, seepage losses can be reduced. One way is to build a cut-off trench along the entire length of the embankment. The cut-off trench is used to prevent leaks caused by water escaping beneath the embankment. Usually the trench does not need to extend across the spillway. The trench is shown in Figures 1, 2, 3 and 4.

The trench should be at least 600 mm deep with a minimum 300 mm extending into impervious soil. The cut-off trench must be backfilled with good clay that is thoroughly compacted.

All farm dams must have a cut-off trench.

Soil compaction

Soil compaction is another way of reducing seepage losses. The soil used to backfill the cut-off trench and to form the embankment should be placed in layers, with each layer thoroughly compacted before the next layer is placed.

Preferably, compaction should be achieved with a sheepsfoot roller; however, a scraper or bulldozer may be satisfactory depending on the soil behaviour and the layer thickness.

A layer 150 mm or less of loose thickness, for a sheepsfoot roller, or 100 mm or less of loose thickness, for a bulldozer or scraper, is recommended.

The number of passes that should be made by the compacting equipment depends on the soil type, but it should be at least four. Generally, embankments lower than about 2–3 m may be compacted satisfactorily with a bulldozer or scraper.

The soil used to build the embankment should not be too wet or too dry. If the soil is too dry when it is compacted there is a good chance that air voids will result and the soil will be permeable. Compaction will also be hampered and produce an unsatisfactory result if the soil is too wet.

A good guide to soil moisture content can be obtained from a simple field test. When soil moisture is at the best level for effective compaction, you should be able to roll the soil between your palms into a thread (about the thickness of a pencil) that just begins to crumble on further rolling. If the soil thread crumbles before it reaches pencil thickness, it is too dry. If the thread can be rolled to a thickness much less than a pencil, then it is too wet.

If the soil is too dry, a water cart can be used to wet it before it is used in the embankment. The best way to do this is to rip the excavation area, wet the soil, allow it to stand for about 24 hours, check its moisture content using the field test described previously, and, if that is right, place the soil in the embankment. Try to avoid wetting the embankment to increase the soil moisture during construction, as this usually causes very uneven soil moisture and uneven compaction.

If the soil in the excavation area is too wet, the drying process can be accelerated by ripping.

Exposed rock

Rock, sand or gravel exposed below top water level allows water to escape from the dam. To prevent seepage, the rock, sand or gravel should be covered with at least 300 mm of compacted clay.

How to look after the dam

To minimise problems with leaking from the dam, it is important to carry out regular maintenance and in particular to observe the following:

- Make sure you have about 100 mm of topsoil over the embankment. Topdress areas that become bare of topsoil as soon as possible. If the stripped areas do not provide enough topsoil, it should be

Figure 5. The recommended clay lining method if both excavation and embankment are pervious

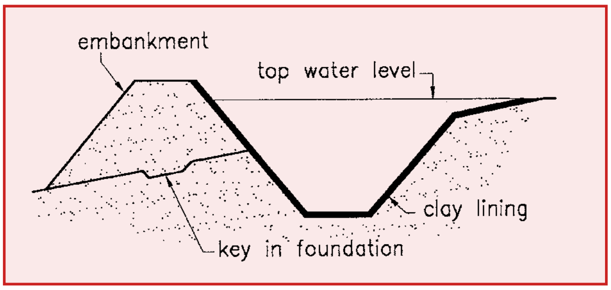


Figure 6. A clay lining is required if the topsoil has not been stripped from below the embankment, or if a cutoff trench has not been constructed

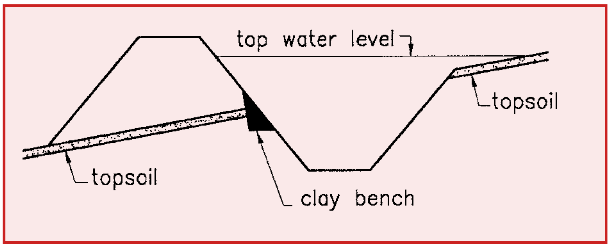


Figure 7. Clay lining treatment if the excavation exposes porous seams of sand or gravel

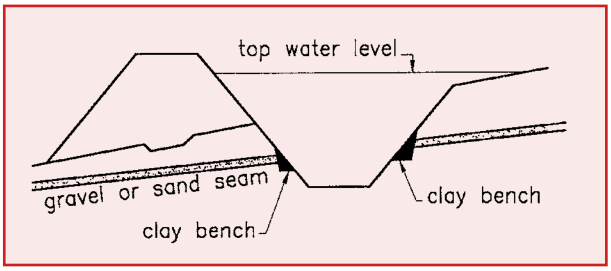
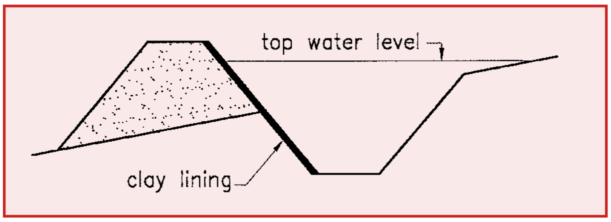


Figure 8. A blanket of clay used to seal a pervious embankment



imported. Avoid topsoil depths greater than about 200 mm, as slumping is likely, and an uneven surface tends to erode.

- Establish a grass cover on the embankment and spillway as soon as possible. A grass that mats, such as kikuyu, is preferable to a grass that tufts.
- Do not let trees or shrubs grow on the embankment, spillway or spillway outlet slope. Roots might disturb the compacted soil and provide a seepage path for water, while trees or shrubs in the spillway area will restrict the flow of flood water.

The importance of maintaining a good grass cover over topsoil cannot be stressed too much. Cracking or eroded soils are potential sources of dam seepage; and protection of the embankment clay is critical (particularly for dispersive clays). Topsoil protects clay soils from drying out and cracking during long dry periods. The grass cover protects the embankment from erosion.

Ways to seal your dam

The method used to repair the dam is often determined by the cost of the repairs in relation to the short- or long-term benefit.

The methods used to seal earth dams include:

- clay lining with available local material
- the use of bentonite
- installing commercial (plastic or synthetic rubber) liners
- chemical treatment of the soil
- the application of a sprayed membrane.

Clay lining

If a suitable clay can be found on or near your property then clay lining may be a cost-effective way of sealing your dam.

There are several ways to use clay lining to seal a dam depending on the nature of the seepage problem. These methods are illustrated in Figures 5, 6, 7, and 8. In all cases, a minimum 300 mm depth of compacted clay must be used. The clay must also be placed and compacted in layers at the optimum soil moisture content, as previously described.

If the dam still holds some water it should be pumped dry. All plants (e.g. reeds), loose sand and silt must be removed to expose a firm foundation on which to place the clay lining. Sometimes a cutting or bench is required to hold the clay, as shown in Figures 6 and 7.

The cost of clay lining depends on many factors, including:

- the transport cost of the clay
- the amount of clay to be moved
- the cost of emptying the dam
- access to the site
- potential crop and income loss (because the dam will need to be emptied).

Bentonite

Bentonite is a naturally occurring clay which is commercially mined. In dam building it is useful because, when it is wet, it swells to many times its dry volume.

Bentonite may be used in several ways depending on the soil type on site and whether it is practical to empty the dam.

On light or loam soils a mixed blanket is worked into the soil. On heavy soils, a pure blanket would be required (similar to a clay lining). In both cases the dam would need to be emptied and allowed to dry. A third option, which is at best hit and miss, would be to broadcast the bentonite on the water surface.

The mixed blanket method mixes bentonite with the first 150–200 mm of soil. The area to be treated is first cleared of loose rocks and vegetation, then it is lightly harrowed. The bentonite is broadcast over the area at a rate of approximately 7 kg/m^2. After the bentonite is spread it is mixed with the existing soil by lightly harrowing and then compacting with a roller.

The pure blanket method also requires the removal of all vegetation and loose rocks in the area to be treated. The bentonite is spread evenly over the area at a rate of approximately 10 kg/m^2.

The bentonite must be covered with at least 100 mm of site soil otherwise you risk cracks developing in the bentonite blanket as it dries out. If stock have access to the dam then the cover to the bentonite must be at least 450 mm to avoid penetration of the bentonite by the stock.

The final step in this method is compaction of the treated area with a roller.

The broadcast technique involves spreading the bentonite over the water surface at a rate of 10 kg/m^2. The bentonite settles to the bottom, hopefully where the problem is, and seals the storage. This method is not recommended, as success cannot be assured. However, if the storage cannot be emptied then it is the only option available to you.

Commercial liners

There are at least five types of commercial liners available to seal leaking dams. They are all flexible membranes but offer different levels of strength, durability and resistance to UV breakdown.

The liners have no structural strength; they rely on a continuous backing for support. This means that the soil on which such a liner rests must be well compacted, offer an even grade, have no vegetation and be free from protrusions like stones and branches which would damage the liner.

A layer of fine soil or sand is required under thinner liners and the soil is sometimes sprayed with a herbicide to prevent any plants growing and penetrating the liner.

All liners must be anchored so that they do not move. The simplest way to provide anchorage is to bury the liner in a trench dug along the perimeter of the storage.

Commercial liners include woven polythene, black polythene, vinyl, HDPE (high density polyethylene), butyl rubber and composites of bentonite and polypropylene.

Woven polythene, in blue or green, resists tearing but is very susceptible to UV degradation. If it is not protected from sunlight with a layer of soil, it has a very short life. Woven polythene is very unlikely to last 5–7 years in the sun. A grade no steeper than 3:1 must be used to keep the soil from slipping off the liner.

Black polythene also has a short life due to UV degradation. It is also quite thin, generally less than 0.4 mm, and is susceptible to puncturing. It must be covered with a layer of soil to prolong its life.

There are two grades of black polythene. One uses reprocessed resin and the other uses prime resin. The prime resin liner lasts longer than the reprocessed resin liner. Also, the thicker the liner, the longer it will last, because it is better able to withstand the continual UV degradation of its surface.

Vinyl (or **PVC**) resists tearing and is more flexible than woven polythene. Again this material needs to be covered with a layer of soil to protect it from sunlight.

HDPE and **butyl rubber**. HDPE has a longer life and is tougher than vinyl or woven or black polythene. It resists tearing and does not need to be protected from UV exposure. Similarly, butyl rubber is resistant to sunlight, flexible and very tough. Both HDPE and butyl rubber are more expensive than vinyl and woven or black polythene.

Composite materials contain a thin layer of bentonite sandwiched between polypropylene material. They are not UV sensitive.

Because of the bentonite material, small ruptures in the liner are self-healed. However, these liners must be covered with soil to protect them from major punctures.

Chemical treatment of soil

Gypsum and sodium tripolyphosphate (STPP) are two chemicals used to seal storages.

Gypsum is used to stabilise dispersive soils so that both surface erosion and potential tunnelling failures are reduced. A fine-grained gypsum is preferable because it is more soluble.

The gypsum is mixed into the first 150–200 mm of surface soil at about 2 kg/m^2, and then the treated area is compacted with a roller. Remember, dry soil will not compact well. Good compaction can only be achieved with a soil near its optimum moisture content, as described previously.

STPP is a chemical which has the opposite effect to gypsum. It is used to disperse the clay particles in stable, but porous, clay soils. These soils are very hard to compact and STPP is used to help the compaction process.

Not all clay soils are suitable for STPP treatment and a laboratory test is needed to determine if the soil will react favourably.

If the soil is suitable for STPP use, the treatment is similar to the bentonite mixed blanket method. The dam must be drained, and the soil allowed to dry. All vegetation, loose gravel and sediment must be removed and the surface cultivated to a depth of about 150 mm.

STPP, in powder form, is then broadcast over the area to be treated at a rate determined from the laboratory tests, usually about 0.5 kg/m^2. The soil must be near its optimum moisture content before the STPP is mixed with the surface soil using a rotary hoe. The treated area must then be compacted with a roller.

Finally, the area must be covered with untreated soil to prevent the STPP/soil mix from drying out and cracking. A compacted thickness of about 300 mm is recommended. Remember that STPP is ineffective in sandy soils or soils high in calcium carbonate.

Sprayed membranes

Concrete and asphalt are examples of sprayed membranes. They are applied to the area to be treated under pressure to form a continuous skin of material that acts to seal the storage. They are rarely used to seal farm dams because of the high cost of the work involved.

Sprayed concrete or **asphalt**. Sprayed concrete (known as gunite or shotcrete) requires specialised equipment and experienced applicators. Its application involves spraying a mix of water, cement and aggregate onto a graded surface. Steel reinforcement is usually required.

Asphalt (bitumen) also requires a prepared, graded surface, experienced applicators and specialised equipment. The process can be messy but no steel reinforcement is required.

Both methods require a depth of at least 75 mm to be effective and are prone to movement cracks and weathering.

Further information

Each dam site is different, and this Agfact is not intended to replace the advice of qualified consultants. For further information, you can also contact your local office of NSW Department of Primary Industries.

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