DEPARTMENT OF
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Agriculture Notes

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Managing Wet Soils: Determining Which Subsurface Drainage System to Use

This Agnote helps you select an appropriate subsurface drainage method for your farm. It explains some practical on-farm tests to help in the selection of the most appropriate system for particular soil types. Other Agnotes in the "Managing wet soils" series provide more technical details of each drainage system.

Introduction

Surveys have found that some farmers are unsure of their soil types and what type of drainage is best suited to their soils. It is important to select the right drainage system because different soil types with different characteristics need different drainage methods.

Subsurface drainage can be achieved by subsurface pipes, mole drains or a combination of both. To decide which subsurface drainage system is most suited to a particular soil type, the soil's permeability (ability to allow water to pass through), its characteristics and its clay content and type must be investigated. The soil's permeability can be measured to give a number, its hydraulic conductivity, which is valuable for selecting a drainage system.

Factors to consider when deciding on a drainage system

The type of subsurface drainage system most suitable for a particular soil type depends on many factors. Certain soil characteristics must be considered such as the soil's texture (content of clay, sand, stones, loam), type of clay (is it suitable for mole drainage or not) and water flow rate through the soil profile (permeability). The soil characteristics in the profile section to be drained must also be determined. For example, how deep is an impermeable layer situated?, how much of the profile is very permeable?, will the soil slake (collapse) or disperse (erode) when excessively wet? etc.

Therefore it is vital to know the soil type and profile when deciding which subsurface drainage system is appropriate. Testing involves digging soil cores so you have an understanding of what the soil types are below the surface. Examining the soil profile and measuring the soil permeability will assist in selecting the drainage method. Other tests are related to clay type and suitability for mole drainage. The practical on-farm tests to assist with decisions are explained later in this Agnote.

Once the soil's suitability for a particular drainage system is determined, the attached flowchart (Appendix 1) provides a further refinement for selecting the appropriate system for different soil types.

Knowing the likely location and level of the outfall for the proposed drainage system is also essential. If there is no suitable outfall, then no drainage is possible unless very expensive sumps and pumps are used.

Questions to ask to indicate which drainage system to install

Examining the soil using the practical on-farm tests will help choose the best suited subsurface drainage system to install. These tests should be able to answer the following questions to help in making the decision:-

Is the soil suitable for subsurface pipe drainage?

Suitable soils for subsurface pipe drainage will be very permeable, free draining, down to depths greater than 1m. There will be sufficient depth and gradient (fall) to ensure a falling gradient for the slotted drain pipe. The location of the outfall must be such to allow this to occur. Pipe drains will work on both permeable and impermeable soils but you would have to put them so close together on impermeable soils that they become uneconomic.

Is the soil suitable for mole drains?

Suitable soils for mole drainage will have a suitable proportion of clay content down to moling depth (400 to 600 mm) and minimal rock or sand at mole draining depth. The clay mineral type will allow the mole channel to hold its shape after moling. When the mole channel is "wetted up" during drainage it will not slake (collapse), and will not be dispersive and prone to tunnel erosion.

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Is the soil suitable for mole draining over a collector pipe system?

Soils suited to mole draining over a collector pipe system will have a suitable clay content and type partially suited to mole draining down to moling depth but will not sustain long mole drains (greater than 80 m) for some reason. Such a reason may be the presence of sand or small rock to varying degrees at or near moling depth. The soil may be marginally suited to mole draining but having closely spaced subsurface pipes to drain water quickly, may extend the mole drain life.

Is the soil suitable for gravel mole drains?

These soils typically are not suited to mole drainage. They may slake after wetting up or may contain sandy or rocky layers or areas. Inserting permeable backfill into the mole slots (actually square channels), will maintain the integrity of the channel slot allowing drain water to be removed.

On-farm tests for determining the most appropriate subsurface drainage system

The following are some practical on-farm tests which farmers and contractors can carry out to ascertain which drainage system is best suited to the particular soil type to be drained. These tests are best and most easily carried out in winter when the soil profile is saturated. However, the same tests can be carried out in dry conditions with greater difficulty but seek expert help if doing so.

If the on-farm tests are indecisive, proper soil tests should be done to indicate more accurately the soil's permeability (bulk density), texture (sand, silt and clay) and suitability for mole drainage (slaking and dispersion tests). An experienced subsurface drainage expert should also be consulted in the designing stage to assist with selecting a system and developing a drainage plan.

1. Factors to consider while digging the holes

Testing a soil's permeability and its suitability for either pipe or mole drainage involves digging holes, collecting soil for slaking/dispersion testing and measuring the rate of water inflow into the hole. These can be done by the landowner or contractor to aid in selecting the correct drainage system.

When the soil profile is saturated, usually in winter or early spring, dig several holes in the problem area to a depth of 1.0 to 1.5 m. Preferably use a hand auger of post hole size diameter (100 to 150 mm diameter). A mechanical auger, tractor driven post-hole digger or a shovel are less useful in picking up some critical factors mentioned below. Before digging, ensure that surface water is directed away from the hole to avoid confusing the observations.

As the hole is dug, take notice of:

- the depth of topsoil (usually a very permeable layer)
- the depth of plant roots (short in poorly drained and/or compacted soils, and in soils with little topsoil)
- any compacted layers throughout the profile (harder to auger) and its thickness
- the cause of the compacted layer (compacted soil due to animal traffic or equipment, coffee rock layer etc.)
- where the clay content increases substantially (not always easy to pick)
- where the top permeable layer meets an obviously much less permeable layer (duplex soil type) and often characterised by a “spewy” later at the interface
- where water begins to flow into the hole (near the top, middle or bottom of the hole)
- how fast the water enters the hole at various depths
- the clay content just above and at moling depths (400 to 600 mm). Collect soil samples at these depths for later testing for mole drainage suitability.

2. Determining the soil's permeability (hydraulic conductivity)

This test will give a rough measure of whether the soil is slowly or rapidly permeable. This test is best carried out a day or so after the hole has been dug to allow the water table to return to a stable level.

You will need a stopwatch (or second hand on your watch) and a flexible cloth-type tape measure with a small light float (eg. a small plastic vile) stuck to its end with the float base opposite the tape's zero reading. Note the height of water in the hole. This is likely to be the water table height in the surrounding soil.

Have a set and easily seen mark on the side of the hole near its surface. Bale out most of the water from the hole, ensuring it and other surface water does not flow into the hole. Lower the float end of the tape into the hole until you can see or feel the float's base sitting on top of the water in the hole.

Gently pull the tape taut, but maintain the float base on the water surface in the hole. Record the tape reading against the set mark immediately. As the water flows into the hole from the soil, the tape will need to be kept taut as the float rises. Record the tape reading every 5 to 10 secs. Where the water enters either very slowly or rapidly alters the rate of recording.

Record tape readings until about a quarter to one third of the removed water volumes flows into the auger hole from the soil profile. This will ensure that the water inflow will be relatively constant and a true indication of soil water conductivity. Repeat this in the same hole several times and in several holes in the area to be drained.

To measure the soil water movement (hydraulic conductivity), calculate the following:

Water flow rate =

Rise in water level (mm) x 360 x time taken (sec)

=………mm per hour water flow rate

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Table 1 provides a guide of the rate of water movement through the soil through a saturated profile for a range of soil classes. The water flow rate (mm per hr) can be used to decide which drainage type may be most suitable.

Table 1. Soil class, water flow rate and soil type

Class	Water flow rate (mm/hour)	Approx. soil textural class
Class 1 Very slow	Less than 1	Clay
Class 2 Slow	1 - 5	Clay loam
Class 3 Mod. slow	5 - 20	Silty clay loam
Class 4 Moderate	20 - 60	Silt loam
Class 5 Mod. rapid	60 -125	Loam
Class 6 Rapid	125 – 250	Sandy loam
Class 7 Very rapid	More than 250	Sand

As a rough "rule of thumb", class 1 – 4 soils, being less permeable, may be suited to mole drainage (depending on clay mineral content, sand/stone presence, etc.) or moles over a collector pipe system. Classes 5 – 7 soils, being more permeable, may be most suited to subsurface pipe drainage. Unfortunately few dairying soils in southern Australian are of this nature.

Assuming the water inflow is entering the hole reasonably quickly and throughout most of the hole's depth, or at the least, is entering in the lower section of the hole (below 500 mm), the soil will most likely be suitable for subsurface pipe drainage.

If the topsoil is relatively deep (more than 200 mm) and/or is relatively permeable but less so at depth, say 600 to 800 mm, then moles over a pipe system might suit.

If water enters slowly throughout most of the hole, the soil's permeability will be low. The earlier collected soil sample from moling depth, will then be used to determine the soil's suitability for mole drainage.

Determining the soil's suitability for mole drainage

Simple tests can be carried out with the soil samples collected at mole draining depth. The tests will determine whether the clay content and its type is suitable for sustaining mole drains (several years life) or whether gravel mole drains are required. These are the ring, ribbon and ball tests. If the soil sample has dried somewhat, add some water and knead the sample until it has the consistency of plasticine or putty.

Ring Test

The ring test will indicate the clay content and possible presence of sand or small stones. Roll the soil sample between your palms into a rod-like shape of approximately 7 to 10 mm diameter and long enough to form a ring of about 30 to 50 mm diameter when the ends are brought together. If the ring is hard to form (continually cracks or falls apart), it probably will not hold a mole drain as its clay content will not be great enough to sustain a mole channel. If easily formed, clay content is high and possibly suitable for moling. Now check the soil for slaking or dispersion with the ball test.

Ribbon Test

Alternatively, the rod formed above could be squeezed between the thumb and forefinger to form a ribbon with a width of about 10 to 13 mm and thickness of about 4 to 5 mm. If a long ribbon can be formed (greater than 40 mm in length), then the soil has a high clay content. If it continually breaks, clay content is probably too low for mole draining. Check for slaking or dispersion using the ball test.

Ball test

The ball test indicates whether a soil is prone to slaking and/or dispersion which will indicate its ability to hold the mole channel shape.

Slaking is the breakdown of the soil aggregates into much smaller aggregates when wet and indicates low organic matter in the soil.

Dispersion is an indicator of sodic soils and occurs when excessive sodium (sometimes magnesium) is present. When water is added the sodium attaches to the negatively charged clay particles. As this is only a weak bond, clay particles are forced apart. This results in a cloud of clay colloids forming around the aggregate (Figure 1). These soils are very prone to tunnel and gully erosion if mismanaged and often difficult to drain safely.

In Figure 1, the petri dish on the left has three surface soil aggregates at the top and three subsoil aggregates at the bottom. Note that no dispersion has occurred for the surface soil but that strong dispersion has occurred with subsoil aggregates. The petri dish on the right has surface and subsoil aggregates placed the same way in a gypsum solution. No dispersion has taken place due to the immediate electrolyte effect of gypsum.

Figure 1. Soil aggregates in distilled water (left) and distilled water plus gypsum solution (right)

The same aggregates as above have also been remoulded (representing ploughing) and then placed into distilled water in the left petri dish (Figure 2). Note that strong dispersion has now occurred with the surface soil as well as the subsoil. Again, no dispersion has taken place in the gypsum solution in the right petri dish.

Figure 2. Aggregates remoulded, gypsum in right dish

Although gypsum is very efficient at reducing dispersion in the upper layers of the soil profile, it is unlikely to penetrate to the depths where mole drainage occurs. Expert guidance is needed when designing a drainage system for dispersive soils.

To test for dispersion knead a sample of the soil into 10 to 20 mm diameter balls and place them gently into distilled water. Observe them regularly for half an hour and if not actively showing any signs of slaking or dispersion, inspect them after two hours and again after 24 and 48 hours.

A soil which slakes or collapses quickly (within hours) is likely to be prone to slaking and, if wetted up after mole drains are installed, will reduce their life substantially. Gravel mole drains may be an option in these soils.

A soil may disperse quickly or slowly and is recognised by a cloud of clay colloids around the clay sample which moves away into the body of the water when disturbed. Many soils may slake first and then disperse. Dispersive soils are a problem for any drainage system so seek expert advice.

Appendix 1 can be used to help decipher the results from the practical on-farm tests and for choosing the best suited drainage system.

A whole farm plan for any likely future extension of the drainage system is crucial to allow for suitably sized main drains and outfall drains. Land topography must be considered also such as water moving down slope to the flats and occurrence and frequency of flood events.

Water Act

The Water Act (1989) provides guidance for the management of waterways and swamps. Before considering draining a wet area you should contact your local Catchment Management Authority for advice, as a permit may be required.

Further References

See other Agriculture Notes in *Managing Wet Soils* series.

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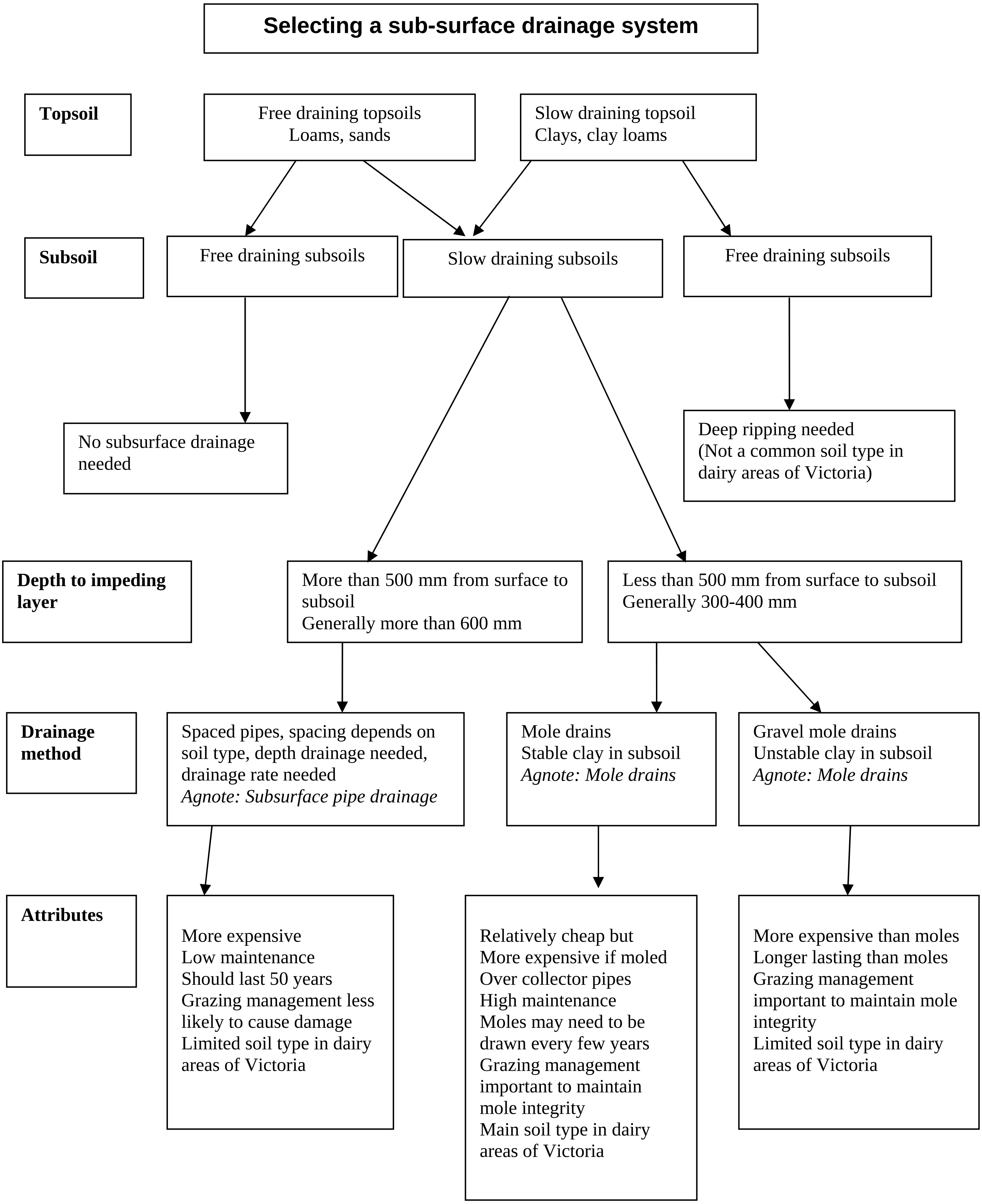
Appendix 1


Selecting a sub-surface drainage system
Topsoil
Free draining topsoils
Loams, sands
Slow draining topsoil
Clays, clay loams
Subsoil
Free draining subsoils
Slow draining subsoils
Free draining subsoils
No subsurface drainage needed
Deep ripping needed
(Not a common soil type in dairy areas of Victoria)
Depth to impeding layer
More than 500 mm from surface to subsoil
Generally more than 600 mm
Less than 500 mm from surface to subsoil
Generally 300-400 mm
Drainage method
Spaced pipes, spacing depends on soil type, depth drainage needed, drainage rate needed
Agnote: Subsurface pipe drainage
Mole drains
Stable clay in subsoil
Agnote: Mole drains
Gravel mole drains
Unstable clay in subsoil
Agnote: Mole drains
Attributes
More expensive
Low maintenance
Should last 50 years
Grazing management less likely to cause damage
Limited soil type in dairy areas of Victoria
Relatively cheap but
More expensive if moled
Over collector pipes
High maintenance
Moles may need to be drawn every few years
Grazing management important to maintain mole integrity
Main soil type in dairy areas of Victoria
More expensive than moles
Longer lasting than moles
Grazing management important to maintain mole integrity
Limited soil type in dairy areas of Victoria