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Deep drains to manage groundwater

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Deep drains to manage groundwater

This publication is for general information only on the role and use of deep drains for groundwater management on farmland. If you are intending to build a deep drain to protect areas of arable land, you should consult an experienced professional for assistance with deep drain design. Poor design and layout can result in reduced effectiveness of the drain and be costly to correct.

A double leveed deep drain with surface water inlet pipe. Surface water can be drained from outside the spoil bank by piped inlets that extend through the bank at ground level and discharge into the drain.

An open (or single leveed) deep drain

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What is a deep drain?

A channel that is 1.0 m to 3.0 m in depth is considered to be a deep drain. The drain is excavated to a depth that is sufficient to intercept the watertable in order to capture and convey that groundwater from flat, poorly drained land.

The drain can either be 'open' to allow the inflow of surface water or 'leeved' to exclude surface water. An open deep drain has its spoil banks placed on one side or on alternate sides of the channel (Figure 1) while a leveed deep drain has continuous spoil banks placed on both sides of the drain channel (Figure 2). Leveed drains are the preferred design in the majority of cases and sites because they prevent surface flows from entering the drain and so reduce the risk of erosion and drain batter collapse.

The purpose of deep drains

Deep drains aim to allow cropping to continue in areas that are threatened by rising watertables and salinity or to reclaim land that is waterlogged and/or salt-affected. Their purpose is to capture sub-surface seepage and groundwater in order to:

- control the depth of the watertable below the soil surface;
- reduce waterlogging and salinity by lowering the watertable level; and
- convey the discharge to a safe disposal point.

An open deep drain is designed to remove surface run-off by allowing it to flow into the channel. However, in most cases, surface water should be excluded from the drain as its depth and shape make it prone to batter erosion as surface water enters the drain, as well as scouring and sedimentation.

An open deep drain is only recommended where surface water cannot be excluded due to the placement or layout of the drain and where the drain is designed to cope with the inflow of surface water.

Where to install a deep drain

Deep drains are used where shallow or rising watertables, waterlogging and groundwater discharge (seepage) are occurring within the landscape. They are constructed in the lower parts of the landscape such as valley floors and coastal plains where the slope of the land is generally less than 0.5 per cent. In some cases, deep drains can be installed at the break of slope near valley floors to capture lateral seepage and prevent it from discharging onto the valley floor.

Deep drains are most effective in draining groundwater when constructed in soils with relatively high permeability. Construction in soils with low permeability will reduce the effectiveness of drains, unless there are preferred pathways or layers of permeable material in the soil profile which allows the water to discharge into the drain. Note that in some soils with high permeability (that is, sandy soils) batter stability can be a problem that results in side wall collapse. This reduces the effectiveness of the drain and increases the need for maintenance.

A single drain can be constructed to follow the alignment of minor natural drainage depressions.

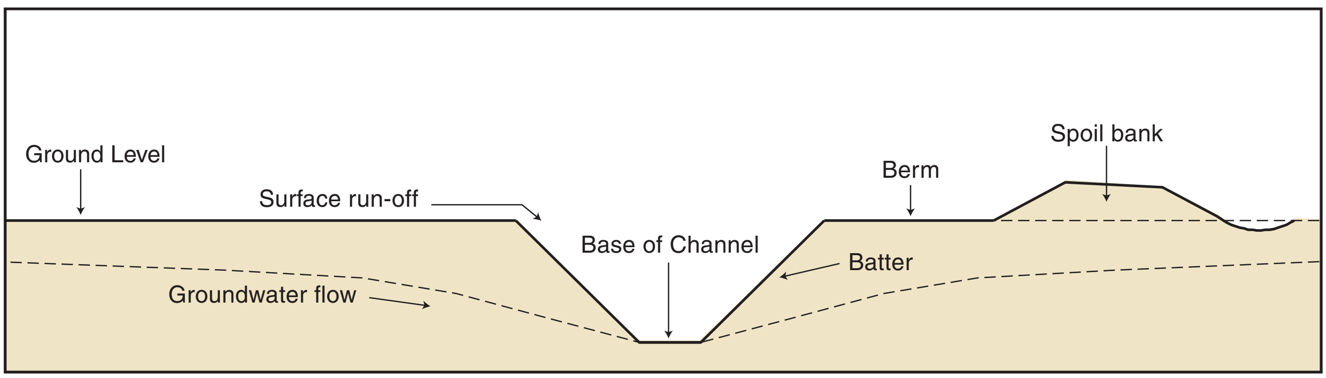

Figure 1. An open deep drain with a spoil bank or levee on one side

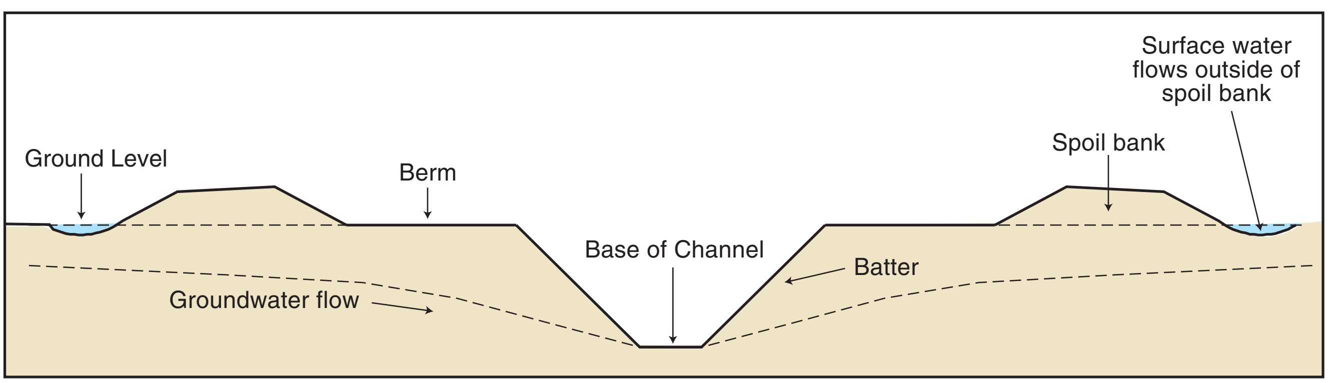

Figure 2. A leveed deep drain with spoil banks (levees) on both sides

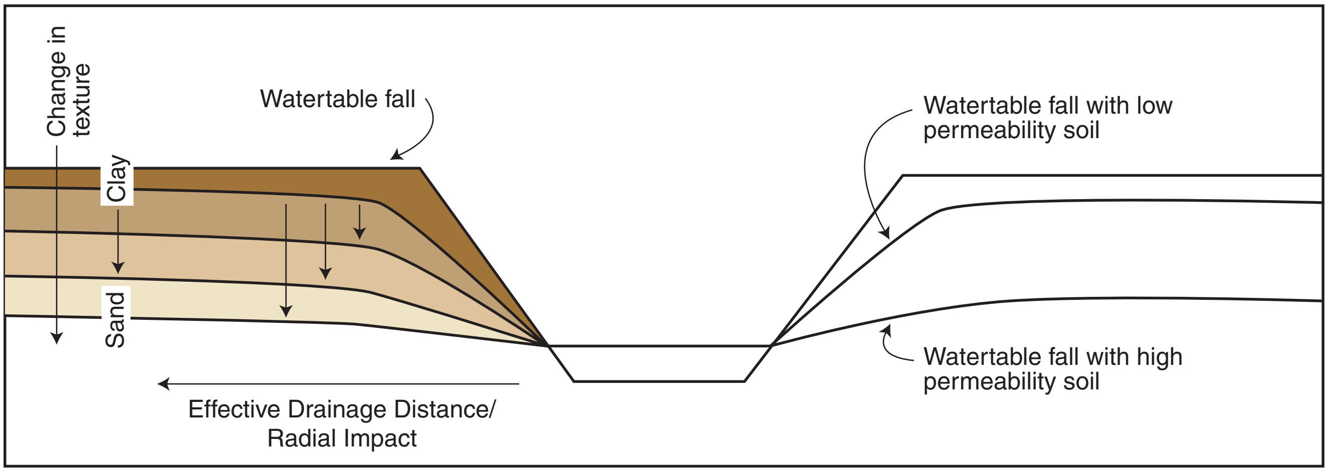

Figure 3. Variations in effective drainage distance (radial impact), relative to soil texture (idealised situation)

Deep drains should not be constructed in drainage lines such as streams or creeks because large flows and flood events can damage the drain structure. Construction within, or interference with, watercourses usually requires approval from the Department of Environment. All deep drains are subject to the *Notice of Intent to Drain* process before construction commences (see 'Legal issues' below).

Deep drains must have a suitable outlet to dispose of the quantity and quality of water collected by the drain. The outlet may be another drain, evaporation basin or natural watercourse into which the disposal of saline discharge has been approved.

How deep drains work

When excavated to a depth below the watertable, groundwater will discharge (seep) into the drain via the side walls and base of the drain. This causes the watertable to fall adjacent to the drain.

The impact of the drain decreases with distance from the drain, that is, the fall in the watertable will be greatest immediately adjacent to the drain and will be less further away from the drain. The distance from the drain that the watertable is lowered is termed its 'radial impact' or 'effective drainage distance'.

The distance from the drain and the amount by which the watertable is lowered is mainly determined by:

- soil permeability (see Figure 3);
- depth the drain is excavated to below the watertable; and
- rate that the groundwater is being replenished from infiltration.

The base of the drain is constructed with a constant low gradient sloping towards the outlet. This allows the drainage water to be conveyed to a safe disposal point without eroding the drain.

Deep drains designed to lower the watertable also enable rainfall to leach salt from the upper soil profile. Rainfall that infiltrates the soil profile can dissolve stored salts. Dissolved salts can then be leached from the upper profile into the drain with seepage. Salt is leached at a faster rate than it is deposited at the soil surface through capillary rise and so reduces salt accumulating at the soil surface.

Removal of salts from some soils may cause them to become dispersive, unstable and prone to erosion due to the loss of soil structure. This makes the soil difficult to work with and reduces the capacity of water to move through the soil.

In some cases these soils will respond to the application of soil ameliorants (for example, gypsum) to improve the soil structure and drainability.

Planning and design

Site assessment

For a drain to be effective it must be planned and designed to address the conditions in the landscape that are causing the problem.

Site assessment is the most important part in planning and designing a deep drain. This process includes undertaking field measurements and surveys and may account for up to 20 per cent of the project budget. A professional engineer, soil conservation specialist or an experienced professional contractor should be employed to undertake the site assessment and design of the drainage scheme. This is highly recommended for drains in excess of 5 km in length or where the drain is likely to cross a public road or impact on other infrastructure.

A thorough assessment of the site, including local ground and surface hydrology, is required to establish if the soils are drainable and to determine the likely effectiveness and estimated cost of the drainage scheme prior to construction. Planning will enable landholders to evaluate the available options and select the most appropriate scheme to meet their needs.

Factors to consider in site assessment include:

- topography and land slope;
- an estimate of surface run-off, velocities and volumes;
- an estimate of the depth to watertable;
- quality and quantity of groundwater to be drained;
- a soil profile description to determine the soil type;

- variations in the soil structural stability and permeability across the drainage site ;
- an estimate of the seepage rate;
- the location and height of the drain outlet;
- the likely discharge receiving environment of safe disposal point;
- the extent of the area affected by waterlogging and/or salinity that is to be treated with drainage;
- the location of any above or below ground services (such as power lines, telephone lines, water pipes) likely to be affected by the construction of the drain; and
- whether the drain will cross any minor or major roads (or railways).

Other considerations

When planning to construct a deep drain the following should be considered:

- The drain should not obstruct, divert or diminish the natural flow of any watercourse.
- If trees and shrubs are to be planted alongside the drain, these should be placed outside the spoil/levee banks to allow maintenance access.
- Non-woody vegetation growth should be encouraged to cover the spoil, berm and channel side slopes to assist with stabilisation and reduce sedimentation of the drain channel.
- Sharp bends (<90°) in the drains should be avoided. Sharp bends can result in extensive erosion and undercutting of the batters. This is particularly important for open drains that allow surface inflow.
- A suitable outlet must be available to dispose of the quantity and quality of water collected by the drain. Drain outlets need to be stable and on a grade to prevent ponding or erosion. The outlet can be another drain, natural watercourse, pumped sump or evaporation basin.
- If possible, estimate how much water, sediments, nutrients and salt might be discharged by the drain.
- Assess the pH of the groundwater to be drained and the likely impact on the discharge environment.
- Fence the entire drain to prevent livestock access. This will protect the stock from injury caused by falling into the drain and protect the drainage structure from livestock trampling.

Drainage scheme

Where deep drains are used to treat an extensive area or catchment, several drains may be interconnected to form a 'drainage scheme'. The topography and purpose of the scheme will determine the appropriate layout.

- A random drainage scheme is one where the drains are aligned to follow and drain naturally occurring depressions (Figure 4a).
- A herringbone layout is used in broad valley floors where the landscape slopes gently towards a central channel. The drains are constructed at regular intervals extending out from the central drainage channel and discharging into it (Figure 4b).
- A parallel drainage scheme is used for large areas of flat land that require a relatively uniform rate of drainage. A number of drains are constructed parallel to each other at a uniform distance apart and discharge into a common collector drain (Figure 4c).

Large drainage schemes should be professionally designed and installed by practitioners with expertise in hydrology and engineering.

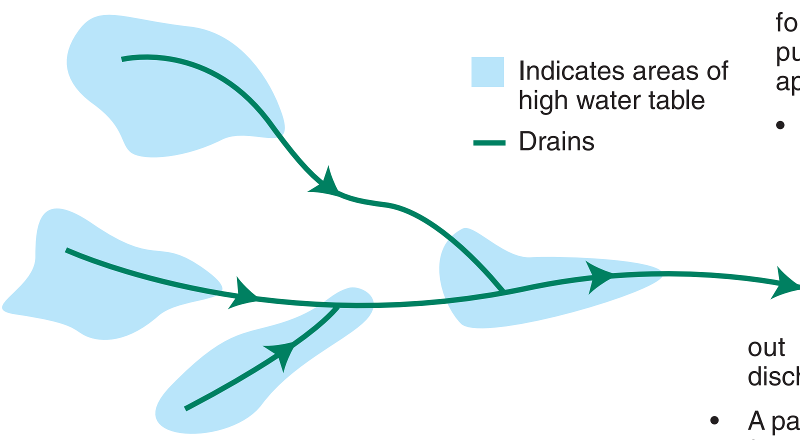

Figure 4a. Random drainage scheme

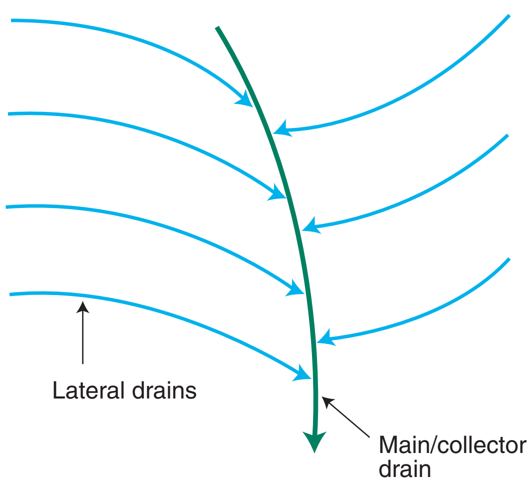

Figure 4b. Herringbone layout of drains

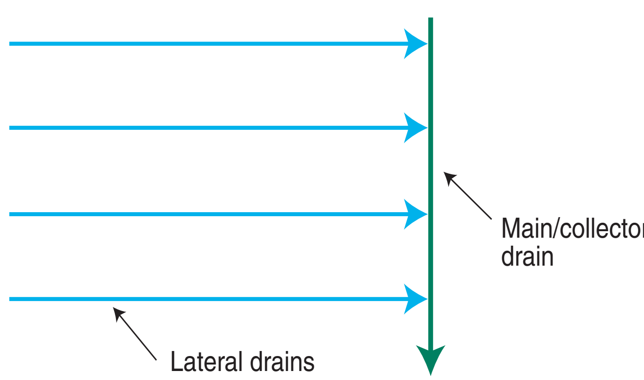

Figure 4c. Parallel drainage scheme

Design characteristics

The Department of Agriculture has developed guidelines for the construction of leveed deep drains (Misc. Pub. 28/ 2002) and open deep drains (Misc. Pub. 29/2002). These publications provide information to assist with the planning, design, survey and construction of deep drains. The guidelines apply to deep drains that have a maximum drain length of 5000 m and are constructed within small catchments of up to 2500 ha.

The depth of the drain is the most important consideration in the drain design. The drain must be deep enough to intersect the watertable, and to lower it sufficiently to control surface waterlogging and the development of salinity.

The cross section of a deep drain is trapezoidal. The slope of the drain batters depends on soil type and should be constructed as steep as possible whilst avoiding the risk of collapse or erosion. Drains with steeper batters require the excavation of less earth and are cheaper than comparable drains with flatter batters. Table 1 indicates the maximum suggested batter slopes for different soil types.

Spoil banks should be shaped so that most of the run-off from the banks flows to the outer sides of the banks or levees and not into the drain. They should be constructed with an inside batter (side slope) ratio of 3:1 and an outside batter of 4:1.

Surface water can be drained from outside of the spoil banks of leveed drains and discharged into the drain channel by installing 150 mm pipes that extend through the spoil banks at ground level. The pipes can be placed at regular intervals along the drain or where surface water is likely to pond outside of the spoil bank.

Construction

The alignment of the drain is pegged and a survey undertaken to ensure that:

- the level of the outlet is at, or can be constructed below, the base of the drain; and
- the gradient of the base of the drain will slope towards the outlet.

Deep drains are usually constructed with an excavator. For the best results, excavation should commence at the

Table 1: Suggested maximum side slope ratios for deep drains

Soil type	Side slope Horizontal:Vertical	
	Channels up to 1.2 m deep	Channels 1.2m and deeper
Sand – clayey sand	2:1	3:1
Sandy loam – silt loam	1.5:1	2:1
Sandy clay loam – light clay	1:1	1.5:1
Light medium clay – heavy clay	0.5:1	1:1

Note: The vertical component of slope is always 1.

The slope of the batters of open deep drains may have to be flatter so that surface water flowing into the channel does not erode them.

Leveed deep drains generally only carry low flows that can be accommodated in a channel with a base width of less than 0.25 m. For open deep drains, the required base width of the drain can be calculated using the same design criteria as for other surface drainage works.

The gradient of the deep drain channel should be no greater than 0.2 per pent.

If the velocity of flow in the drain is likely to result in erosion, culverts can be installed in the drain to reduce the velocity, or the rate of surface water inflow can be controlled.

The spoil is shaped into a bank and placed clear of the excavation to create a berm or ledge between the drain and spoil. The berm allows access for machinery to enable maintenance to be carried out and reduces the likelihood of spoil washing into the drain. The minimum width of the berm should be at least equivalent to the depth of the drain.

A wide berm between the drain and spoil bank allows machinery access for maintenance.

outlet of the proposed drain and proceed up slope along the drain alignment.

The batter formed during excavation is determined by operator technique and/or bucket shape. The bucket of the excavator may be wider at the top edge than the bottom. This wing shaped bucket creates the side batters but limits options for cross sectional shape.

The spoil is placed along one or both sides of the drain to form a spoil bank. The spoil banks may be smoothed out to form either a continuous or broken levee bank using a road grader or bulldozer. This is important as it fills in low points and provides compaction of the levee. The area between the top edge of the drain and the spoil bank is referred to as a berm. The berm needs to be of sufficient width to prevent spoil being washed back into the drain or the weight of the spoil bank causing the sides of the drain to collapse.

Maintenance

Drain batters are prone to slumping and erosion due to soil instability. Erosion of deep drain batters or side slopes will occur. This is because of the difficulty in revegetating the steeper slopes and the often unstable soil conditions associated with drained environments.

For leveed deep drains, the sides remain exposed to raindrop impact and run-off generated from the inside spoil banks and berms. Sediment will usually accumulate at the base of the drain as there is normally insufficient flow within the channel to remove it. This can severely restrict the effectiveness of the drain.

For open deep drains, batter erosion will be greater because of surface run-off. While the surface run-off may generate sufficient flow within the channel to dislodge the sediment, it will accumulate at points along the drain and at the outlet where the velocity of flow is lower. In any event, the sediment will have to be removed as it will reduce the effective depth of the drain.

The spoil banks of leveed drains may need to be reformed periodically to ensure that surface run-off is excluded. Pipes placed through the banks to discharge surface water into the drain will need to be checked frequently for livestock damage and blockages. In the case of PVC pipes, these become brittle due to UV radiation and may need replacement.

The frequency of maintenance will depend mainly on the soil conditions and the intensity of rainfall and run-off to which the drain is exposed. A single flood event can completely fill the drain channel with silt if it is built within a floodway or watercourse. In all cases, stabilising the drainage structure with vegetation will reduce the frequency of maintenance.

Legal issues

Notice of intent to drain

An owner or occupier of land must give the Commissioner of Soil and Land Conservation at least 90 days notice of an intent to drain water where:

- the water to be drained is subsurface water;
- the purpose of the drain is to control salinity; and
- the drainage water will discharge onto other land, into other water or into a watercourse.

The notice must be in writing and comply with the *Soil and Land Conservation Regulations 1992.* A Notice of Intent to Drain form is available from the Department of Agriculture.

For proposals to drain land within the Peel–Harvey Catchment Area, proponents must give at least 90 days written notice and use a separate form available from the Department of Agriculture.

Proceeding with a drainage proposal without complying with the Notice of Intent provisions is an offence, and can lead to prosecution. The maximum penalty is $2,000 for an individual and $10,000 for a body corporate.

Environmental harm offences

A person failing to lodge a Notice of Intent to Drain when required to do so may face a charge of causing serious or material environmental harm under recent changes to the *Environmental Protection Act 1986*. Maximum fines for causing serious environmental harm are up to $500,000 for an individual and $1 million for a body corporate. To avoid these fines, owners and occupiers should always lodge a Notice of Intent to Drain when required to do so.

Other approvals

In addition to the above, approval may be required for drains in the following cases:

- planning approval – some shire councils require development approval for certain types of earthworks, which may include deep drains. Check with your shire council to see if any approval is required before starting work.
- public land – where your drain is proposed to cross or discharge onto public land (such as a road reserve, rail reserve or conservation reserve), you must seek approval from the public authority responsible for that land before starting work.
- native vegetation – if your drain requires the removal of native vegetation, or will lead to the destruction of native vegetation, a permit may be required from the Department of Environment.
- interfering with watercourses – watercourses in some parts of the State are subject to special controls and may require the approval of the Department of Environment.
- protected wetlands – wetlands (lakes, swamps, estuaries) may be protected under state and federal laws. Before constructing a drain that might interfere with a wetland, check with the State and Federal Environment Departments to see whether any approvals are required.
- telecommunication services – always make sure that the excavation of a drain does not interfere with or damage telecommunication cables, as repair costs can be significant.
- If the drain crosses minor or major roads, approval may be required from the shire council or the Main Roads Department.

Common law

You may also be liable under Common Law for damage caused to a neighbour's property by the construction or operation of a drain. Therefore, the planning should consider likely impacts on neighboring properties or receiving waterways. You should also seek the written consent from any person who may be affected by the drainage works to minimise the risk of legal action for subsequent damages.

Safety

The *Occupational Safety and Health Act* , Regulation 3.1 Workplaces Safety Requirements and 'Code of Practice: Excavation' apply during the construction phase of deep drains. Persons or livestock falling into or becoming trapped within the steep-sided drain can suffer injury or death.

Liability for any personal injury passes from the contractor to the landholder once construction of the drainage scheme is complete. Landowners have a duty of care and should take reasonable measures to ensure the works are safe. This may include advising employees and visitors of the presence of deep drains by warning signs, reducing batter slopes and fencing off the drain. Landowners are encouraged to discuss the nature of the drainage works with their public liability insurers prior to commencing the works.

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