Chapter 15 — Engineering methods

Engineering options such as drainage, pumping and water diversion for managing salinity and taking advantage of excess water include:

- intercepting groundwater before it reaches the discharge area, and possibly using this water, depending on quality, for irrigation or stock watering
- draining excess groundwater from discharge management areas
- diverting surface water away from discharge management areas
- evaporating saline water from evaporation basins or ring tanks.

Initial costs in implementing engineering options may appear high, but these can be balanced against potential losses from reduced land values and lost productivity and income from possible alternative uses of the water. In fact, the costs of implementing engineering options such as drainage and pumping, even during the limited period in which other controls are being established, can be considerably less than the cost of lost productivity.

Assistance with aspects of water supply, irrigation and drainage schemes is available from farm advisory services.

Drainage

Drainage can be an attractive option in situations where recharge areas are not under the control of the landholder with the salinity problem and groundwater quality is good.

Extensive hydrological investigations may be required to determine whether drainage is a viable option under local conditions and to predict its likely effectiveness. When investigating drainage as a salinity management option, these factors need to be considered:

- Effective drainage requires a height difference between the watertable and the drain outlet. To drain flat or insufficiently sloping areas, pumps may be required, increasing the cost of implementation.
- The hydraulic conductivity of the soil dictates drain spacing. To be effective in clay soils, drains may need to be positioned so close together that this form of management becomes impractical. A minimum workable spacing for drains is considered to be about 80 m.
- Drainage effluent requires disposal. If the groundwater is saline, the effluent may be too salty to be released into local waterways (except possibly during times of flood). However, it may be possible to dilute the effluent with channel water for use downstream or in irrigation areas. This can be a particularly sensitive issue in some areas where drainage water, in addition to being saline, may also carry high levels of nutrients and chemicals.

When drainage is being designed, future extensions, improvements and the drainage of adjacent areas need to be taken into account. Local extension officers (specialising in soil conservation or water resources) offer a comprehensive service for designing and installing surface and subsurface farm drainage systems.

Drainage water disposal

Any proposal to dispose of pumped or drained water requires a permit from the appropriate authority. Appropriate permits, licences, easements and so on must be arranged for any effluent disposal, regardless of the quality of the water. Outlets must be designed to prevent damage to the receiving watercourse, and the disposal of poor quality water must be managed to prevent adverse effects on other lands and water supplies.

Surface drainage

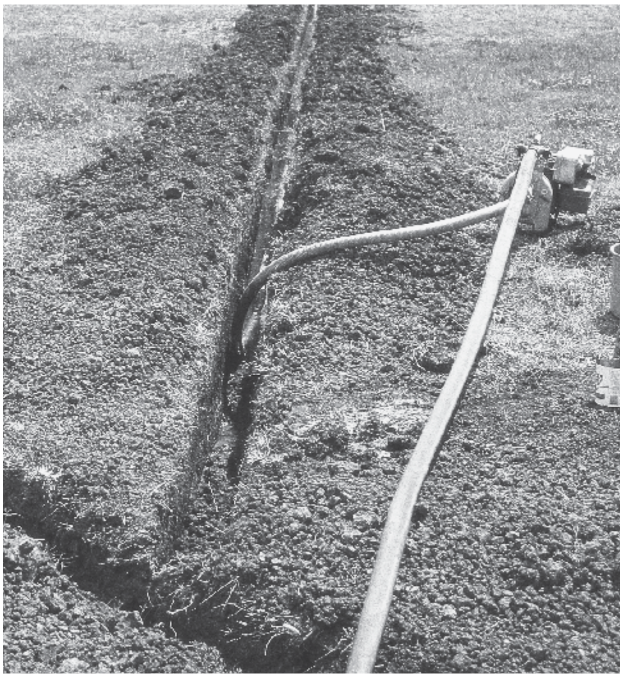
Surface drains are used to route floodwaters, subsurface drain outflows, irrigation tailwaters and any other excess surface water away from problem areas. This may reduce recharge, erosion and prolonged waterlogging and ponding, as well as providing an opportunity for reusing excess water.

Subsurface drainage

Subsurface drainage can be used to prevent waterlogging in two ways:

- **Relief drainage** is used where there is already a high watertable to lower the watertable below the root zone of the crop.
- **Interception drainage** is used to prevent waterlogging and high watertables on lower ground by intercepting seepage and transmission of groundwater from higher ground.

Figure 60. Installation of subsurface drainage into a salt-affected drainage line at Warrill View, Queensland.



Many subsurface drainage systems rely on buried slotted agricultural pipe or slotted PVC pipe drains with non-slotted pipe taking the water to the discharge point. Clay pipes (tile drains) or rubble drains have also been used, but these are difficult to install and maintain. Most types of pipes tend to become blocked by plant roots after a period of time.

In suitable soils, mole drains can be used to enhance flow into collector drains. Mole drains are created by dragging a 'plug' through the soil to create a tunnel for water to flow into and along to some type of outfall. The amount and type of clay and the ESP level of the soil will determine the stability and useable life of mole drains. The quality of the drainage water will also affect the dispersibility of the soil and thus the stability of the drain.

The optimal depth for drains depends on soil type and crop. The aim is to maintain the watertable below the root zone of the crop for relief drainage, and to intercept as much seepage as possible for interception drainage.

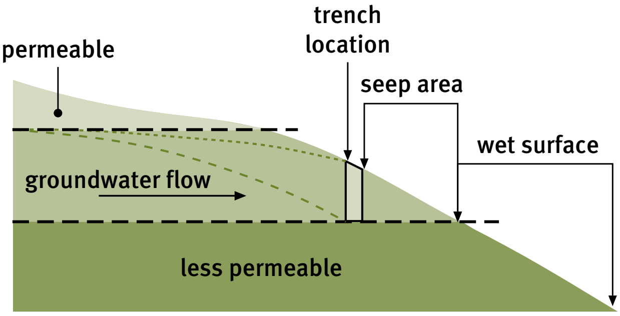
Interception trenches

Groundwater interception trenches at right angles to the hydraulic gradient (direction of flow) can be used to intercept groundwater (Figure 61). Large trenches can provide water storage and can be pumped with conventional pumping equipment. This engineering option will only be effective in areas where the groundwater can be accessed fairly close to the surface (1.5 to 5 m depth). This system is being used in the Kingaroy area (Figure 62).

Trenches which are located above breaks-of-slope, toeslopes or wetter areas upslope of some subsurface barrier to water movement will act as surface storages, being constantly recharged by the groundwater seepage.

Trenches can be pump-tested in a similar manner to bores (refer to ***Pump site planning*** page 112). The volume of initial storage needs to be taken into account together with the number of trenches when determining the volume of available water. Water quality and potential uses also need to be considered before trenches are constructed.

Figure 61. Section through a seepage area with a trench showing the change in depth to watertable (Grainger 1995).



Groundwater pumping

To determine whether groundwater pumping is a viable option for managing salinity, the following need to be determined:

- the volume of water that needs to be pumped to reclaim the affected area
- how efficiently this volume can be extracted, method of extraction and cost
- the quality of the water to be pumped
- options for using and disposing of water of this quality, and possible benefits and consequences of its use.

The quantity of water that needs to be pumped to reclaim a waterlogged or salt-affected discharge area can be roughly estimated by calculating a groundwater balance for the catchment (see ***Catchment groundwater balance estimation*** page 70). The transmissivity of the aquifer and hydraulic head will determine whether the required volume can be extracted from the aquifer efficiently.

While some information can be inferred from surrounding existing bores, water quality and flow rate can only be accurately determined from a test bore in the target interception area. Flow rate will indicate which pumping options will be appropriate and economical.

Figure 62. A groundwater interception trench in the Kingaroy district, Queensland.

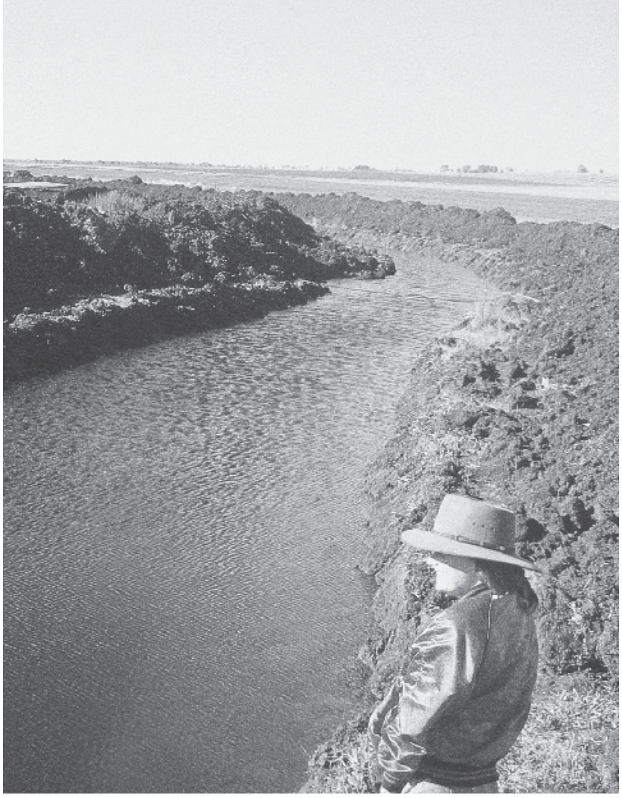


Figure 63. Air injection to clear a bore hole prior to insertion of a piezometer tube at Boonah, Queensland.

Depending on the quality of the water, it may be suitable for irrigation (as is or mixed with other water supplies) or for watering stock. (Water quality criteria for irrigation are provided in **Irrigation** page 81. Mixing water for irrigation is discussed in the following section **Marginal quality irrigation waters** page 116. Water quality criteria for stock are provided in **Stock watering** page 79.) As noted earlier, any proposal to dispose of pumped or drained water into a watercourse requires a permit from the appropriate authority. A licence to drill a bore is also required.

Irrigation quality water from low-flow bores can be stored in dams for later use. Storage dams need to be constructed to minimise any leakage to the groundwater. The size of the area to be irrigated will often be restricted by the available water from the bore(s). A guide to the storage volume required for irrigation is given by:

$$S = \frac{A(1500 - r)}{100} \quad \text{.......................... } 33$$

where

S	is	storage volume (ML)
A	is	area to be irrigated (ha)
r	is	annual rainfall (mm).

Pump site planning

Preliminary investigations are necessary to determine the best point(s) for groundwater extraction. To select sites for preliminary investigations, the best sources of information are local knowledge, data on hydrogeology, and results of previous drilling in the area. This information will provide a guide to the likely depth to which bores will have to be sunk, and thus the likely cost of drilling. Other information that should be obtained before carrying out preliminary investigations includes whether a licence is needed to drill, the type of drill rig most suited to the job, and the means of constructing the bore(s).

Once a bore has been constructed, a pump test is useful for determining the characteristics of the aquifer at that site. This involves pumping the bore for 24 hours and measuring the change in water level over time in the bore and the volume of water being extracted at regular time intervals.

The success of a bore for groundwater extraction will depend on factors such as the extent of the aquifer, the ability of the aquifer to drain water freely, the diameter and design of the bore, and pumping interference from other bores in the vicinity. An analysis of results from preliminary investigations will determine the effect of these factors and provide an indication of the maximum capacity of the bore, optimum pump inlet level, long-term reliability of the bore and stability of the aquifer.

If the transmissivity of the groundwater aquifer is low, multiple bores may need to be installed to obtain the required quantity of water. Supplying pumps and energy sources to each of these bores would quickly make such a system uneconomical. One option is to use smaller diameter (and thus less costly) bores and manifold these together to make a single inlet for a large surface-mounted pump. However, if one bore breaks suction, the whole system will fail. Because of the limits on suction lift of a surface-mounted pump, depth to the watertable and distance between the bores will be limiting factors in this type of system.

A multiple bore system is more likely to have an even drawdown of the groundwater than a single pumped bore. As a result, a multiple bore system will provide better results when the water is being extracted near to the area affected by the high watertable.

Pumps

In the case of a conventional single bore, pumping options include electric submersible pumps, electric or diesel turbines, helical rotor pumps, solar electric pumps, and windmills. Air pumps are particularly suitable for multiple bore systems.

Commercially available pumps can be categorised into three types:

- **Low flow pumps**. Generally intended for stock and domestic water movement, these pumps are designed to be very low maintenance and cost almost nothing to run. Solar pumps and windmills are in this category because these pumps do not need to be located near a conventional power source and can be left unattended for long periods. Pumping starts and stops automatically, depending on the system's energy requirements. Some domestic pumps require conventional power, but these systems are commonly located near a house where power is available. These systems generally pump up to 1 L/s, although volume throughputs in the range 0.7 to 1 L/s generally require larger, more expensive systems.
- **Low to medium flow pumps**. These are generally fire fighting type pumps for surface pumping applications with a volume throughput of 0.7 to 5 L/s. Small turbine and helical rotor pumps in this range are used for some small-scale irrigation, but as these pumps can only service a small area, they are most economical when used to irrigate high-value crops.
- **Medium to high flow pumps**. Mostly used for large-scale irrigation, these are pumps with a volume throughput greater than 5 L/s, and include diesel and electrically driven turbine and helical rotor pumps. As most of the cost of these pumps is in the drive systems and motors, their use under low to medium flow conditions is generally uneconomical.

Low to medium flow pumps with a volume throughput of approximately 0.7 to 5 L/s are appropriate for managing salinity by pumping in the transmission area. As multiple bore holes and pumping systems will probably be required to intercept a sufficient amount of water, pumps with the energy, maintenance, running and cost characteristics of low flow pumps will be most suitable.

Electric and diesel pumps

Electric pumping systems can be automated easily for on and off times and extended running periods. However, automated systems are limited to a single pump rate unless the pulleys are changed to vary pump speed. There can be considerable expense involved in making electricity available at the bore site if it is not already available. Tariff ratings and possible guarantees of use also need to be considered.

Diesel systems can be easily placed near to bore sites. Fuel storage will limit running times, but the pump rate can be easily changed by varying the governor setting.

Protection equipment for monitoring temperatures and pressures can easily be attached to both electric and diesel systems.

Sun- and wind-powered pumps

If the flow is small, solar electric pumps and windmills can be used economically. If an unused (but working) windmill is available, pumping with a windmill can be particularly economical. However, some of these systems rely on close tolerances for turbines, and pistons are susceptible to dirty, salty, sandy water; damage will result if the bore runs dry. The helical rotor pump and some solar diaphragm pumps can generally handle contaminated water without damage.

Solar-powered systems can only operate during daylight hours unless generated electricity is stored in a battery. However, it is usually cheaper to store water than electricity. As these systems are electric, it is relatively easy to install automated control and safety cut-outs. Solar powered systems are relatively portable and have a similar effective lifespan to both windmills and diesel pumps.

Air pumps

Another type of pump, not widely used in agriculture, is the air pump. These pumps can be used to provide a low-cost dewatering system for regions with low yields of 0.5 to 3 L/s.

Air pumps are particularly suitable for multiple bore systems because one compressor can be used to drive a number of bores. This is achieved by installing a network of inexpensive piping between the compressor and the water extraction points (distances can be up to several kilometres).

There are two basic types of air pumps:

- **Air injection type**. Air injected at the base of a submerged discharge pipe forms a mixture of water and air which is lighter than the head of water at this point, so the aerated water rises to the surface.
- **Pressure vessel type**. A submerged chamber is alternately filled with water and with air; when the chamber is filled with water, a control device (electronic or mechanical) directs compressed air into the chamber, which forces the water into a discharge pipe; when the chamber is empty of water, the compressed air is shut off, the vessel is allowed to refill with water, and the process repeats.

The air injection system has no moving parts in contact with water, and the pump foot piece is simple and inexpensive. The control devices used by the pressure vessel type pumps may become unreliable in the long term, and dirty water can reduce the performance of these pumps by inhibiting the action of the non-return valves. With both types, if the bore runs dry, pumping automatically resumes as the bore replenishes.

The efficiency of the air injection type is greatest when the head above the pump (that is, the depth to which the pump is submerged below the watertable) is at least 70% of the total lift required. In other words, the depth of the pump below the watertable needs to be at least 2.3 times the height difference between the watertable and the outflow point. For example, a pump situated 7 m below the watertable will lift water efficiently to 10 m. (If the watertable is lowered by pumping, the pump will need to be lowered to maintain efficiency.) Thus this system of pumping is most efficient in areas with shallow watertables where the water can be disposed of nearby using flood or furrow irrigation or held in temporary surface water storages.

Figure 64. Air supply for an air pumping system.

Figure 65. Above-ground component of a small-scale air injection pumping system.