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Catchment Water Management: Guidelines for those considering drainage for waterlogging and salinity management

Department of Agriculture and Food, Western Australia

Water and Rivers Commission

State Salinity Council

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Salinity is one of the biggest threats to rural land, water and biodiversity resources in the south-west agricultural region of Western Australia. It has been estimated that, unless action is taken, up to 30 per cent of the agricultural land area could become salt affected in the future. Action needs to be taken now, but information about available management options is either incomplete or not readily accessible in a format that is easy to understand.

Water management through surface and subsurface drainage can help to mitigate soil and land degradation by reducing the effects of water erosion, groundwater recharge, adverse interactions between waterlogging, salinity and soil structural decline. Drainage may reduce losses in production caused by waterlogging, inundation and salinity. However, drainage systems are complex management tools. They can include surface water management options through the construction of shallow drains, or groundwater management through deep drains or pumping. Consideration needs to be given not only to the sorts of problems that need to be addressed, but how the drainage works will impact on other resources such as infrastructure and the environment, both on- and off-site. Surface water management and deep drainage address quite different issues with different techniques for each.

Landholder groups and government agencies are continuing to develop "best drainage practice" guidelines and these will increase our knowledge of drainage, and deep drainage in particular, as a management tool. The brochure does not provide all the answers, but is intended to provide some basic information to assist landholders who may be considering some form of water management or drainage systems.
DEFINING THE ISSUES

There is no one solution or management tool to address salinity, waterlogging and inundation. Options may include re-vegetation with native or commercial species, adopting high water-using farming systems, and surface water management. The effectiveness of engineering options will vary according to where you are located. Before deciding which management system to adopt the following points should be considered:

I. Location in the State

The most suitable sites for earthworks are dependent on a number of factors such as rainfall and landscape type. You can identify the zone in which you are located from Figure 1. The descriptions of each zone are generalised but will assist in determining if drainage is the best option to use:

Zone 1 has flat, poorly drained land and low rainfall. Broad valley floors can become saturated. Drainage is one option but saline water disposal is difficult because of the low gradients, high evaporation rates, and low rainfall.

Zone 2 has high relief landscape and medium rainfalls with good natural drainage. Engineering options are more flexible with better opportunities for discharge management.

Zone 3 has high rainfall with low gradients, waterlogging and inundation. Drainage systems are designed more for waterlogging and inundation management than for salinity control.

Landholders should identify the regional catchment or river basin in which they are located (Figure 2). Some regions have Natural Resource Management (NRM) groups (for example, the South West Catchment Council, the Swan Catchment Council and the Avon Working Group) which may be able to provide information on water management problems and best management practices suited for that region.

2. Location in the landscape

The best management option is largely dependent on the nature of the landscape in which a drainage project is planned. The shape, soil types and underlying geology of the landscape play a significant role in determining the salinity or water management option. The four examples illustrated in Figure 3 can help in identifying your own particular issues. However, it should be recognised that different management options may also be applied in each landscape type.
Figure 3 (a) Mid-slope seepage and waterlogging caused by outcropping bedrock and dolerite dykes. These structures can act as carriers and barriers to groundwater flow. Deep drains and pumping are generally not cost effective. Re-vegetation above the seep and management of rainfall runoff and infiltration above the geological structure may be required.

Figure 3 (b) Break of slope seeps. Drilling may be required to confirm seep type (i.e. perched or groundwater aquifer). If suitable soil types exist for drainage construction, deep drains or subsurface interceptor drains placed at the break of slope may alleviate water logging on the valley floor. Effective for sandplain seeps above clayey valley floors.

Figure 3 (c) Sandplain seeps. These can be reclaimed through drainage and re-vegetation (Refer to the AGWEST Farmnote No. 116/88). Drainage can be effective where safe disposal of drained waters can be achieved.

Figure 3 (d) Valley convergence seeps. These occur where valley floors narrow and the confinement causes groundwater to rise. The amount of discharge may vary seasonally. Water management including runoff and sub-surface interception on slopes above the valley floors can reduce waterlogging and inundation.

3. Location in the catchment area

Where the property is located within its catchment, will determine the effectiveness of the water management options that are available. Drainage or pumping water from a property may have either benefits or unacceptable impacts on others in the catchment.

Issues to be considered are:

Where is the water coming from and where does it go after it leaves the property?

What type of drainage system or pumping is required (i.e. is it a surface or groundwater problem)?

What will occur if earthworks are used to manage runoff?

Who (e.g. neighbours) or what (e.g. wetlands, roads) will be affected by the discharge?

How will the drains be stabilised?

Will the drain transport (salt, sediment, nutrients, etc and how will this affect the water quality?

What benefits can realistically be expected?

Has any provision been made to augment winter flushing of receiving wetlands?

Waterways and wetlands in catchments are important to the local ecology, local drainage, nature conservation, and floodwater discharge. If additional water is discharged into them, the changed patterns of flow may disrupt the natural water balance of existing ecosystems. All landholders have a duty of care to the land and to other landholders. Inappropriate action could cause loss of flora, fauna and wetlands flooding, damage to other properties, damage to infrastructure, and the transfer of salinity problems from one area to another.
Once the above information has been obtained, particularly in relation to regional strategies and policies, the landholder is in a position to make an informed, responsible decision about the most suitable water management options for their property. There are also certain legal aspects to be satisfied under common and statute law before any earthworks are constructed.

I. Vegetation management
Re-vegetation and careful management of remnant vegetation are important, relatively low-cost, low-impact strategies that should be included in a planned approach to water management. Integrated vegetation and engineering solutions will return the best results.

II. Earthworks to manage surface water discharge
A range of earthworks are commonly used to alleviate problems associated with water management in a catchment or on the farm. Each design has a set of design criteria for minimum risk planning, location within the landscape and maximum economic benefit. Moving fresh surface water is generally less risky and potentially of greater benefit than draining saline groundwater.

Earthworks constructed for surface and sub-surface water management are considered to be the more economic design option, as opposed to pumping and deep drains. Examples of surface earthworks include grade banks, seepage interceptor drains, spoon or W-drains, broad shallow drains and levees (which confine streamflow).

If constructed properly these types of earthworks have certain advantages:
- Cost of construction is relatively low and may be recovered through productivity gains in subsequent years.
- Surface runoff is usually of good quality and can be stored or directed into natural watercourses.
- Groundwater recharge is reduced.
- Peak streamflow in creeks is reduced, so reducing flooding, channel erosion and sedimentation.
- Minimal maintenance is required.
- Notification is not required under the Soil and Land Conservation Act.

Interceptor/Grade banks should be constructed on a grade that ensures adequate flow without causing scouring of the channel. There is a range of design options but generally they are constructed to intercept both surface water run-off and sub-surface flow in duplex profile soils on sloping landscape positions. Lower-cost banks built with a grader are suitable for shallow duplex soils. More expensive bulldozer construction may be required on deeper soils or where larger capacity level banks are needed. These structures are often very effective in reducing waterlogging and controlling soil erosion.

Spoon or W-drains are effective in removing ponded water. The drains are located in the lower landscape where waterways would be ineffective because of low gradients and are used to intercept overland flow in low-lying areas. Problems associated with these works can be minimised through the provision of a safe discharge area. However some disadvantages are:
- Run-off is increased after rainfall and stream peak flows may be increased.
- Flood storage that is provided by natural ponding is reduced.
- Nutrient discharge may be increased, particularly in sandy soils.
- Natural flood flows may be altered, directing floodwaters into unintended areas, if incorrectly designed.

Broad shallow drains can be constructed in poorly-defined watercourses to increase streamflow. They are most suited to the ancient drainage zone of the Yilgarn plateau (see Figure 1).

Disadvantages occur if these drains substantially increase the speed and power of streams and damage natural ecosystems along the original watercourse.

Levees are used to confine streamflow and are generally not used in well-dissected landscapes. Potential disadvantages are the same as for spoon drains and broad shallow drains. Levees can cause considerable damage to river environments if incorrectly located. Levees that have been properly designed and placed in the landscape should not significantly increase streamflow during high rainfall events.
GROUNDWATER MANAGEMENT

Groundwater recharge and discharge problems are sometimes addressed through deep drainage or pumping. There is divided opinion about the effectiveness of deep drains and there is limited monitoring information available for clear decisions to be made. However, there are a number of issues that should be considered prior to developing a groundwater management plan:

1. **The effectiveness of deep drains is dependent on site characteristic**

   There is a need to assess on-site characteristics (soils, geology, and gradient) to determine potential for drainage success. The rate at which water will flow into a deep drain is dependent on the soil profiles’ ability to conduct water. Sandy, coarse soils are good conductors, whereas heavy clay soils are poor conductors. Deep drains constructed in heavy clay soils in the lower landscape are not generally effective in lowering the water tables, unless they penetrate a layer of conductive or permeable soil.

   Drains are effective mainly in sandy textured, permeable soils or in deep duplex soils. However, sandy soils are prone to erosion and batter slump, requiring considerable ongoing maintenance that increases the cost of the drains. The diagram below (Figure 4) indicates the relative effectiveness of soils in transmitting water.

2. **Deep drains are expensive**

   Note that it may cost more to install and maintain deep drains than is recovered from productivity increases. Additional cost may be incurred for the design of culverts for road crossings, disposal facilities and maintenance. Deep drains have greater economic benefit where high value crops (such as horticulture) are protected. They are also important in the protection of dams, infrastructure and towns where there are other high-value economic considerations. The benefits accumulated need to be at least equal to or greater than the cost of implementation. Alternative less costly earthworks should be assessed prior to committing to deep drains.

3. **The off-site impacts of deep drains need to be considered**

   The discharge from deep drains should be disposed of in a responsible manner. The discharge is often saline but may vary with seasonal conditions. Deep drains are intrusive on the landscape and are not always conducive to best land management practice. Where surface water can enter the drainage system in an uncontrolled way they can channel significant amounts of water towards the eventual disposal point. This may be a natural waterway, a wetland or storage basin that may be unable to cope with the amount of water or the quality of water discharged.

GROUNDWATER PUMPING

Pumping can be effective in lowering groundwater levels to protect high value assets. Pumps may be expensive to install and maintain. They are most effective in permeable aquifers. The discharge is often saline and will have negative impacts on waterways, wetlands and other water resources.

EVAPORATION BASINS

Evaporation is very high in summer and can be put to use in the control of groundwater discharge from deep drains, relief wells and pumping. Evaporation basins provide the best means of exploiting high evaporation rates, but are expensive to construct and have the potential to leak, causing localised recharge. They can be used with drains and groundwater pumping as a means of disposing of saline groundwater if other disposal sites/methods are not available. High evaporation rates mean that the basins need to be located close to the point of discharge. There is some potential for integrating evaporation basins and saline discharge with aquaculture operations.

Guidelines on evaporation basin construction are available from AGWEST (Misc.Pub. 21/99).

WINTER RELEASE

Detention storage (i.e. dams) can be used to retain flows from saline seeps or from groundwater pumping during periods of low streamflow (e.g. summer) or low rainfall. Water contained in the storage can then be released during high rainfall events or during periods of high streamflow (e.g. winter). In this way saline effluent can be disposed of into natural drainage lines with limited impact on the environment. Water quality should be monitored to minimise any negative impacts of saline water disposal.
1. Obtain relevant information

Before any decision is made about water management options, information is needed about the property and its location. This includes where it is in the State, where it is in the landscape and where it is in the regional catchment. An assessment is required of water movement (i.e. inputs: rainfall, outputs: runoff/streamflow) in the catchment area in normal, wet and dry years.

Landholders should consider what specific issues they have to address and at what scale. How much land has been lost and how much more land will be lost if drainage is not undertaken? What is the current value of production lost as a result?

This information is critical in deciding which management option is best suited to the problem. Each option should be assessed against the design requirements, soil types and costs of alternatives. Assistance may be required in deciding the best solutions.

2. Community consultation

As drainage systems can impact on other properties, proposals for catchment water management should be integrated into a locally-agreed catchment management strategy. Everyone who may be affected should have an opportunity to comment, negotiate trade-offs and, possibly, share costs. Consultation is not always easy, but it is one of the best ways to obtain and share factual information that may reduce the potential for conflict in the long term.

3. Assess alternatives

Earthworks associated with shallow drains and surface water management can be implemented without a Notice of Intent to the Commissioner of Soil and Land Conservation provided they do not impact on other areas of land. Each landholder has a duty of care and certain responsibilities under common law. The effectiveness of earthworks should be assessed before implementing deep drains. Shallow drains are cheaper, more easily modified and may solve the problem without the need for further, more expensive structures. Incorporating modified farming systems and re-vegetation strategies into the catchment water management plan will increase the potential for success.

4. Deep drainage proposals are Notifiable

If deep drainage is being considered the proposal must be submitted under a Notice of Intent to the Commissioner of Soil and Land Conservation. The proposal will move through the assessment process more rapidly if it:

- involves community cooperation;
- is part of an integrated catchment or community proposal;
- has been agreed to by all parties involved or affected;
- has an impact assessment attached providing details of the anticipated on- and off-site impacts; and
- the target receiving area for the drained water has been identified and plans made to manage the flow, including evaporation rates and flooding.
SUMMARY

Deep drainage and groundwater pumping are expensive options and may have negative off-site impacts. The expected benefits need to offset any losses incurred.

Your position in the catchment and how you influence the water movement on your property affects others within the catchment and region (fig 6). What you do on your property can impact on others. Drainage systems with a mix of surface and sub-surface engineering and bio-physical water management options should be part of an integrated community and catchment plan. All parties involved should be in agreement on what is to be done and how the costs will be shared.

Fig 6. Consider the position of your farm in your catchment and region.
FURTHER INFORMATION

Local information is available from:

- **Northern Agricultural Integrated Management Strategy (NAIMS)**
  C/- Agriculture WA
  PO Box 110
  Geraldton WA 6531
  Tel: 9956 8555

- **Avon Working Group**
  C/- Avon Catchment Network
  PO Box 311
  Northam WA 6401
  Tel: 9622 7600

- **Swan Catchment Council**
  Swan Catchment Centre
  108 Adelaide Terrace
  East Perth WA 6004
  Tel: 9221 3840

- **South Coast Regional Initiative Planning Team**
  C/- Agriculture WA
  444 Albany Highway
  Albany WA 6330
  Tel: 9892 8537

- **Blackwood Basin Group**
  PO Box 231
  Boyup Brook WA 6244
  Tel: 9765 1555

For areas in the South West other than the Blackwood, contact South West Catchment Council.

- **South West Catchment Council**
  C/- Water and Rivers Commission
  PO Box 261
  Bunbury WA 6231
  Tel: 9721 0696

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The Avon Catchment Network web site www.avonicm.org.au
Agriculture WA Publications:

"Common Conservation Works Used In Western Australia"

"An Assessment of the Efficacy of Deep Drains Constructed in the Wheatbelt of Western Australia"

“Evaporation basin guidelines for disposal of saline water”

Other sources of information are:

- Agriculture Western Australia, South Perth
  Phone 9368 3333

- Water and Rivers Commission, East Perth
  Phone 9278 0300

Department of Conservation and Land Management
Phone 9334 0333