

# CODE OF PRACTICE

for Environmentally Sustainable  
Vegetable and Potato Production  
in Western Australia



POTATO GROWERS ASSOCIATION OF W.A. (INC)



Department of Agriculture  
Department of Environmental Protection  
Water and Rivers Commission



WESTERN POTATOES



Horticulture Australia

# Acknowledgements

A world-wide community demand for accountability when producing food products was the catalyst for, the Vegetable and Potato Growers' of Western Australia to produce a Code of Practice and a Best Environmental Management Practices Reference Manual.

## **The Code and Manual were compiled by:-**

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- WA Vegetable Growers Association (Inc)
- Department of Agriculture
- Department of Environmental Protection
- Water and Rivers Commission
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# Foreword

Western Australian vegetable and potato industries have responded positively to demands for change over the past decade. Environmental management reflecting community values has significantly influenced the direction of change. Consumers are not only demanding quality; they are demanding safety and accountability through transparent best management practices. Supply chain management with communication and information sharing is a vital ingredient for the successful economic development of our horticultural industries.



*Sam Calameri (left) and  
Dom Della Vedova (right)*

The adoption of technology and intensive inputs has enabled horticultural production in Western Australia to maintain economic profitability despite a decrease in real returns and in the numbers of growers in the industry. This high input system is coming under increasing scrutiny not only by the wider community, but also by the growers themselves who realise that long term sustainable productivity from their own farms is linked to the environmental viability of the soil and water resource base.

This Code of Practice is an initiative by the Potato Growers' Association of Western Australia (Inc.), in conjunction with WA Vegetable Growers' Association, Western Potatoes, Department of Agriculture, Department of Environmental Protection and Water and Rivers Commission. It is one part of a trilogy of initiatives for sustainable vegetable and potato production:

- The Code of Practice, which identifies expected environmental outcomes and principles for sustainable vegetable and potato production in Western Australia.
- A Manual of Best Environmental Management Practices for sustainable vegetable and potato growing in Western Australia.
- An Environmental Management System of on-farm management.

The Code of Practice and Best Environmental Management Practices documents will be made available to all growers. The Environmental Management System will be a voluntary, auditable system, which growers can adopt to improve environmental sustainability.

The Potato Growers' Association of Western Australia and the WA Vegetable Growers' Association encourage growers to familiarise themselves with the Code of Practice and consider its application on their own property. Never before has such a comprehensive guide been produced for Western Australia's vegetable and potato growers. This Code endeavours to cover all of the principles and refers to all of the current information that vegetable and potato growers are likely to need to enable them to minimise environmental impacts and manage rural-urban conflicts of their operations.

**Dominic Della Vedova,**  
President, Potato Growers'  
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President, WA Vegetable  
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### How to use this Code of Practice Document

The subsections under each numbered principle contain an explanation of the issue and why one or more best environmental practices are needed. A brief description of the practice is written in indented bold with the symbol □.

Where more technical and background information is required for the grower to be able to conduct the best practice, this can be found in the companion document, 'Best Environmental Management Practices for Environmentally Sustainable Vegetable and Potato Production in Western Australia'

(referred to in the text as the BEMP Manual).

The numbering, section headings and colour coding of both the Code document and the BEMP Manual are the same to enable easy cross- referencing.

### New and/or expanding development proposals

Proponents of new vegetable and potato growing proposals are advised to refer to Section 13 'How to Seek Approval and Other Legislative Requirements'. This section outlines the government regulatory approval processes that may be required.

This Code of Practice has been endorsed by the following Departments of the Government of Western Australia:

- Department of Agriculture
- Water and Rivers Commission
- Department of Environmental Protection

#### *Disclaimer*

*The Chief Executive Officer of the Western Australian Department of Agriculture, the State of Western Australia and the Potato Growers' Association of WA (Inc) accept no liability whatsoever by reason of negligence or otherwise arising from use or release of the information in this Manual or any part of it.*

*Mention of product or trade names does not imply recommendation*

# Introduction

Horticultural land in Western Australia is the most productive of all agricultural land in the State. The value of irrigated vegetable and potato crops is \$10,000 to \$20,000 per hectare and above, compared with less than \$500 per hectare for most dry land grain cropping and grazing land uses. Land with suitable soils and fresh water for irrigated horticulture is also very limited in area, with about 11,100 hectares currently under production (Agriculture Western Australia, 1997). Maintaining and improving the quality and productivity of our horticultural soils is therefore of utmost importance to the horticultural industry now and for future generations.

The gross value of Western Australia's vegetable and potato production is over \$181 million, potatoes accounting for about \$40 million. Western Australia is Australia's largest exporter of fresh vegetables. About 40% of production is sent to over 20 countries, the principal markets being Singapore, Malaysia and Hong Kong. Over 80% of the exports are carrots and cauliflowers, with potatoes, melons and strawberries becoming increasingly important. Some vegetable exports are growing rapidly, for example carrot and cauliflower exports grew by about 15% per year in the late 1990s (Agriculture Western Australia Bulletin "A Snapshot of Horticulture, Western Australia")

Vegetables and potatoes are grown in four main regions of Western Australia. These are the South West coastal plains, South West high rainfall hills, Gascoyne irrigation area and the Ord irrigation area.

- The South West coastal plain horticultural areas produce about 40 % of the State's vegetables and potatoes, most of this coming from the Shires of Wanneroo, Cockburn and Rockingham, which are in the Perth metropolitan area. Other coastal plain growing areas are Myalup (in the Shire of Harvey), Greenough (near Geraldton) and Gingin. The coastal plains have a mild, Mediterranean climate with cool wet winters, warm dry summers and 600 - 900 mm rainfall. Carrots, potatoes, cauliflowers, melons, strawberries and tomatoes are the main crops, mostly grown in summer and irrigated with groundwater. Soils are generally deep grey to yellow sands.
- The major South West hills horticultural production area is in the Shire of Manjimup (including Pemberton), which produces more vegetables and potatoes than any other shire in the State (value of production about \$40 million). There are smaller areas in the Shires of Busselton, Donnybrook and Albany. This area also has a Mediterranean climate, with 800 to 1200 mm rainfall. The main crops are generally summer-grown potatoes, cauliflowers, other brassicas and sweet corn. Irrigation is by surface water collected in gully dams. Sites are sloping and soils are sandy loams and gravels.
- The Gascoyne irrigation area is situated near the town of Carnarvon, on the mid-west coast. The climate is hot dry tropical with a rainfall of less than 300 mm. Vegetables such as melons, tomatoes and capsicums with a total value of about \$12 million are grown mainly in winter and are trickle irrigated with groundwater. The growing areas are flat flood plains with alluvial silt and clay based soils.

- The Ord irrigation area is situated near Kununurra in the far north of the State. The climate is hot tropical monsoonal, with 1000 - 1500 mm rainfall. Gross annual value of vegetable production is about \$26 million and this area has great potential for expansion. Melons and pumpkins are produced, mainly for the winter market in southern Australia. Crops are mostly flood irrigated from the Ord Irrigation Dam. Soils are heavy silts and clays (Agriculture Western Australia, 1997).

### **Environmental issues of the vegetable and potato industry**

The risks of adverse impacts on the environment are higher for vegetable and potato production than for most other agricultural land uses and the need to conduct best practices to minimise these risks is greater.

The high production rates from vegetable and potato cropping require high inputs. Compared to cereal cropping over one year, the fertiliser inputs are up to 20 times higher, two to five times as many soil cultivations are required and up to 10 times as many spraying and other machinery operations may be conducted. Hence there is a need to use best soil and water management practices to prevent degradation of soil and water resources.

In Western Australia, most vegetable crops must have fresh water for irrigation. For this reason, a majority of growing operations are located on or near groundwater aquifers, which have other existing or potential uses. Some growing operations are in close proximity to freshwater streams and wetlands with high flora and fauna conservation values, which must be safeguarded from nutrient and chemical pollution, salinity and invasion by weeds.

Over half of the vegetable and potato production is conducted within 10 kilometres of residential areas. Major vegetable and potato producing areas in the Perth metropolitan area, such as Wanneroo and Baldivis, and near rural towns such as Manjimup, Carnarvon and Kununurra present risks of adverse impacts on communities and urban lifestyles. In other areas, impacts of spray drift and noise on other industries such as tourism also need to be considered.

### **The scope and use of the Code**

The scope of this Code of Practice is to explain why and how environmentally sustainable vegetable and potato growing should be conducted. For the purposes of this Code, sustainable production is defined as:

*“A system of agricultural production that aims to reduce environmental degradation, maintain agricultural productivity, promote economic viability in both the short and long term and maintain stable rural communities and quality of life”* (University of New Hampshire, 2001).

The Code is owned and administered by the Western Australian Vegetable and Potato Growers' Associations and is endorsed by the Department of Agriculture, Department of Environmental Protection and the Water and Rivers Commission. It sets out the industry and government's expectations of growers for environmental management.

The document covers the production of annual horticultural crops in Western Australia, including potatoes, melons, strawberries and vegetables such as cauliflowers, carrots, onions, sweet corn, broccoli, tomatoes, cucurbits and pumpkins.

Production of cereal crops, mushrooms and perennial horticultural crops such as tree fruit, nuts and vines and any crop grown by hydroponics is not covered in this Code.

Growers and the staff of industry associations will use the Code as a reference in their efforts to improve their environmental management. It will be a useful information source for planners, government decision-makers and allied industries such as supermarkets, vegetable wholesalers, and exporters. The Code will also be useful in resolution of disputes about environmental issues that may arise from growing operations.

The Code of Practice is designed to be used in conjunction with the companion publication 'Best Environmental Management Practices for Environmentally Sustainable Vegetable and Potato Production in Western Australia, a Reference Manual' (BEMP Manual). This manual describes how to implement the best environmental management practices outlined in the Code. Both texts are written under the same numbered, colour coded sections and principles, to enable easy cross-referencing.

The Code, together with the BEMP Manual, outlines the expected environmental outcomes, principles and practices that will enable growers to conduct their operations in harmony with the environment and surrounding land uses. Many growers will find that they are already complying with the Code in many if not all aspects of their operations and most will find that there are some areas in which they can improve.

Compliance with the Code is voluntary. It is not intended as a set of regulations that must be followed, but rather as a set of guidelines to facilitate continual improvement in environmental management of the industry. The Code and BEMP documents will themselves be updated periodically as practices and community expectations change.

A model Environmental Management System (EMS), which growers can adapt to produce their own management system tailored for their particular growing enterprise, will form the third part of this trilogy of documents. The EMS will be voluntary and would be designed to give growers the benefits of a formal environmental accreditation or 'green tick' for their enterprises. In developing their EMS, growers would apply the principles outlined in the Code and select appropriate practices from the BEMP Manual to address the environmental issues relating to their situation.



*Harvesting cauliflowers at Baldivis.*



*A well planned diversified farm in Pemberton.*



*Best environmental practices for vegetable and potato growing are essential to minimise impacts on the adjacent land use, such as the urban area (above) and aquaculture ponds (below).*



# SECTION 1



## **Farm Planning**



# Farm Planning

## **Expected environmental outcome:**

*All growers to have developed a farm plan that minimises operational impacts on the environment.*

Managing a vegetable or potato growing property is not a simple business. In addition to managing the financial, agronomic and machinery aspects the grower needs to deal with specific environmental issues, which relate to the particular farm and operation. The first planning opportunity arises when selecting the site. Thorough investigation to choose a suitable site location and soil type to minimise environmental impacts will save a lot of time and cost over the life of the project. The next important step towards achieving sustainable production and minimising negative environmental impacts is to develop a whole farm plan.

All reasonable and practicable measures should be adopted to apply the following planning principles:

### **1.1 Select suitable sites where environmental problems will be minimal.**

### **1.2 Plan the whole farm to minimise environmental impacts.**

#### 1.1 Select suitable sites where environmental problems will be minimal

Choice of site location is critical if vegetable or potato production is to have minimal impact on the environment and remain economically viable. Selection of the most appropriate site will increase the probability of the new or expanding operation gaining approval and minimise the number of costly design and management conditions that may be required by regulatory authorities. Section 13 outlines the legislative requirements for new and expanding vegetable and potato growing operations.

To minimise environmental problems, a vegetable or potato growing site needs to have the following attributes:

- Be in a location zoned for horticulture.
  - Be located with adequate buffer distances from sensitive environments such as residential areas, streams, wetlands and conservation areas.
  - Not be located in a P1 and P2 Public Drinking Water Source Area.
  - Have well-drained soils with adequate nutrient holding capacity.
- First consider land capability and location suitability when selecting land for a new or expanding vegetable or potato growing operation.**

#### 1.2 Plan the whole farm to minimise environmental impacts

A farm plan typically consists of an aerial photograph and associated overlays of physical features such as ridges, valleys and flow lines, height contours and soil types as well as existing farm infrastructure. Farm plans also detail the works proposed for efficient, sustainable farming including the design and costing of works, soil tests and records of crop yields and fertiliser applications for each paddock.

#### Example

The Peel-Harvey and Scott Coastal Plain catchments drain through sensitive wetlands and estuaries, which have valuable conservation, tourism, fishing, residential and recreational uses. Horticulture development applications in these catchments require up to four levels of government assessment due to requirements to minimise movement of nutrients into wetlands and estuaries. Some horticultural developments on the Scott Coastal Plain have been allowed to proceed on condition that:

- Development plans showing appropriate buffers, drainage, nutrient stripping areas, streamline protection and revegetation were approved by government agencies.
- Acceptable fertiliser and soil conservation strategies are adopted.
- Water sampled and monitored regularly at the farm boundary and in bores is of acceptable quality.
- Continuation of the water licence is dependent on the development conditions being met.



The plan is an important tool by which the grower can integrate planning and management of environmental issues into the overall management of the farm. Farm infrastructures need to be located to minimise soil erosion, export of nutrients and chemicals and the impacts of air and noise pollution while being practical for the management of the farm. Farm planning is an ongoing process and the plan should be reviewed and updated at least once per year.

Far from being just another imposition on the grower's time, the farm plan enables more effective fertiliser application, soil management and costing of works. Time spent developing the plan will be repaid many times, as subsequent cropping operations are made more efficient and fuel, soil and fertiliser are saved. Farm plans are useful to illustrate physical aspects of the farming business in discussions with bank lending officers, consultants, government agency staff and neighbours.

- Plan the whole farm to minimise environmental impacts. Continually update and improve the plan with changing circumstances.**
- Be prepared to liaise with neighbours where aspects of planned farm infrastructure or works may impact on them.**

Farmers with computing skills can have their plan maps and records stored on computer, making updates easier and planning calculations much easier to do.

### **Essential components of a whole farm plan**

To start with, scaled aerial photos and a contour map are needed. A soil landscape map of the district makes soil mapping much easier, if this is available. The length of fence lines, access tracks and earthworks and areas of paddocks are easily measured off the map.

- **Soil types.** Map soil units of a large enough size to be practical for management (known as land management units).
- **Surface water control.** For properties in hilly or flood plain areas, the most essential works map is the surface water control plan. Erosion control earthworks need to be planned to ensure that they will not adversely affect other areas of the farm and neighbours' operations. The paddock layout, access and all other infrastructure need to be planned around the erosion control earthworks. For example, access tracks can be located alongside grassed waterways and diversion banks.

Growers on river flood plains should consult their local catchment group to ensure that proposed surface water control works fit the guidelines of their catchment flood plain strategy. In this way, soil erosion and nutrient pollution during flood events can be minimised.



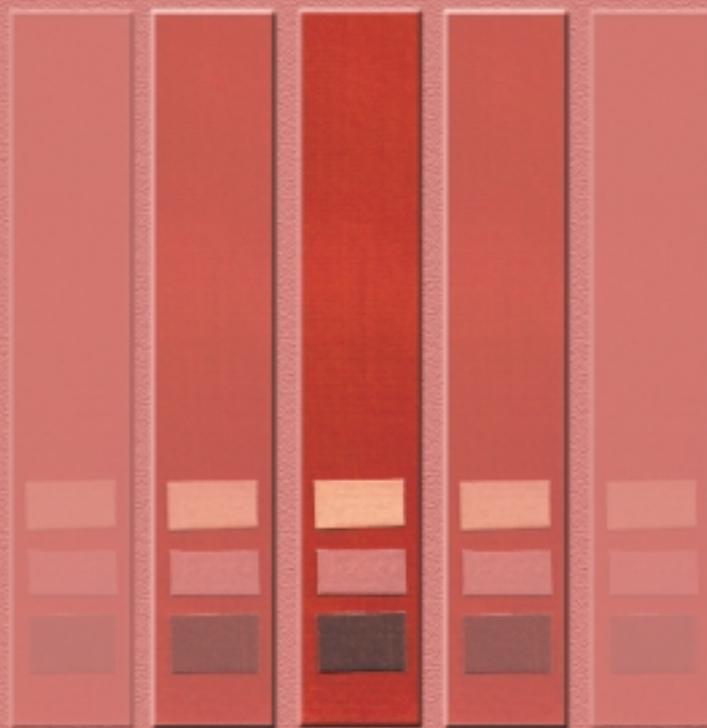
*Permanent surface water control works are an essential component of the farm plan for cropping hill slopes.*

- **Opportunities to harvest surface water.** Water is a scarce resource in Western Australia. In some areas, where the streams are saline or water supplies are inadequate, it is useful to harvest more water by means of diversion banks into dams constructed on hillsides. In these situations, surface water control planning is a first step towards obtaining more water.
- **Fences and infrastructure.** The whole farm planning process involves mapping the location of current and proposed infrastructure and works. Farm infrastructures that may impact on soil, land and water include access tracks, fencing, chemical storage sheds, fuel tanks and fertiliser storage facilities. It is difficult to compensate for poor location of farm infrastructure by trying to improve operational management. For example, a fence in the wrong place may be an ongoing impediment to efficient fertiliser application or effective surface water control. By using farm plan maps and photos, the fence could be optimally located according to soil type and terrain or alongside waterways and access tracks.
- **Windbreaks and vegetation.** The location of windbreaks, vegetation corridors and buffer zones should be drawn on a separate overlay. These areas may have buffering, soil conservation, and flora and fauna habitat and water resource protection values. Developing a concept plan is the only way to ensure that these values are enhanced where possible, while not impeding other practical aspects of farm operations.
- **Paddock fertiliser history.** Soil and paddock maps can be linked with recorded data such as yield, time of cropping, fertiliser application, disease history and soil tests, building up a history of inputs, production and soil quality for each paddock. These records give a clear picture of where operations need to change or where infrastructure needs to be relocated.
- **Paddock cropping history.** The record of crops grown in each paddock each year, which can be linked to records of yield, disease outbreaks and chemical application.
- **Monitoring locations.** Soil monitoring points, sampling transects and where applicable water monitoring points should be marked on a map.



*Good planning put into practice – this paddock has been cultivated across the slope and the flow-line left as a grassed waterway.*

# SECTION 2



## **Soil Management**

# Soil Management

## **Expected environmental outcomes:**

- *Sustainable productivity of soils is maintained or improved.*
- *Soil management minimises off-site environmental impacts.*

Soil erosion and decline in soil health are major interrelated issues that are crucial to sustainable vegetable and potato growing.

Healthy soil is an essential resource for sustainable horticultural production. Soil is not indestructible and needs to be managed carefully to prevent erosion, soil structure decline and loss of fertility.

When soil, which often contains nutrients and chemicals, is washed or blown across the farm fence, damage to water resources, road verges, road infrastructure, conservation reserves and other properties is likely to result.

This section of the Code sets out principles and gives examples of practices, which minimise the impacts that cultivation and cropping operations may have on the soil and land resources, the conservation values of adjacent natural ecosystems and the surrounding community.

All reasonable and practicable measures should be adopted to apply the following soil management principles.

### **2.1 Minimise or virtually eliminate soil erosion.**

### **2.2 Maintain or improve soil physical and biological health.**

### **2.3 Manage soil and drainage to minimise export of nutrients and chemicals.**

### **2.4 Manage soil acidity, sodicity, salinity and other soil chemical problems.**

## **2.1 Minimise or virtually eliminate soil erosion**

Soil erosion loss is a major issue for the industry. Loss of topsoil from a site results in reduction of its future capacity to produce horticultural crops. Erosion is also a major cause of nutrient and chemical pollution of waterways and natural ecosystems.

Rates of soil loss of over 10 mm of topsoil (100 cubic metres per hectare) per cropping operation have been measured on some steeper cultivated sites under poor management (Mc Farlane, D.J., *et al*, 2000). The topsoil is typically only 100 - 200 mm in depth and at this rate of soil loss, these sites would have completely lost all topsoil after 10 - 20 crops. This is clearly inconsistent with this Code of Practice and it is also completely avoidable, as well-managed vegetable growing sites have been found to have negligible soil loss.

### **Protecting bare cultivated soil**

Preventing soil erosion is mainly about protecting cultivated soil, which is very susceptible to erosion by water and wind. Any strategy for minimising soil erosion must first include means of both protecting cultivated soil and minimising the time it is left bare.

**❑ Check cultivated paddocks regularly for signs of erosion.**

- Rills, washes, gullies and soil build-up along fence lines are all evidence of unacceptable water erosion.
- There should be no run-off from cultivated soil during irrigation or rainfall events of normal intensity. Even during extreme rainfall events, run-off should be minimal and controlled.
- Wind blown surface and dust are signs of wind erosion.

These are all warning signs that soil management needs to be improved.

**❑ All growers need to have a soil erosion prevention strategy for each of their cultivated sites, according to site and soil conditions, seasonal risks and the cropping operation.**

Some growers may choose to formalise their soil management strategies as part of an Environmental Management System.

Soil management strategies for all sites should include (Section 2.2):

- Minimising the number of cultivations and using ‘soil-friendly’ implements.
- Protecting the soil surface by retaining crop residues, planting cover crops or spreading surface mulch.
- Maintaining or improving soil biological health by mulch cropping or adding soil amendments.

Some sites will also require extra soil protection measures:

- Surface water control earthworks.
- Windbreaks.

### **Site water erosion risks**

It is the infrequent intense high rainfall events that cause most water erosion of soil. Erosive rainfall events are not predictable but in the South West they are most likely to occur in the early winter months.

Land with a very high erosion risk is best excluded from cropping. Very steep slopes present a very high risk of soil erosion during or after vegetable and potato cropping. Other examples where soil erosion or nutrient pollution risks are high are permanently waterlogged and frequently flooded areas.

Land that has a significant erosion risk may be safely cultivated only if adequate surface water control earthworks are always in place. The following guidelines apply to vegetable and potato operations:

**❑ Slopes over 15% gradient should not be cropped, as the risk of erosion when the soil is cultivated is too high.**

Such land may be suitable for pasture or perennial crops such as orchards, vines or trees.

## Example

A potato grower in the lower South West hills had a large centre-pivot irrigation site, which was eroding after planting and after harvesting. The erosion was worst on natural flow lines, access tracks and in the irrigator wheel ruts. Grade furrows installed hastily one year in an attempt to remedy the problem burst in some places, causing worse erosion. The grower realised that the main problem was that the surface water control earthworks had not been planned and surveyed properly and decided that year to start developing a surface water control plan for the whole farm. The next year's cropping sites were well planned and the following earthworks were surveyed in and constructed:

- Permanent grade banks above all sites
- Permanent grade banks across some sites with an access track constructed alongside
- Several grassed waterways running down the slope in natural flow lines.
- Short temporary grade furrows into the grassed waterway and onto pasture alongside the cropped area

There was plenty of time to establish grass on the waterways and diversion banks before cropping commenced and the grower made sure that the machinery operators did not cultivate over the grassed waterways. The results were that none of the earthworks failed and erosion was reduced by over 80 %. The access tracks did not erode and the crop yielded more evenly.

- ❑ Slopes of 10 - 15% gradient are highly susceptible to erosion. They should only be cultivated with strict adherence to best soil management practices, including adequate protection by surface water control earthworks at all times.
- ❑ **Cultivated slopes greater than 5% gradient and more than 50 metres in length will require careful soil management and some protection by surface water control earthworks.**

The degree of protection required depends on gradient and length of the slope, soil type, risk of intense rainfall and cultivation methods used.

- ❑ **Land at risk of waterlogging during cropping or post-harvest cover crop establishment should not be cropped.**

### Erosion prevention by surface water control

Appropriate surface water control earthworks are essential to minimise erosion on cultivated slopes where surface run-off is known to occur, in particular the high rainfall (>700 mm) hills areas. In addition to hundreds of tonnes of topsoil loss, thousands of dollars in crop yield reduction per hectare have been commonplace on unprotected sites.

Surface water control works are not expensive and, like insurance, are means of managing risk. Although they may not be needed every year, they must be in place to prevent soil erosion and crop damage when unforeseen severe rainfall events occur. The design and degree of protection required depends on soil and site characteristics and the probability of erosive rainfall events occurring during cropping and post-harvest crop establishment.

- ❑ **When growing on hill slopes, plan a surface water control strategy at least one year prior to cropping a paddock.**
- ❑ **Install surface water control works adequate to protect the site from erosion.**
  - **Always have a cut-off diversion bank at the top of the cropped area to prevent run-off from up-slope from running onto the cultivated area.**
  - **Cultivating across the slope on a gradient of 2-3% is recommended for slopes of up to 7% gradient. If this is done, grade furrows will not be necessary.**



*Slope of about 10% grade, planted with cauliflowers and well-protected by temporary grade furrows leading into a grassed waterway (centre).*



*Permanent grade banks – planned, surveyed and shown being constructed by a road grader.*

- **On slopes longer than 70 m and more than 5% gradient, install either temporary grade furrows or permanent grade banks across the slope to divert any run-off from the cultivated soil into stable waterways or onto pasture.**
- As a 'rule of thumb', the grade furrows or diversion banks should be at spacings of no more than 50 m, depending on slope and soil type. They should be surveyed on the correct gradient, properly constructed and maintained (BEMP Manual Section 2.1).

❑ **Be prepared to liaise with neighbours where surface water run-off to or from adjoining properties may impact on them.**

Situations where best surface water control practice is crucial in the South West are:

- After harvest of root crops, particularly if this is in autumn or winter.
- After cultivation and planting in winter.
- After planting or sowing of any crops on steep or long slopes.
- Where finely tilled soil is left bare, such as after soil fumigation.

Full details of permanent and temporary soil conservation earthworks are detailed in Section 2.1 of the BEMP Manual.

## Cover crops

- ❑ **Establishing a cover crop immediately after harvest is of prime importance, both on the high rainfall hills land to prevent water erosion and on the sandy coastal plain to prevent wind erosion.**
- ❑ **Irrigation of bare, cultivated soil during the period between crops or while the cover crop is establishing, is the only way to stop wind erosion on some sandy sites.**

Growers should choose cover cropping strategies to address their particular risk factors and site conditions.

## Wind protection

Loss of topsoil from dry, unprotected soil due to wind erosion can be extreme during severe wind events. Protection from wind is especially important on the



*Irrigated potato crop in a wind-prone area at Myalup, well protected by windbreaks.*



*A best practice for sowing a post-harvest cover crop – broadcasting the seed and following with a narrow-tined chisel plough.*

### Examples of cover cropping strategies

1. For growers going into a pasture phase after cropping, grasses can withstand trampling better than legumes and so are able to protect the soil in higher velocity winds. The ideal is an evenly - mixed sward of clover and grasses. The minimum vegetative cover required to hold sandy soils is 50 per cent ground cover.
2. A vigorous, leafy variety of oats, such as Saia, broadcast at twice the normal rate is the preferred option for potato farmers in the high rainfall hills to rapidly establish ground cover after late harvest of potatoes in Autumn. A Manjimup potato grower broadcasts oats at twice the normal rate before harvest. If time permits, the farmer follows the harvester with a harrow, chisel plough or crumbler to level the paddock. Some farms on the Swan Coastal Plain sands are cropped continually with vegetables. Sands have little permanent structure and soil stability is provided by plant roots and adequate organic matter levels. To achieve this, 'nurse crops' of cereals are grown with root crops to provide a fine root mass and crop residues are chopped up and turned in to increase soil organic matter. Wheel ruts are ripped after each crop to break up subsoil compaction. Wheat is the preferred cereal for growing as a nurse crop with summer grown carrots during early establishment. It establishes a root system quickly and is easily sprayed off when the carrot plants grow larger.

## Examples

1. Large-scale growers of potatoes and carrots at Myalup on the Swan Coastal Plain had open sites in an area of high wind frequency and intensity, with light sandy soils. Wind erosion had been a problem. They planned and successfully implemented a wind erosion prevention strategy consisting of planting windbreaks 20 tree heights (300 metres ) apart along laneways, planting a nurse crop of wheat with the summer carrot crop and irrigating cover crops of oats immediately after harvest to ensure good ground cover.
2. A Donnybrook farmer grows winter potatoes on gravelly hill slopes in an area of moderate winter wind intensity. The ground is never dry during crop establishment and the soil type forms natural gravel surface mulch. The site was considered to have a low risk of wind erosion. An oat- pasture cover crop sown immediately after harvest provided adequate wind protection.

Swan Coastal Plain with its flat terrain, sandy soils and high wind frequency and intensity.

- ❑ **Minimise the time that the soil surface is left bare and dry. Best practices include:**
  - **Leave crop residues on the soil surface as mulch.**
  - **Plant vegetable crops with a cereal ‘nurse crop’ for protection during establishment.**
  - **Plant post-harvest cover crops and irrigate to establish them on sandy soils during summer.**
- ❑ **When growing in wind prone areas, include windbreaks in the soil management strategy.**

Factors that increase the risk of wind erosion are:

- High wind frequency and intensity, such as occurs in coastal areas.
- Sandy soils with no gravel content.
- Open site terrain.
- High intensity of cropping, particularly planting or harvesting during summer.

When planning their wind protection strategy, growers need to weigh up all of these factors as they relate to their particular operation. There are many best management practices to minimise wind erosion and these together with information on wind frequency can be found in Section 2.1 of the BEMP Manual.

### All weather access

Farm access tracks can cause erosion if located and constructed improperly. Tracks running across slopes at an angle will collect and channel water running off from up-slope thus causing erosion. Unsurfaced dirt tracks also present a bare unstable surface, which is likely to erode.

- ❑ **Stabilise access tracks by the following methods, according to the situation:**



*Manjimup potato grower Bob Pessotto in a post-harvest cover crop. The oats will be cut for hay and a legume-ryegrass pasture direct drilled in the following autumn.*



*Carrot seedlings protected by a cereal ‘nurse crop’ that has been sprayed off with a selective herbicide.*



*Rocked chute under construction on an eroding sandy gully, Manjimup.*

- **Construct tracks at ground level.**
- **Locate tracks on ridge lines or directly up and down slope to minimise collection of water.**
- **Install ‘speed bumps’ to divert water off the track.**

## Rehabilitation of eroded and landslip areas

Eroded gullies need to be repaired promptly to prevent the damage worsening rapidly. Expensive stabilisation works may be necessary for eroded gullies that carry high peak flows. Peak flows for the catchment should be calculated and repair works designed accordingly.

Preventing erosion by fencing and/ or permanently vegetating streams and flow lines is much less expensive in the long term than trying to repair erosion after it has occurred.

- Establish and/or maintain perennial vegetation on waterways.**
- Treat erosion gullies as soon as possible after they start, as the damage may worsen rapidly. Options include:**
  - **Filling, grassing and constructing diversion banks up-slope.**
  - **Rocked chutes.**

Landslips occur occasionally on steep hill slopes in the high rainfall South West hills, usually associated with shallow bedrock or shear zones.

- Treat landslips early by fencing and planting with trees and shrubs to prevent worsening erosion and slippage.**

## 2.2 Maintain or improve soil physical and biological health

Horticultural growers’ main asset is their soil. Poor soil management or use of a site beyond its capability will result in a ‘downward spiral’ of soil decline. Loss of soil structure and biological activity leads to accelerating soil erosion and loss of the topsoil, which results in reduced soil organic matter content, which in turn leads to further soil structure decline and so on. In extreme cases of prolonged poor soil management, the productive capacity of the soil may be permanently lost.

### Understanding soil quality and health

Gaining an understanding of how the soil works is the first step a grower needs to take to improve soil quality and health. Traditionally farmers have focused on one aspect of the chemical health of their soils, their nutrient status, and managed this by adding fertiliser. This alone is not sufficient to maintain soil in a healthy state. Physical state or soil structure, biological health and chemical status determine the quality and health of a soil. These interact to determine soil fertility and ultimately, sustainability of production.

**The physical properties** of a soil include texture, structure, hardness, infiltration rate, stability and wettability. The physical status of a soil is influenced by inherent qualities, such as particle size distribution, texture, chemical characteristics such as exchangeable sodium percentage and organic carbon content. It is also greatly affected by the way the soil is managed, for example:

#### Example

A small ephemeral stream on a horticultural property in the Manjimup area was cleared. Poorly planned infrastructure facilities in the catchment above made the problem worse by greatly increasing surface water run-off. Repairing the eroded gully by constructing a rocked chute cost \$15,000 (in the order of \$60,000 per kilometre). It would have cost about \$2000 to fence and revegetate the same stream to prevent erosion.

**Example**

In vegetable row cropping of hilly areas, erosion is most likely to occur in wheel ruts. By using a wide boom spray, and carefully laying out the cropping bays, a grower at Manjimup has confined spraying traffic to the access ways plus one wheel track in the middle of 50 m wide cropping bays.

- Method and frequency of cultivation.
- Treatment of crop residues.
- Crop and pasture rotation strategy.

**The biological health of a soil** is important because it affects both the physical health and chemical status of the soil. Organic matter in the soil retains nutrients and moisture. Soil biological activity is the action of soil organisms, from microscopic fungi and bacteria to mites, worms and soil insects, in consuming and breaking down organic matter in the soil. This releases nutrients slowly, helps plant roots to take up nutrients, improves soil structure and provides pathways to aerate the soil and allow infiltration of water deeper into the root zone.

**Excessive cultivation** is the main cause of declining soil biological health. It accelerates oxidation of organic matter, destroys the natural organic topsoil layer, destroys soil structure and accelerates erosion. Soil biological health is improved by adding organic matter and minimising cultivation. The organic carbon test is one indicator of biological health but the abundance of soil organisms is the only true measure.

**The chemical status** of a soil is essentially the chemical factors that affect plant growth. It is complex to determine in full, but there is a standard set of tests that soil laboratories conduct for all soil samples. These tests indicate the availability of major plant nutrients in the soil, its acidity (pH) and salinity (EC). For certain soil types and situations soil consultants may recommend additional laboratory tests such as phosphorus retention (PRI test), soluble aluminium, trace elements and heavy metals. Maintaining soil chemical health without causing nutrient pollution of the surrounding environment is covered in Section 3 Fertiliser Management.

### Field tests for soil health

Growers can gain an understanding of their soil types and identify soil structure problems by doing simple field tests. A set of tests for infiltration rate, soil compaction (penetrometer resistance), water repellency, erosion, slaking and dispersion, root depth, presence of large soil organisms, texture and gravel content can be done by the grower in less than one hour per site. (Section 2.2 BEMP Manual). The penetrometer resistance test is the quickest and easiest. It is a most useful indicator of soil health and can be conducted over the whole paddock with a simple instrument at the same time as soil sampling.

- Monitor and record soil health and change or modify soil management accordingly.**

### Minimising soil compaction

**Reduce soil compaction and machinery operating costs by:**

- **Keeping tyre pressures as low as possible.**
- **Controlling traffic during all cropping operations.**
- **Making a single pass with a narrow-tined implement in the wheel ruts after planting.**
- **Keeping machinery and stock off wet soil.**

## Minimising cultivation

Frequent or fine tillage destroys soil structure by breaking up the natural crumb structure of soil aggregates, destroying root pathways and causing soil compaction.

Although horticultural cropping, particularly for potatoes and other root vegetables, requires relatively intensive cultivation, traditional methods often involved far more cultivation than was necessary. Trials at Manjimup and in New South Wales have shown that potatoes can be grown with four cultivations including planting without any reduction and sometimes with increases in yield and quality (Rose, 1997).

### □ Minimise tillage to maintain soil structure:

- **Keep cultivation and soil disturbance to the minimum required to grow the crop successfully.**
- **Where possible use narrow-tined implements. Avoid deep ploughing and rotary hoeing.**
- **Use slow rotation and travel speeds rather than fast speeds.**

## Cropping rotations

Crop rotation strategies appropriate to the soil type and cropping operation are crucial to sustainable soil management. Pasture grasses such as rye grass and some cereals such as oats have dense, fibrous root systems, which exude substances that 'glue' soil particles together. Soil structure is thus significantly restored when there are at least two years in rye-grass/ legume pasture or cereal crops grown under minimum or no tillage between vegetable crops.

### □ Adopt cropping rotations that restore structure and organic matter to the soil.

## Increasing soil organic matter

Adequate organic matter in the soil is essential to improve the water holding, structural, pH and nutrient availability qualities of the soil. Soil organic carbon is generally in the range of one to four percent in the topsoil. Excessive cultivation and erosion will reduce soil organic matter levels rapidly. However, it can be slowly built up by good practices. More than ten green mulched oat crops are required to raise the soil organic carbon by one percent.



*Use of rotary hoes is poor management practice because fast rotation speed pulverises the topsoil and the broad blades smear and seal the subsoil.*



*Deep ripper, hiller and basin tillage implement mounted on the same toolbar – a best practice for post-plant cultivation of potatoes.*

### Examples

1. A 'dammer dyker' basin tillage implement can be mounted on the same 3-point linkage tool frame behind hillers and rippers. After planting potatoes or cauliflowers, three 'soil friendly' operations can be achieved with one pass of the tractor. The rippers break compaction pans under the wheel ruts and small ponds made by the basin tillage reduce runoff. The result is improved infiltration of water along the wheel ruts and a saving in machinery operation cost and time.
2. Loamy soils on hill slopes in the Manjimup district are susceptible to soil structure decline, compaction and water erosion. They need to have a pasture phase to maintain soil quality. A common crop rotation in this district is cauliflowers and potatoes in the same year, followed by oats and two to four years of pasture.

## Example

Yield increases were indicated in trials and demonstrations applying 25 tonnes per hectare of compost prior to planting potatoes in the Manjimup district.

## Example

Research carried out by Agriculture Western Australia looked at the application of 100 tonnes per hectare of subsoil with a 30% clay content, mixed into the top 100 mm of soil. This amendment is continuing to produce positive results in grain yield even 8 years after the first application. Yields of barley from clay treated trials are averaging 1.2 tonne per hectare extra barley each year for the last 8 years compared to no clay treatment. Lupin yield increase was 0.7 tonne.

❑ **Maintain or increase soil organic matter by:**

- **Green mulching**
- **Mulching and lightly incorporating crop residues**
- **Applying compost**

### Claying of light sands

Grey and white sandy soils are often water repellent, are prone to leaching of nutrients and have poor moisture retention. This is mainly due to their having very low to zero clay content. Claying (spreading and incorporating clay) increases infiltration by overcoming water repellency and improves moisture retention on sands. An amount of 200 tonnes per hectare of a subsoil with a 30% clay content, mixed into the top 150 mm is recommended, bringing the clay content of the topsoil to over 3%.

❑ **The quality of sandy soils can be improved by adding soil amendments such as clay.**

### Site specific soil management strategies

Sustainable soil management is best described by its outcome, which is a soil that is maintained indefinitely in a healthy, stable state with no damage to the surrounding environment. In general as a soil is cropped more frequently more organic matter and nutrients must be replaced and more skilled, exact management of cultivation, irrigation and fertilisers is required. Even with the best management, every soil type has limits to how intensively it can be cropped. It is the responsibility of growers to ensure that their soil management is sustainable.

❑ **Select best soil management practices according to the soil type, the environmental risks presented by the location and the kind of cropping operation. Integrate these in a strategy for sustainable soil management.**

Some vegetable and potato growing operations on the deep sands of the Swan Coastal Plain near the Perth metropolitan area are cropped continuously with two crops per year. The major environmental risks are nitrogen and chemicals leaching into potable groundwater aquifers and wind erosion. An appropriate soil management strategy should include:

- Fertilising 'little and often' for example, fertigation through trickle irrigation.
- Mulching crop residues on the surface.
- Post-harvest cover crops.



*An aerating machine manufacturing compost in windrows. Amazon Soils, Wanneroo.*

- Windbreaks.
- Nurse crops.
- Irrigation system designed for frequent, accurate watering, with scheduling, automated timing and wind resistant sprinklers.

It may also include using plastic surface mulches and soil amendments such as compost or clay.

On loamy hill slopes in the Manjimup Shire, a potato and a brassica crop are often grown in one year followed by a pasture phase. Here the main environmental risks are water erosion and pollution, siltation and destabilisation of streams and gully dams. The soil management strategy should include:

- Cover cropping.
- Surface water control earthworks.
- Minimising tillage.
- Controlled traffic.
- A low rate sprinkler irrigation system.
- A pasture or cereal crop phase of at least three years.

At Carnarvon, two crops per year of vegetables are grown on hardsetting alluvial soils in hot conditions. The environmental risks are hard setting and/or sodic soils, periodic flooding and irrigation salinity. A soil management strategy to address these risks should include:

- Trickle irrigation under plastic sheet mulch.
- Applying gypsum to sodic soils.
- Flood control works according to the local flood management plan.
- Adding organic matter where possible.
- Deep ripping.
- Controlled traffic and raised beds.

## 2.3 Manage soil and drainage to minimise export of nutrients and chemicals

### Export of nutrients and chemicals

Export of nutrients and chemicals from the soil in cropped paddocks occurs when they are dissolved in water or attached to soil particles and transported by:

- Run-off and lateral leaching.
- Downward leaching.
- Erosion of soil by water or wind.
- Waterways and drains that are unprotected or poorly designed.

The rainfall, soil characteristics and drainage type are the main factors influencing export. It occurs mainly in periods of intense rainfall when there is flow of surface water.

#### Examples

1. A grower in the Manjimup area had steep hill slopes with 'karri loams'. The crop rotation was cauliflowers, potatoes, then three years in a pasture phase. Yields had been good but erosion problems were worsening and yield declining slightly. A compaction layer was developing under some parts of the paddock. The grower adopted the recommendations of a soil consultant, including:
  - Grow green mulch crops and incorporate the residues instead of grazing them off.
  - Deep rip only the compacted areas.
  - Cultivate less and cease using rotary hoes or mouldboard ploughs.
  - Install grade furrows to prevent erosion after planting and harvest.
 The soil monitoring program showed that erosion and compaction had been reduced.
2. At Carnarvon, vegetables are grown on raised beds under plastic mulch with trickle irrigation. The raised beds prevent compaction of the cultivated area by controlling traffic. The plastic mulch protects the soil from erosion and prevents evapo-concentration of salts on the soil surface. Some growers are improving their soil structure by using organic fertilisers made from composted manures, adding gypsum and applying green mulch compost made from municipal garden wastes.

## Examples

1. Farmers in the Peel- Harvey catchment have fenced and revegetated ('streamlined') streams and open drains running through their properties. This has reduced nutrient concentrations to about 25 % of those measured in unprotected sections of the stream.
2. Valley and hillside seepage areas present soil erosion and salinity risks. These sites are best fenced to exclude stock and left vegetated or revegetated with the native 'tea-tree' and rush species, which are well adapted to waterlogged conditions.

Export of nutrients and chemicals from vegetable and potato growing operations can result in pollution of water resources, the effects of which are described in Section 5 Water Resource Management. It can be minimised by proper management of soil and drainage.

## Erosion

Erosion by water is a major, direct cause of export of nutrients and chemicals attached to eroded soil particles. Sites most prone to this fall into two categories:

1. Sites that are waterlogged in winter and have a water table within 2 m of the surface in summer, particularly those with wet grey sandy surface soils.
2. Steep slopes with high soil erosion risk.

Wind erosion also causes export of nutrients and chemicals attached to dust particles. Minimising wind erosion is crucial to prevent this, particularly on sandy open sites adjacent to wetlands.

- Application of the best practices under Section 2.1 'Minimise or virtually eliminate soil erosion' is of prime importance in minimising export of nutrients and chemicals.**

## Leaching

Leaching is the process of removal of nutrients and chemicals from the topsoil, dissolved in water running through and over the topsoil, or infiltrating downwards to the water table.

Organic matter in the soil retains water and nutrients in the plant root zone thus reducing leaching. It also helps improve soil structure, which allows water to infiltrate into the plant root zone thus reducing surface run-off. Adding clay soil amendments has a similar effect, particularly in retaining phosphorus in the soil.

- Appropriate crop rotations, mulch cropping and the use of soil amendments (Section 2.2) are also good practices for reducing leaching of nutrients and chemicals .**

## Waterlogged sites

Sites that are waterlogged for long periods have more surface water run-off, are often unstable, likely to erode and prone to export nutrients and chemicals when cultivated. As most horticultural crops will not tolerate waterlogged conditions, these sites are often not suitable for horticulture. Careful management of fertiliser (Section 3) and soil cultivation (Section 2.2) are crucial in limiting nutrient and chemical export from waterlogged sites. Proper drainage practice is also very important.

## Correct drainage practice

In some situations waterlogged flats can be effectively drained. However the high costs and risks should be weighed up against the likely productivity of the drained area before proceeding with the project. In many cases the costs of the required earthworks and the risk of export of nutrients and chemicals are too high and the sites would be unsuitable for vegetable and potato growing.

**❑ Plan carefully before proceeding with drainage:**

- **Notification of drainage that may affect downstream users is required. The local catchment group and downstream neighbours should be consulted to ensure that planned drainage is in accordance with the local water management plan.**

Wet, unprotected soils, especially sands, are unstable and at great risk of erosion.

To prevent erosion, the drainage route should be carefully surveyed and the drains made broad and shallow, with shallow, flat profiles. Deep or V shaped drains should not be constructed in wet sands unless they are to be stabilised with rock fill or concrete.

**❑ Obtain expert help with drain design and surveying to ensure that the drainage is suitable for the soils, terrain and local drainage system. For drains in waterlogged areas:**

- **The grade should generally not exceed 0.5%.**
- **Spoon or W shaped drains are most appropriate.**

**❑ Fence off and revegetate major drains.**

**❑ Run drainage water through vegetated nutrient stripping areas where practical (Section 5.3).**

Winter waterlogging also occurs on some gentle slopes with shallow duplex (sand or gravel over clay) soils. On these sites graded interceptor banks can be constructed to intercept the fresh water perched over the clay. These can reduce waterlogging for up to 50 metres down-slope. If properly constructed and fenced to exclude stock and fertilisers they can also reduce export of nutrients and chemicals.

**❑ Graded interceptor banks are a way of reducing waterlogging on slopes with duplex soils.**

Sub-surface drainage by perforated drain coil pipe or mole drainage are other options, but are not recommended for wet grey sands as these soils have a low capacity to retain nutrients and chemicals. Phosphorus and nitrogen may be leached from the soil into the drainage outflow where it may enter wetlands or waterways.

## 2.4 Manage soil acidity, sodicity, salinity and other soil chemical problems

### Soil acidity

Horticultural cropping acidifies the soil at a faster rate than other agricultural activities because it removes more plant products and requires more fertiliser. Plant material is generally alkaline. When it is removed the soil becomes more acid, especially in the root zone at 5 - 20 cm depth. Significant yield reductions will occur for nearly all crops and pastures when the pH (in CaCl<sub>2</sub>) falls below 4.5.

Managing soil acidity is an important activity for all horticultural growers. It is most crucial in acid sandy soils and soil types where acidity increases at depth.

**❑ Include pH and lime requirements in the soil test and nutrient management strategy before each vegetable crop.**

#### Example

Carnarvon, at the mouth of the Gascoyne River, is an important horticultural area for subtropical and tropical crops. This irrigation area is prone to floods resulting in severe loss of soil and production and damage to infrastructure. Soil erosion alone is estimated to cost about \$ 4 million every 15-20 years during river flood events. A Soil and Land Conservation Action Plan for Carnarvon Irrigation Precinct is proposed as part of the Lower Gascoyne Management Strategy (which incorporates other flood plain management initiatives). The action plan will achieve the adoption of contemporary soil conservation and resource management practices, to reduce the impact of floods by catchment and flood plain planning, grower education and training and demonstration projects.

#### Example

In pasture trials on the Scott Coastal Plain, addition of 2 tonnes per hectare of lime increased dry matter production by over 20% on wet grey sandy soils.

- ❑ **Regular and substantial lime applications will be necessary to maintain productivity of sandy soils.**

Some fertilisers such as ammonium sulphate, ammonium nitrate, di-ammonium phosphate, elemental sulphur and to a lesser extent urea generate acidity in the soil. Most acidifying are the ammonium fertilisers, which release H<sup>+</sup> ions when ammonium is converted to nitrate in the soil. Acidification is made worse if the fertiliser is leached below the root zone and not used by the plant (Moore, G, 1998).

- ❑ **On acid soils, use non- acidifying fertilisers, such as ammonia-free nitrogen sources and gypsum, in preference to acidifying fertilisers.**
- ❑ **Mulch cropping and application of compost are good practices for acid sands because they increase the organic matter content of the topsoil, which buffers and increases soil pH.**

### **Soil salinity**

In Western Australia many soil profiles contain significant amounts of salt, which was originally brought in from the sea via rainfall and prevailing winds. In the lower South West coastal areas where rainfall is more than 800 mm there is generally from 20 – 500 tonnes of salt per hectare stored in the soil profile, depending on the position in the landscape and profile depth (Moore 1998).

Secondary salinity is developing in some Western Australia landscapes as a result of land clearing. The replacement of perennial native species with annual pastures or crops has brought about rising saline water tables that bring salt to the surface, causing some areas which were non-saline to become saline. The process of secondary salinisation is still occurring and more land will become salt affected before a new hydrological equilibrium between recharge and discharge is reached (Moore, 1998).

Horticultural crops are generally salt sensitive and small increases in soil salinity will have significant effects on crop yields.

- **Request that ECe (conductivity) test be done for all samples tested at soils laboratories.**

Soil conductivity readings in soil test records provide a good indicator as to whether the soil is becoming more saline.

Salt affected plants usually appear normal although they are stunted and may have darker green leaves. Details of irrigation water salinity tolerance of various horticultural crops can be found in the BEMP Manual Section 4.3.

### **Identifying and managing saline land**

Expert help may be required to map saline land, locate saline seeps and identify where the saline water table is recharged. Techniques for measuring soil salinity such as using an EM38<sup>TM</sup> electromagnetic inductance instrument, are outlined in Section 2.4 of the BEMP Manual. Saline land is generally not suitable for horticulture.

- ❑ **Identify land with saline subsoils and map it in the farm plan.**
- ❑ **Recommended practices for treating saline land are:**
  - **Plant salt and/or waterlogging tolerant native vegetation on land where saline groundwater is within 2 m of the surface. This will reduce capillary rise and concentration of salts on the soil surface.**
  - **Plant high water use vegetation in recharge areas above saline seeps on the farm. Commercial tree lots are ideal.**
  - **In some cases such as the irrigation area near Harvey, sub-surface drainage can help prevent the salinisation of land with saline subsoils.**

### **Irrigation salinity**

Irrigation salinity, is the salinisation of land that is artificially irrigated. In Western Australia, most horticulture is conducted on sites with deep, well-drained soils such as the deep karri loams and jarrah duplex loams of the South West hills and yellow sands of the Swan Coastal Plain. There is little risk of irrigation salinity developing on these soils as any salts will generally remain deep in the soil profile or be flushed out of the surface soils by the high rainfall. However, it can and does occur on some sites.

The major cause of irrigation salinity is when water containing high concentrations of salts is used and irrigation is not managed properly

- ❑ **Avoid irrigating with water containing high salt concentrations and where this cannot be avoided manage irrigation carefully** (Section 4.3).

There are other site factors and practices that significantly increase the risk of irrigation salinity developing:

- Poorly drained soils.
- Subsoils with high salt content.
- Saline water table less than 2 m from the surface.
- Clay or fine textured topsoils, which are slower to drain.
- Flood irrigation on poorly draining soils.
- Irrigation during hot weather, which will increase the rate of concentration of salts due to evaporation on the soil surface.
- Cropping on or near seepage areas.

At the ‘critical depth’ of around 1.8 m, saline water can reach the surface by capillary rise in medium textured or clay soils, in sufficient quantities to decrease wheat yields (Moore, 1998).

- ❑ **Be aware of conditions and practices that increase the risk of irrigation salinity and avoid them.**

Another practice that can contribute to the salinisation of cropped land is the use of fertilisers containing chloride such as muriate of potash (potassium chloride). These can increase soil salinity by increasing the soil chloride ion concentration. Too much chloride is toxic to plants and will reduce crop yields.

- Avoid using muriate of potash (calcium chloride) as a potassium fertiliser. Use other sources such as potassium sulphate which do not increase soil salinity.**

### **Aluminium toxicity**

Aluminium toxicity is caused by high levels of free or soluble aluminium (the Al<sup>3+</sup> ion) in the soil. The symptoms are stunted root systems, poor plant growth and drought stress. The condition is common in some acid, gravelly soil types.

- If aluminium toxicity is suspected, ask the laboratory to test for soluble aluminium.**
- The treatment for aluminium toxicity is the same as for soil acidity, that is applying lime to raise the soil pH.**

### **Heavy metals**

Cadmium is a heavy metal contaminant of some fertilisers and can affect potatoes (Section 3.1 Cadmium in Phosphorus Fertilisers). Cadmium can be taken up by plant roots. It is most readily available in sandy or saline soil or where saline irrigation water is being used, and these are site risk factors for cadmium.

The only situations where other heavy metals may become a problem is when soil amendments with high heavy metal content, such as some sewage sludges, are applied.

- Where there is risk of heavy metal contamination, test the metal concentrations in fertilisers, soil amendments, soil and tubers**

### **Soil sodicity**

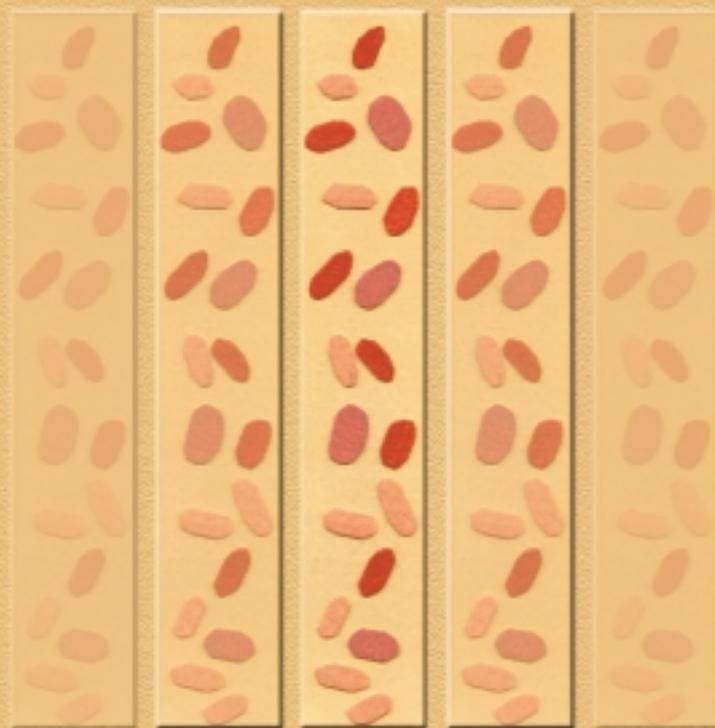
Soil sodicity is generally not a problem in the soils of the South West horticultural areas but does occur on the tropical flood plain horticultural areas such as Carnarvon. Indicators of sodic soils are:

- Dispersing of clay in the soil, indicated by 'cloudy' or coffee coloured puddles when the topsoil is saturated.
- Poor soil structure indicated by clods remaining after cultivation.

For Australian soils there is a high correlation between sodicity and alkalinity. Soils of pH greater than 8 are generally sodic and sodicity increases with alkalinity (Moore, 1998). A simple field test can be conducted, which indicates sodicity by the 'cloudiness' of a soil- water solution. This is cheaper and simpler than laboratory methods.

- Test clay or alkaline soils for sodicity.**
- Sodic soils can be treated by applying gypsum to reduce the sodicity of the surface soil, adding organic matter and carefully applying best practices to maintain and improve soil structure.**
- Crops that are more tolerant of alkaline, saline soils should be grown.**

# SECTION 3



**Fertiliser Management**

# Fertiliser Management

## Expected environmental outcomes:

- *Minimal run-off and leaching of nutrients and chemicals from vegetable and potato production.*
- *Vegetable and potato cropping activities not causing an increase in nutrient concentrations in groundwaters and surface waters.*

Modern cultivated horticulture maximises yield and quality through ‘high input-high output’ growing systems, which make heavy demands on the soil resource. Growers must use fertilisers to supply adequate nutrients to grow commercial crops. Fertilisers are chemical or organic products containing nutrients that promote plant growth.

Fertiliser management is both an art and a science. The grower needs to supply the right types of fertilisers in the right quantities at the right times to supply the crop’s nutrient requirements. However, if too much nitrogen or phosphorus is applied, it may be leached or washed out of the topsoil. These nutrients are common causes of algal blooms and pollution (eutrophication) of water resources.

Poor management of nitrogen fertilisers is also a significant contributor to the pollution of the atmosphere by nitrous oxides, which are powerful greenhouse gases that contribute to global warming.

It is crucial for growers to conduct best environmental practices in fertiliser management to minimise these serious environmental impacts.

To achieve sustainable fertiliser management when growing vegetables and potatoes, all reasonable and practicable measures should be adopted to apply the following three principles:

### 3.1 Optimise application of nutrients to plant and soil requirements.

### 3.2 Minimise loss of fertiliser into the environment.

### 3.3 Minimise leaching of nutrients.

## 3.1 Optimise application of nutrients to plant and soil requirements

Modern ‘high input-high output’ horticulture requires that an adequate amount of each nutrient is applied for crop production and soil requirements. Traditionally some growers and fertiliser consultants have tended to recommend higher fertiliser application rates than are required for optimal yields. One reason for this has probably been that the fertiliser companies who have a vested interest in selling more fertiliser have employed the consultants making the recommendations! Another reason is that many growers have not understood the nutrient requirements for optimal production of the various crops.

As fertiliser has been considered to be a relatively small part of total input costs, some growers have tended to adopt the attitude ‘if in doubt apply more’. This is no longer acceptable as agricultural fertilisers are major pollutants of water resources. The adverse effects of elevated levels of nitrates, phosphorus and ammonia on water quality and aquatic life are described in Section 5.1.



## Soil sampling and testing

Nutrient application rates need to be matched as closely as possible to crop requirements. This can only be achieved by conducting a regular soil sampling and testing program.

**❑ Sample and test each soil type or land management unit in each paddock at least every three years or prior to each vegetable crop.**

Correct soil sampling technique is crucial to obtaining a true representation of the nutrient status in the root zone (BEMP Manual Section 3.1).

Western Australian laboratories such as CSBP™, Chemistry Centre™ and Analabs™ use standard soil tests and it is recommended that these be used. Laboratories in other States or countries are not recommended as they may use different chemical analyses, which give different readings.

The standard set of tests for the major soil nutrients, which is available at most soil laboratories, should be conducted for all soil samples. The phosphorus retention (PRI) test should also be conducted on all grey and white sand samples and trace element tests done periodically.

## Calculating fertiliser application rates

The amount of each nutrient that needs to be applied depends greatly on the amount of available nutrient already in the soil as shown by the soil test. Crop production response curves for nutrients ‘flatten out’ after a threshold rate of fertiliser application is reached for a particular soil type. For example, doubling the amount of a nutrient applied may result in only a five percent increase in production. The threshold rates of nutrients are all that are required for optimum production. These rates depend on soil type, soil nutrient level, crop type and yield.

Accurate calculation of soil nutrient requirements and the correct types and application rates of fertilisers to provide the required nutrients are complex. Soil consultants have the necessary tables to calculate fertiliser application rates. These include:

- Crop replacement requirements for various crops.
- The effect of soil factors such as texture and clay content on the availability and leaching of nutrients.
- Nutrient content of various fertilisers.

Other factors such as soil texture, reactive iron content and pH will also influence the soil nutrient requirements.



*Different fertiliser strategies are used for the potato crops on the grey sand soil type on the right and the karri loam (left).*

- Engage an experienced, independent soil nutrient consultant to analyse soil test results and prescribe fertiliser application rates.

Tables of nutrient application rates for some crops on some soil types with different soil test levels are given in Section 3.1 of the BEMP Manual. These should only be used as a guide and are only an indication of the requirements for some soil types.

### Phosphorus management

Application of excessive amounts of phosphorus fertiliser has been the cause of significant damage to aquatic environments (Section 5.1). From an environmental perspective, it is most important to avoid applying excessive phosphorus fertiliser on all soil types. Sandy soils pose a high risk of phosphorus leaching (Section 3.3). Heavier soil types (with PRI > 20) have a high capacity to bind excess phosphorus and leaching is unlikely. However, phosphorus can still be exported from these soils bound to fine clay and organic matter fractions, which are eroded and transported in surface water run-off. Phosphorus can be released into water bodies from sediments in warm anaerobic conditions, which prevail during summer.

- ❑ **On all soil types, apply phosphorus according to soil phosphorus test levels. (refer to Section 3.3 of the BEMP Manual for details of phosphorus management on sands and loams).**

Many cropping soils have built up high levels of soil phosphorus, due to many years of application of superphosphate fertilisers. These soils often do not need high applications of phosphorus. The required application rate can only be determined by soil testing.

### Choosing the right fertilisers

It is important to order the right types of fertilisers mixed in the right proportions for the soil conditions and crop requirements. Standard blended products such as Potato E™, NPK Blue™ and Superphos™ contain two or more nutrients mixed in a certain proportion. They are usually granulated, which has the advantage that nutrients are distributed more evenly. However, using standard blended products alone is often not the best practice because in order to apply enough of one nutrient there will be too much of another.

- ❑ **Order custom blended fertilisers mixed in the proportions recommended by the soil test analysis, in preference to using only standard blended products.**

Alternatively the nutrients can be applied in the correct proportions in separate fertiliser applications, whichever is most convenient for the grower. The fertilisers



*Excessive application of phosphorus and nitrogen fertiliser is a major cause of algal blooms and excessive weed growth in wetlands and waterways.*



applied may include some standard blend products, but the main thing is that the right balance of nutrients is applied according to the soil test.

Fertigation enables soluble nutrients to be applied in balanced amounts. However, some soluble fertilisers react together and should not be mixed in the fertigation tank (BEMP Manual 3.1).

Slow release phosphorus and sulphur fertilisers are available at little extra cost and are worth considering for light sands (Section 3.3).

### **Cadmium in phosphorus fertilisers**

Cadmium levels in potatoes may reach problem levels if fertilisers high in cadmium have been used over a long period, increasing the cadmium content of the soil. The quality assurance program for the potato industry (SQF 2000) sets the limit on Cd in phosphorus fertilisers at 150 mg Cd per kg of phosphorus. Most fertiliser companies are aware of the problem and have products with < 100 mg Cd/ kg P.

Every year Western Potatoes (Potato Marketing Corporation of Western Australia) take a random sample of all ware potato growers' product and submit it to Chemistry Centre (WA) for cadmium testing. The purpose of the test is to verify that cadmium levels in ware potatoes are below the ANZFA maximum permitted concentration of 0.1 mg/kg and to identify properties where high soil cadmium levels may need to be managed. Cadmium levels in potatoes are also monitored nationally by ANZFA as part of the annual Australian Total Diet Survey.

- Potato growers should always select phosphorus fertilisers with less than 100 mg of Cd per kg of phosphorus and be aware of sites with cadmium risk factors** (Section 2.4 Heavy Metals).

### **Trace elements**

Most soils in Western Australia are ancient and highly weathered. When newly cleared, they are often acutely deficient in the major nutrients, phosphorus, nitrogen and some trace elements, for example copper, zinc and sometimes molybdenum and manganese. Profitable crop production has only been achieved by applying fertilisers.

- Include trace elements in the soil tests periodically.**

Trace elements can be applied to the soil or as foliar spray, according to soil consultants' recommendations (Moore, 1998).

## **3.2 Minimise loss of fertiliser into the environment**

Much nutrient pollution has resulted from poor fertiliser handling, inadequate storage facilities and poor application practices. These contribute significantly to fertilisers entering the surrounding environment directly and also result in costly wastage.

### **Storage and handling of fertilisers**

In the past, some growers have dumped fertiliser on the ground and transferred it into spreading equipment with a front-end loader. This practice is no longer acceptable for any fertiliser, even on heavy soil types. A few centimetres of fertiliser



mixed with soil are left over an area of about 10 by 10 metres amounts to over 100 kg of concentrated fertiliser left on or near the soil surface. There is a high risk of this residual fertiliser causing nutrient pollution as it can easily be washed directly into drains and streams either in solution or attached to soil particles or leached downwards into groundwater aquifers.

- ❑ **Store fertilisers in covered field bins or sheds that keep the product dry and prevent contact with the ground.**

A closed shed with concrete floor underlain with a waterproof plastic membrane is sufficient. Covered metal field storage bins on legs of the type hired out by fertiliser companies are also adequate, as are truck mounted bins with augers or conveyor belts to transfer the product.

### **Accurate application of fertilisers**

Excess fertiliser applied or deposited in the wrong place, at the wrong time or in the wrong form can be easily leached or washed into streams and water bodies. In order to minimise loss of fertiliser into the environment, the aim is to ensure that as much of the applied fertiliser as possible is taken up by the crop. Most vegetable crops are fast growing and do not have extensive root systems.

To ensure that the crop uses fertiliser efficiently, application must be accurate in terms of rate and placement. This is particularly important on sandy sites where leaching is a problem and hilly sites where run-off may occur.

- ❑ **Banding or dropping and incorporating fertiliser close to the plants using an accurately calibrated fertilising or planting implement are the best practices for pre-plant fertiliser application on most soils except light sands.**

### **Fertigation**

- ❑ **Fertigation is a recommended means of post-planting fertiliser application if conducted according to best practice.**

Fertigation is the application of soluble fertilisers through the irrigation system. Nitrate, potassium, some types of phosphate fertilisers and most trace elements are available commercially in soluble forms suitable for fertigation. Fertigation equipment is available for most types of irrigation systems. However, it must be carefully managed and done with suitable equipment or it too can result in nutrient loss (Section 4.1 for details on fertigation).

- ❑ **Application of soluble fertilisers by boomsprayer is the best and the most accurate practice in windy areas where sprinkler distribution uniformity is often poor.**

### **Broadcasting**

Broadcasting is the spreading of granulated fertilisers over the whole soil or pasture surface. Broadcasting with 'multi-spreader' type machines is an inaccurate way of applying fertiliser and for this reason should be avoided where possible during vegetable and potato cropping. However, broadcasting of fertiliser on pasture (termed topdressing) is necessary during pasture phases.



Topdressing needs to be conducted with caution because the fertiliser is at risk of being washed away in surface run-off or wasted due to inaccurate placement. Fertiliser spread onto dry ground early in the season before germination is easily blown away or washed off during heavy rains, particularly if the soils are at all water repellent.

- Avoid broadcasting fertiliser on vegetable or potato crops where possible. If broadcasting must be conducted ensure that an accurate calibrated implement is used and that fertiliser is not broadcast outside the cropped area.**
- Do not topdress pasture land when it is dry and bare.**
- When topdressing pastures or crops, the best time is after germination when the topsoil is moist.**

Spreading fertiliser directly into streams or drains is an obvious cause of nutrient pollution but nevertheless it still occurs.

- Fence off a vegetated strip along each side of waterways to ensure fertiliser is not spread in or near them when broadcasting.**

Applying fertilisers onto wet paddocks with water pooled on the surface greatly increases the likelihood of fertiliser being washed away in solution in surface run-off.

- Avoid applying fertilisers to wet paddocks.**

### **Erosion of soil fertility**

Soil erosion is a major cause of declining soil fertility because the fine clay and organic matter components of the topsoil, which contains most of the soil nutrients, are the first to be lost during erosion events. The essential functions of the clay and organic matter components of soil are:

- Capacity to take up, retain and slowly release nutrients.
- Capacity to hold water.

The fertility of soil is greatly diminished when these functions are lost. Topsoil loss caused by erosion can take decades or even centuries of good management to replace.

Fertiliser lost due to erosion is also a waste of money and this is another incentive for farmers to prevent soil erosion. However, loss of soil fertility is a long-term, intangible cost of erosion and is far greater than the immediate cost of fertiliser lost.

- Applying best practices to minimise soil erosion (Section 2) is essential to prevent loss of nutrients from the topsoil.**

### **3.3 Minimise leaching of nutrients**

Minimising leaching is a major principle of nutrient management for environmental and economic reasons:

- Leaching is a major contributor to export of nutrients and chemicals, resulting in pollution of groundwater and surface water bodies.

- Leaching results in costly wastage of fertiliser.
- Crop nutrient deficiency can occur when one or more essential nutrients are leached from the root zone during growth.

Leaching is most severe in sandy soils because these contain very little clay and iron, which normally bind nutrients. In white or grey sands, nutrients tend to remain in solution and mobile in the soil.

- Nitrogen is the most mobile nutrient and can leach through all soil types.
- Sulphur and to a lesser extent potassium leach rapidly through wet sands.
- Phosphorus also leaches rapidly from grey and white sands.

### **Minimising leaching of nitrogen**

Nitrogen is the most mobile nutrient in the soil and the one most likely to cause damage if it leaches into water tables or is carried by surface run-off into water bodies. Heavy application of nitrogen fertiliser at planting is poor practice for environmental and agronomic reasons. Excess nitrate cannot be taken up by plant roots and is leached rapidly down the soil profile, eventually reaching the groundwater table.

- ❑ **Apply no more nitrogen fertiliser than the crop needs for good growth. Refer to Department of Agriculture fertiliser recommendations for different crops.**

Too much nitrogen early in the growth of potatoes increases vegetative growth but can significantly reduce yield and quality. A light application banded at planting, with several small applications during crop growth, will minimise leaching and give optimal yield and quality.

Vegetable and potato crops grown on light sands require frequent application of small amounts of nitrogen and to a lesser extent phosphorus as often as every 10 to 14 days.

- ❑ **Apply nitrogen fertiliser in small, regular doses throughout the life of the crop. This is especially important on sandy soils.**
- ❑ **Match nitrogen application rates with crop growth stage. When plants are young, place nitrogen fertiliser with droppers immediately adjacent to plants.**

Plant tissue testing is recommended as the most accurate means of determining whether and when to apply more nitrogen and other nutrients during growth of vegetable and potato crops. Plant tissue samples need to be carefully collected to prevent contamination. Accredited laboratories conduct accurate nutrient analyses cost effectively with results generally being available within a few days.

Alternatively, sap testing kits provide a quick method to determine the nitrogen status of a crop.

- ❑ **Conduct tissue testing to determine whether the crop has sufficient nitrogen and adjust nitrogen applications.**

Most manures, particularly poultry manure, and some composts are high in nitrogen. Growers need to know the nitrogen content of these products and factor it into the total nitrogen application.



- ❑ **Do not apply high rates of poultry manure, which will increase soil nitrogen levels far beyond what the plant can use and lead to nitrogen leaching.**

Groundwater may also contain significant amounts of nitrogen leached from previous applications. Growers should test bore water to determine nitrogen content (Section 5.1).

- ❑ **Factor groundwater nitrogen into total nitrogen application.**

### **Minimising leaching of phosphorus on light sands**

Phosphorus is the main nutrient that causes algal blooms. It is bound to clay particles in most soils but is easily leached from grey or white sands and can enter waterways and wetlands via run-off and seepage.

These soils should be tested for phosphorus retention index (PRI). Sands with PRI <5 pose the highest risk of export of nutrients and chemicals and pollution of water resources, especially groundwater.

The PRI reading will greatly influence the fertiliser requirements; the lower PRI soils will require less phosphorus. Large applications of superphosphate fertilisers will result in excess soluble phosphorus in the soil that cannot be taken up by the plant roots. It will be quickly leached out of the topsoil and poses a threat to the natural biodiversity of waterways and wetlands.

- ❑ **Apply phosphorus according to soil phosphorus test levels (refer to Sections 3.1 and 3.3 of the BEMP Manual for more details).**
- ❑ **Have the PRI test conducted on light sandy soils. The PRI test result is important to determine the fertiliser strategy for these soils.**
- ❑ **Over 70% of the total nitrogen and phosphorus fertiliser should be applied post-planting, 'little and often' on light sandy soils.**

Another environmentally acceptable alternative is to use fewer applications of slow release sources of phosphorus such as reactive rock phosphate, and sulphur such as crushed rock gypsum. Organic manures are also suited to these conditions as they release nutrients more slowly than soluble fertilisers. However these should be in dried granulated forms as raw manures present fly breeding and odour hazards.

- ❑ **Consider using slow release sources of phosphorus and sulphur and dried granulated manures on light sands with low PRI.**

### **Other post-plant fertiliser applications**

Sulphur and to a lesser extent potassium are also easily leached from the soil, particularly from sands with a low phosphorus retention index (PRI). Although sulphur and potassium do not pose major threats to waterways and wetlands, they need to be managed carefully to supply crop requirements as determined by tissue testing. Extra potassium can be applied by fertigation or banding when required. Extra sulphur may be required for good production on winter-wet sands. It can be applied prior to planting in a slow release form such as crushed rock gypsum or elemental sulphur.

#### **Example**

Traditional practice to supply phosphorus and sulphur requirements for potatoes is to apply Superphos' or Potato E' in one heavy application of over 2 tonnes (about 200 units of phosphorus) per hectare. This is not appropriate for grey sands because it results in leaching of excess phosphorus into waterways and groundwater. The phosphorus requirement for potatoes on grey sands is only 100- 140 units of phosphorus per hectare, depending on the soil test level. The phosphorus is best applied 'little and often' by banding or fertigation in several light applications. Extra sulphur may also be required and should be applied in a slow release form such as crushed rock gypsum (Paulin, 2000).

## Soil amendments

Organic matter is essential to soil fertility because it retains soil nutrients and releases them slowly as it decomposes and oxidises. Practices such as minimising cultivation, turning in crop residues, planting green mulch crops and applying compost all contribute to increasing soil organic matter.

Clay and red mud are soil amendments that will improve the capacity of light sands to retain phosphorus, potassium and sulphur in the topsoil where they are released to plants over a longer period.

☐ **Increase the clay and organic matter content of grey and white sands by:**

- Turning in mulch crops
- Applying compost
- Claying

More details of these practices can be found in Section 2.2 under ‘Increasing soil organic matter’ and ‘Claying of light sands’.



*Spreading compost.*

# SECTION 4



## **Irrigation Management**



# Irrigation Management

## Expected environmental outcomes:

- *Irrigation system design and management is efficient.*
- *Efficient irrigation, resulting in minimal leaching of nutrients and chemicals and minimal wastage of water.*

The main environmental risks to consider in irrigation are:

- Run-off, resulting in erosion and export of nutrients and chemicals. The main causes of run-off during irrigation are leakages, watering for too long or watering at a rate too high for the soil to absorb the water.
- Downward leaching of nutrients and chemicals due to excessive watering.
- Spray drift resulting in export of nutrients when soluble fertilisers are applied through the irrigation.
- Wastage of surface water which contributes to depletion of stream flow for downstream users and the environment.
- Wastage of bore water, which can contribute to depletion of valuable groundwater aquifers.

A well-maintained irrigation system that is properly designed for the site and application is essential for efficient, even and accurate water delivery. This is crucial for optimum crop growth and to minimise these environmental risks.

The aim is to supply irrigation as closely as possible to crop demand and evaporation. Monitoring of weather conditions, evaporation and soil moisture content are essential in achieving this.

All reasonable and practicable measures should be adopted to apply the following three principles:

### **4.1 Use an efficient, properly maintained irrigation system.**

### **4.2 Apply irrigation in accordance with crop demand and evaporation.**

### **4.3 Manage salinity of irrigation water.**

#### **4.1 Use an efficient, properly maintained irrigation system**

Uneven watering, over-watering, leakages and spray drift occur when irrigation systems are not working efficiently due to poor design or maintenance. The direct results, such as crop yield losses, wastage of water and wastage of fuel can amount to significant economic costs. The consequences for the environment, such as erosion and export of nutrients and chemicals by leaching, run-off and spray drift can be even more serious.

A well-designed irrigation system should:

- Provide the necessary amount of water, with due consideration of vegetable, tuber or fruit growth rate, soil type and daily evaporation rate, wind effects, soil temperature and available soil moisture.



- Apply water at a rate that does not exceed the infiltration rate of the soil type when it is cultivated.
- Apply water evenly despite the effects of wind or uneven terrain.
- Include soil and air sensing devices to monitor evaporation and soil moisture, enabling irrigation to be varied according to crop and evaporation requirements.
- Enable multiple applications of water per day when establishing crops and allow for wind variations.
- Minimise evaporation and wind effects. Sprinklers should apply coarse water droplets but not so coarse as to erode or compact soil.
- Include a monitoring system that will identify malfunctions, including high and low pressure or flow protection devices that will isolate a section of the reticulation system in the event of a problem.

### Selecting the right type of system

There are many types of irrigation systems in use for horticulture. Most common in Western Australia are semi-permanent and permanent sprinkler systems. Examples of systems used and their suitability for different site and soil types are (BEMP Manual Section 4.1):

- Dripper systems are best to minimise water use and leaching on sands.
  - The more intensive operations often use permanent sprinkler systems with buried PVC reticulation.
  - Semi- permanent systems with detachable coupled aluminium pipes or poly pipe are suited to situations where there is a pasture or dryland cropping phase.
  - Centre pivot irrigators work well on sites with little slope and uniform well-drained soil types but often cause erosion problems in hilly terrain. They cover a large circular area 400 - 750 metres in diameter and the ability to vary water application within that area is limited.
  - Gun type travelling irrigators are prone to causing erosion and while they are acceptable for pasture, are not suited to many cultivated cropping situations.
  - Flood irrigation is a cheap way of irrigating pasture flats but is inefficient and presents high risks of nutrient and chemical export when used for cultivated cropping.
- Consider environmental risks when selecting the system type and design best suited to the soil, terrain and wind conditions.**

### System components

There are two main aims in designing an efficient irrigation system:

1. To deliver the right amount of water for crop requirements.
2. To deliver a uniform coverage of water.

Designing an irrigation system involves selecting the right components and integrating them in an effective layout. This is a specialised task and requires the input of a qualified consultant.



- ❑ **When selecting and designing an irrigation system, employ a ‘Certified Irrigation Designer (CID)’ accredited consultant.**
- ❑ **Ensure the system has an effective means of controlling the time and duration of water application.**

To manage irrigation properly and minimise the environmental risks, the type, design and layout of the irrigation system must be suitable for the soil and site conditions.

There are many different types of components available for each system. Components such as pipe diameters and pressure-compensating devices need to be selected to compensate for variations in pressure in hilly terrain. When selecting sprinklers or drippers, the soil, terrain and wind conditions should be considered. Growers should observe and ask about the performance of different system components on similar sites before deciding on the best ones for their operation.

- ❑ **Select the system components to best suit the site and crop conditions, with consideration of environmental risks.**

In constructing flood irrigation, special attention is required to the surveying and construction of earthworks and selection of flow control devices to ensure that erosion and over-watering do not occur.

- ❑ **The application rate of the sprinklers or emitters should not exceed the infiltration rate of the heaviest soil type in the block.**

If water runs off the surface during irrigation, then the rate of application is too high. Runoff during irrigation wastes water, exports nutrients and erodes soil.

### **Sprinkler system design and wind considerations**

A uniformity coefficient of 85 - 90% with a distribution uniformity of 80% or greater is recommended. The watering rates and operating pressures of the sprinklers selected are crucial to achieving uniform application of water. High sprinkler pressures will create misting. Low pressures will give poor distribution.

- ❑ **Restrict operating pressures to the manufacturer’s recommended range.**

Keep pump operating pressure within the system limits and always fit pressure relief valves.



*This semi-permanent sprinkler system is ideal for irrigating sandy sites but may not be suited to hilly terrain.*



*Centre pivot irrigators are cost efficient and suitable for large areas of even terrain.*



- ❑ **Do not use sprinklers of different types, precipitation rates or operating pressures within any sector of an irrigation system, unless specified by a ‘CID’ accredited design for the site.**

Pressure compensating devices should be specified on hilly land where laterals cannot be positioned on the contour.

Wind speed and direction is a major factor causing distortion in the uniformity of irrigation. Besides increasing water loss by evaporation, wind affects distorts sprinkler distribution patterns. Any sprinkler system operating under windy conditions must be designed to take in to consideration the effect of wind speed on its performance.

Choose sprinklers and nozzles and design the sprinkler layout to counteract the effect of wind velocities.

- **Sprinklers that produce coarser droplets minimise evaporation losses and are less susceptible to wind drift.**

Proper spacing of the sprinklers is of paramount importance to achieve an acceptable level of distribution uniformity under windy conditions. For example, on a site with a prevalent wind speed of 13 km/hr, a system with sprinklers spaced 16 m x 16 m would have to be run 30% longer to apply the same minimum depth of irrigation water as 14 m x 14 m spaced sprinklers. This would cause over- and under-irrigation in some spots within his paddock leading to poor quality produce and leaching of fertilisers. (Gupta *et al*, 2001; Calder, 1992).

- **For windy sites, a combination of smaller spacings and lower operating pressures is desirable.**
- **Use windbreaks to reduce wind speed.**

### Reliability of irrigation fittings

Failure of irrigation fittings is a common cause of system leakage or even ‘blow-outs’ of irrigation lines. Neither event is acceptable, as water is wasted and the resultant drop in pressure decreases the efficiency of the whole system. Even more serious is the soil erosion that is likely to result from ‘blow-outs’. Choosing the right types of fittings for the purpose can greatly improve the reliability of the system and reduce the amount of maintenance that will be required.

- ❑ **Do not use unsuitable or failure-prone fittings.**



*This plastic ‘rotator’ sprinkler type used at close spacing delivers a good combination of low application rate and acceptable performance in moderate wind conditions.*



*Latch type aluminium pipe couplings (right) are less prone to failure than the twist type (left).*

#### Examples

1. Low watering rate sprinklers such as the plastic rotator types are best for loamy soils on hill slopes where run-off occurs.
2. Knocker type sprinklers with a high delivery rate often cause unacceptable run-off and erosion on hill slopes. They may be acceptable for flat sites with deep permeable soils.

#### Examples of irrigation fittings prone to failure:

- Some types of aluminium pipe couplings can twist and uncouple accidentally. The ‘latch type’ design is far more reliable than the ‘twist type’.
- Some PVC plastic risers and joiners can become brittle and break after prolonged exposure to sunlight. Galvanised or UV stabilised polyethylene fittings are more suitable.
- Some types of flexible polyethylene stand couplings for plastic sprinklers occasionally pop out of the grommet seals. However, newer designs are less prone to leakage than most aluminium semi-permanent systems.

## Fertigation and Chemigation

Fertigation/chemigation is the injection of soluble fertilisers or agricultural chemicals into water flowing through an irrigation distribution system for application to land or crops or both. It has potential benefits, including savings on labour and fuel costs and convenience for frequent applications at low rates.

However, fertigation and chemigation must be conducted according to best practice to minimise risks of nutrient and chemical pollution by spillage, leaching and spray drift. Best practice fertigation and chemigation aims to ensure the following:

- Accurate application.
  - Minimal risk of spillage.
  - Containment and clean-up in the event of spillage.
  - Back-flow of nutrients and chemicals into the water resource can not occur.
  - Minimal spray drift.
- Read the label, or clarify with the agent to ensure that a chemical is suitable for application by chemigation.**
- Ensure that the rate of chemical applied per hectare is according to label recommendations.**

Accurate fertigation/chemigation relies on an irrigation system that can apply water and fertiliser uniformly over the crop, with minimal spray drift. Non-uniform application of plant nutrients results in uneven crop growth. In over-watered areas, fertiliser or chemical may leach past the root zone, resulting in higher fertiliser costs and possible groundwater pollution. Spray drift can pollute surrounding natural and human environments.

- If fertigation or chemigation is to be practiced, ensure that the irrigation system has a high coefficient of uniformity and low spray drift.**

The point of injection of concentrated fertilisers and chemicals into a fertigation system is a high spill risk area

- Locate fertigation and chemigation injection equipment in a dished, waterproof spill containment trough or slab.**
- Have a spill kit at the site if chemicals are to be injected.**

Traditionally, fertilisers and chemicals were often injected into the suction pipe below the pump, near the water resource. This method presents the highest risk of pollution of the water resource and should not be used. The injection system should be located along the mainline, away from the water source.



*This suction feed chemigation system, located close to a dam and unprotected, is poor practice because it presents a water pollution hazard.*



- Do not inject fertilisers or chemicals into fertigation systems at or near dams, bores or any other water resource.**
- Suction injection systems are not acceptable, as they have a high risk of causing water resource pollution.**

It is essential that the fertigation/chemigation system has fail-safe means of preventing nutrients or chemicals from flowing back down the mainline and polluting the water resource in the event of pump failure.

- Anti-siphon devices and check valves must be fitted and operating according to the manufacturer's approved design specification, to prevent back-flow of chemicals and nutrients into the water resource.**

### System checks and maintenance

To get the best results from an irrigation system you need to check its efficiency periodically. It is important to test both old and new systems: new ones because they should be operating to design specifications; old ones because their efficiency deteriorates with use.

Regular inspections and maintenance of the irrigation system are necessary to keep the water supply, electronics and sprinklers operational and to ensure the uniform precipitation rate that the system has been designed to achieve is maintained. Excessive operating pressures may cause system failures and will decrease droplet size, increasing wind drift. Inadequate pressure will adversely affect the uniformity coefficient.

- Check and maintain the irrigation system regularly.**

Items that need to be routinely checked or measured are:

1. Pump operating pressure and the operation of all pressure relief valves.
2. Draw down of bore water supplies.
3. System pressures and pressure variation.
4. Pressures at the sprinkler.
5. Leaking pipes and sealing rings.
6. The flow and operation of each sprinkler or water distributor.
7. Depth of water applied.
8. Sprinkler system uniformity.
9. Operation of fertigation equipment.

#### 4.2 Apply irrigation in accordance with crop demand and evaporation

Applying irrigation in accordance with crop demand and evaporation is crucial for the minimisation of leaching and run-off of nutrients and chemicals. If too much water is applied, it will infiltrate below root depth, where it is wasted and increases the potential for nutrient leaching. If water is applied at a faster rate than it can infiltrate into the soil, it runs off the soil surface and is likely to cause nutrient export and soil erosion.



The aim of irrigation should be to apply only as much water as the crop requires, after taking into account evaporation losses. Watering should aim to provide water to the root mass, most of which is located in the upper 200 millimetres of soil.

### **Irrigation scheduling**

Irrigation scheduling is deciding how frequently to irrigate and how much water to apply.

Effective irrigation scheduling will:

1. Replace the water used (transpired) by a crop.
2. Minimise evaporation during application and replace that which is lost.
3. Maintain adequate soil moisture in the root zone.
4. Minimise water drainage through the soil below the root zone.
5. Minimise leaching of nutrients and chemicals.

**For effective scheduling of irrigation, it is important to monitor and record both:**

- **evaporation data; and**
- **soil moisture readings.**

By using this information, growers can become very efficient at irrigation scheduling. Both systems have weaknesses. In combination they provide useful cross checks.

### **Monitoring evaporation rate**

In general, the volume of water used by a crop reflects the moisture lost through the day by evaporation from the leaves and soil surface. This can be estimated by knowing the pan evaporation rate, which is easily measured by instruments, and the crop factor, which can be derived from water use tables for various crops. It is essential for the growers to measure the pan evaporation rate on their property in order to estimate how much water has been used by the crop since the last irrigation and how much needs to be applied to replenish the soil water store.

In the period May to August in Perth, rainfall normally exceeds evaporation. Deduct rainfall from the amount of water to be applied and on some occasions, the irrigation system may be switched off. Evaporation rate varies from 0 mm to about 10 mm per day, depending on:

- Relative humidity.
- Wind speed.
- Daily solar radiation (UV).
- Air temperature.

Average daily evaporation rates for WA vegetable growing areas are shown in Appendices 4.1 and 4.2 of the BEMP Manual.



**☐ Monitor pan evaporation rate and factor it into the daily estimation of the quantity and frequency of water application that will be required.**

Continually applying excess water to ensure that the crop does not lack water is unacceptable because:

- It greatly increases the export of nutrients and chemicals by leaching and/or surface run-off.
- Many thousands of dollars in unnecessary pumping costs may be incurred.
- Much of the water applied will be wasted.

The traditional method of estimating pan evaporation rate was to measure in millimetres the drop in water level in a flat open pan full of water. However, various electronic instruments are now available. Modern fully automated watering systems have sensors that detect both evaporation rate and soil moisture. They can be programmed to achieve close to ‘best practice’ standards for watering.

**Irrigating in hot windy conditions**

Loss by evaporation during irrigation is significant and can amount to an economic cost, particularly during hot and or windy conditions. Wind also greatly reduces the efficiency of sprinkler irrigation by distorting the sprinkler pattern.

For example, tests on a cool morning with no wind and high humidity showed water losses as low as four per cent, compared with similar tests on a hot day with no humidity and light winds, when the loss was over 40 per cent.

**☐ To minimise evaporative losses apply water during the coolest time of the day and at times when there is least wind.**

There is less wind in the early morning and at night in SW coastal areas during summer.

**☐ Water early in the morning if using sprinklers**

Watering at night presents higher risks of nutrient leaching occurring particularly on the sandy soils of the Swan Coastal Plain. Plants use little water at night and as these soils do not hold water well, excess water applied will drain rapidly beyond the root zone.

However, it is recognized that that it is often too hot or windy to apply sufficient water during the day. Watering at night may also be necessary for frost control.

**☐ If watering at night:**

- **Water lightly (less than 5 mm) and as close to dawn as possible.**

**Or**

- **Have an efficient automated soil monitoring system that switches the pump off when the soil becomes saturated.**

**☐ Drippers and sprinklers that produce coarser droplets minimise evaporation losses.**



## Monitoring soil moisture

Soil moisture needs to be monitored to determine when to re-start the irrigation. Excess water application can be detected by monitoring the soil moisture content within and below the root zone. This can save water (and money), reduce the leaching of nutrients to the environment and improve the growing conditions for the crop.

- **Install moisture-detecting sensors within and below root depth to determine when irrigation is required and gain an understanding of the soil moisture profile.**

The sensor location should be based on the depth of the root system and include monitoring just below the root zone. The effect of moisture on the vegetable quality can also be assessed by factors such as appearance (wilting).

Types of soil moisture instruments in common use are:

- Tensiometers.
- Neutron moisture probes.
- Electronic capacitance probes.

Use of these instruments is fully described in Section 4.2 of the BEMP Manual.

## Avoiding over-irrigating

Over irrigating is a major potential cause of nutrient leaching on sands. The hydraulic conductivity of sands increases 20-fold when the sand is completely wet and at this point, excess water applied leaches rapidly beyond the root zone.

- Use an efficient and accurate method of soil moisture monitoring, particularly on sandy soils.**
- Ensure that irrigation is stopped before water infiltrates past the root zone.**

Use of a best practice method of soil moisture monitoring is essential to determine when the watering should be restarted. This can save water (and money), reduce the leaching of nutrients to the environment and can improve the growing conditions for the vegetables.

- Ensure that irrigation is stopped before water runs off the soil surface.**

Run-off during irrigation may also be an indication that the application rate of the sprinkler system is too high for the soil type.

- Deduct rainfall from the amount of water applied.**

Rainfall should be deducted from the amount of water applied and, on some occasions, the irrigation system may be switched off.



### 4.3 Manage salinity of irrigation water

Irrigating with water that has salt concentrations near crop tolerance limits may result in:

- Build-up of soil salts in the root zone.
- Evapo-concentration of salts on the soil surface and leaves of the crop.

With reference to crop production, the use of saline water reduces yields by causing:

- Water deficiency, where plants actively restrict uptake of saline water.
- Growth inhibition due to the toxic effect of the chloride ion.
- Burning of leaves.

(George, R. *et al*, 1996).

Different vegetable crops vary greatly in their tolerance of irrigation water salinity (Section 4.3 of the BEMP manual for tolerances). Most vegetable crops are very salt sensitive and will not tolerate water over 200 mS/m without significant yield losses. Water with conductivity over about 650 mS/m is generally not suitable for irrigating any vegetable crop.

- Test your irrigation water at the end of summer and select crops that can tolerate the salt levels without unacceptable yield loss.**
- When the irrigation water has conductivity in the range 90- 600 mS/m and there is no fresher water supply:**
  - **Avoid cropping on heavy or poorly drained soils.**
  - **Apply more water to flush salts from the root zone when using sprinklers.**
  - **Monitor the soil conditions under the root zone and take action before salt accumulation becomes a problem.**

**When irrigating with water near the limit of the crop's tolerance:**

- **Using dripper irrigation systems and applying mulch are the best options to minimise evaporation and concentration of salts near the soil surface and root zone.**
- **Keep the water off the leaves to avoid burning.**
- **If using sprinklers, water using continuous wetting sprinklers and avoid light, frequent watering during hot weather.**

Dams often become saline late in summer when water levels are low and salts have become concentrated by evaporation.

- Monitor salinity of dam water regularly. Reduce the risk of dams becoming saline by applying best practices described in Section 2.4 under 'Soil salinity'.**

Saline groundwater inflows can affect bores in some areas especially late in summer.



- ❑ **Regularly test the salinity of bore water and reduce or cease drawing water from the bore if saline inflow occurs.**

If after conducting all best practices, the salt concentration is causing unacceptable crop stress and yield loss, then there are only two alternatives:

- Develop a fresher water source.
- Grow more salt tolerant crops.

Some crops will tolerate water with marginally high salt content if the time and amount of irrigation is carefully managed. (BEMP Manual Section 4.3).



*Lateral-move irrigation system.*



*Large centre-pivot irrigation system.*

# SECTION 5



## Water Resource Management

# Water Resource Management

## **Expected environmental outcomes:**

- *Water resource quality is maintained at levels acceptable for all of its beneficial existing and potential uses.*
- *Fertilisers and chemicals used for vegetable and potato production do not pollute water resources.*
- *Stability and character of waterways are maintained and where possible enhanced.*

The Western Australian vegetable and potato growing industry relies on a constant supply of fresh water for irrigation. For this reason, production is usually located close to ground and surface water resources.

A major objective of this Code of Practice is to maintain the high quality water resources that exist in most of Western Australia's horticultural areas. These resources invariably have current or potential value for uses other than horticulture. Wetlands have nature conservation values. Dams on streams need to have 'environmental flows', that is, sufficient flowing water to maintain the natural biodiversity in the water and on the banks. Fresh groundwater aquifers may be required for potable water supplies in the future. Many estuaries are used for recreation and tourism activities and fisheries. The water quality of these resources must be maintained at levels suitable for all current and potential uses.

Pollution of water resources by agricultural nutrients and chemicals are major issues for the industry. Excessive levels of phosphorus and nitrogen can cause algal blooms in surface water during summer. Groundwater may be contaminated if management fails to prevent the downward leaching of fertilisers. In some parts of Europe and the USA, agricultural activities are regulated because groundwater aquifers have become so badly polluted by nitrates from fertilisers and by the chemical atrazine that they are unfit for human consumption.

All reasonable and practical measures should be adopted to apply the following five principles:

**5.1 Minimise nutrients entering surface and groundwaters.**

**5.2 Maintain or restore the character and bed stability of waterways.**

**5.3 Safeguard streams, water bodies and drains.**

**5.4 Minimise salinity of water.**

**5.5 Prevent contamination of water by chemicals and fuels.**

## 5.1 Minimise nutrients entering surface and groundwaters

### **Sources of nutrients and chemicals**

Export of nutrients and chemicals from vegetable and potato cropping sites into waterways is mainly from diffuse sources. The main diffuse sources of nutrients are (Moore, 1998):

- Fertilisers and manures applied to crops are the source of the majority of nutrients exported from most operations.



- Animal wastes (if livestock are run on the property and streams are not fenced to exclude stock).
- Leguminous pastures such as clovers are a diffuse source of nitrogen.
- Chemicals sprayed onto crops (Section 5.5).

Point sources, intensive nutrient generation at a particular point, can also account for a significant portion of the nutrients exported from some operations. Manure heaps, waste heaps, fertiliser storage areas and waste from processing and septic tanks can be point sources of nutrients if not designed and constructed properly and located away from water resources. Potential point sources of chemical pollution are storage facilities and accidental spills (Section 5.5).

Export of nutrients can be minimised by:

- Applying nutrients according to plant and soil requirements.
- Minimising leaching.
- Minimising soil erosion.
- Proper design and management of drainage.
- Minimising spray drift during fertigation.

### **Minimising leaching**

Leaching is the major process by which nutrients and chemicals are exported from paddocks into groundwater aquifers and also surface waters. In Western Australia, catchments on the Swan Coastal Plain and Scott Coastal Plain with light coloured sands and high rainfall present the highest nutrient leaching risk. They are underlain by extensive potable groundwater resources and contain wetlands, which are very sensitive to nutrient pollution.

Nitrates are very soluble and mobile in all soil types. Excess nitrogen that is not used by plants remains in solution in the soil, is leached down beyond the plant roots and can eventually pollute groundwater aquifers.

Lateral leaching of phosphates and nitrates from fertilisers is a major factor contributing to algal blooms and eutrophication in surface water bodies particularly in catchments with wet sandy soils.

#### **☐ Conducting best practice to avoid applying fertiliser in excess of crop and soil requirements is of prime importance in minimising leaching.**

If irrigation water is applied at a faster rate than the crop uptake and evaporation it will either run off the surface and into waterways, or infiltrate past the root zone to the water table, carrying dissolved nitrogen and other nutrients.

#### **☐ Irrigate according to crop needs and evaporation.**

Unacceptably high concentrations of nitrogen and phosphorus have been measured in sub-catchments with wet grey sandy soils in the Ellen Brook, Peel and Scott River catchments. Poor fertiliser practice associated with cultivated horticulture has been found to be a major contributing cause of this.

- ❑ **When cropping wet sandy sites, take special care in planning a fertiliser strategy (Sections 3.1 and 3.2).**

Clays and red mud 'alkaloam' reduce leaching of nutrients by improving soil nutrient retention, wettability and water holding capacity.

- ❑ **Consider applying soil amendments to light sandy soils (Section 2.2).**

There are risks of nutrient leaching from activities and facilities that concentrate nutrient rich materials such as manure heaps, septic tanks and fertiliser storage.

- ❑ **In relation to the design and location of nutrient producing activities and infrastructure:**

- **Always locate them away from waterways and wetlands.**
- **Avoid sites that are prone to waterlogging.**
- **Design storage facilities to include a weatherproof cover and waterproof barrier underneath to prevent downward leaching.**
- **Ensure that leach drains are surrounded by clay or iron rich soils that trap nutrients.**

### **Nitrates in groundwater**

Drinking groundwater that has high levels of nitrates is dangerous to health, particularly of young children.

Nitrates from nitrogen fertiliser are readily leached from all soils, most rapidly on sands. A bore sampling survey of 40 horticultural properties found that just under half contained in excess of the World Health Organisation guideline of 10 mg/L of nitrate nitrogen.

Conducting best practice in the management of nitrogen fertiliser (Section 3.1) is of prime importance to the environmental sustainability of all growing operations, in particular those on coastal plains underlain by valuable groundwater aquifers.

A significant portion of crop nitrogen requirements can be supplied by nitrogen already in bore water. By taking this into account, growers can save fertiliser costs and greatly reduce nitrogen application.

- ❑ **Growers using bore water or nutrient rich surface water should:**

- **Have the water tested twice yearly for nitrogen concentration**
- **Take into account the nitrogen in the irrigation water when calculating the nitrogen fertiliser application required for crops.**

Calculations for this can be found in Section 5.1 of the BEMP Manual.

Best fertiliser management practices for reducing nitrogen leaching can be found in Section 3.3 'Minimise leaching of nitrogen' and best irrigation management practices for minimising leaching are outlined in Section 4.2.



## Minimising erosion

Erosion by water and wind is the other major process by which nutrients and chemicals are exported from paddocks into waterways, wetlands and water bodies. Nutrient pollution of the surrounding environment is an intangible (non-dollar) cost of erosion but it is far greater in the long term than the immediate dollar costs of erosion, such as loss of fertiliser and decreased yields.

- To minimise export of nutrients and chemicals, conduct best practices to minimise soil erosion** (Section 2.1).

## Minimising nutrients in drainage

Poorly designed, inappropriate or unprotected drains are major causes of nutrients and chemicals entering streams and water bodies. In planning, consideration needs to be given to where drainage water from the farming property would flow to and the drainage route it would follow. In catchments with wetlands or estuaries with natural conservation values, there are strict requirements for limiting nutrient concentrations in the water.

- Conduct best drainage practice** (Section 2.3).

## Water reuse

Where fresh water supplies are limited, the use of collected stormwater or the reuse of wastewater is encouraged, provided that it is treated correctly and does not contaminate the product.

- Tailwater dams are recommended downstream of vegetable and potato growing sites where practicable, to collect and re-use nutrient rich run-off.**

## 5.2 Maintain or restore the character and bed stability of waterways

Stable stream banks are essential to prevent nutrient pollution and maintain the natural character of the stream. Erosion of the banks of streams and drains is a major cause of nutrient and sediment export, which can pollute and silt up pools, wetlands, lakes and estuaries downstream.

Riparian vegetation (natural vegetation along streamlines) prevents erosion of stream banks by binding the soil with a mass of roots and providing logs and debris, which slow the stream-flow.

Healthy vegetation on stream banks is also essential to maintain the natural character of the stream and the flora and fauna along it and in it. Vegetation shades and cools the water, providing the conditions necessary for healthy aquatic life. The decline of marron and native fish in many cleared rivers in the South West is largely due to prolonged periods of high water temperatures. Native riparian vegetation is most suitable and where it still exists it should be protected and enhanced, as it is costly to replace.

***What is riparian land?***

Simply put, riparian land is any land that adjoins or directly influences a body of water. It includes:

- the land immediately alongside small creeks and rivers, including the riverbank itself
- gullies and dips which sometimes run with surface water
- areas surrounding lakes and wetlands
- areas on river floodplains which interact with the river in times of flood.

Good management of riparian lands is not a substitute for good land management practices elsewhere in a catchment. However, it is an essential component of sustainable management of a property or landscape and can yield numerous benefits.

**Eleven good reasons to manage riparian lands with care**

(Land and Water Resource Research Development Corporation, 2001).

***1. Decreased erosion***

Over-clearing and intensive use of riparian lands results in more water moving quickly off the land surface in times of heavy rain - leading to floodouts, stripping of topsoil and accelerated bank erosion which can result in the loss of valuable agricultural land. Replanting of deep-rooted species on riparian land can help to stabilise riverbanks, and protect them in times of flood. Well-vegetated streambanks are more resistant to undercutting and slumping.

Replanted riparian vegetation with in-stream structures, such as rock riffle bars, can help reduce headcutting and other forms of streambed erosion.

***2. Filtering of nutrients leading to improved water quality***

Well-managed, healthy riparian vegetation traps soil and nutrients. The results are:

- Decreased risk of algal blooms.
- Improved water quality.
- Decreased loss of in-stream habitat through siltation.

***3. Provide habitat and shade for aquatic life***

Healthy riparian vegetation helps maintain good habitat for aquatic animals, including insects and the fish and crustacea that feed on them.

It also shades the water, keeping the temperature low enough for fish and crustacea to survive over summer. The results are:

- Increased stocks of fish and crustacea
- Reduced growth of algae and weeds.

Streams are an important recreational resource and, in this way, can be a source of income for landholders and regional communities.



#### *4. Healthy ecosystems*

Good management of riparian land can prevent or minimise damage to both land-based and river ecosystems. Such damage can upset fragile biological balances and lead to a decrease in productivity and the deterioration or even destruction of interdependent environmental systems. Riparian lands serve as corridors between tablelands and lowlands and enable essential seasonal movement of species between the two.

#### *5. Maintaining river courses*

Increased flow from cleared land and riverbanks can cause rivers to change their courses and form new meanders or flood channels. There are many examples where headcutting and meanders threaten roads, bridges and even buildings.

#### *6. Stock management*

Stock allowed free and uncontrolled access to riparian land can directly foul the water with their own wastes, and increase soil erosion by overgrazing and developing walking tracks and pads, reducing both water quality for downstream users and stock performance. It is not uncommon for stock to fall down steep riverbanks or become bogged in riparian zones, resulting in injury, death or their destruction. This is not only expensive for the stockholder but also can lead to pollution of water supplies for other stock and humans.

#### *7. Decrease in insect pests*

Healthy, vegetated riparian land provides habitat for insect-eating birds and insect parasites that can protect pastures and crops from damage. Losing even a small number of birds can allow significantly more below-ground pasture grubs to survive and become adults.

#### *8. Increase in capital values*

Anecdotal evidence from real estate agents suggests that well-managed riparian frontage can add up to ten per cent to the market value of a property. This is important whether the landholder wishes to sell the property, pass it on in good condition or use it as security.

#### *9. Opportunities for diversification*

Some landholders have combined riparian management with agroforestry production. Others have used riparian land for producing hay or other stored forage, or for growing firewood or specialist crops. These farmers have increased the diversity and sustainability of their property while, simultaneously, protecting its most valuable land.

#### *10. Climate protection*

Well-managed riparian zones can provide windbreaks, slowing the wind that would dry out pastures and crops or remove valuable topsoil. Riparian vegetation can also shelter stock from the sun and heat in northern areas or from the wind and cold in the south.

### 11. Lowered water tables

Deep-rooted vegetation may, in some circumstances, act to lower water tables, reducing the flow of salt and nutrients into streams from sub-surface flows.

Best practices to protect the character and stability of streams are:

- Manage remnant native riparian vegetation to maintain or improve its health. Establish native trees, shrubs and rushes along denuded sections of the stream.**
- Consider rocked or logged riffle zones or chutes to stabilise eroding streambeds, increase habitats for aquatic life and oxygenate the water.**
- Where riparian vegetation remains, don't clear it.**

### 5.3 Safeguard streams, water bodies and drains

The wetlands and other surface water resources of Western Australia are very low nutrient ecosystems. Vegetable and potato growing, with its high inputs of nutrients and chemicals, can have significant impacts on the natural biodiversity of these ecosystems. Water bodies are susceptible to contamination by materials including sediment (soil particles), nutrients, salts, agricultural chemicals, microbes and litter. These could be carried via surface run-off into waterways and wetlands and can also move through the soil and contaminate groundwater.

In addition to applying best soil and nutrient management practices, surface water bodies need to be physically safeguarded, by fences, buffer areas and filter strips.

#### **Fencing to protect riparian land and vegetated buffers**

Where there is any grazing, it is essential to fence riparian land to control access by livestock. Uncontrolled access by livestock damages riparian land and water resources by:

- Fouling the water directly with animal wastes.
- Destabilising the banks by the trampling action of hooves, resulting in erosion.
- Destroying the riparian vegetation and its ability to maintain good water quality.
- Fence to keep livestock off the banks and fringing vegetation (riparian areas) around wetlands, waterways and dams on streams.**
- **Where watering points are required for livestock, construct rocked access points or pump water out into troughs.**



*A fenced buffer strip reduces nutrient export into the drain and protects vegetation.*



## Vegetated buffer strips to trap nutrients

Recent studies in Australia have shown that both natural vegetation and grassy filter strips can trap or absorb around 90% of the sediment moving from upslope land (Land and Water Resource Research Development Corporation, 2001).

Strips with dense vegetative cover such as native grasses and reeds, trees and woody debris between horticultural operations and waterways can reduce contamination from nutrients and sediment by:

- Filtering sediments and absorbing nutrients running off horticultural operations.
- Preventing fertilisers and livestock wastes from being deposited directly in the water body.

Livestock wastes are a major source of nutrient pollution being high in nitrogen and phosphorus. Heavy grazing denudes the filtering vegetation and the action of hooved animals destabilises the banks and beds of streams causing erosion and mobilising nutrients. If there are livestock on the property it is essential that the vegetated strips are fenced to control grazing.

### Establish filtering vegetation along the banks of streams, dams and water bodies and where necessary fence vegetation to exclude livestock.

The selection of appropriate vegetation will determine how far sediments and nutrients are filtered. The Land and Water Resource Research Development Corporation have prepared a number of issue sheets for rivers and riparian lands and their management and restoration. These issue sheets cover topics such as managing riparian land, water quality, stream bank stability, river ecosystems and land-based ecosystems and can be accessed on the Internet at:

[www.lwrrdc.gov.au/html/publications/catalogue/rivers.htm](http://www.lwrrdc.gov.au/html/publications/catalogue/rivers.htm)

## Separation buffers for sensitive water resources

Separation buffers to water resources are created mainly to provide barriers to limit the passage of contaminants during normal land use activities or as a result of chemical spills or similar emergencies. Other functions of separation buffers are:

- Maintenance of ecological processes and major food chains.
- Protection from nutrient inputs that could lead to eutrophication.
- Protection from increased salinity from the ingress of saline water.



*A fenced, grassed filter strip which protects the water resource.*

Separation distances may not always be a strip of set width along a watercourse or wetland. The distance should match the risk and needs of the local environment. The separation distances outlined in Table 1, Section 13.2 are recommended by the Water and Rivers Commission for new or expanding vegetable and potato growing operations proposed in the vicinity of water resources.

- ❑ **In liaison with the Water and Rivers Commission and neighbours, establish adequate buffers to protect environmentally sensitive wetlands and wells or reservoirs used for drinking water supplies.**

## 5.4 Minimise salinity of water

### Minimising salinity of groundwater

Some groundwater supplies may become saline by the ingress of salt water from adjacent saline aquifers or the sea when the aquifer is over-used. In these cases the grower needs to understand the groundwater system and monitor the bores.

- ❑ **To prevent salinisation of irrigation bores, monitor the bores to quantify abstraction rates and salinity. Reduce or cease abstraction when salinity increases.**

The extensive deeper aquifers of the Swan Coastal Plain, the Yarragadee and Leederville aquifers, which are most widely used for horticulture, are generally fresh enough for most horticultural uses and are not at risk of increasing salt concentration.

### Minimising salinity of surface water

Surface water bodies generally fall into two categories:

- Dams on farms, which are used for irrigation in South West high rainfall hills areas.
- Wetlands and streams on or near farms.

Dams used for irrigation of vegetables and potatoes are generally gully dams constructed on fresh water streams, such as those in the Manjimup and Pemberton areas. Some streams have many irrigation dams constructed on them, some of which may be used for aquaculture. Some streams also run through State forest, national parks or nature reserves, which have high natural biodiversity values that require protection. It is in the grower's interest and in the interest of downstream users and environmental flows that the salinity of the stream water is maintained as close as possible to natural levels.

Gully dams often increase in salinity in late summer and autumn by the following processes:

- Evaporation from the dam surface causes salt concentration to increase.
- Salt from saline seepages is washed into the dam by early rains.
- Salt from irrigation water may be concentrated by evapo-transpiration and washed back into the stream.



❑ **Minimise the salinity of stream and dam water by:**

- **Planting windbreaks of native trees around their dams to shelter and shade the water surface, thus reducing evaporation.**
- **Flushing gully dams and ensuring that water is allowed to flow through the gate valve in early winter.**
- **Reducing discharge into dams and streams from saline groundwater seeps and reducing saline run-off from saline land (Section 2.4).**

❑ **Protect wetlands from salinity by:**

- **Creating vegetated separation buffers and planting high water use and salt tolerant vegetation in the buffer areas.**

## 5.5 Prevent contamination of water by chemicals and fuels

Many farm chemicals, especially pesticides, are toxic to humans and other living organisms at extremely low concentrations and some may persist in the aquatic environment for long periods.

The main sources of chemical pollutants on farms are:

- Herbicides and insecticides applied before rain or excessive irrigation (diffuse sources).
- Spilt fuels and chemicals (point sources).

The nutrient export reduction practices, minimising leaching and erosion and proper design of drainage (Section 5.1), also minimise the risk of chemical export.

Contamination with farm chemicals and fuels is a particular risk to the groundwater aquifers that underlie the Swan Coastal Plain. These valuable groundwater resources are widely used for private and public drinking water supplies.

The hydrocarbons that constitute fuels are toxic in drinking water at extremely low concentrations. Hydrocarbon contamination can persist for long periods and the contaminated groundwater can move laterally for considerable distances under the influence of prevailing groundwater flow. It is technically difficult and costly to decontaminate water resources to potable standards once they have become polluted with petroleum hydrocarbons.

### **Storing and dispensing fuels and chemicals**

Fuel tanks are an integral part of vegetable and potato growing operations and they often have to be located near dams or over groundwater aquifers for irrigation pumps. Leakage or spillage from poorly designed fuel storage facilities can cause contamination of water resources either through infiltration to groundwater or run-off into surface waters.

Likewise, chemical storage sheds pose a water pollution risk if they are not designed and located properly because spilled chemicals can contaminate water resources in the same way as fuels.

**❑ Conduct best practice for storage, transport and dispensing of fuels and chemicals.**

Details of these best practices can be found in Sections 6.2 and 6.3 of the BEMP Manual.

Fuel storage systems in Underground Water Pollution Control Areas (UWPCAs) require permit approval from the Water and Rivers Commission.

The Water and Rivers Commission policy 'Pesticide Use in Public Drinking Water Source Areas' applies special controls in Public Drinking Water Source Areas.

**❑ Pesticide formulations or concentrates should not be stored, mixed or diluted within the following areas without the prior approval of the WRC:**

- Reservoir protection zones.
- Priority 1 areas.
- Within 50 metres of any water body or water course.

### **Toxicity of chemicals to aquatic life**

The level of toxicity and persistence of pesticides in the environment is generally not stated on the label. However, the label will contain environmental warning statements as required by the relevant labelling code, for example 'dangerous to fish'. The LD50 and poison schedule of a pesticide (Section 6.4) is not a good indication of how long it may persist in the environment or how toxic it may be to organisms other than mammals. To be safe, all pesticides except biological insecticides (e.g. *Bacillus thuringiensis*) should be assumed to be toxic to aquatic life and used with caution accordingly.

Certain groups of insecticides are particularly toxic to aquatic life, for example (Bureau of Rural Sciences, 2001):

- All pyrethroids (active ingredient ending in -thrin, for example cypermethrin) and rotenone (a plant derivative) are very toxic to fish and crustacea and may persist in the aquatic environment for several weeks.
- Most organo-phosphates (name of active ingredient generally contains -thion, -oate, -phos or -fos), for example clorpyrifos.
- Organo-chlorines.
- Some carbamates, for example, methiocarb and propoxur.

Nearly all wetting agents used with herbicides are toxic to aquatic fauna, particularly frogs (Thompson, 1998). Herbicides that are registered for use near wetlands have 'frog friendly' wetting agents.



*Poor practice:*

- Both fuel tank and fertigation equipment are not standing on spill containment slabs.
- Fertiliser and chemicals are being injected too close to the water resource.



The triazine group of soil pre-emergent herbicides, which includes atrazine, is an example of chemicals that are at high risk of being transported into streams, wetlands and dams by run-off and erosion. The herbicidal properties of triazines can persist for up to four months.

- When selecting pesticides and additives for use near water bodies, be aware of the types that are particularly toxic to aquatic fauna and avoid using them near sensitive wetlands or aquaculture ponds.**

## **Chemical use near water resources**

Farm chemicals used in operations have the potential to pollute water resources by run-off and spray drift into surface waters and infiltration to groundwater.

The likelihood of a chemical being present in a water resource at levels high enough to affect public health or the aquatic biota is determined by several factors:

- Level of use of the chemical in the catchment.
- Mobility of the chemical in the catchment environment.
- Toxicity of the chemical and its metabolites.
- The length of time that the chemical or its metabolites remain in a toxic state in the environment.
- The sensitivity of individuals in a population to the chemical or chemicals.
- The extent to which users adhere to the directions for use on the product label, such as the application rate.
- Container and waste disposal.

To minimise the risk of water resource contamination when using chemicals near water bodies:

- Always use pesticides according to their label directions.**
- Avoid mixing or transferring pesticides and additives into spray tanks anywhere near water bodies.**
- Minimise run-off; consider the impacts of weather, irrigation and slope.**
- Triple rinse used chemical containers and dispose of them at Drum Muster recycling facilities.**
- Remove any unused chemical concentrates from drinking water source areas and dispose of old residual chemicals through the ChemCollect™ scheme.**

These practices are described in more detail in Sections 6.2, 6.4 and 8.1. Water quality protection notes outlining the recommended management practices for storage of chemicals with potential to contaminate water resources can be found in Section 5.5 of the BEMP Manual.

Due care should be taken to avoid spray drift over dams, streams and wetlands.

- Use best practices to avoid spray drift (Section 10.1) when spraying any pesticides near water bodies and wetlands.**
- On no occasion should misters or aerial spraying be used over or near water bodies.**

Vegetation around water bodies may give some (but not complete) protection against spray drift entering water bodies.

- Maintain buffer areas that are not sprayed around sensitive aquatic environments.**

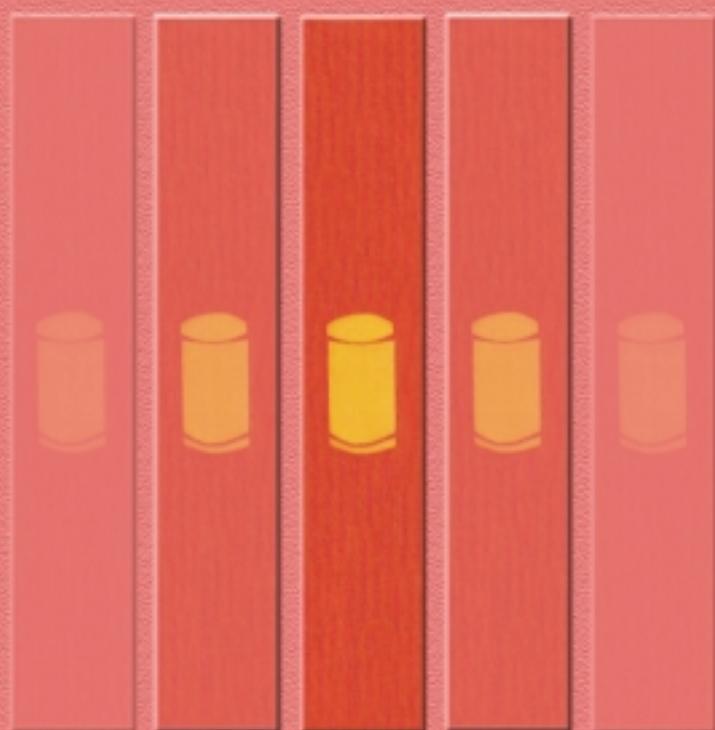


*Planting a vegetated buffer around an irrigation dam at Manjimup.*



*Growers need to ensure that their practices do not affect the health of pristine rivers, such as the Warren, near Pemberton.*

# SECTION 6



**Chemical Management**

# Chemical Management

## **Expected environmental outcome:**

*No pollution of the environment by chemicals and fuels.*

Chemicals such as pesticides (herbicides, insecticides and fungicides), spray additives, solvents, cleaning agents and dip solutions and fuels are essential inputs used every day for many operations on modern large-scale vegetable and potato farms. It is not uncommon for large growers to use fifty thousand litres of fuel and fifty large (twenty-litre) containers of pesticides each year.

Most growers are becoming increasingly aware of the adverse effects of over-use of chemicals and poor spraying practice. Chemical use is a major environmental consideration for growers because:

- Chemicals are used frequently and often in high volumes.
- There is risk of contamination of food produce.
- Many operations involving chemicals are in close proximity to water resources.

The great majority of growers use pesticide chemicals for controlling pests and diseases. Pesticides are damage control agents that prevent, destroy or control any unwanted species of plants or animals that interfere with the quantity or quality of agricultural commodities during production, processing, storage, transport or marketing. Pesticides provide a number of economic benefits but conversely they can have significant negative impacts, especially if not applied in an appropriate manner. There is simply no such thing as a completely safe pesticide. For example, (OECD, 1997):

- Pesticide residues in food, air and groundwater can affect public health.
- The application of pesticides without adequate protection can pose health risks to farm workers.
- Pesticides may destroy beneficial predator species allowing populations of other organisms to reach pest proportions.
- Excessive use of pesticides may lead to the emergence of pesticide resistant strains of existing pests.
- Pesticides can have adverse impacts on biological diversity by acting on non-target species of plants and animals.

Growers should make every effort to minimise the use of toxic chemicals and ensure that correct practices are established and followed. This section covers the safe transport and storage of farm chemicals and fuels and the safe use of pesticides. More information on preventing pollution of water resources by chemicals and fuels can be found in Section 5.5.

All reasonable and practicable measures should be adopted to apply the following four principles:

**6.1 Minimise use of chemicals that are toxic to humans or the environment.**

**6.2 Transport chemicals and fuels safely.**

**6.3 Store chemicals and fuels safely.**

**6.4 When using pesticides, minimise risks to human health.**



## 6.1 Minimise use of chemicals that are toxic to humans or the environment

The first and most obvious way to reduce the impacts of those chemicals that pose risks to the environment and human health is to use less of them. The main way to achieve this is by implementing an Integrated Pest and Disease Management (IPDM) strategy. There are many management practices that do not involve the use of toxic pesticides and that will reduce the incidence and severity of pest and disease outbreaks. IPDM is an approach to make pest control more effective by coordinating these non-chemical and chemical methods of pest control. Non-chemical and ‘soft’ chemical options are used where possible before resorting to more toxic pesticides. IPDM is outlined in Section 7 ‘Controlling Pests and Diseases’.

- Use an Integrated Pest and Disease Management strategy to minimise use of chemicals.**
- Where possible, select chemicals that are least hazardous to the surrounding natural, aquatic and human environment (Section 5.5).**

## 6.2 Transport chemicals and fuels safely

The largest spills and those most likely to cause poisoning of humans by direct contact with undiluted chemicals are at greatest risk of occurring during transport. Traffic accidents can happen even when travelling only a short distance and improperly loaded pesticide containers can fall off the vehicle and be punctured or torn. Because pesticides are transported on public roads, the potential impacts of such accidents are great.

Hydrocarbon chemical constituents of fuels are toxic in drinking water at very low concentrations and contamination can persist for long periods. Clean up of water contaminated with petroleum hydrocarbons to drinking water standards is technically difficult and costly.

For this reason, the Dangerous Goods Regulations 1992 set out safety standards for transporting farm chemicals and fuels.

### Safe transport of fuels on farm

- Ensure that mobile fuel tankers on farm are constructed to approved design, with fail safe spill prevention devices.**

### Safe transport of chemicals

The following best practices should always be adhered to when transporting chemicals (Dept of Agriculture, 2001. Ogg *et al*, 2001).

- Never carry chemicals in the cabin of a vehicle, or on any vehicle containing food, feedstuffs or fertiliser.**
- Transport chemicals safely and securely in the back of a truck or utility that has a tray with sides and a tailgate, lined with an impervious material.**
- Always carry correct documentation, displayed in a prominent position in the cab, describing the dangerous goods that are on board.**



- ❑ **If required, comply with other provisions of the Dangerous Goods (Transport, Road and Rail) Regulations 1999, such as the placarding of vehicles, personal protective clothing and public liability insurance.**
- ❑ **Always carry a spill kit in the vehicle.**
- ❑ **In the event of a spill in a public place, advise the local shire. In the event of a major spill local government would contact the Department of Environmental Protection and emergency organisations to initiate appropriate actions.**

### 6.3 Store chemicals and fuels safely

Many farm chemicals, particularly pesticides and hydrocarbon fuels such as diesel, can contaminate water resources and are extremely toxic to humans and aquatic flora and fauna. The effect of chemical and fuel pollution on water resources is outlined in Section 5.5. Every effort should be made to handle, store and use these substances safely, for the purpose and in a manner for which they were intended.

#### Safe storage of fuels

Leakage and spillage of fuels are the commonest accidents resulting in pollution of water and soil on farms.

Common causes of accidental spillage are jamming of dispensing nozzles, broken hoses, leaking or broken fuel lines in motors and accidental rupture of mobile fuel tanks. The risks of occurrence of these accidents can be greatly reduced by using appropriate, well-maintained equipment:

- ❑ **Ensure that all tanks, pumps, hoses and fittings for storage, transport and dispensing of fuels are fabricated to approved designs and properly maintained to safeguard against leaks and accidental spillage.**

Refer to Section 6.2 of the BEMP Manual for best management practices and design of fuel and chemical storage systems.

#### Safe storage of chemicals

It is critical that chemicals are stored safely to reduce the risk of leakage to the environment. The leakage of concentrated pesticides to the environment is of extreme concern as concentrated pesticides in soils, protected from sunlight and air, will not decay readily and may persist for decades.

A storage shed in an area prone to flooding after extreme rainfall events is an environmental disaster waiting to happen. Pesticide containers may be damaged and fractured during flooding and streams grossly polluted. Likewise, a chemical storage shed located in bushland presents high fire and pollution risks. Toxic fumes may be released in the event of the containers being destroyed in a bushfire. Essential features of safe chemical storage facilities are outlined in Section 6.2 of the BEMP Manual.

- ❑ **A properly equipped chemical shed, purpose-built to an approved design is essential.**
- Limit access to authorised personnel only.
- Locate the facility well away from water resources.
- The site needs to be clear, to minimise fire risk.

### Chemical spills

- ❑ **Have properly equipped chemical spill kits located in the vicinity of the chemical storage and mixing areas.**

Refer to the BEMP Manual Section 6.3 for details of what a spill kit should contain and how spills should be treated.

- ❑ **If a spill occurs, soak it up with the spill kit materials, place them in a marked container and hand them in at ChemCollect™ venues (Section 6.4 of the BEMP Manual).**

### Chemical records

Most growers have a lot on their minds, so relying on memory for inventories of chemicals stored and used is unwise. It is sensible to keep on file permanent records of all chemical purchases and their use. Records will enable growers to examine the efficiency and cost effectiveness of their chemical use and compare results from season to season. The records are also essential for the grower to know what chemicals are in the storage shed, in the event of fire, spillage or other accidents in the shed.

- ❑ **Keep comprehensive records of chemical purchases and uses.**

### Cleaning of spraying equipment

Residual chemicals left in spray tanks or on machinery may increase the risk of operator poisoning and can corrode or block delivery mechanisms. In some cases, the toxicity and effectiveness of chemicals may be altered when they are mixed.

- ❑ **Spray all of the contents of the spray tank onto crop or pasture. Wash fresh water through it and hose down the equipment after each operation. Do this in the field, away from water resources to avoid pollution or concentration of chemicals at a single wash point.**



*Fuel storage and pesticide mixing areas.*



## 6.4 When using pesticides, minimise risks to human health

This principle focuses on understanding the hazards that pesticides can present to farm workers, local residents and consumers of vegetables and potatoes. It outlines correct procedures for the safe use of pesticides.

When used excessively or inappropriately, pesticides can have adverse effects on human health:

- Operators may be poisoned by direct contact with the chemicals.
- The health of the wider community may be indirectly affected through ingestion of pesticide residues in produce and groundwater or inhalation of spray drift.

There is a need to control the type and amount of pesticides and how they are used, to ensure that there are no significant adverse effects on human and environmental health. There are several Government Acts and Regulations that provide for the safe handling and use of farm chemicals in Western Australia (Appendix 1).

### **Pesticides and human health**

Poisoning occurs when pesticides enter the body following exposure either through the mouth by swallowing, through the lungs by inhalation or through the skin after contact. Significant causes of acute and chronic poisoning are:

- Failure to follow directions on pesticide labels.
- Use of unregistered chemicals, or using chemicals for purposes other than those they are registered for.
- Skin contact or inhalation due to failure to use the correct protective equipment.
- Frequent skin contact with contaminated equipment, for example exposure over time to chemicals in contaminated truck or tractor cabs.
- Accidental ingestion due to storing a pesticide in an unlabelled container.

Symptoms of poisoning vary according to the pesticide used and the degree of exposure. Mild poisoning may be indicated by such symptoms as headache, skin irritation, dizziness, weakness, nervousness, nausea, sweating, diarrhoea, eye irritation, irritation of the nose or throat, sore joints or changes of mood. Severe poisoning may be indicated by vomiting, loss of reflexes, difficulty in breathing, involuntary muscular twitching, visual disturbances, convulsions, unconsciousness, severe secretion or salivation, fever and in extreme cases, death.

Examples of common pesticides that are particularly toxic to humans are the herbicides paraquat and diquat and anticholinesterase insecticides such as methidathion and methamidophos. Residue testing is important for growers who use chemicals frequently, particularly the organophosphates and carbamates, which are anticholinesterases, which affect the nervous system.

- Growers and operators who use pesticides frequently should undergo pesticide residue tests to guard against over-exposure.**
- If poisoning is suspected:**
  - **Follow first aid and safety directions on the label of the pesticide container.**
  - **Contact the Poisons Information Centre on 131126 (all hours).**
  - **See a doctor or take the affected person to hospital. Write down the name of the product and/ or active ingredients and concentration, or take the empty, rinsed container with you.**

Antidotes for organophosphate or carbamate poisoning such as atropine should be prescribed and administered only by a doctor (ChemCert Western Australia™, 2000).

### **The product label**

The essential information for safe use of a chemical is always included on the product label. The *Agricultural and Veterinary Chemical Code Act 1994* requires that all farm chemical products must have a label printed in accordance with a national code of practice on labelling. It also requires that all pesticides, herbicides and crop regulators must be registered for specific uses in each State of Australia and that this is shown on the label. Part of the registration process is an assessment of how effective the pesticide is and how hazardous it is to human and environmental health.

- It is crucial that all operators read and understand the directions on the product label before using any farm chemical.**
- By law, pesticides must not be stored in unlabelled containers.**

All pesticides are scheduled according to how hazardous they are and information on this is included in the following warning statements on the label:

- Schedule 7 pesticides, label signal words are “DANGEROUS POISON”. These are the most dangerous and only licensed pest control operators and other authorised persons are permitted to purchase and use them.
- Schedule 6 pesticides, label signal word is “POISON”. Moderately toxic, more freely available but retailers may require a permit to sell them.
- Schedule 5 pesticides, label signal word is “CAUTION”. Low toxicity, with no restrictions on their sale.
- Unscheduled pesticides require no label signal words. Very low toxicity.

The ‘Directions for Use’ panel of the product label clearly shows in which States of Australia and for what purposes the chemical is registered.

- Do not use any chemical other than in the manner and for the purposes shown on the label.**

To do so may harm operators, neighbours or the environment and may constitute an offence under the Health (Pesticides) Regulations Western Australia, 1956.



The withholding time is the minimum time that must elapse between applying a chemical and harvesting the crop. If a withholding period is required, it will always be stated on the label. It is most important that this is observed, to prevent excessive pesticide residues in produce for human consumption or in crop residues to be fed to livestock.

- Be aware of the withholding time stated on the label before applying any chemical to a crop.**

### Preventing poisoning

The product label will always specify type of protective clothing and handling precautions required. More protective equipment and stringent precautions are required for the more toxic (S7 and S6) poisons.

Chemicals are most hazardous in their concentrated form, particularly S7 chemicals. Following safety directions and wearing protective clothing is particularly crucial when conducting high-risk activities, for example adding concentrate to the spray tank or applying seed dressings.

- Wear the recommended protective clothing as stated on the product label when decanting, mixing and applying chemicals.**
- Take special care when handling concentrated chemicals – use “sucker- flusher” chemical transfer where possible.**
- Have water on hand and if you get any chemical on yourself, wash it off immediately.**
- Wash and decontaminate the cabs of spray vehicles and change filters on enclosed cabs regularly.**
- Do not blow out nozzles with your mouth.**
- Wash spray clothes separately from family clothes.**
- Do not store spray clothes or protective equipment in the chemical shed.**
- Do not mix pesticides or wash chemical equipment near water sources.**



*Operator wearing the correct protective equipment for mixing an S6 scheduled poison.*



*Symbols for protective equipment.*



## Choosing the safest chemical pesticide

When all physical and biological measures have been considered and use of a chemical pesticide is the only practical option, the safest, most selective chemical option should be chosen (Section 7 'Controlling Pests and Diseases').

The toxicity of chemical pesticides is expressed as an LD50 number, which is the number of milligrams (thousandths of a gram) per kg of body weight required to kill 50% of a population of animals. LD50 is not stated on the product label. However, it is related to the poison schedule, for example, S7 poisons have an LD50 of less than 50 mg/kg and unscheduled poisons have an LD50 of greater than 5,000 mg/kg (ChemCert Western Australia™, 2000). The poison schedule signal heading on the label is a good indicator of the acute toxicity hazard of the chemical to humans.

- If there is a choice of pesticides choose the one with the lowest poison schedule rating to minimise the human health hazard.**

## Training and licensing

The risks to the human and natural environment are too great for untrained staff to be allowed to use chemicals or conduct spraying operations. The rationale behind this is the same as drivers having to be licensed before they drive on roads, where incompetence will endanger the lives or health of other people. ChemCert™ is a good example of a one-day course, which covers all aspects of chemical use including pest management, legislation, pesticide residues, pesticide labels, formulations, applications, personal safety and records. A current ChemCert certificate is a prerequisite for anyone undertaking the SQF 2000 cm or SQF 1000 cm quality assurance programs.

- Under Occupational Safety and Health legislation, all users of pesticides and other hazardous chemicals must be accredited in a current, approved chemical user-training course.**
- When using a contract pesticide sprayer, ensure that they are licensed with the Department of Health.**
- Have knowledge or current reference information (AVCARE, 2001), as to:**
  - **Which chemicals are registered for use on various pests in Western Australia.**
  - **The modes of action, environmental impacts and toxicity of the various pesticides.**
  - **How to rotate pesticide groups to minimise build-up of pesticide resistance.**

To check if pesticide uses and products are registered, refer to the National Registration Authority for Agricultural and Veterinary Chemicals website [www.nra.gov.au](http://www.nra.gov.au)

## Material Safety Data Sheets

The Material Safety Data Sheet (MSDS) contains additional information about the chemical such as its density (whether it is heavier than water), volatility (whether it forms gases) and whether it is flammable (burns easily). This information is necessary for the operator to assess the hazard presented in the event of spillage, fire or other accidents. The MSDS is not part of, or a substitute for, the product label.

Suppliers are required under the Occupational Safety and Health Regulations 1996 to provide an MSDS on the first sale of a hazardous substance and thereafter on request (ChemCert, 2000). MSDSs of all chemicals registered for use in Australia are available on the 'Infopest' CD produced by Queensland Department of Primary Industries, or the 'Infinder' CD produced by Primary Industries and Resources South Australia.

- Employers are required to obtain Material Safety Data Sheets (MSDS) and make them available to persons using hazardous substances.**



*This chemical shed is well marked, but it should have been located away from other buildings and the chemicals should be locked inside it at all times.*

# SECTION 7



## **Controlling Pests and Diseases**

## Examples

1. The Western Australian Seed Potato Certification Scheme is an industry cooperative scheme administered by The Department of Agriculture. Certified seed potatoes are produced over a maximum of five field generations from mini-tubers or plantlets produced in accredited laboratories from pathogen- tested stocks maintained in tissue culture. Pathogen- tested stocks of the required varieties are periodically tested for diseases such as blackleg, bacterial wilts, ring rot, powdery scab, black scurf, gangrene, wilts, dry rots, black dot, potato leaf roll virus and other potato viruses. Under the Scheme, seed potatoes are grown under strict guidelines as to location, separation between plots, irrigation and requirements for certified or registered planting material. To be certified, a seed crop must be inspected twice during the growth stage, with a particular emphasis on detecting virus infection and the presence of aphid virus vectors. All or part of a crop can be rejected if it fails to meet the standards applying to the nominated generation, for example (AGWEST Plant Laboratories, 1998):
  - Potato Cyst Nematode- zero tolerance.
  - Virus diseases- 0.05% in second generation seed.
  - Bacterial wilt- zero tolerance.
2. The seeds of brassicas, tomato, celery, carrot and pumpkin are treated by careful immersion in hot water and application of fungicide dusts to kill a wide range of fungal, bacterial and viral diseases which can infect germinating seedlings.

# Controlling Pests and Diseases

## Expected environmental outcome:

*Integrated Pest and Disease Management practices that minimise the quantity and the associated environmental impacts of agricultural chemicals used.*

Controlling pests and diseases enables Western Australian growers to harvest quality produce at a minimum cost for local and overseas markets. Moreover, the control methods need to have minimal impacts on the environment and human health. This means minimising the use of those chemicals that are toxic to humans or the environment.

Integrated Pest and Disease Management (IPDM) is an approach that aims to minimise the risk to human health and the environment while maintaining pest populations below levels at which crop damage may occur. IPDM makes pest control more effective by coordinating non-chemical and chemical methods of pest control. IPDM can be defined as: 'Utilising a range of pest management tools to provide economically, environmentally and socially sustainable production.'

All reasonable and practicable measures should be adopted to apply the following three principles of Integrated Pest and Disease Management:

### 7.1 Minimise occurrence of pest and disease outbreaks.

### 7.2 Monitor for pests and diseases and base decisions to spray on 'economic injury' thresholds.

### 7.3 Control weeds and invertebrate pests by timely physical, biological and chemical means.

## 7.1 Minimise occurrence of pest and disease outbreaks

### Hygiene practices

Hygiene and where necessary, pre-plant chemical treatments are the only lines of defence against many soil borne nematodes, diseases and insect pests. Once a paddock is infected, control of soil borne diseases, such as club-root and Sclerotinia rots, is costly and ongoing. Once introduced, there is a greatly increased probability of infection of neighbouring paddocks by spores transported by wind, water and soil (fungal diseases) or by insect vectors (virus and bacterial diseases).



*Seed potatoes affected by rot. Pathogen-tested stocks and seed certification are essential to avoid this.*



*Cleaning machinery is an important hygiene measure.*

- ❑ **Use of clean certified planting material is crucial to preventing viral, bacterial and fungal diseases in all horticulture crops.**
- ❑ **Check the quality of the nursery used to supply seedlings and how their seed and potting mixes are treated.**

Nurseries accredited under the Nursery Industry Accreditation Scheme (NIASA) are recommended as they adhere to prescribed hygiene practices.

Removal of soil from vehicles, machinery and boots is the most effective hygiene measure for soil borne diseases.

- ❑ **Check and clean all equipment and visitors' vehicles carrying mud, that come onto the property. Remove soil, plant material and seeds.**
- ❑ **A wash station set up at or near the entrance to the property is ideal for this purpose. Fungicide dips can be used as an extra measure for disinfecting boots and small items.**

### Crop rotation strategies

An essential component of any disease minimisation strategy is an appropriate crop rotation strategy. Most diseases require plants of certain species to act as 'hosts' on which they can breed and produce more spores. The life cycle of the disease organism can be broken by ensuring that other crops or pastures of non-host species are grown in the period between cropping of the species susceptible to the disease.

- ❑ **An adequate inter-rotation period is crucial to control soil borne fungal diseases and nematodes. For most diseases this is at least three years under non-host crops or pastures and in many cases longer.**

Though it is not a guarantee against infection, crop rotation will help to reduce the impact of the disease if it does occur. Details of crop rotation requirements for different diseases can be found in vegetable growing handbooks.

- ❑ **Where possible select inter-rotation crops or pastures with bio-fumigation or pest deterrent properties.**

### Crop cultural strategies

How, when and where the crop is grown influence the risk of many pests and diseases becoming established in the crop. Over the years, many of our cropping plants have been selected for their yield, product quality and resistance to specific pests. Unfortunately, a strain bred specifically for resistance to one pest may be more susceptible to another pest. Today through plant breeding and genetic engineering, many disease and pest resistant varieties are available worldwide.

- ❑ **First consider resistance to locally occurring diseases when selecting the variety of potato or vegetable.**

Good crop nutrition and watering will ensure a healthy, growing crop and healthy crops generally have higher resistance to insect pests.

- ❑ **Consider conditions for pests and diseases when timing irrigation schedules.**

Plant spacings affect the humidity, light and temperature conditions in the growing crop and can thereby influence the incidence of diseases.

#### Examples

1. Clubroot, a major fungal disease of cauliflowers and broccoli, has been introduced to the Manjimup area. It is spread by infected transplants and in soil carried onto the property by machinery, tyres and boots. Many properties are still free of the disease due to stringent wash down and disinfecting procedures adopted by growers and the good hygiene practised by local nurseries.
2. Some areas on the Swan Coastal Plain are infected with potato cyst nematode. Bins from these properties are thoroughly cleaned of all soil before being sent to Albany to collect seed potatoes.

#### Example

Rotation of cruciferous crops with non- cruciferous crops is important to reduce the clubroot spore load in the soil. For example cauliflowers followed by potatoes, then sweet corn and finally three years in pasture. Lowering the number of spores in the soil will lead to healthier crops. The time between cruciferous crops should be at least five years.

#### Examples

1. Irrigating after sunset is a good practice to prevent build- up of diamondback moth numbers immediately after they are first seen in the crop as it disrupts egg laying.
2. Delay irrigation for as long as possible after applying chemicals to the crop, to maximise the time they can take effect before being washed off or diluted.

## Example

Carry-over and build-up of diamondback moth in brassica crops can be minimised by mulching or turning in crop residues as soon as possible after harvest to prevent this host specific pest from building up large numbers in 'volunteer plants' over the summer period.

## Examples

1. Using dung beetles to remove manure from pastures is a method to control fly populations.
2. Controlling brassica weed species such as wild radish in the intercrop rotation period is an important strategy for controlling clubroot in cauliflowers.
3. Capeweed and sorrel are hosts of various weevil pests and controlling these weeds in the year prior to cropping and around the crop during cropping are important control measures (Learmonth, 2001).

## Example

Although they do not generally cause economic damage to plants directly, the green peach aphid and potato aphid are the main carriers of the potato leaf roll virus. Potato crops grown for certified seed are inspected twice during the growth period and are rejected if aphids are found to be present above threshold tolerance levels. Ensuring that seed potatoes are grown a long way from and preferably up-wind of cropping areas that are infested with the aphid is another important practice in controlling the virus in Western Australian potato crops.

- Consider conditions for pest and disease threats when deciding on optimum plant spacings.**

### Pest habitats and hosts

Plant residues harbour many fungal soil diseases. Fungal root diseases such as *Rhizoctonia* sp. and damping off fungi such as *Sclerotium* sp. thrive on rotting plant material and can easily infect crops. Green mulch crops and vegetable residues break down in a few weeks when chopped up as finely as possible on the surface with a flail mower or mulcher. Light disc cultivation may also be necessary for coarser residues. Avoid inverting the soil profile and leave some plant material exposed to protect the soil surface.

This mulching procedure also ensures that all crop plants are killed as soon as practicable after harvest. Any remaining 'volunteer' crop plants can act as hosts allowing many crop pests and diseases to carry over and infect the next crop or crops planted in adjacent areas.

- Ensure that plant residues are broken down well before planting, to decrease the likelihood of disease outbreak.**
  - **Chop and lightly incorporate crop residues into the soil.**
  - **Spray off pastures several weeks before cultivation for cropping.**

Spraying off pasture and leaving it for several weeks to break down on the surface before cultivation will minimise the risk of soil erosion and at the same time ensure that there will be minimal rotting plant material present in the seedbed. Many crops can then be planted soon after soil preparation.

*Note: Surface water control measures (Section 2.1) may also be needed to protect the cultivated soil from erosion, particularly if deeper ploughing has been practised to control Sclerotinium diseases.*

By denying a suitable habitat for one stage of the life cycle of an insect, the pest population can be controlled.

- Destroy pest life-cycle habitats and control pest hosts.**

### Disease carrier species

Some invertebrate pest species are carriers (vectors) of diseases and in many cases controlling the pest vector is an important part of the strategy to control the disease.

- Control disease carrier species.**



*These 'volunteer' potato plants should be sprayed off immediately with a selective herbicide.*

## Lures, traps and deterrents

Poison baits and lures in traps can be a good option to avoid application of pesticides onto the product and are often used by organic producers. Potent attractants such as sex pheromones can be used to attract insects into traps or to attract natural predators into the crop under attack. Baits containing the pest's preferred food can be placed around the crop to divert and kill the pest.

- Use lures and traps where possible to monitor for and control invertebrate pests.
- Use netting and deterrents for vertebrate pests.

## 7.2 Monitor for pests and diseases and base decisions to spray on 'economic injury' thresholds

By using simple, reliable pest monitoring procedures the grower can determine whether a disease or pest is present at levels likely to cause economic damage and make confident decisions as to whether chemical control will be necessary.

Monitoring entails:

- Monitoring and recording the incidence of pest and diseases on the site to build up a site history.
- Monitoring the site prior to soil preparation to detect the incidence of pests and diseases.
- Monitoring at regular intervals during crop growth to detect when insect pest numbers have reached threshold levels.

### Soil borne pests

Routine soil chemical treatment of all horticulture sites is both undesirable and unnecessary. Soil fumigation with the toxic chemical metham sodium, though sometimes necessary, is expensive and involves a health risk to the operator. By monitoring for the presence of a pest in the paddock several months prior to planting it is possible to determine whether there is likely to be an outbreak (BEMP Manual Section 7.2). For example, the risk of outbreaks of soil borne insects can be assessed in this way. If the risk is assessed as being very low, it is not necessary to conduct costly and soil degrading pre-plant fumigation or insecticide treatments.

- Use prescribed techniques to monitor for soil borne pests prior to soil preparation.

### Regular crop monitoring

Effective IPDM can only be achieved if the grower conducts monitoring programs involving the estimation of numbers of pests and predators and their rate of increase, at regular intervals. Initially, growers are encouraged to engage consultants or farm advisers specialising in IPDM to monitor the dynamics of the pest and predator populations to determine if it is necessary to take additional action. There are also professionals in most horticultural areas who provide 'pest scout' services and growers can increase their knowledge initially by hiring and working with them.

#### Examples

1. Fencing cropping paddocks with secure mesh fences is common practice to prevent damage by rabbits and kangaroos.
2. Bird scaring gas guns are used to deter wood duck, or maned duck, which can uproot vegetable seedlings soon after planting.

#### Examples

1. Pheromone traps are a recommended early detection monitoring method for diamondback moth.
2. Attractants such as yellow sticky traps reduce the abundance of whitefly in glasshouses.
3. Metaldehyde or methiocarb baits are effective in reducing snail and slug numbers.
4. Bran bait mixed with maldison can be used to control wingless grasshoppers.
5. Baits of cracked wheat, sunflower oil and chlorpyrifos can be used to control some soil insect pests and European earwig.

Example - Soil borne pest

(Learmonth, 2001)

White-fringed weevil is a serious soil borne insect pest, the larvae of which damage potatoes and can render a crop unsaleable. Monitoring for the presence of white-fringed weevil adults in the summer before planting will help determine whether it is necessary to fumigate the soil prior to planting. The recommended monitoring procedure is to conduct six 30-minute searches of the pasture at 3-4 week intervals during the summer period mid-December to May. Inspect green grassy patches and random points on dry pasture. If no adult weevils are observed over this period, it is a good indication that the paddock is not infested and in this situation fumigation is not required. If several adult white-fringed weevils are found in any one search, this is an indication that unacceptable weevil damage may occur. Inspection of the soil for larvae by taking 100 shovelfuls of soil from the paddock in winter before planting, is recommended as a final precaution. If no weevil larvae are found, soil fumigation should not be necessary.

**□ Obtain expert assistance in crop monitoring to gain a sound practical knowledge of insect behaviour in the crop.**

Knowledge of the basic biology of the pests that affect crops and at what stage of the life cycle they should be treated enables more effective control.

**□ Know the life cycles and basic biology of pest species.**

The majority of organisms are not pests, in fact most are beneficial in that they prey on or inhibit pest and disease organisms. Field guides are available for the correct identification of pests, diseases and beneficial insects in vegetable and potato crops. Examples are:

Heisswolf and Brown, (1997).

Donald *et al*, (2000).

Llewelyn, (2000).

**□ Be able to identify pest and beneficial species.**

With this knowledge, growers can undertake the regular monitoring of pest and predator populations in their crops and determine when intervention may be necessary. As the grower gains experience, inspections may be less frequent, concentrating on the critical times in the insect's growth cycle and during periods of unseasonable weather conditions.

**□ Monitor the crop regularly for pests and diseases.**

Pests do not respect property boundaries. Growers need to know what pests are occurring in the area and what measures are being taken to control them.

**□ Participate in pest monitoring networks, communicating with other growers in the area to ensure a coordinated approach to pest control.**

Such a strategy could be used to coordinate spraying of wild radish, which is a serious weed and host plant for many pests of brassica vegetables.

**Spray strategies based on 'economic injury' thresholds**

Traditionally, many growers have formed the habit of spraying pesticides according to a pre-set program. This practice entailed many unnecessary applications of pesticides, as breeding dynamics vary from season to season and site to site and the pests are not always a problem at the pre-set times. The consequences were increased risks of harm to the environment, pest resistance and destruction of beneficial species. For these reasons, pre-set spraying programs are no longer acceptable and are not necessary.

**□ Do not spray to a pre- set program.**

A fundamental principle of IPDM is for the grower to be content to allow pest populations to exist at levels that do not exceed the 'economic injury level'. This is the threshold level that will cause damage, in monetary terms, in excess of the value of the control measures. Today's vegetable and potato growers need to be aware of market quality specifications and the levels of damage that are acceptable with minimal downgrading for loss of quality.



- Consider the use of pesticides as a last resort, when the economic injury level of a crop is likely to be exceeded and there are no feasible biological control methods available.**

For organic growers, spraying of all but natural and some mineral formulations is not permissible. They must rely on physical and biological controls and hope that reductions in yield and quality incurred by pest invasions will be compensated for by the higher price received for the organically grown product.

### 7.3 Control weeds and invertebrate pests by timely physical, biological and chemical means

In many cases the old adage ‘a stitch in time saves nine’ holds true with pest populations. The use of physical and biological control measures pre-planting or when a pest is first detected is always preferable to using chemical pesticides after pest populations have reached damaging numbers.

#### New weed threats

There are many examples of weeds, which cause serious damage to horticulture in other countries and the eastern States of Australia. One of the great advantages of Western Australian horticulture is that most of these weeds have not become established here and grower vigilance can prevent this from happening.

- Be vigilant for new noxious weeds and report their occurrence to the Department of Agriculture immediately.**

The serious weeds listed below pose particular threats to our industry as they have caused serious economic damage to horticulture overseas and in some areas of Australia.

#### Inter-rotation crops for weed control

Weeds such as wild radish can be a real problem when coming out of a weed infested pasture phase. Many weed species have seed dormancy of more than one year and do not seed or germinate evenly, making their control during the vegetable cropping operation particularly difficult.

- Planting a break crop is a good practice to reduce risk of weed competition in the vegetable or potato crop.**



*The parasitic weed, Orobanche (broome rape), in a carrot crop.*

#### Examples

Monitoring for diamondback moth numbers during the growth of brassica crops is essential to ensure that the crop is protected and that spraying is cost effective. In the Manjimup area, professional crop scouts are paid to monitor diamondback moth numbers. Moth numbers decrease as summer progresses and it may cost more to spray low-density infestations at this time than can be justified by the small gain in product harvested.

Examples of weeds threats that occur in Western Australia and would cause serious damage if introduced to vegetable and potato growing areas.

- Orobanche
- Small-seeded dodder
- Mimosa bush
- Ragwort
- Skeleton weed
- Parkinsonia
- Golden dodder
- Mesquite
- Bathurst burr

The cultivation will kill a large portion of the weed population and more will be killed by competition from the fast growing cereal crop, greatly reducing numbers of viable weed seeds left in the ground. Break crops have added benefits when lightly mulched in, providing soil stability and increasing soil organic matter. Money saved in weed control and the soil health benefits gained are almost certain to exceed the cost of growing a break crop and any grazing value that may be foregone.

### Treating weeds

It is far easier to remove a few weed plants when they are first seen on the property than to wait until a full-scale control effort is necessary. This is particularly true of persistent species with long seed dormancy such as doublegees or Patterson's curse.

- Where a few weeds are found, pull or spot spray them by hand before they have seeded.**

Pre-planting weed control measures such as cultivation or spraying with pre-emergent herbicides are far preferable and less costly than attempting to treat a weed population in a crop. Control of large weed populations in vegetable and potato crops is very difficult and usually uneconomic once the plants are more than 10 cm in height.

- Control emergent weeds when they are very small, by selective herbicides, mechanical or hand weeding, flaming or weeding.**

Weeds in access ways and waterways should be controlled because they are a source of seed for further spread and also may harbour pest and diseases. In these situations, erosion is likely to be a problem and the area should remain vegetated.

- To control weeds in access ways and waterways, use the following alternatives:**

- **Mow or slash at or before flowering, leaving the mulch to protect the surface.**
- **Use selective herbicides instead of cultivation.**

### Preventing herbicide resistance

Herbicide resistance, the emergence of populations of weeds that are resistant to herbicides, is already a serious problem in some cereal cropping areas. Where spray-seeding has been practised for many years, resistant strains of rye-grass have emerged and it is no longer economic to crop some farms. In intensive vegetable growing areas where there is frequent use of herbicides, there is a high risk of herbicide resistance.



*A weed-free carrot crop on the Swan Coastal Plain.*

**To prevent herbicide resistance:**

- **Rotate the herbicide types used.**
- **Reduce frequency of herbicide application by considering physical alternatives such as mechanical weeding, cultivation and flaming.**

To achieve effective herbicide rotations it is necessary to carefully record when and what chemicals were used and what and where weed outbreaks occurred.

## **Biological control of invertebrate pests**

Biological control is the utilisation of predators, parasites, nematodes, fungi, bacteria and viruses to attack many insect pests. In an undisturbed environment, the numbers of pest insects and their natural enemies remain relatively stable. The abundance of any pest species depends upon the amount of food, the competition from other species and the number of predators.

Nearly all insect pests have natural enemies (termed ‘beneficial species’) and if the environment or their breeding habits can be manipulated to achieve a large population, they can control the pest.

**Use biological control as the first choice for early intervention against insect pests.**

### **‘Soft’ pesticides for control of invertebrate pests**

Beneficial species are those that predate, deter or compete with pest species. Most invertebrate species in the soil and crop are indeed beneficial. The repeated use of powerful, broad-spectrum pesticides may kill beneficial species along with the target pests.

‘Soft’ pesticides, those that are most specific and least toxic to beneficial species and humans, should always be considered before the more toxic, broad spectrum pesticides.

The major ‘soft option’ for spraying is the use of biological pesticides, commonest of which is *Bacillus thuringiensis*, a stomach pathogenic bacteria which is non-toxic to humans and specific in its action against leaf eating caterpillars. Some chemicals are also specific in their action against certain insect pests. There are many others that are ‘predator friendly’, they do not harm beneficial species.

**Wherever possible, use the most pest specific pesticides, that is biological pesticides or those labelled ‘predator friendly’.**

## **The spray diary**

Keeping a spray diary enables growers to refer to prior actions and results to:

- Identify the most specific, least toxic pesticide and the minimum quantity required for control of the target pests.
- Improve the efficiency and cost effectiveness of their pesticide use.
- Review suitability of chemicals for future applications.
- Prevent build-up of pesticide resistance in the pest species.

#### Example

A predatory mite can be obtained and introduced against the pest two spotted mite in strawberries.

#### Examples

1. *Bacillus thuringiensis* (Bt) sprays are an important part of strategies to control leaf eating caterpillars such as diamondback moth (RIRDC, AGWEST, 1999). Bt sprays are recommended to control diamondback moth during early growth of brassica crops, when the moth larvae (grubs) are small. For control in mid to late crop stages, rotating spraying with different chemical insecticides minimises the risk of the insect developing resistance to a chemical. Use of extremely toxic organophosphate insecticides such as Mevinphos can usually be avoided.
2. Pirimicarb is the best chemical to use against aphids as it does not affect beneficial insect species (Learmonth, 2000).

- ❑ **Maintain a detailed spray diary and record in it:**
  - **Pesticides used, rate of application, cost.**
  - **Date of spraying.**
  - **Crop sprayed, crop growth stage and crop vigour.**
  - **Effectiveness of the treatment.**
  - **Other factors that can influence the effectiveness of a control measure, such as weather conditions, site history of the pest.**

### **Insecticide resistance management**

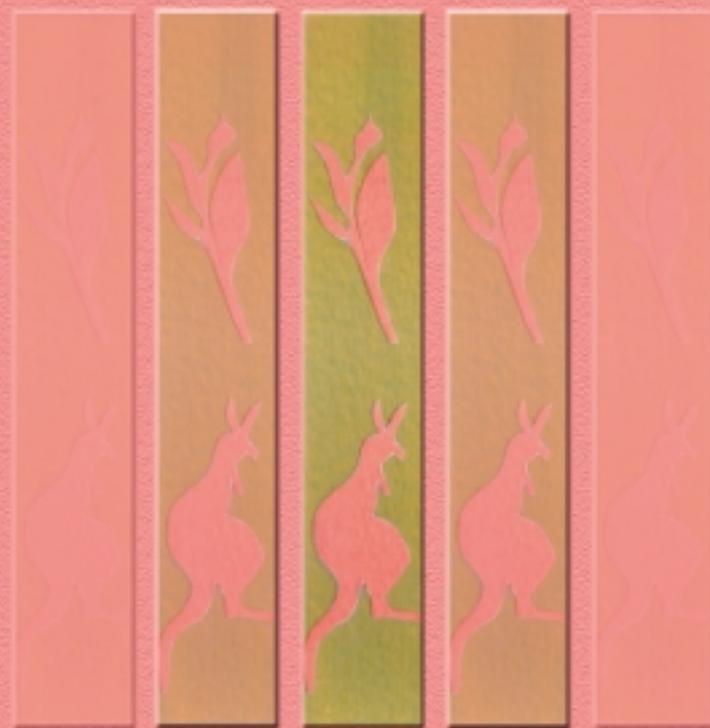
If one group of insecticides (or indeed any other pesticides) is used excessively, pests may build up resistance to those chemicals. Spray diary records enable the grower to follow a resistance management strategy.

- ❑ **Implement insecticide resistance management strategies.**
  - **Minimise the use of insecticides by Integrated Pest and Disease Management.**
  - **Use insecticides from different groups in rotation.**



*Healthy potato plants indicate that the IPDM strategy is working.*

# SECTION 8



## Maintaining our Native Flora and Fauna



# Maintaining our Native Flora & Fauna

## **Expected environmental outcome:**

***Local natural ecosystems and their native flora and fauna are conserved or enhanced.***

In Western Australia, there is a pressing need to protect native flora and fauna from the impacts of agriculture. In the South West particularly there is an exceptionally high level of species diversity, with many species restricted to small areas (localised endemism). Western Australia has signed a national strategy committing the State to conserve its natural biodiversity as well as complying with the recently introduced *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) which came into force on 16 July 2000. The Act enables the Commonwealth to join with the States and Territories to provide a national scheme of environment protection and biodiversity conservation.

In Western Australia our natural biodiversity is currently not well protected. Many areas have never been properly surveyed but, when they are, previously undiscovered species and occurrences of rare species are often found. In regions that are extensively cleared, reserves are not adequate for conservation. In some shires where horticulture is practised, very little land is in reserves, for example only 2% of land in Rockingham, 6% in Cockburn and 17% in Swan is protected in reserves (Agriculture Western Australia, 1999). Periodic studies have shown that a number of vegetation communities are poorly represented in these reserves. We still have a poor understanding of processes that threaten native flora and fauna, and find that in the coastal plain even the larger reserves are still losing species.

To conserve native flora and fauna, both species and their habitats need to be protected and maintained. Issues arising with management will differ from district to district. Even on one farm, a range of ecosystem types may exist, with each requiring a different management strategy. Landcare or Bushcare groups exist in most districts. One of their main roles is to obtain advice and funding to take effective action to rehabilitate streams and native vegetation. Farmers seeking help with these issues are encouraged to join.

All reasonable and practicable measures should be adopted to apply the following four principles:

- 8.1 Manage remnant vegetation on the farm to enhance its quality.**
- 8.2 Conserve and enhance the native plant and animal species in local natural ecosystems.**
- 8.3 Control weeds on farm and adjacent road verges.**
- 8.4 Control feral animals.**



## 8.1 Manage remnant vegetation on the farm to enhance its quality

Native vegetation on the farm has many benefits for horticultural growers. Some useful functions that healthy native vegetation can provide to the farmer are:

- Drought tolerance. Some native species can survive in rocky areas with shallow soil.
- Deep-rooted native vegetation can help lower water tables thus reducing waterlogging and the risk of salinity, when planted strategically.
- Windbreaks of native plant species, if located correctly, can improve crop productivity.
- Native plant species planted along stream banks and around wetlands control stream bank erosion and trap nutrients and chemicals.
- It can function as a buffer between different land uses.

However, native vegetation will not remain healthy and continue to perform useful functions unless some care is taken to manage it.

### Fencing native vegetation

Constructing appropriate fencing around native vegetation is essential to reduce the amount of grazing allowed by animals.

- ❑ **Fencing to exclude stock is the first measure that should be taken to allow remnant native vegetation to regenerate naturally. It is important to maintain access for weed control and fire management.**

Part funding to fence remnant vegetation is available through the Remnant Vegetation Protection Scheme (contact Department of Agriculture) and the Bushcare program (contact Department of Conservation and Land Management or local Community Landcare Coordinator).

### Managing native vegetation

It is much easier to properly manage existing native vegetation and keep it in a healthy condition than to replant or rehabilitate it after it has died off or become weed infested.



*Riparian and remnant native vegetation provides a refuge for native fauna species.*



## SECTION 8

### Example

The Peel-Harvey and Scott Coastal Plain catchments drain through sensitive wetlands and estuaries, which have valuable conservation, tourism, fishing, residential and recreational uses. Horticulture development applications in these catchments require up to four levels of government assessment due to requirements to minimise movement of nutrients into wetlands and estuaries. Some horticultural developments on the Scott Coastal Plain have been allowed to proceed on condition that:

- Development plans showing appropriate buffers, drainage, nutrient stripping areas, streamline protection and revegetation were approved by government agencies.
- Acceptable fertiliser and soil conservation strategies are adopted.
- Water sampled and monitored regularly at the farm boundary and in bores is of acceptable quality.
- Continuation of the water licence is dependent on the development conditions being met.

- ❑ **The following measures, if undertaken appropriately, can keep native vegetation healthy and protect native fauna.**
  - **Minimise disturbance of healthy native bush.**
  - **Plan the timing and intensity of control burns to maintain or increase the diversity of native plant species.**
  - **Control introduced weed species in the native vegetation area.**
  - **Control the numbers of feral animals within the native vegetation area.**
  - **Plant native under-storey species along stream and water body buffers and windbreaks to encourage native fauna.**

### Revegetating unproductive areas

Rehabilitation and reclamation of degraded areas is beneficial for the reasons stated under 8.1 above. The farm plan should include establishing native vegetation on unproductive areas. This can be done with minimal loss of productive land.

- ❑ **Where possible, revegetate unproductive land to become part of a windbreak and wildlife corridor system on the farm.**

### 8.2 Conserve and enhance the native plant and animal species in local natural ecosystems

Natural ecosystems adjacent to the property can be greatly affected by vegetable and potato growing. Activities such as vegetation clearing, pesticide spray drift and incursion of feral animal and weed species have had a significant impact on the surrounding native flora and fauna.

#### Buffer areas

- ❑ **Where properties are located adjacent to sensitive natural ecosystems, leaving fenced vegetated buffers of appropriate width around them is of prime importance.**

Conservation and management of existing native vegetation in and adjacent to the horticultural farm should be included in the farm plan where appropriate (Section 1.2).

### 8.3 Control weeds on farm and adjacent road verges

Many weeds have a detrimental effect on native vegetation as they compete for the same resources of water, light and nutrients. Some weeds (termed environmental weeds) are highly aggressive and have the ability to smother native vegetation and waterways if left unchecked.

- ❑ **To control weeds in native vegetation:**
  - **Select herbicides, wetting agents and application rates carefully to minimise impacts on non-target species.**
  - **Treat weeds at the optimum time to minimise the rate of herbicide application required.**



- **Replace weeds with native vegetation. It is most important that treated areas are revegetated with native species to prevent re-invasion of weeds.**

Road verges can have a significant environmental value. Many verges still retain native vegetation and act as buffers and wildlife corridors.

- ❑ **Growers are encouraged to work with their neighbours, landcare group or local shire to ‘adopt a verge’ or ‘adopt a stream’ in or near their property, which involves helping to control weeds and maintain native vegetation in it.**

### **Aquatic weeds**

Some declared species of aquatic weeds are banned throughout Western Australia. These include salvinia, water hyacinth, senegal tea, alligator weed and horsetails. There have been several recent finds, mostly around Perth but some as far afield as Kununurra and Albany.

These weeds all have the potential to block waterways and pose a serious threat to irrigation channels. A common feature of all these weeds is their ability to spread rapidly and form a dense mat above or below the water. This mat stops light entering the water and depletes the water body of oxygen. Fish and other creatures will die and all the native plants will be shaded out.

- ❑ **Protecting agriculture and the environment is everyone’s business. Report any suspect declared plants to your nearest Department of Agriculture office.**
- ❑ **Declared aquatic weeds must not be kept or sold, and must not be imported. If you have any of these plants in a pond or aquarium, they must be destroyed.**

### **8.4 Control feral animals**

Feral animals can have a devastating impact on native vegetation through trampling, grazing and destruction of vegetation through burrowing. They can also devastate native fauna indirectly by impacting on their habitats and directly by killing them, particularly small mammals.

It is therefore necessary to control the access and numbers of feral animals such as foxes, rabbits, and feral cats, dogs, pigs and goats on the farm. Humane ways of controlling feral animals are outlined in Section 8.4 of the BEMP Manual. Further advice can be obtained from the local Department of Agriculture District Protection Officer or Department of Conservation and Land Management (CALM) Wildlife Officer.

- ❑ **It is recommended that the following measures be taken to control feral animals:**
  - **Bait foxes in liaison with neighbours, Department of Agriculture and Department of Conservation and Land Management.**
  - **Control rabbits by destroying burrows and poisoning.**
  - **Control feral dogs, cats and pigs by baiting, trapping or shooting.**
  - **Watch for new introduced pest species such as sparrows and starlings and report sightings to Agriculture Protection officers immediately.**



- **If control of native animals such as ring-neck parrots or kangaroos is necessary, use deterrents, netting or fences, or cull as a last resort with permits from Department of Conservation and Land Management.**

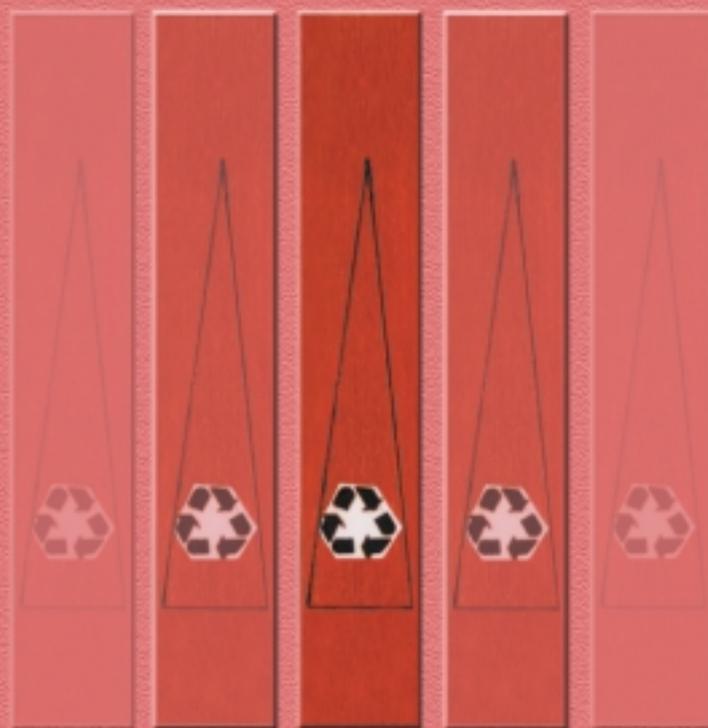
The most effective fox control can be achieved during late winter and spring when food demands are high as foxes are rearing their young. Rabbits are most effectively controlled in late summer when rabbit numbers are already low and feed is limited. Baiting is best done in cooperation with neighbours, for example many landcare groups coordinate an effort to bait a whole area at the optimum time each year.

Baiting with 1080 is the main effective means of baiting feral animals in most situations. When approved, landholders may lay 1080 baits themselves. However, the baits must be specially manufactured and can only be purchased by obtaining a voucher from a Department of Agriculture District Protection Officer, who conducts a risk assessment of the area before giving approval for baiting. Many native animals have a high level of tolerance to 1080 but domestic stock and pets are very susceptible and are likely to die if they ingest it.



*Wetland surrounded by a vegetated buffer – a valuable flora and fauna area.*

# SECTION 9



## **Waste Management**



# Waste Management

## Expected environmental outcomes:

- *Minimal wastes and pollutants generated from farming activities.*
- *No pollution of the environment due to the disposal of wastes.*

Large quantities of packaging are brought onto today's large-scale vegetable and potato farms. It is not uncommon for large growers to use more than fifty 20-litre containers of farm chemicals in a year. Added to this are wastes such as disposable plastic containers, wrappings, plastic sheeting used for surface mulches and plastic irrigation pipe.

This section outlines practices for waste minimisation by recycling and reuse. All reasonable and practicable measures should be adopted to apply the following principle:

### 9.1 Reduce, re-use and recycle wastes where possible.

#### 9.1 Reduce, re-use and recycle wastes where possible

Many waste materials, which have the potential to pollute the environment, are generated during modern horticultural operations. These wastes fall into three categories:

1. Residual farm chemicals, for example residues left in empty containers and on spraying equipment.
2. Solid non- biodegradable wastes, for example empty chemical containers, plastic wrapping, plastic mulch and plastic irrigation pipe, scrap metal.
3. Biodegradable wastes, for example crop residues, manures, and domestic putrescible wastes.

All of these wastes can be managed so that they will not pollute the environment, by using the recommended practices described below.

### Used chemical containers

Chemical residues left in containers have the potential to poison stock, contaminate food products or pollute water bodies. All farm chemicals are now packaged in either recyclable or re-useable containers or water-soluble packs that dissolve in the spray tank. Burning chemical containers can produce toxic gases and particulates, which cause air pollution and pose a health threat to those living or working on the farm and to neighbours. ***Do not burn any chemical containers. This practice is illegal.***

Plastic materials will not break down in the soil and chemical residues may contaminate groundwater. ***Avoid burying empty chemical containers on the farm.***

If rinsed and recycled, chemical containers do not pose a threat to the environment.

- Triple rinse all used chemical containers. Return the rinse water to the mixing tank.**

There are adequate facilities available for growers to recycle their used chemical containers. The DrumMuster program has collection points in most South West areas and the shires provide details of the local collection venues. Some suppliers of large containers of farm chemicals now offer a return packaging policy for their re-useable containers.

- Recycle all rinsed chemical containers by either returning them to the manufacturer or depositing them at a DrumMuster collection point.**

### Disposing of residual chemicals, oils and dip solutions

Many growers have containers of residual chemicals that can no longer be used because they are either out of date, no longer registered for use or unidentified. These pose a threat to human health and the environment, particularly if they are in unlabelled or corroding containers.

#### To avoid having left-over chemicals:

- Only purchase enough of the chemical for the job you have to do.**
- Avoid mixing more spray than is required. Systems that automatically inject the pesticide into the spray line are recommended.**

Residual pesticides and other farm chemicals that can no longer be used should not be kept on the farm and particular care needs to be taken in their disposal. The only safe way to dispose of them is through the ChemCollect™ scheme.

- Place containers of residual chemicals in larger leak proof containers for safe storage and transport. Keep them in a locked chemical shed until they can be taken to the nearest ChemCollect™ venue for disposal.**

ChemCollect™ is a scheme for the safe collection of residual chemicals. Enquires may be directed to local government authorities or the Department of Environmental Protection (DEP) for details of collection points and times.

The Code of Practice ‘Disposal of Pesticide Residues from Pesticide Spray Applications’ by the Health Department of Western Australia offers practical advice to pesticide users.



*Dumped chemical containers – poor practice.*



Burning of oils is not acceptable as toxic air pollutants are produced. Neither should used oils be emptied onto the ground as they pollute soil and water for long periods of time. Used engine oils may also contain contaminants such as metal particles, heavy metals, fuel, rust and carbon.

- ❑ **Store used engine oils in leak proof containers and deposit these at places with approved receptacles for recycling used oils such as service stations or refuse and recycling centres.**

Dipping solutions are sometimes used to treat vegetables, for example where quarantine conditions for export require this to be conducted. Dipping solutions are much lower in concentration than dip concentrates but can still pose hazards to the environment and operators. They should not be emptied directly onto the ground. Various pre-treatments can be used to deactivate the chemicals. Commonest of these is hydrated lime but this is not suitable for all dip chemicals. Growers should refer to the label, MSDS sheet for the chemical, Section 9.1 of the BEMP Manual or contact the regional Department of Environmental Protection office if more information is required.

- ❑ **Approved practices for disposal of dip solutions are:**

**Pre-treating the solution and spreading it onto pasture or cereal crop, where it will be biodegraded naturally. Avoid grazing the pasture for 28 days.**

**Or**

**Store in a safe chemical storage tank for collection and off-site disposal by an approved hazardous waste contractor.**

### **Disposal of plastic and other solid wastes**

Experience throughout the world has shown the persistence of plastics, usually empty plastic containers. Every effort should be made to ensure these wastes do not enter the environment.

Some intensive vegetable production systems, for example growing strawberries and melons, result in significant volumes of waste plastic sheeting and irrigation tubing. Most plastics, such as the polythene used for agricultural plastic sheeting and irrigation tube, do not degrade and take up large volumes in landfill sites. They are classified as hazardous wastes in some States. Low temperature (open air) burning of plastics is illegal. Currently the best option for disposal of plastic waste is recycling. Biodegradable plastic mulches, which can be ploughed in and break down in the soil, are being developed (HRDC, 2001).

- ❑ **Separate plastic wastes into their plastic groups. Press and bale the waste using a commercial baling unit. In some cases, hay balers can be used. Deposit the bales at one of the many recycling depots provided by local government.**
- ❑ **Use biodegradable plastic mulch products when they become commercially available.**

Scrap metal waste has a lasting negative aesthetic impact when dumped in the environment. This is unnecessary as many scrap metals have an economic value.



- ❑ **Separate scrap metals into metal groups and either re-use on farm, deposit at recycling depots or have them collected by scrap metal companies.**

The lead contained in batteries is a toxic heavy metal that can contaminate land and water resources, resulting in poisoning of stock and native fauna. Lead can be absorbed through the human skin. Batteries should not be buried or mixed with other wastes. Lead can easily be recycled.

- ❑ **Use the facilities provided by local government or scrap metal companies to deposit batteries for recycling.**

### **Disposal of plant, putrescible and domestic wastes**

Discarded vegetables or other green wastes placed in a rotting heap are a potential source for fly breeding and vermin. Some domestic plant wastes can shoot and have the potential to become weeds within areas of native vegetation. Green wastes buried in landfill produce methane, which is a powerful greenhouse gas (Section 10.3). Both of these practices should be avoided.

- ❑ **The best practice options for disposal of green wastes on farm are:**
  - **Vegetable wastes and crop residues can be chopped up, spread in the paddock and incorporated lightly into the soil.**
  - **Green wastes are readily composted under controlled conditions and the compost may ultimately be returned to the soil.**

Domestic wastes are often a mixture of paper, plastic, metal and putrescible waste that is difficult to sort but requires regular disposal.

- ❑ **Where possible, use local government refuse and recycling facilities to dispose of domestic waste. In situations where this is impracticable, the alternative is to bury it on the farm at a suitable site. The water table should be more than 3 metres from the surface, the site should be well away from waterways and wetlands and preferably within clay sub-soils.**

## Disposal of wastewater

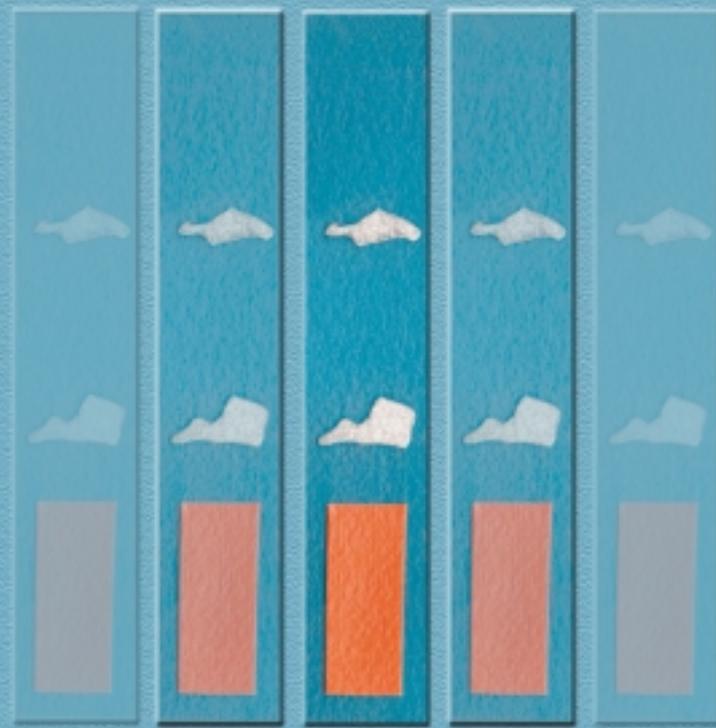
Wastewater includes contaminated water and drainage from processing or storage sites. It may contain contaminants such as pathogens, pesticides and high levels of nutrients and chemicals. The Water and Rivers Commission outlines the correct treatment and disposal of wastewaters in the Water Quality Protection Note: 'Irrigation of vegetated land with nutrient rich wastewater' (Section 9.2 of the BEMP Manual).

- Drain wastewaters into impermeable storage/ treatment ponds and dispose by controlled on-site irrigation.**



*Treated liquid effluent can be irrigated onto paddocks.*

# SECTION 10



**Minimising Air Pollution**



# Minimising Air Pollution

## Expected environmental outcomes:

- *Airborne emissions minimised to levels that have no adverse impacts on surrounding environments.*
- *Practices and equipment that generate unacceptably high levels of greenhouse gases are not used where there are practical cost effective alternatives.*

Air quality is an important issue for the vegetable and potato industry. Machinery operators, neighbours and the adjacent environment can be adversely affected by excessive air pollution. Activities that create excessive dust, spray drift and odour affect air quality and should be restricted and conducted using best environmental practice. Where air pollution nuisances from operations give rise to complaints from neighbours, growers should be prepared to negotiate to arrive at mutually acceptable solutions.

The greenhouse effect is a serious environmental impact affecting all industries and indeed all individuals in the world today. Its consequence, global warming, has the potential to have more dire and widespread consequences than any other environmental issue.

All reasonable and practicable measures should be adopted to apply the following three principles:

### 10.1 Minimise spray drift from the application of pesticides.

### 10.2 Minimise impacts of dust, odours and flies.

### 10.3 Minimise emissions of greenhouse gases and ozone depleting gases on farm.

#### 10.1 Minimise spray drift from the application of pesticides

The necessity of spray application of pesticides in modern horticulture is widely recognised. However, conducting best practice in pesticide spraying is of prime importance to human and environmental health. Many pesticides are toxic to humans and other living organisms at extremely low concentrations and can persist in the environment for sustained periods. Minimising spray applications by applying a pesticide only if economic thresholds warrant an application is also basic practice to minimise the total off-site impacts of pesticides (Section 7.2).

#### Selecting equipment and nozzle types

High volume mist sprayers pose a high risk of spray drift and should never be used in wind velocities likely to cause spray drift that could affect the sprayer operator or other staff working in the vicinity or off-site situations.

All nozzles produce a range of droplet sizes. Some spraying equipment produces large amounts of very fine droplets below 100 - 150 microns, which are the main cause of spray drift. A droplet size in the range 300 - 500 micron will ensure good coverage and minimise spray drift. The small, drift-prone particles cannot be eliminated but they can be reduced and kept within reasonable limits.

- ❑ **Select suitable equipment and operate it properly to minimise spray drift, for example (Schulz, *et al* 2001):**

- **Avoid using nozzles that produce large amounts of very fine droplets under 150 microns.**
- **Use drift reduction nozzles where possible, for example, nozzles that produce bubbles that burst and produce fine droplets only when they contact the crop.**
- **When using conventional boom sprays, operate the boom at a low height and keep it stable.**
- **Keep travelling speed below 8 km/hour.**
- **Use shielded booms and shroud covers when band spraying, especially for operations near residential areas.**

### Setting up spray equipment

Spray equipment can be set up to reduce the amount of over-spray and spray drift that may lead to off-site contamination. All sprayers need to be calibrated, with trial runs (using water) to ensure the rate of application is even and correct before application of chemicals commences.

- ❑ **Avoid using high operating pressure as it creates finer droplets and more spray drift. The recommended maximum for conventional broadcast spraying is 40 PSI (276 kPa) and they can usually be operated at 25-35 PSI (172-240 kPa).**

### Following directions for use of chemicals

Surveys indicate that approximately 65% of the drift complaints involved application procedures in violation of the directions on the label. Instructions on the pesticide label are given to ensure the safe and effective use of pesticides with minimal risk to the environment. Each pesticide is registered for use on specific sites or locations and this information is given on the label. It is important to read and follow these instructions.

- ❑ **It is important to use pesticides and spray additives within label guidelines.**

Spray additives include surfactants, which influence droplet size and pesticide effectiveness, and wetting agents, which have been shown to reduce spray drift.

Non-volatile chemicals are much less likely to cause spray drift. Information on volatility can be found on the Material Safety Data Sheets.

- ❑ **Use low or non-volatile pesticides in preference to volatile types.**



*Spraying cauliflowers with a boomspray.*



*Spray-nozzle selection is important.*

## Weather conditions

Spray drift is minimal when wind velocity is under 15 km/h if appropriate equipment is used.

- Avoid spraying when wind speed is greater than 15 km/h or blowing towards sensitive crops, gardens, dwellings, livestock, water sources or wetlands.**

Temperature inversions sometimes occur on still mornings when cold air forms a layer near the ground, preventing the normal upward dispersion of air pollutants. These can keep spray drift close to the ground where it is most likely to affect people in the surrounding area.

- Avoid spraying in conditions where temperature inversions exist.**

## Aerial spraying

Of all spray application methods, aerial spraying presents the greatest risk of spray drift. Aerial spraying in inappropriate weather conditions or using poor practice can cause airborne contamination up to kilometres from the site of application.

- Do not conduct aerial spraying unless weather conditions are optimal.**
- Be aware of those pesticides for which regulations prohibit aerial application.**

## 'Sprayplans' and 'Spray Drift Awareness Zones'

(Department of Agriculture, 2001).

Some areas are particularly sensitive to contamination by some chemicals and high priority should be given to avoiding off-site chemical contamination of these areas by spray drift.

- Prepare a 'Sprayplan' for all routine spraying operations, as part of your farm plan, identifying and mapping all sensitive areas such as residential or public areas, aquaculture dams, sensitive wetlands, remnant vegetation, crops and buildings in the vicinity of the property.**
- Ensure that the operator has an up to date copy of the 'Sprayplan' before each spraying operation.**
- Adopt the concept of a Spray Drift Awareness Zone (SDAZ).**

The SDAZ is a zone for consideration of impacts of spraying operations. It could extend up to 1 km for ground spraying operations or well beyond that distance for aerial spraying. The following are some factors that should be considered within SDAZs:

- Method of application. Aerial spraying may have impacts kilometres away. Ground application where hooded drift reduction nozzles are used may not have impacts more than 20 metres from the operation.
- The nature of the sensitive environment, for example, an A-class wetland bird breeding reserve or a residential area would require maximum precautions.
- Toxicity of the chemicals to the particular sensitive environment. For example, pyrethroids should not be used where spray drift may contaminate aquaculture ponds and any spray drift over residential areas would be unacceptable when spraying organophosphate pesticides.

## Duty of Care

- ❑ **All spray operators have a duty of care to minimise air pollution, including:**
  - **Being properly trained to conduct spraying.**
  - **Not undertaking tasks known to be illegal or unsafe.**
  - **Ensuring that spraying is done according to the spray plan.**
  - **Notifying neighbours and erecting signs where there is risk of spray drift.**

## Hormone herbicides

Hormone herbicides have the potential to damage surrounding sensitive crops by spray or vapour drift. Regulations restrict the use of some hormone formulations within a five km radius of vineyards or tomato gardens. An outline of these regulations and list of the various hormone herbicides can be found in Section 6.1 of the BEMP Manual.

- ❑ **If using hormone herbicides, ensure that this is conducted in accordance with the Agriculture and Related Protection (spraying restrictions) Regulations 1979.**

## 10.2 Minimise impacts of dust, odours and flies

Dust and odours and flies from poorly managed vegetable and horticulture often evoke complaints from near neighbours. This is not surprising, as these nuisances are likely to result in health problems, especially in aged or sensitive individuals.

### Dust

Most dust problems are from on-site machinery operations and vehicle traffic on unsealed farm tracks. For the health and welfare of humans and other sensitive environments, dust should be kept at a minimum.

- ❑ **Practices to minimise dust problems include:**
  - **Avoiding cultivating at high speeds when the soil is dry.**
  - **Driving at moderate speeds especially on unsealed roads.**
  - **Vegetated screening buffers.**
  - **Irrigate bare cultivated soils during windy conditions.**

Wind strengths and directions should be observed, to determine the likely directions in which dust will be blown. Vegetation screens are an important part of dust control and their location will be determined by the orientation of buildings, prevailing wind direction and proximity to neighbours.

### Odours and flies

Burning of plastics and other solid wastes produces smoke, which is a nuisance to neighbours and often contains toxic air pollutants. It is known that certain toxins produced from burning plastics can remain in the human body for long periods of time and that some of these, such as dioxins, are carcinogenic. These wastes should never be burned and there are disposal alternatives (Section 9.1).

#### Example

The Department of Environmental Protection has set a guideline minimum separation distance of 500 metres between vegetable and potato growing operations and residential development in areas zoned residential.



Manures are useful organic fertilisers as they are good sources of nutrients and provide organic matter for the soil. However, pig and poultry manures are common sources of odours and breeding places for flies when used in their raw form.

❑ **Treat manures to eliminate odours and flies by either:**

- **Composting with other organic wastes to give the required carbon: nitrogen ratio for use as soil amendments.**
- **Transporting them to factories where they are dried and granulated to produce organic fertiliser products such as Dynamic Lifter™.**

Care should also be taken to prevent wastes such as empty bags, paper and plastic wrapping from growing operations from being blown into surrounding areas and creating a litter problem.

❑ **Cover garbage bins and loads of potentially polluting materials such as garbage and manure.**

### 10.3 Minimise emissions of greenhouse gases and ozone depleting gases on farm

#### **What is the greenhouse effect?**

The greenhouse effect is caused by increasing levels of greenhouse gases in the atmosphere. These gases trap radiated energy from the sun within the atmosphere, gradually increasing average global temperatures. The results are detrimental effects on the Earth's climate, rising sea temperatures and rising sea levels. The greenhouse effect is becoming a major environmental issue of the 21st Century.

Climate modelling by CSIRO scientists predicts that the south west of Western Australia will be one of the worst affected areas. By 2070, average temperatures are predicted to be 1-5 degrees higher (depending on strategies adopted). Rainfall is predicted to be up to 20% lower, more erratic and with more rainfall and wind events. Even a one-degree increase in temperature will increase evaporation by 80 mm and more than double the number of severely hot days, which will have significant impacts on the horticultural industry (CSIRO, 2001).

The greenhouse gases are mainly carbon dioxide, methane and nitrous oxides. The main sources of greenhouse gases and their contribution to the total in Australia are (Australian Greenhouse Office, 2001):

- Burning fossil fuels for power generation (57%)
- Agriculture, from ruminant animals, nitrogen fertilisers and cultivation (21%)
- Burning fossil fuels for transport (16%)
- Industrial, waste and 'fugitive' emissions from coal oil and gas extraction (6%)

Land clearing makes an additional contribution equivalent to about 15% of emissions by converting carbon that was permanently stored in forests into carbon dioxide.

**Table 10.1 Relative effect of greenhouse gases**

Greenhouse gas	Formula	Source	Global warming potential relative to 1 tonne of CO <sub>2</sub>
Carbon dioxide	CO <sub>2</sub>	Burning organic matter in air	<b>1</b>
Methane	CH <sub>3</sub>	Anaerobic decomposition of organic matter	<b>21</b>
Nitrous oxides	NO <sub>x</sub>	Burning fossil fuels	<b>310</b>

Of the 49.3 million tonnes of CO<sub>2</sub> (equivalent) produced annually in Western Australia, 27% is emitted from the agricultural sector (Australian Greenhouse Office, 1998).

**Table 10.2 Source of greenhouse gas emissions from agriculture in Australia**

Source	% of total net emissions Australia
Livestock	13.7
Agricultural soils and burning vegetation (soils about 2/3 of this)	6.6
Fossil fuel use	Not available for agriculture
Rotting of manures and mulches	<0.1%

### Reducing greenhouse gas emissions on the farm

Horticultural operations are relatively large producers of greenhouse gases.

For vegetable and potato growing operations the main sources greenhouse emissions are:

- Nitrous oxides from nitrogen fertilisers.
- Methane and carbon dioxide from cultivation of soil and crop mulching practices.
- Consumption of fossil fuels by irrigation, other machinery and vehicles to produce carbon dioxide and nitrous oxides.
- Rotting of mulches and manures in piles that are not aerated, producing methane.
- Land clearing (if this is conducted).

Every effort should be made to minimise generation of greenhouse gases on farm. The practices used in several aspects of management of vegetable and potato growing operations greatly influence the quantity of greenhouse gases produced.

Nitrogen fertilisers produce nitrous oxides, which are 310 times more powerful greenhouse gases than carbon dioxide. The most important practices to minimise greenhouse gas emissions from vegetable and potato growing relate to management of nitrogen fertilisers:



- ❑ **Minimise quantity of nitrogenous fertilisers used and use best practice for efficient application** (Section 3).

- ❑ **Do not apply nitrogen to waterlogged ground.**

Good soil management reduces greenhouse gas emissions by increasing the soil organic carbon sink. A carbon sink is something that removes or stores carbon dioxide from the atmosphere. Soil organic carbon, forests and permanent native vegetation are large carbon sinks. Increasing the soil organic carbon content by 1% over one hectare would prevent over 10 tonnes of CO<sub>2</sub> emissions. Mulching of crop residues near the soil surface increases soil organic carbon, while improving soil health and minimising methane production.

- ❑ **Ensure that organic wastes are composted or mulched on or near the soil surface.**

Excessive tillage is to be avoided because it accelerates the rate of oxidation of soil organic matter thus producing carbon dioxide and methane.

- ❑ **Minimise tillage to maintain high soil organic carbon levels.**

Although most vegetable and potato growers are not usually involved in clearing land, revegetation is to be encouraged because it has the opposite effect to land clearing. Woody vegetation removes carbon dioxide from the atmosphere and converts it to wood, a carbon sink.

- ❑ **Avoid clearing woody vegetation and where possible revegetate with woody species.**

Fossil fuel usage is a major source of greenhouse gases on horticultural farms, chiefly from the operation of irrigation pump motors and tractors. A large operation with annual fuel usage of 60,000 litres is equivalent to running about 30 cars.

- ❑ **Reduce fossil fuel use by making irrigation, cultivation and transport as fuel-efficient as possible.**

Natural gas is more 'greenhouse friendly' than other fossil fuels. Petrol, diesel and coal produce increasing amounts of greenhouse gases per kilogram used. Conversion of engines to gas is to be encouraged particularly where properties have access to piped natural gas.

- ❑ **Where there are economic alternative energy sources consider the one with least greenhouse impact.**

Solar hot water systems are an economic option for domestic and industrial purposes and the only greenhouse gases produced are in the manufacture of the hot water system. Solar water heating can reduce fossil fuel consumption in a typical household by over 30%.

- ❑ **Use solar hot water and other renewable energy systems to supplement household and industrial requirements where possible.**

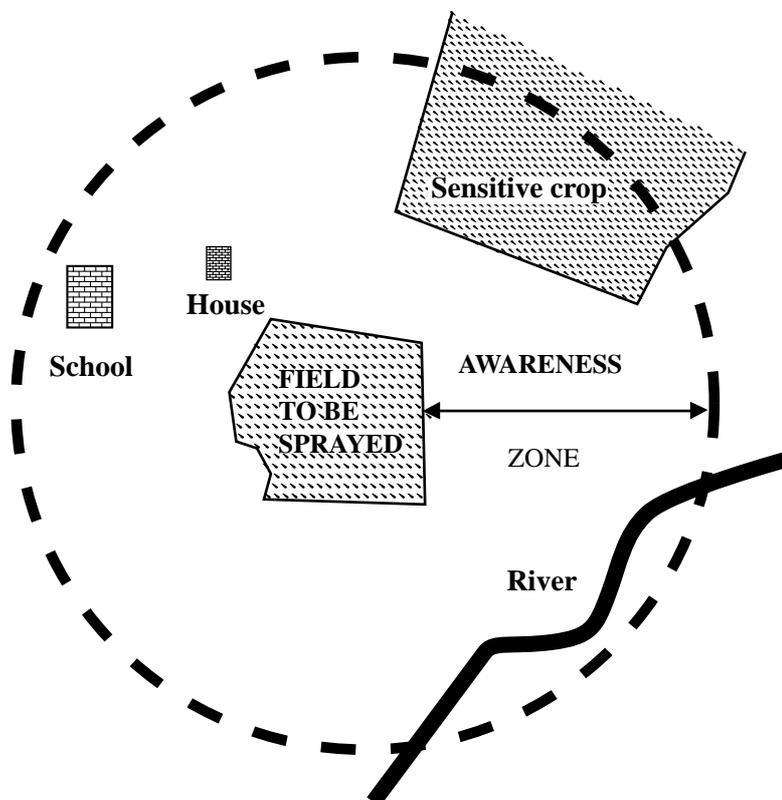
Bio-fuels are a 'renewable energy' source and are 'greenhouse friendly' fuels. There is the potential to set up commercial bio-fuel production from crop wastes and other renewable energy generation such as wind power and solar power on large farms and at packing or food production operations. Power generated at private premises can now be sold through the State power grid.

- ❑ **Current and future efforts towards on- farm production of renewable energy are greatly encouraged.**

### Ozone depleting gases

Emission of ozone depleting gases is another air pollution issue. These gases are mainly man-made chlorofluorocarbon chemicals produced in relatively small quantities for specific purposes, such as refrigerants. However, they have devastating effects on the atmosphere by destroying ozone and causing 'ozone holes' in higher latitudes, resulting in increased ultra-violet radiation reaching the earth's surface. This has severe negative health impacts on animal and plant populations, including higher incidence of skin cancers in humans.

- ❑ **Take old refrigeration equipment and fire extinguishers (the yellow ones) to licensed refrigeration technicians for degassing. They will store the ozone depleting chemicals for treatment and safe disposal.**
- ❑ **Methyl bromide fumigant is an ozone depleting substance and its use is prohibited.**



*Example of spray drift awareness zone, identifying sensitive areas.*



*Clean air and clean water – on both sides of the fence.*

# SECTION 11



## **Minimising Noise Impacts**

# Minimising Noise Impacts

## **Expected environmental outcome:**

### *Noise nuisance minimised*

Normal vegetable and potato growing practices are likely to create noise that may exceed the background noise level and prove annoying to householders residing close by. Noise from machinery, mechanical equipment and stock are a potential source of complaint from neighbours, particularly when the noise is generated at night. Farmers should be prepared to discuss with their neighbours any issues of noise emissions from growing operations and negotiate mutually acceptable solutions.

All reasonable and practicable measures should be adopted to apply the following principle:

### **11.1 Minimise noise impacts on neighbours.**

#### 11.1 Minimise noise impacts on neighbours

### **Noise impacts and site location**

Both the site selected and the layout of the farm will influence the level of noise nuisance.

#### **Factors to be considered in relation to noise when selecting a site are:**

- **Proximity of dwellings.**
- **Normal background noise from other sources.**
- **Topography, for example, sound travels a long way up valleys.**
- **The direction of prevailing winds.**

Background noise levels vary considerably from area to area. For example, background noise levels in parts of Wannon Shire will be relatively high due to road traffic and industry while in the Pemberton area background noise levels may be extremely low. In Wannon because of the higher background noise levels many people may be accustomed to or accept the intermittent noise from night-time activities in vegetable growing.

Most people accept reasonable levels of noise and odours generated by activities of their neighbours and will move into areas provided they are made aware of the nature of such activities. This acceptance could be formalised by an appropriate memorial on the titles of land holdings, such as new subdivisions adjacent to Areas of Agricultural Significance.

### **Farm layout and separation buffers**

Noise levels fall as the distance from the source increases. As an example, noise emissions from a typical tractor will be about the same as average street traffic, 85 - 90 dB(A) when measured at 7.5 metres from the tractor, and about the same sound level a close conversational speech, 50 - 55 DBE (A) when measured at 500 metres. At 500 metres, a noise emission from a tractor operating in a rural area will be clearly audible during the day and most likely be intrusive at night time.

A hill in the separation buffer will considerably reduce noise, whereas vegetation may have some moderating effect.

- When selecting a new location and when planning farm layout, consider the adequacy of buffers separating noise sensitive areas.**

### **Night-time activities**

The Environmental Protection (Noise) Regulations 1997 recognises the need for some farming activities to be carried out at night. Vegetable and potato growing operations are classified as rural premises under the Regulations and noise emissions from certain farming activities are bound by the requirements of the Regulations. Near residential areas, local by-laws relating to night-time noise also need to be complied with.

- Plan night time activities with appropriate care and consideration for neighbours and be aware of local government noise by-laws.**

On many rural operations night-time activities are occasional and thus can be tolerated provided noisy night-time activities are kept to a minimum. Gas guns and other means for bird scaring may generate intrusive noise in the early hours of the morning and their use should be avoided where neighbours could be affected.

### **Limiting noise from machinery**

It is important to ensure that all farm machinery and ancillary equipment meets the appropriate environmental and legal noise requirements. The noise from machinery such as fans and elevators may exhibit tonal components, frequency modulations or impulses and these will increase the annoying effect of the noise generated.

- Ensure that noise suppression devices are fitted on all noisy machinery according to the manufacturer's specifications. Maintain machinery especially noise suppression components to help minimise noise emissions.**

Where a problem with noise is evident, the vegetable and potato grower may need to seek technical advice on noise or sound level measurement from a suitably qualified person.

- Ensure that all machinery operators wear ASA approved ear-muffs or ear plugs for hearing protection when operating noisy machinery.**



*Irrigation pumps and tractors can create a noise nuisance to neighbours if due consideration is not taken.*

# SECTION 12



## **Genetically Modified Organisms**

# Genetically Modified Organisms

## **Expected environmental outcome:**

***No adverse impacts of genetically modified organisms on the environment and human health.***

Genetically modified organisms are a contentious issue in horticulture. On the one hand, they promise higher production and resistance to pests. On the other, there are questions about risks to human health and new varieties of ‘super weeds’.

The Western Australian vegetable and potato industry takes a cautious approach. All reasonable and practicable measures should be adopted to apply the following principle:

### **12.1 Prevent any adverse impacts of genetically modified organisms.**

#### **12.1 Prevent any adverse impacts of genetically modified organisms**

The Western Australian potato industry does not produce genetically modified varieties of potato. Breeding for eating qualities, pest and disease resistance is primarily conducted by conventional methods although there is research being conducted into genetically modified potato varieties as there is for most other food crops.

The Western Australian industry monitors the development of genetically modified potatoes globally. It recognises that significant advances in sustainable production may be made in future with genetic engineering.

- The Western Australian potato industry would not consider the adoption of genetically modified varieties unless all of the following conditions were met:**
- **Marketing of the variety is in step with community support.**
  - **State, national and international public opinion is favourable.**
  - **As with all genetically modified foods, whether locally produced or imported, any genetically modified potato varieties would be required by law to be stringently assessed and specifically labelled by the Australian and New Zealand Food Authority (ANZFA) which is the peak Australian body responsible for food safety and labelling.**

# SECTION 13



**Legislative Requirements  
for New or Expanding  
Horticultural Operations**

# Legislative Requirements for New or Expanding Horticultural Operations

## **Expected environmental outcome:**

*Approval for proposed or expanding vegetable and potato growing operations is in accordance with the prescribed legislation and regulations relevant to the industry.*

The information in this section is provided to assist those seeking approval for new or expanding operations. Table 13.2 shows the approvals needed and lists the government agencies that can provide advice.

The applicable legislation is outlined in Appendix 1 and a list of contacts for the relevant government agencies is included in Appendix 2.

Proponents for new or expanding vegetable or potato growing operations should contact the planning department of the relevant local government office at the earliest possible stage to discuss the proposed location of the development.

New and/or expanding vegetable and potato growing enterprises are subject to several approval processes, which are designed to ensure that the operation will be sustainable and that there will be no adverse impacts on other land uses and natural resources. When planning proposed developments, apply the following principles to seek statutory approvals:

### **13.1 Submit a horticultural development application.**

### **13.2 Obtain a license and, where necessary, statutory approvals to extract water.**

### **13.3 Obtain a statutory approval to clear land.**

## **13.1 Submit a horticultural development application**

A Horticultural Development Application (HDA) kit is available from the Water and Rivers Commission, Department of Agriculture or Department of Environmental Protection and contains guidance notes for seeking the necessary approvals.

The HDA kit contains applications for the clearing of native vegetation, and for abstracting groundwater and surface water for the establishment of a horticultural industry required by the various government agencies. The relevant forms should be completed then submitted to the appropriate agencies for consideration. The application may be rejected or approved, with or without conditions.

The following details should be included with the Horticultural Development Application:

- A locality map showing:
  - Areas of remnant vegetation.
  - Proximity of the property to wetlands, surface waters, drains or watercourses within 200 metres of the proposed development and wells or water reservoirs within 500 metres.
- A site map to scale showing:
  - Where the development is to be located, with lot numbers, road names and, where practical, contours and structures.



- Soil profile description and types.
  - Production bores.
  - Irrigation bores.
  - Native vegetation or bush to be cleared.
  - Areas to be replanted with perennial vegetation (specify whether native bushland or plantation trees).
  - Areas of waterlogging.
  - The size of the land holding on which the development is to be established or expanded and areas of initial and proposed growing operations.
- Identification of:
- Whether the proposed vegetable and potato growing operation is within a proclaimed Public Drinking Water Source Area.
  - Existing land uses within a 3-kilometre radius. Consult with local government planning officers about possible future changes in land use and strategies to identify possible future constraints.
  - Any Aboriginal archaeological sites or other cultural or scientifically significant areas.

Additional information may be required by the relevant decision making authority. Information on wetlands and Public Drinking Water Source Areas can be obtained from the Water and Rivers Commission. The Department of Aboriginal Affairs should be consulted for information on Aboriginal sites.

### 13.2 Obtain a licence and, where necessary, statutory approvals to extract water

Proponents considering drawing water from a well, lake or stream should contact the Water and Rivers Commission to find out their statutory obligations and if sufficient water is available. Approvals for drawing water from a well, lake or stream are necessary. Applications for a groundwater well or surface water licence are contained in the Horticultural Development Application kit.

Developments occurring within Underground Water Pollution Control Areas (UWPCA) need a permit application. A groundwater or surface water abstraction licence for development in UWPCA cannot be issued until a permit is issued.

The Peel-Harvey and Scott Coastal Plain Catchments drain through sensitive wetlands and estuaries, which have valuable conservation tourism, fishing, residential and recreational uses.

Horticulture development applications in these catchments require up to four levels of government assessment due to requirements to minimise movement of nutrients and chemicals into wetlands and estuaries.

#### **Separation buffers**

Materials including sediment (soil particles), nutrients and chemicals, salts, litter, agricultural chemicals and microbes from vegetable and potato growing activities



may contaminate water resources unless adequate separation distances are observed. These materials could be carried via surface run-off into waterways and wetlands and can also leach through the soil and contaminate groundwater.

Separation distances between growing operations and water resources are established for a number of purposes including:

- Protection from nutrient inputs that could lead to eutrophication. Separation distances provide barriers to slow down or limit the passage of contaminants during normal land use activities or as a result of chemical spills or similar emergencies (Table 13.1).
- Protection from increased salinity from the ingress of saline water.
- Maintenance of ecological processes and major food chains.

It is particularly important that adequate separation distances are established to protect any wells or reservoirs used for drinking water supplies and environmentally sensitive wetlands.

Well-vegetated strips such as native grasses and reeds, trees and woody debris, between the vegetable or potato growing operation and waterways, can filter out sediment and reduce contamination from nutrients and chemicals. The selection of appropriate vegetation to form strips between the vegetable or potato growing operation and alongside the waterway will determine how far sediments and nutrients are filtered. The Land and Water Resource Research Development Corporation have prepared a number of issue sheets for rivers and riparian lands and their management and restoration. These issue sheets cover topics such as managing riparian land, water quality, stream bank stability, river ecosystems and land-based ecosystems and can be accessed at the following web address.

[www.lwrrdc.gov.au/html/commissioned\\_programs/commissioned\\_programs.html](http://www.lwrrdc.gov.au/html/commissioned_programs/commissioned_programs.html)

Recent studies in Australia have shown that both natural vegetation and grassy filter strips can trap around 90% of the sediment moving from upslope land (Land and Water Resource Research Development Corporation). These strips can be equally effective in trapping or absorbing nutrients. It is recommended that prior to forming or restoring a vegetated filter strip, Water and Rivers Commission be consulted.

The separation distance required depends on the purpose of the buffer and should account for:

- Soil type and infiltration rate of the soil.
- Type and quantity of vegetation and how effective it is at stabilising ground.
- Slope of the land.
- Nutrient retention ability, for example Phosphorus Retention Index of the soil.
- Functions of the buffer, for example habitat protection, nutrient attenuation.
- Contaminant travel time (for groundwater systems).
- Intensity of land use development.
- Environmental values of the water resource (water quality range required to maintain current use, dependent ecosystems and ambient water quality attributes).



Separation distances may not always be a strip of set width along a watercourse or wetland. The distance should match the risk and needs of the local environment considering the above factors. Separation distances may vary on a case by case basis according to the proposed use, the environmental values and beneficial uses of the water resources. It is the responsibility of the proponent to demonstrate that proposed distances are sufficient to minimise the risks to groundwater and surface water bodies.

The separation distances outlined in Table 13.1 are recommended for new or expanding vegetable and potato growing operations proposed in the vicinity of water resources.

**Table 13.1 Recommended minimum separation distances for new and/or expanding vegetable and potato growing operations to sensitive water resources** (Water and Rivers Commission, 2000)

Water Resource	Separation Distance	Justification
Wetlands and estuaries (including conservation wetlands and wetlands resource enhancement)	200 metres	Recommended separation distance to reduce nutrient inputs and sediment transfer.
Bores, wells, soaks and dams used for private drinking water supply	100 metres	This separation distance has been set to protect water resources used for public water supply. Under the <i>Metropolitan Water Supply, Sewerage and Drainage Act 1909</i> by-laws, a minimum separation distance of 100 m is allocated.
Well used for public water supply	300 metres	This separation distance has been set to protect water resources used for public water supply. Under the <i>Metropolitan Water Supply Sewerage and Drainage Act 1909</i> by-laws, for Wellhead Protection Zones in Priority 2 and 3 public drinking water source areas, a separation distance of 300 m is allocated.
Banks of permanent streams and rivers	100 metres	Recommended separation distance to reduce nutrient inputs and control turbidity from potential sources.
Banks of natural water courses that flow intermittently	50 metres	Recommended separation distance to reduce nutrient inputs from potential sources.
Groundwater table (historical minimum depth of water table from ground surface)	1.5 metres	This separation distance has been recommended to reduce nutrient inputs from potential sources.



It should be noted that these values have been empirically derived and are thought to provide adequate protection of water resources, recognising the beneficial use of the resource. These are the Water and Rivers Commission recommended minimum separation distances in the absence of employing techniques to reduce the impact of the activity on nearby water sources.

The Water and Rivers Commission realises that in practice it may not be possible to achieve these buffers in all cases. Smaller buffers may be negotiated where environmental conditions and/or management techniques of the land use activity are favourable for water quality protection. In addition, the Environmental Protection Authority requires adequate separation distances for the protection of conservation wetlands, as part of the environmental assessment of project proposals.

Planners should also be aware that the planting of trees is not always an acceptable alternative to separation distance, as the trees harbour birds, which may cause severe crop losses and possible additional costs for netting.

Horticultural operations proposed within 200 metres of a wetland area should therefore be referred to the Water and Rivers Commission for appraisal. The Commission requires that adequate vegetated buffers be maintained between cultivated areas and wetlands, estuaries and streams to minimise the risk of degradation of water quality and ecology. Buffer widths can vary depending on the design and management measures that are used to effectively minimise pollution risks. Where wetlands have high conservation values or the proposed management practices are insufficient to prevent wetland degradation, larger vegetated buffers may be required.

If the land is in a Swan River Trust Management Area, approval is required from the Minister for Water Resources.

### 13.3 Obtain a statutory approval to clear land

If the clearing of more than one hectare of land is likely, the proponent should contact the Department of Agriculture as soon as possible to seek advice on land clearing approvals. Under the Soil and Land Conservation Act and Regulations, owners or occupiers of land are required to notify the Commissioner for Soil and Land Conservation of their intention to clear more than one hectare where there is a change in land use. Notification is to be at least 90 days prior to the expected commencement of that clearing.

Approval for clearing native vegetation for dams must be obtained in a similar manner as for the clearing of vegetation for other purposes. If the clearing of more than one hectare of native vegetation is being considered the proponent should refer to the 'Memorandum of Understanding for the protection of remnant vegetation on private land in the agricultural region of Western Australia'.

A proposed vegetable or potato growing operation that appears likely to have a significant effect on the environment may be referred, by local government, members of the public, or other bodies to the Environmental Protection Authority and may be assessed under Part IV of the Environmental Protection Act.



**Table 13.2 Approvals which may be required when establishing or expanding a vegetable or potato growing operation**

<b>Approval required</b>	<b>Comments</b>	<b>Agency</b>	<b>Relevant Acts</b>
Development	Must be consistent with Town Planning Scheme	Local Government	<i>Town Planning and Development Act 1928</i>
Environmental	An Environmental Impact Assessment may be required under Part IV of the <i>Environmental Protection Act</i> .	Department of Environmental Protection	<i>Environmental Protection Act 1986</i>
Development near prescribed water resources such as public drinking water source areas or waterways management areas	A permit is required for Priority 3 Underground Water Pollution Control Area as horticultural activities are conditional over this area and only permitted where adequate buffers to wetlands and waterways are provided. Horticultural activities are unacceptable in Priority 1 and Priority 2 source protection areas, wellhead protection zones, reservoir protection zones and within buffers to designated waterways and wetlands.	Water and Rivers Commission	<i>Metropolitan Water Supply Sewerage and Drainage Act 1909</i> <i>Country Areas Water Supply Act 1947</i> <i>Waterways Conservation Act 1976</i>
Licence to draw water from water resources	Required to draw water from a proclaimed Groundwater Area (which is the case for most of the State) or if drawing from a confined aquifer.	Water and Rivers Commission	<i>Rights in Water and Irrigation Act 1914</i>
	Required to draw water from a proclaimed Surface Water Catchment.	Water and Rivers Commission	<i>Rights in Water and Irrigation Act 1914</i>
Development in a Swan River Trust Management Area	Development approval required from Minister for Water Resources.	Swan River Trust	<i>Swan River Trust Act 1988</i>
Land clearing licence (for clearing >1 hectare of land)	Commissioner of Soil Conservation has responsibility to issue approvals to clear land. Applications will be assessed by Dept of CALM and DEP where appropriate to ensure there are no threatened ecological communities.	Department of Agriculture	<i>Soil and Land Conservation Act 1947</i>

## Complaints relating to Breaches of the Code of Practice

The issues of noise, pesticide spray drift, dust and odour can cause conflict between vegetable and potato growers and residents. The challenge is to acknowledge the issues and evolve management and planning practices to resolve and avoid conflict.

However if complaints do happen, specific complaints about smell, dust, noise or chemical spray drift from a rural property can be referred to the Agricultural Practices Board established under the *Agricultural Practices (Disputes) Act 1995*. The Board has a wide range of expertise in local government, environment, agriculture and law.

This Code of Practice may guide the Board in deciding what is normal, acceptable farm practice.

The legislation is based on the principle that farmers must have the right to farm, while other rural people have the right to be protected from nuisance caused by unacceptable farming practices. Under the Act, an agricultural practice is considered to be normal if:

- It is carried out and managed in a manner consistent with proper and accepted customs and standards, as established and followed in similar agricultural operations under similar circumstances.
- It complies with the requirements of a Code of Practice made or approved by the Department of Environmental Protection or under any written law.

Normal farm practice may include the use of innovative technology and management practices. The Board may declare that an existing agricultural practice is a normal farm practice, even if it does not comply with existing environmental laws. However, such laws can only be waived for a maximum of two years.

If a person carrying on an agricultural operation fails to comply with an order of the Board, that practice may not be considered a normal farm practice.

When a dispute is referred to the Board, the Board will appoint a suitably qualified mediator to ensure both parties become fully cognisant of all the issues and sort out any misunderstandings and resolve the conflict. If mediation is unsuccessful, the Board may convene a formal hearing to determine if the 'nuisance' constitutes normal farm practice. If the Board considers the practice is normal, there is no further involvement from the Board.

If the practice is considered not to be normal, the Board may ask the farmer to alter the practice or cease it completely. The Board's decisions are not binding in a legal sense but they are admissible as evidence in civil proceedings.

# Glossary

For the purposes of this Code, the terms used are assumed to have the following meanings:

<b>aquifer</b>	Discrete underground water resource.
<b>best environmental management practice</b>	The best practical methods of meeting expected environmental outcomes.
<b>biodiversity</b>	The variety of all forms of life, including the different plants, animals and micro-organisms, the genetic material they contain and the ecosystems they live in.
<b>brassica</b>	Family of vegetables including cauliflowers and broccoli.
<b>conservation</b>	Protecting and preserving natural life forms or resources.
<b>environmental</b>	About the surrounding conditions that sustain all forms of life.
<b>Environmental Management System</b>	A voluntary, audited system, which growers can develop for their operation to improve environmental sustainability.
<b>evapo-concentration</b>	Process by which salts become more concentrated and may crystallise when evaporation occurs on the surface of saline water or soils.
<b>eutrophication</b>	Nutrient enrichment of waterways leading to algal growth and deterioration in water quality.
<b>export of nutrients and chemicals</b>	Process by which nutrients and chemicals can move through and over soils dissolved in water or attached to soil particles.
<b>expected environmental outcome</b>	Expected general condition or state of any aspect of the environment resulting from the practices of growers.
<b>farm chemicals</b>	Commercially produced substances with specific uses in agriculture or horticulture. Includes pesticides, spray additives, solvents, cleaning agents and veterinary chemicals.
<b>fertigation</b>	Application of soluble fertiliser through an irrigation system.
<b>fertiliser</b>	Chemical or organic products that contain nutrients to promote plant growth.
<b>fossil fuel</b>	Fuel originating from fossil plant or animal remains, such as coal, oil and natural gas.
<b>genetically modified organism</b>	Any living thing, which has genes that have been altered by mankind.

<b>greenhouse gas</b>	Gas that contributes to the global warming phenomenon known as the greenhouse effect.
<b>integrated pest and disease management (IPDM)</b>	Utilising a range of pest management tools to provide economically, environmentally and socially sustainable production. The aim of IPDM is to minimise the risks to human health and the environment while maintaining pest populations below levels at which crop damage may occur.
<b>invertebrate pests</b>	Adult and larval forms of pests that are ‘animals without backbones’, such as insects, mites and nematodes.
<b>irrigation scheduling</b>	Monitoring soil moisture and evaporation to decide when and how much a crop needs to be irrigated.
<b>legislative</b>	Relating to laws.
<b>natural ecosystem</b>	System of interacting native plants and animals in a particular area or habitat.
<b>nutrient</b>	Chemical elements of fertilisers or manures, which are essential for plant growth, for example phosphorus, nitrogen, potassium, calcium, sulphur and trace elements.
<b>pan evaporation rate</b>	Standard measure of evaporation, equal to millimetres of water evaporated off a still water surface.
<b>pesticides</b>	Chemicals (or in exceptional cases biological or fungal agents), usually man-made, used to kill pests or diseases. Includes herbicides, insecticides and fungicides.
<b>phosphorus retention index (PRI)</b>	Numerical index expressing the ability of a soil to hold on to phosphorus. Low numbers denote a low capacity to hold phosphorus.
<b>principles (of environmental management )</b>	Fundamental element of the code of practice, stated in general terms, that guides best management practices in relation to a particular aspect of management.
<b>renewable energy source</b>	Energy source that can be replaced, such as wind or solar energy and biofuels. Fossil fuels are not renewable.
<b>riparian (land and vegetation)</b>	Adjoins or directly influences a body of water, including <ul style="list-style-type: none"> <li>• immediately alongside small creeks and rivers, including the riverbank itself and flood plain.</li> <li>• gullies and dips which sometimes run with surface water.</li> <li>• surrounding lakes and wetlands.</li> </ul>

<b>sodic soil</b>	A soil containing sufficient sodium to interfere with the growth of most crops plants.
<b>soil structure decline</b>	When excessive cultivation of or traffic on the soil breaks down the aggregates that make up soil types with clay and loam content. The result is a compacted, poorly aerated soil that forms clods when cultivated.
<b>sustainable</b>	Describes land uses or development that has the capacity to be continued in perpetuity without due impact on environmental, social or economic values.
<b>sustainable production</b>	A system of agricultural production that aims to reduce environmental degradation, maintain agricultural productivity, promote economic viability in both the short and long term and maintain stable rural communities and quality of life.
<b>tensiometer</b>	A simple instrument that measures soil water content.
<b>Underground Water Pollution Control Areas</b>	Public Drinking Water Source Areas for underground water which are proclaimed and protected by the Water and Rivers Commission under government Acts. The WRC can regulate potentially polluting activities and land use, inspect premises and to take steps to prevent or clean up pollution.

## Bibliography

- Agriculture Western Australia, 1997. *Agricultural Statistical Overview Series, 1996-97*.
- Agriculture Western Australia, 2000. *A Snapshot of Horticulture, Western Australia*, bulletin.
- Agriculture Western Australia, 1999. *AGMAPS Horticultural Land Capability Maps, Swan Coastal Plain, Lancelin to Augusta*, CD.
- Australian Greenhouse Office, 1998. *Australia's State and Territory Greenhouse Gas Inventory*.
- Australian Greenhouse Office, 2001. *1999 National Greenhouse Inventory*.  
<http://www.greenhouse.gov.au/inventory/facts>
- AVCARE, 2001. *National Association for Crop Production and Animal Health*.  
(Website): <http://www.avcare.org.au>
- Bureau of Rural Sciences, 2001. *Managing pesticides for sustainable crop production and water quality protection*. Accessed from Agriculture, Fisheries and Forestry website [www.dpie.gov.au/content/output](http://www.dpie.gov.au/content/output)
- ChemCert Western Australia™, 2000. *Farm Chemical Users' Training Manual*.
- CSIRO, 2001. *Climate Change Projections for Australia*. Brochure,  
<http://www.dar.csiro.au/publications/projections>
- Donald, C., Enderby, N., Ridland, P., Porter, I. and Lawrence, J. 2000. *Field Guide to Pests, Diseases and Disorders of Vegetable Brassicas* ISBN 0 7311 44740. Department of Natural Resources and Environment, Vic.
- George, R., Weaver, D. and Terry, J., 1996. *Environmental Water Quality, a Guide to Sampling and Measurement*.
- Government of Australia Gene Technology and Information Service, 2000, *Genetically Modified Foods- Information and Answers to Your Questions*. Leaflet.
- Health Department of Western Australia, 2001 *Environmental Health Guide: Pesticide Safety*, Perth, Western Australia.
- Heisswolf, S and Brown, E., 1997. *Pests and Beneficials in Brassica Crops* Agdex 253/620 Qld Department of Primary Industries.
- Horticultural Research and Development Corporation (HRDC) and National Land and Water Resources Audit, 2001. *Horticulture Productivity and sustainability*.
- Land and Water Resources Research and Development Corporation, 2001. *Rivers and Riparian Lands: Fact Sheets* accessed via website <http://www.rivers.aus.net/> on 4 December 2000.
- Learmonth, S. (Dept of Agriculture senior entomologist), 2001. pers. comm.
- Lantzke, N. et al (ed), 1997. *Codes of Practice for Vegetable Production on the Swan Coastal Plain*.
- Llewellyn, R., 2000. *Sweet Corn Insect Pests and their Natural Enemies - an IPM Field Guide*. ISBN 1 86423 972 7. Bio Resources P/L. Greenridge Press.

- Mc Farlane, D.J.; George, R.J., Loughran, R.J., Elliot, G.L., Ryder, A.T., Bennett, D. and Tille, P.J., 2000. *A National Reconnaissance Survey of Soil Erosion in Australia*. Agriculture Western Australia publication.
- McTainsh, G.H. and Boughton, W.C., 1993. *Land Degradation Processes in Australia*. Longman Cheshire.
- Monaghan, J. and Associates, 1997. *Scott Coastal Plain Study, Background and Issues Paper for Land Use Development and Environment*.
- Moore, G. (ed), 1998. *Soils Guide, A Handbook for Managing and Understanding Agricultural Soils*. Agriculture Western Australia Bulletin 4243.
- Ogg, C.L. *et al.* *Safe transport, storage and disposal of pesticides*. University of Nebraska Cooperative Extension EC 01-2507.
- Organisation for Economic Co-operation and Development, 1997. *Agriculture, Pesticides and the Environment: Policy Options*. Organisation for Economic Co-operation and Development, Paris, France.
- Paulin, R., 2000. *Best Management Practices for Vegetable Production at Scott Rive*. Department of Agriculture (unpublished).
- Prosser, I., Bunn, S., Mosisch, T., Ogden, R. and Karssies, L., 1999. *The delivery of sediment and nutrients to streams*. From 'Riparian Land Management Technical Guidelines Volume 1'. LWRRDC, Canberra.
- Queensland Department of Primary Industries, 2001. *Infopest CD*.
- Queensland Fruit and Vegetable Growers Association, 1999. *Farmcare - Cultivating a Better Future - Code of Practice for Sustainable Fruit and Vegetable Production in Queensland*.
- Rose, B., 1997. *Preventing Erosion and Soil Structure Decline, a Soil Management Practices Guide for Farmers in the South West High Rainfall Hills*. Agriculture Western Australia Miscellaneous Publication 23/97.
- Schulz, L. D. *et al* 2001. *Spray Drift of Pesticides*. University of Nebraska Lincoln, accessed via website <http://www.ianr.unl.edu/pubs/pesticides>
- Thompson, W.T., 1998. *Agricultural Chemicals, Book 1 Insecticides*, 14th edition. University of New Hampshire, 2001. *University of New Hampshire Sustainable Horticulture*, accessed via website <http://horticulture.unh.edu> on 20 March 2001.
- Water and Rivers Commission, 2000. *Pesticide Use in Public Drinking Water Source Areas, Statewide Policy No. 2*.
- Western Australian Department of Agriculture, Potato Growers Association of WA (Inc) *et al*, 2002. *Best Environmental Management Practices for Environmentally Sustainable Vegetable and Potato Production, a Reference Manual*. (Referred to in the text as the BEMP Manual).
- Western Australian Department of Agriculture, 2002. *Code of Practice for the Use of Agricultural and Veterinary Chemicals in Western Australia*. Bulletin 4527.

# Appendix 1

## Relevant Legislation

### 1. *Environmental Protection Act 1986*

The *Environmental Protection Act 1986* (EP Act) is the primary legislation for the protection of the environment and control of pollution.

It is specifically ‘...an Act to provide for an Environmental Protection Authority, for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing.’

The EP Act provides a number of mechanisms for preventing and controlling pollution:

- Part III of the Act enables Environmental Protection Policies to be established for the ‘prevention, control or abatement of pollution’.
- Part IV of the Act requires the environmental assessment of proposals ‘likely, if implemented, to have a significant effect on the environment’.
- Part V of the Act provides for the licensing of the activity as a ‘prescribed premises’ and addresses specific issues such as limits on waste disposal.

The EP Act may apply to the establishment and running of a vegetable or potato growing operation through Part IV (assessment) and/or Part V (pollution and offences).

### 2. *Water and Rivers Commission Act 1995*

The *Water and Rivers Commission Act 1995* (Water and Rivers Commission Act) contains a number of subsidiary Acts and by-laws to protect water resources. It is administered by the Water and Rivers Commission.

Under the Water and Rivers Commission Act, the Commission has responsibility for the conservation, protection and management of the State’s water resources. The Act assigns to the Commission the responsibility for administering the following Acts:

- *Country Areas Water Supply Act 1947* (CAWS Act)
- *Metropolitan Water Supply, Sewerage and Drainage Act 1909* (MWSS&D Act)
- *Rights in Water and Irrigation Act 1914* (RIWI Act)
- *Waterways Conservation Act 1976*

#### *Public Drinking Water Source Areas (PDWSA)*

The quality of public drinking water sources is protected by proclaiming Underground Water Pollution Control Areas, Catchment Areas and Water Reserves under the MWSS&D and CAWS Acts. These proclaimed areas are collectively referred to as Public Drinking Water Source Areas (PDWSAs).

The by-laws under the MWSS&D and the CAWS Acts enable the Water and Rivers Commission to regulate potentially polluting activities and land use, to inspect premises and to take steps to prevent or clean up pollution.

In public drinking water source areas, the Water and Rivers Commission has defined three levels of priority classification employing different management strategies as follows:

**Priority 1 (P1)** source protection areas are managed in accordance with the principle of *risk avoidance*. The source protection objective for P1 areas is to ensure no degradation of source water quality. Land is generally in public ownership and development is generally precluded from P1 areas. Vegetable and potato growing is an incompatible activity in P1 areas.

**Priority 2 (P2)** source protection areas are managed in accordance with the principle of *risk minimisation*. The source protection objective for P2 areas is to ensure that there is no increased risk of water pollution to the water resources. Land is generally in private ownership and typically supports low intensity rural and rural lifestyle uses. Urban and industrial land uses are precluded. Vegetable and potato growing is an incompatible activity in P2 areas.

**Priority 3 (P3)** source protection areas are managed in accordance with the principle of *risk management*. The source protection objective for P3 areas is to maintain water quality within health guidelines. Land is generally in private ownership and may include urban, light industrial and rural uses. Heavy industry and processing/treatment of animal wastes are precluded. Vegetable and potato growing is a restricted activity in P3 areas. They would be acceptable to the Water and Rivers Commission provided they adhered to the water quality protection recommendations in this Code.

In addition to priority classification areas, wellhead protection zones and reservoir protection zones are defined to protect the water source from contamination in the immediate vicinity of production wells and reservoirs. Additional restrictions apply within these zones. The Water and Rivers Commission will be pleased to provide advice on the locations and restrictions applying in these zones.

#### *Waterways Conservation Act 1976*

The Water and Rivers Commission has planning and pollution prevention powers under this Act within declared areas to ensure the conservation and management of these waterways and associated lands.

The Water and Rivers Commission is responsible for the management of all waterways and has active programs to manage the following waterways: Avon River, Peel Inlet, Leschenault Inlet, Albany Waterways, Wilson Inlet and adjoining land in management areas declared under the Act. This adjoining land extends to the entire catchments of the Avon River, Albany Waterways and Wilson Inlet. Detailed assessment and site specific conditions to protect water resources apply in these management areas.

#### *Rights in Water and Irrigation 1914*

This Act makes provision for the regulation, management, use and protection of water resources to provide for public schemes and for irrigation purposes. The Act

covers the licensing and construction of wells drawing water from aquifers and the taking of water from proclaimed rivers and streams. Licenses are required for commercial water supplies in proclaimed groundwater and surface water catchment areas.

### **3. *Swan River Trust Act 1985 (SRT Act)***

The Swan and Canning Rivers are administered under the *Swan River Trust Act*. The Swan River Trust (SRT) has the overall planning, protection and management responsibilities for the Swan and Canning Rivers. The SRT assesses development referrals and makes recommendations on development and land use applications that may affect water in its management area.

### **4. *Town Planning and Development Act 1928***

The *Town Planning and Development Act 1928* gives local government the responsibility to prepare town planning schemes (TPSs) that may include local or rural strategies for areas within its municipal boundaries. TPSs may vary between local government and therefore it is possible for councils to have different conditions for establishing and operating vegetable and potato growing.

A Land Zoning Map may be viewed at the Council offices and the zoning of the proposed vegetable or potato growing site determined.

### **5. *Soil and Land Conservation Act 1982***

The *Soil and Land Conservation Act 1982* provides for the conservation of soil and land from the effects of erosion, salinity, flooding and eutrophication. It is administered by the Department of Agriculture.

Land degradation is the main cause of loss of production capacity. Land degradation includes the removal or deterioration of natural or introduced vegetation, soil erosion and flooding where these impacts may be detrimental to the present or future use of the land, and eutrophication of water bodies.

In 1995 State Cabinet directed that

*Existing controls on clearing under the Soil and Conservation Act and the Country Areas Water Supply Act be augmented by a system to ensure that other natural resource conservation issues are considered before any further clearing occurs on private land*

and that

*In Shires with greater than 20% total remnants the Commissioner of Soil and Land Conservation will decide on the need to inform the Environmental Protection Authority of any clearing proposal, in accordance with an agreed Memorandum of Understanding.*

“The Memorandum of Understanding for the protection of remnant vegetation on private land in the agricultural regions of Western Australia, March 1997” implements these directives. It recognises that the retention of existing native vegetation is of vital importance in supporting private and public efforts to reverse land degradation and loss of native species, and intends to prevent these problems worsening while solutions are found and implemented.

The following entities are signatories to the Memorandum:

- Commissioner for Soil and Land Conservation
- Environmental Protection Authority
- Department of Environmental Protection
- Department of Agriculture
- Department of Conservation and Land Management
- Water and Rivers Commission

This Memorandum applies to proposals to clear more than one hectare of native vegetation on rural zoned land in southern Western Australia, south or west of the eastern boundaries of the main agricultural areas. In areas where more than 20% of the original vegetation remains, the process will follow the four-level evaluation procedures implemented through the Memorandum.

In local government districts where less than 20% of the original vegetation remains within the main agricultural area, the Commissioner for Soil and Land Conservation already considers further clearing carries an unacceptable risk of increased land degradation, as defined in the *Soil and Land Conservation Act*. In these areas the Commissioner will object to any clearing unless the proposal has been assessed by the Environmental Protection Authority and approved by the Minister for Environment Heritage. Landholders will be expected to provide all information needed for that evaluation.

The over-riding philosophy is that as the development of a vegetable or potato growing operation proceeds, there should be no net loss of native vegetation or of the condition or extent of that vegetation.

The booklet 'Land Clearing Proposals For Rural Zoned Land In Western Australia' in accordance with the Memorandum of Understanding deals principally with clearing proposals on rural zoned land.

1. If the land proposed to be cleared is zoned other than 'rural', it is assessed under a single evaluation process according to the 1997 Memorandum of Understanding and subsequent policy statements.
2. If the land proposed to be cleared is zoned other than 'rural', it is assessed by the Commissioner under the 1994 procedures for the assessment of clearing proposals. Other relevant agencies may be notified of the proposal.

Soil and land conservation requires the use of appropriate land management practices to maintain the stability of that land in perpetuity. In the context of the legislation, land conservation is achieved by application of appropriate land use. Soil and land conservation is the opposite of exploitative land use.

Where a landholder causes land degradation and this is brought to the attention of the Commissioner, the Commissioner, after consultation with the landholder, may issue a Notice directing the landholder to rectify the situation.

### ***6. Agricultural Practices (Disputes) Act 1995***

The *Agricultural Practices (Disputes) Act 1995* provides for the resolution of disputes related to the carrying on, or management, of agriculture. It is administered by the Agriculture Protection Board of Western Australia established under section 7 of the Act.

The objects of the Act are to:

1. Ensure that the normal farm practices are not impeded by unnecessary litigation.
2. Set up the Agricultural Protection Board and give power to the Board.
3. Provide a referral process to the Board who may inquire into, resolve by mediation and make a determination on the referral. The Board assumes the power to determine whether an agricultural practice is 'normal farm practice'.

The Act applies to disputes in which the issue is a complaint relating to odour, dust, noise, smoke, fumes, fugitive light, or spray drift, emanating from an agricultural operation.

### ***7. Agriculture and Related Resources Protection (Spraying Restrictions) Act 1981***

The use of hormone herbicides is controlled within close proximity to commercial vineyards.

Within a five kilometre radius of commercial vineyards only amine sodium and potassium salt formulations are approved for spraying under permit. Between a five and ten kilometres radius, both amine, sodium and potassium salt and low volatile ester formulations can be used without a permit. Outside a ten kilometre radius all formulations, such as amine, sodium and potassium salts, low volatile and volatile ester formulations can be used without a permit.

### ***8. Quarantine Act 1908 (Cwlth)***

In summary, plant material, machinery and equipment are prohibited entry into Australia except by permit. A permit for planting material allows its entry subject to screening for pests and diseases in post-entry quarantine for at least 2 years. A machinery and equipment permit allows importation subject to inspection on arrival for freedom from soil and plant material. However, State legislation prohibits its entry into Western Australia.

### ***9. Plant Diseases Act of Western Australia 1914 as amended by the Plant Diseases Amendment Act 1993***

Under the above legislation, the import of planting material into Western Australia (including those tissue cultured) is controlled, when brought from overseas and other States.

The Act confers the powers to:

- Ensure only disease free plants are introduced into Western Australia.
- Destroy infected plants.

# Appendix 2

## Department of Agriculture

### Perth

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SOUTH PERTH Western Australia 6151  
Phone: (08) 9368 3333  
Fax: (08) 9368 1205  
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Locked Bag 4  
Bentley Delivery Centre Western Australia 6983

### Albany

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ALBANY Western Australia 6330  
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### Bunbury

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### Karratha

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KARRATHA Western Australia 6714  
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### Kununurra

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Fax: (08) 9166 4066

### Merredin

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### Moora

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### Carnarvon

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(PO Box 522)  
CARNARVON Western Australia 6701  
Phone: (08) 9956 3333  
Fax: (08) 9941 8334

### Esperance

Private Mail Bag 50  
ESPERANCE Western Australia 6450  
Phone: (08) 9083 1111  
Fax: (08) 9083 1100

### Geraldton

283 Marine Terrace  
(PO Box 110)  
GERALDTON Western Australia 6530  
Phone: (08) 9956 8555  
Fax: (08) 9921 8016

### Katanning

149 Clive Street  
KATANNING Western Australia 6317  
Phone: (08) 9821 3333  
Fax: (08) 9821 1028

### Manjimup

Rose St  
MANJIMUP Western Australia 6258  
Phone: (08) 9771 1299  
Fax: (08) 9771 2544

### Narrogin

10 Doney Street  
NARROGIN Western Australia 6312  
Phone: (08) 9881 0222  
Fax: (08) 9881 1950

### Northam

Lot 12, Old York Road  
(PO Box 483)  
NORTHAM Western Australia 6401  
Phone: (08) 9690 2000  
Fax: (08) 9622 1902

## Department of Environmental Protection

### Head Office

141 St Georges Terrace  
PERTH, Western Australia 6000  
Phone: (08) 9222 7000  
Fax: (08) 9322 1598

Postal Address  
PO Box K822  
PERTH, Western Australia 6842

### Kwinana Office

Parmelia House  
165 Gilmore Avenue  
(PO Box 454)  
KWINANA, Western Australia 6167  
Phone: (08) 9419 5500  
Fax: (08) 9419 5897

### Karratha Office

Chiratta Road  
KARRATHA, Western Australia 6714  
Phone: (09) 9144 2000  
Fax: (08) 9144 2610

### Kununurra Office

Lot 225 Bandicoot Drive  
KUNUNURRA, Western Australia 6743  
Phone: (09) 9168 1082  
Fax: (08) 9168 3174

### Geraldton Office

5 Burgess Street  
GERALDTON, Western Australia 6530  
Phone: (08) 9964 3844  
Fax: (08) 9964 3681

### Kalgoorlie Office

Viskovich House  
377 Hannan Street  
KALGOORLIE, Western Australia 6430  
Phone: (08) 9021 3243  
Fax: (08) 9021 3529

### Bunbury Office

U2 Leschenault Quays  
Austral Parade  
BUNBURY, Western Australia 6230  
Phone: (08) 9721 0666  
Fax: (08) 9721 0600

## Water and Rivers Commission

### Head Office

Level 2, Hyatt Centre  
3 Plain St  
EAST PERTH, Western Australia 6004  
Phone: (08) 9278 0300  
Fax: (08) 9278 0585

### Swan-Goldfields-Agricultural

7 Ellam St,  
VICTORIA PARK Western Australia 6100  
Phone: (08) 6250 8000  
Fax: (08) 6259 8050  
Or  
254 Fitzgerald St  
NORTHAM Western Australia 6401  
Phone: (08) 9690 2821  
Fax: (08) 9622 7155

### South West

U2 Leschenault Quays,  
Austral Parade  
BUNBURY Western Australia 6230  
Phone: (08) 9721 0666  
Fax: (08) 9721 0600  
Or  
'Sholl House'  
21 Sholl St  
MANDURAH Western Australia 6210  
Phone: (08) 9535 3411  
Fax: (08) 9581 4560

### Swan River Trust

Level 3, Hyatt Centre  
87 Adelaide Terrace  
EAST PERTH, WA 6004  
Phone: (08) 9278 0400  
Fax: (08) 9278 0401

### South Coast

5 Bevan Street  
ALBANY Western Australia 6330  
Phone: (08) 9842 5760  
Fax: (08) 9842 1204

### North West

Chiratta Road  
KARRATHA Western Australia 6714  
Phone: (08) 9144 2000  
Fax: (08) 9144 2610  
Or  
Lot 225 Bandicoot Drive  
KUNUNURRA Western Australia  
Phone: (08) 9168 1082  
Fax: (08) 91683174

### Mid-West Gascoyne

Pass Street  
GERALDTON Western Australia 6530  
Phone: (08) 9964 5978  
Fax: (08) 9964 5983

## Health Department of Western Australia

### Head Office

Environmental Health Service  
PO Box 8172  
Perth Business Centre  
PERTH Western Australia 6849  
Phone: (08) 9388 4999

### Local Contacts

In your local area, contact the Environmental Health Officer at your local government offices.

### WorkSafe Western Australia

Westcentre  
1260 Hay Street  
WEST PERTH, Western Australia 6005  
Phone: (08) 9327 8711  
Fax: (08) 9321 1277

### Worksafe W.A.- Bunbury Regional Office

Inspectors: Ron Jenkins & Tony Robertson  
Bunbury Tower  
Floor 8, 61 Victoria St  
BUNBURY Western Australia 6230  
Phone: (08) 9791 7211  
Fax: (08) 9701 8047  
Email: bunbury@bigpond.com  
Website: www.wt.com.au/safetyline

### Quarantine Legislation

#### From interstate:

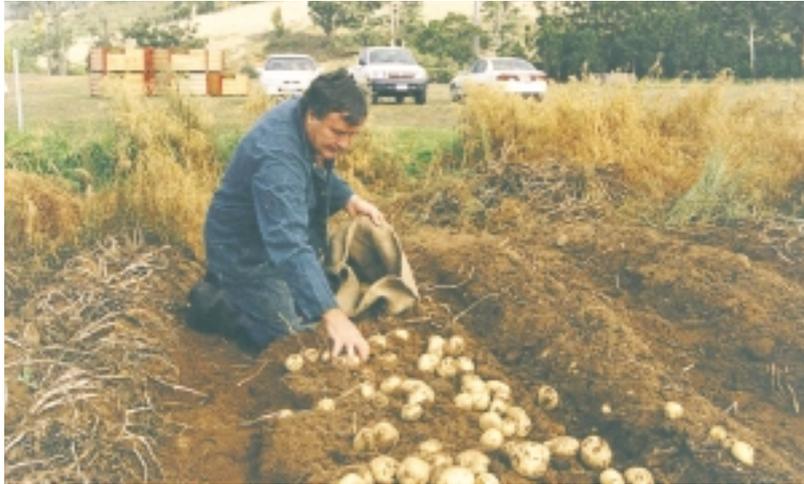
Kingsley Cunningham  
Western Australian Quarantine  
and Inspection Service  
PO Box 1410  
CANNING VALE 6410  
Western Australia  
Phone: (08) 93115329  
Fax: (08) 94560206  
Email: kcunningham@agric.wa.gov.au

#### From overseas:

Allan Morley  
Australian Quarantine and Inspection Services  
PO Box 1410  
CANNING VALE 6410  
Western Australia  
Phone: (08) 93115332  
Fax: (08) 94553052  
Email: allan.morley@aqis.gov.au



*A healthy crop brings smiles.*



*Quality potatoes and vegetables.*



*Clean water and healthy ecosystems.*

