10-2006

Water supplies for horticulture in the Lower Great Southern

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ISSN 1833-7236
Bulletin 4701
Replaces Miscellaneous Publication 17/95

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October 2006

Department of Agriculture and Food
Government of Western Australia

SCRIPT
South Coast Regional Initiative Planning Team

Contents

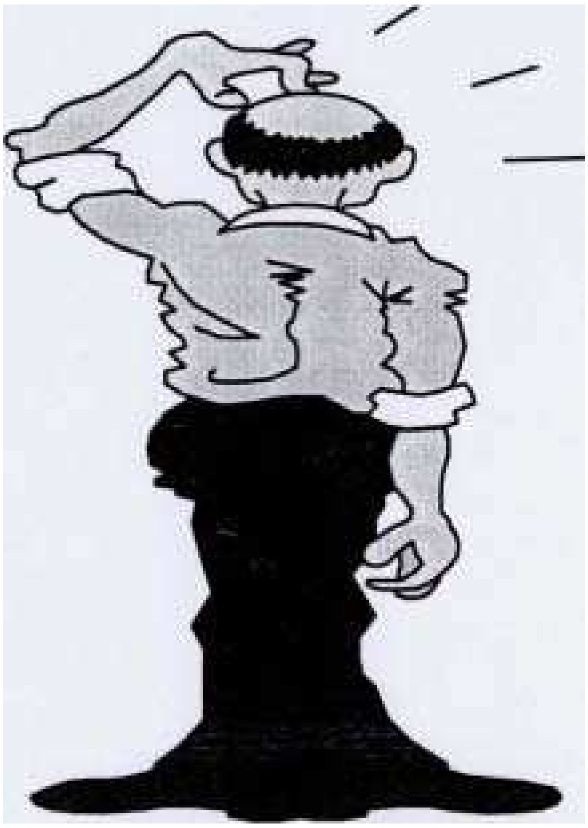
1. What is this publication about?

This bulletin answers common questions about the availability, quality and collection of water for growing horticultural crops in the Lower Great Southern. It is intended for existing or potential horticulturalists in the Albany, Denmark, Plantagenet and Cranbrook Shires.

Water is a major limiting factor for the growth of horticultural industry. Almost all growers need to consider water supplies closely if they are to grow marketable and profitable crops.

Such information can also be used by graziers who need water for stock. However the amounts and the quality of water for stock are not considered (see Resource Management Technical Report 60 'Consumption of water by livestock' by G. Luke).

Information on water availability is changing continually and we suggest that you contact one of the organisations listed in Section 11 or read the suggested articles for more details about your particular circumstances.



2. How much water do horticultural crops need?

It is common to underestimate or overestimate the amount of water needed to grow a crop successfully. Water may be needed to irrigate the crop, cool some crops (e.g. lettuces), stop sandblasting, wash in fertilisers, prevent frost damage, wet the soil before planting, and to apply chemicals. Other factors to consider are whether the crop is annual or perennial, its age and growth stage, the soil type, the amount of effective evaporation and the irrigation efficiency.

In the Lower Great Southern fruit crops usually only need irrigation between late November and early April, but vegetables require water for slightly longer. Significant falls of rain during summer are common in coastal areas but should be considered as a bonus, not something to be relied on.

The Department of Agriculture and Food has a Crop Irrigation Requirement software program (Aylmore, Luke and Hauck 1994), which can help estimate how much water is needed by crops in different areas. This estimates the long-term water needs but it cannot be used to schedule irrigation needs on a day-to-day basis. For this, growers need to measure evaporation or soil water content every day. Alternatively, some research stations monitor daily evaporation rates which are broadcast on country radio and television.

Computer software is available for predicting the irrigation requirements of annual and perennial crops grown in different regions. It can also be used as a guide for estimating requirements under different management strategies or for groundwater allocation. Download from:
www.agric.wa.gov.au/pls/portal30/docs/FOLDER/IKMP/LWE/WATER/IRRIG_CALCULATOR_NLANTZKE.HTM.

The method used by Aylmore *et al.* (1994) is explained below with examples of how it can help guide water needs.

Factors affecting water needs

Water use = effective evaporation x crop factor x irrigation factor x soil factor.

This means that the amount of water needed by a crop depends on:

- The amount that evaporation exceeds rainfall (assuming that on each rainy day, the first millimetre of rain is ineffective).
- Type of crop – some need more water, particularly at certain growth stages (crop factor).
- Efficiency of irrigation system – some are more efficient than others. For most purposes, assume that only 75% of irrigation water is effective and the rest (25%) is lost due to inefficiency. Therefore you will need to add a third more water to account for the losses.
- Soil type – coarse sands hold little water, whereas heavy textured soils can hold more. Clayey soils may need a lot of water to wet them if they are dry, but less water needs to be added and less often once they are moist, compared with sandy soils.

Effective evaporation for three selected areas is shown in Table 1. Monthly crop factors for three areas are shown in Tables 2, 3 and 4 and soil factors that affect water requirements are shown in Table 5. For strawberries, a combination of both overhead sprinklers (which help to cool the crop in hot weather) and trickle systems is ideal. It is recommended that 100% of evaporation is applied to strawberries if overhead sprinklers are used; 40-60% of evaporation for trickle systems on heavy soils; and 100% for trickle systems on sandy soils.

Table 1. Monthly effective evaporation for Albany, Mt Barker and Manjimup (from Aylmore *et al.* 1994)

Centre	Effective evaporation (mm)											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
Albany	205	157	133	36	0	0	0	0	20	42	115	184
Mt Barker	222	184	154	57	0	0	0	0	29	60	127	220
Manjimup	195	160	124	33	0	0	0	0	0	31	108	180

Table 2. Monthly crop factors in the Albany region (based on Aylmore *et al.* 1994)

Crop	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
Almonds	.35	.20	.10	.20	.30	.40	.45	.50	.60	.60	.50	.45
Apples (early)	.55	.55	.55	.55	.40	.00	.00	.00	.30	.30	.55	.55
Apples (late)	.55	.55	.55	.55	.40	.00	.00	.00	.30	.30	.55	.55
Apricots	.80	.40	.40	.40	.40	.00	.00	.00	.30	.30	.55	.80
Avocados	.80	.80	.80	.80	.65	.65	.65	.65	.80	.80	.80	.80
Cherries	.40	.40	.40	.40	.40	.00	.00	.00	.30	.50	.70	.70
Citrus	.55	.55	.55	.55	.45	.45	.45	.45	.55	.55	.55	.55
Cut flowers	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65
Kiwi fruit	.80	.80	.80	.80	.40	.00	.00	.00	.00	.30	.65	.70
Nashi	.70	.70	.70	.40	.00	.00	.00	.00	.30	.30	.40	.55
Natives	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Nectarines (early)	.80	.40	.40	.40	.00	.00	.00	.00	.30	.40	.80	.80
Nectarines (late)	.80	.80	.80	.40	.00	.00	.00	.00	.30	.30	.40	.80
Nurseries & bowling greens	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80
High water pastures	.65	.65	.65	.65	.50	.00	.00	.00	.00	.65	.65	.65
Low water pastures	.50	.50	.50	.50	.30	.00	.00	.00	.00	.50	.50	.50
Peaches (early)	.80	.40	.40	.40	.00	.00	.00	.00	.30	.40	.80	.80
Peaches (late)	.80	.80	.80	.40	.00	.00	.00	.00	.30	.30	.40	.80
Pears	.70	.70	.70	.40	.00	.00	.00	.00	.30	.30	.40	.55
Pecans	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30
Plums (early)	.80	.40	.40	.40	.00	.00	.00	.00	.30	.30	.40	.80
Plums (late)	.80	.80	.80	.40	.00	.00	.00	.00	.30	.30	.40	.40
Proteas	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Turf, low water recreation	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Wine grapes	.15	.15	.15	.00	.00	.00	.00	.00	.00	.00	.00	.15

Table 3. Monthly crop factors in Mt Barker region (based on Aylmore *et al.* 1994)

Crop	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
Almonds	.35	.20	.10	.20	.30	.40	.45	.50	.60	.60	.50	.45
Apples (early)	.55	.55	.55	.55	.40	.00	.00	.00	.30	.30	.55	.55
Apples (late)	.55	.55	.55	.55	.40	.00	.00	.00	.30	.30	.55	.55
Apricots	.80	.40	.40	.40	.40	.00	.00	.00	.30	.30	.55	.80
Avocados	.80	.80	.80	.80	.65	.65	.65	.65	.80	.80	.80	.80
Cherries	.40	.40	.40	.40	.40	.00	.00	.00	.30	.50	.70	.70
Citrus	.40	.40	.40	.40	.30	.30	.30	.30	.40	.40	.40	.40
Cut flowers	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65
Kiwi fruit	.80	.80	.80	.80	.40	.00	.00	.00	.00	.30	.65	.70
Nashi	.70	.70	.70	.40	.00	.00	.00	.00	.30	.30	.40	.55
Natives	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Nectarines (early)	.80	.40	.40	.40	.00	.00	.00	.00	.30	.40	.80	.80
Nectarines (late)	.80	.80	.80	.40	.00	.00	.00	.00	.30	.30	.40	.80
Nurseries & bowling greens	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80
High water pastures	.65	.65	.65	.65	.50	.00	.00	.00	.00	.65	.65	.65
Low water pastures	.50	.50	.50	.50	.30	.00	.00	.00	.00	.50	.50	.50
Peaches (early)	.80	.40	.40	.40	.00	.00	.00	.00	.30	.40	.80	.80
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Pears	.70	.70	.70	.40	.00	.00	.00	.00	.30	.30	.40	.55
Pecans	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30
Plums (early)	.80	.40	.40	.40	.00	.00	.00	.00	.30	.30	.40	.80
Plums (late)	.80	.80	.80	.40	.00	.00	.00	.00	.30	.30	.40	.40
Proteas	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Turf, low water recreation	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Wine grapes	.15	.15	.15	.00	.00	.00	.00	.00	.00	.00	.00	.15

Table 4. Monthly crop factors in Manjimup region (based on Aylmore *et al.* 1994)

Crop	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.
Almonds	.35	.20	.10	.20	.30	.40	.45	.50	.60	.60	.50	.45
Apples (early)	.55	.55	.55	.55	.40	.00	.00	.00	.30	.30	.55	.55
Apples (late)	.55	.55	.55	.55	.40	.00	.00	.00	.30	.30	.55	.55
Apricots	.80	.40	.40	.40	.40	.00	.00	.00	.30	.30	.55	.80
Avocados	.80	.80	.80	.80	.65	.65	.65	.65	.80	.80	.80	.80
Cherries	.40	.40	.40	.40	.40	.00	.00	.00	.30	.50	.70	.70
Citrus	.55	.55	.55	.55	.45	.45	.45	.45	.55	.55	.55	.55
Cut flowers	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65
Kiwi fruit	.80	.80	.80	.80	.40	.00	.00	.00	.00	.30	.65	.70
Nashi	.70	.70	.70	.40	.00	.00	.00	.00	.30	.30	.40	.55
Natives	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Nectarines (early)	.80	.40	.40	.40	.00	.00	.00	.00	.30	.40	.80	.80
Nectarines (late)	.80	.80	.80	.40	.00	.00	.00	.00	.30	.30	.40	.80
Nurseries & bowling greens	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80
High water pastures	.65	.65	.65	.65	.50	.00	.00	.00	.00	.65	.65	.65
Low water pastures	.50	.50	.50	.50	.30	.00	.00	.00	.00	.50	.50	.50
Peaches (early)	.80	.40	.40	.40	.00	.00	.00	.00	.30	.40	.80	.80
Peaches (late)	.80	.80	.80	.40	.00	.00	.00	.00	.30	.30	.40	.80
Pears	.70	.70	.70	.40	.00	.00	.00	.00	.30	.30	.40	.55
Pecans	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30
Plums (early)	.80	.40	.40	.40	.00	.00	.00	.00	.30	.30	.40	.80
Plums (late)	.80	.80	.80	.40	.00	.00	.00	.00	.30	.30	.40	.40
Proteas	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Turf, low water recreation	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40
Wine grapes	.15	.15	.15	.00	.00	.00	.00	.00	.00	.00	.00	.10

Table 5. Soil factors (from Aylmore *et al.* 1994)

Soil type	Annual crops	Perennial crops
Light (sandy)	1.0	1.2
Medium (loamy)	0.9	1.1
Heavy (clayey)	0.8	1.0

Example 1

How much water will a 1 ha early apple orchard require in January of a year with average rainfall, if it is on deep gravelly soils in the Mount Barker district?

Effective evaporation in January = 222 mm (from Table 1), crop factor = 0.55 (from Table 3), irrigation efficiency = 0.75, soil factor = 1.2 (from Table 2).

Water use = (222 x 0.55 x 1.2)/0.75 = 195 mm or 0.195 m

1 hectare = 10,000 square metres

Volume required = 0.195 x 10,000 = 1,950 cubic metres or kilolitres (1 kL = 1,000 litres)

This estimate is for a year of average rainfall. Rain may be substantially less than average in some years (see Section 4) which needs to be taken into account when estimating needs.

Example 2

How much water will a 0.5 ha cherry orchard on loamy soil near Mount Barker require in an average year?

January	=	0.222 x 0.4 x 1.33 x 1.1 x 5000 = 644 kL
February	=	0.184 x 0.4 x 1.33 x 1.1 x 5000 = 538 kL
March	=	0.154 x 0.4 x 1.33 x 1.1 x 5000 = 451 kL
April	=	0.057 x 0.4 x 1.33 x 1.1 x 5000 = 167 kL
September	=	0.029 x 0.3 x 1.33 x 1.1 x 5000 = 64 kL
October	=	0.060 x 0.5 x 1.33 x 1.1 x 5000 = 219 kL
November	=	0.127 x 0.7 x 1.33 x 1.1 x 5000 = 650 kL
December	=	0.220 x 0.7 x 1.33 x 1.1 x 5000 = 1,127 kL
Annual need		= 3,860 kL (3,860 cubic metres)

This also shows that the water requirement reaches a peak in December but remains substantial until the end of March.

Annual crops

The program by Aylmore *et al.* (1994) can be used to estimate the water requirements of a number of annual crops. It can also estimate the number of growing days and the harvest date. The day-to-day irrigation needs of crops should be calculated from daily evaporation rates, not monthly or annual averages, because evaporative demand varies substantially from day to day.

Paust (1992) showed that growing annual crops into and out of winter could significantly reduce the amount of water needed for irrigation. For example, he suggested that it should be possible to grow cauliflowers at Denmark, Albany and Mt Barker with little or no irrigation if they were planted in May or June. However, if planted in December, 3,000 to 4,000 kL of water would be required to irrigate each hectare of crop and a further 1,000 to 1,500 kL would be required to wet each hectare of soil before planting.

It is important to note that these suggestions are based on 10-year averages of rainfall and evaporation data and not the daily needs of cauliflower crops. In practice, it has been found (Greg Luke, pers. comm.) that cauliflower crops planted in May and June may still need

some irrigation because of the variability in evaporative demand from day to day. This highlights the need for growers to use average climatic data as long-term guides only, not for daily scheduling needs.

Growers in the Mt Barker area need to budget for substantially more water than growers in Denmark because of the lower rainfall and higher evaporation rates at Mt Barker.

3. Measuring water quality

Units of water quality

Water quality can be measured in a number of ways:

- The electrical conductivity is a quick and usually reliable guide to salinity. Conductivity can be measured with a portable meter as well as in the laboratory. The units are usually millisiemens per metre (mS/m).
- Total soluble salts (TSS) or total dissolved solids (TDS) are measured in milligrams per litre (mg/L) which is the same as parts per million (ppm). This is determined most accurately in a laboratory.
- The old unit for measuring salinity (to be discouraged as much as possible!) is grains per gallon (g/gal).

The conversion between units is shown in Table 6 and worked examples follow.

Table 6. Water quality conversion factors

To convert mS/m to mg/L multiply by 5.5
To convert mg/L to mS/m multiply by 0.18
To convert g/gal to mg/L multiply by 14.3
To convert g/gal to mS/m multiply by 2.6

Examples

1. A water sample has a conductivity of 250 mS/m. How many mg/L is that?

   250 mS/m x 5.5 = 1,375 mg/L

2. Potatoes require water less than 1,500 mg/L. How much will that be on your conductivity meter?

   1,500 mg/L x 0.18 = 270 mS/m

3. A driller tells you that your bore water is 125 grains per gallon but all your plant requirements are listed in mg/L or mS/m. What does this mean?

   125 grains per gallon x 14.3 = 1,788 mg/L

   125 grains per gallon x 2.6 = 325 mS/m

Quality of irrigation water

The ability of a crop to handle salty water depends on:

- Soil type – salts can be leached (washed through) more easily from the root zone in sandy soils than heavier clay or loam soils.
- Plant health – diseased plants are less tolerant of salty water.
- Irrigation method – spraying salty water onto plants damages the leaves (especially on hot dry days) whereas drip irrigation systems can use saltier water.
- The amount of water applied. Avoid light, frequent watering because the salts in the water must be leached below the root zone – or can affect growth.
- Time of the day. Fresher water is needed when watering in hot conditions.
- Stage of development. Young seedlings are particularly sensitive to salt.

For vegetables and crops, see Farmnote 34/2004 (Water salinity and crop irrigation). Detailed information on the maximum salt levels that can be tolerated by different crops is available in Farmnote 71/99 (Tolerance of plants to salty water). Information from the Farmnote is summarised in Table 7.

Table 7. Tolerance of crops to salty irrigation water (based on Farmnote 71/99)

Conductivity in mS/m (mg/L)	Salinity tolerance level	Crops	Precautions
0-90 (0-500)	Highly salt-sensitive	Fruit – persimmon, passionfruit, strawberry, raspberry, avocado, loquat, almond, stonefruit, citrus, apple, pear Vegetables – green bean, parsnip, celery, radish, squash, pea, onion, carrot	1. Avoid wetting leaves on hot dry days.
90-270 (500-1,500)	Mildly salt-sensitive	Fruit – mulberry, grape Vegetables – cucumber, capsicum, lettuce, sweet corn, rock melon, potato, cauliflower, cabbage, water melon, broccoli, pumpkin, tomato	1. Avoid wetting leaves during day. 2. Avoid light, frequent watering. 3. Water quickly and use continuous wetting sprinklers if wetting the leaves.
270-635 (1,500-3,500)	Slightly salt-sensitive	Fruit – olive, fig, pomegranate Vegetables – spinach, asparagus, kale, garden beet	1. Avoid wetting leaves of most plants where possible. 2. Adequate leaching necessary.

4. How reliable is rainfall in the Lower Great Southern?

The South Coast has a reliable rainfall compared with most other parts of Australia. However, when estimating reliability it is best to avoid using figures from average years, because during half of the years you can expect less than the average. Rainfall data from dry years will be more useful.

Figure 1 shows the minimum rainfall that we would expect in seven years out of every 10, i.e. in three years out of 10 we would expect less than the amount shown[1].

On average, Mount Barker will get less than about 625 mm of rain in three years out of every 10 and Denmark will get less than 900 mm. This helps to determine whether dams will receive enough run-off to irrigate crops in dry years (see Section 5).

If you need water supply to be effective for at least nine years out of 10, then Figure 2 should be used. On average, Mount Barker will receive less than 520 mm of rainfall in one year out of every 10 and Denmark will receive less than 850 mm.

The amount of water crops require between November and April depends on summer rainfall. Again, averages of summer rain are not a good guide as they are affected by the very heavy rains that fall occasionally. Figure 3 shows that Mount Barker can expect at least 140 mm, and Denmark at least 200 mm, in three 'summers' (early November to late April) out of 10.

More information about the rainfall and other climatic data in your district can be obtained from several sources. Farmnote 111 (sources of climate data) describes how to access some sources of these data.

[1] It is more accurate to say that there is a 30 per cent chance in any one year that less than that amount of rain will fall. Having had a dry year does not affect the probability for the next year.

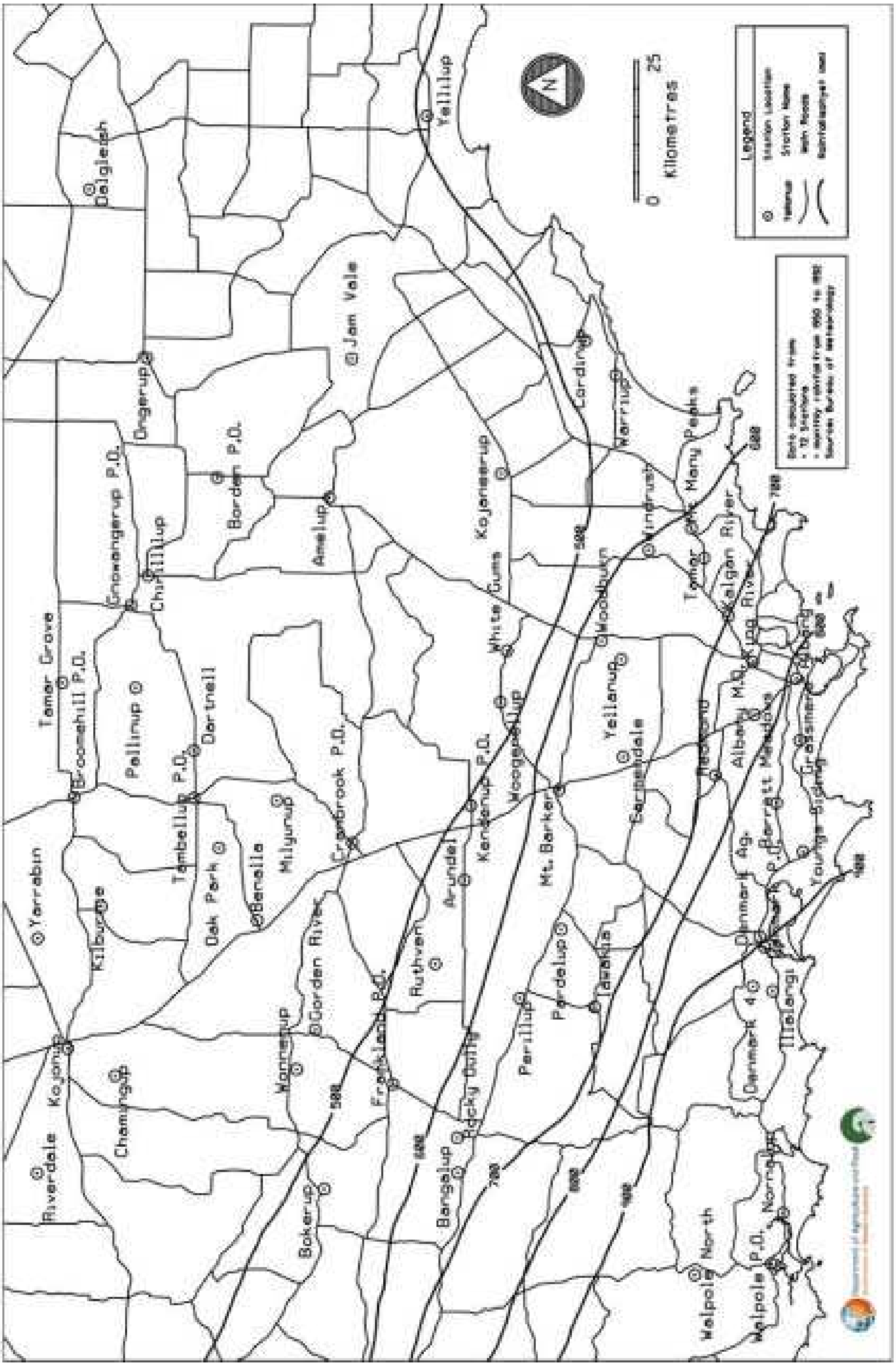

Figure 1. **Annual rainfall expected to be equalled or exceeded in seven years out of every 10 (i.e. In three years out of 10 less than this amount will be received).**

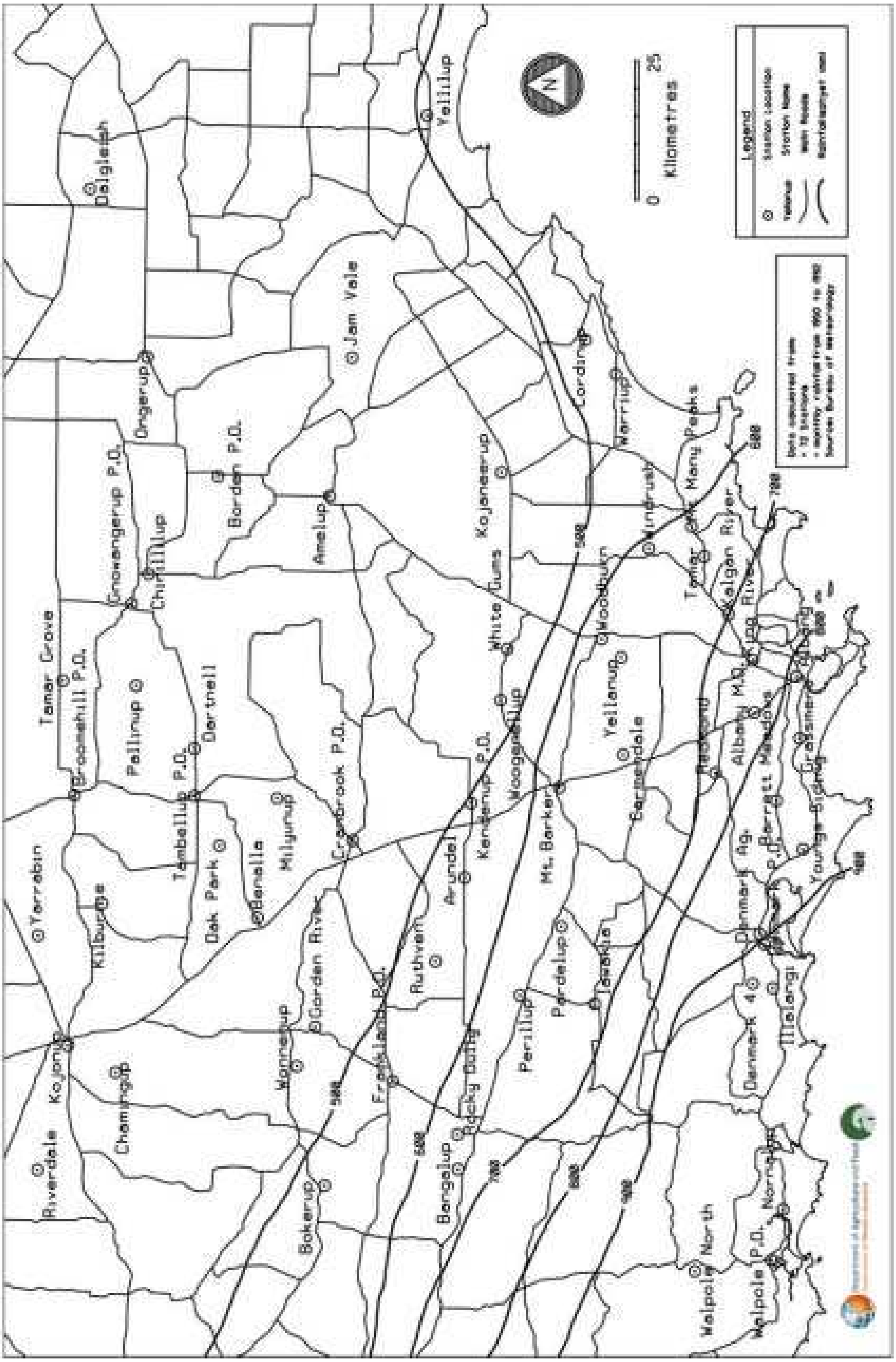

Figure 2. Annual rainfall expected to be equalled or exceeded in nine years out of every 10 (i.e. In one year out of 10 less than this amount will be received).

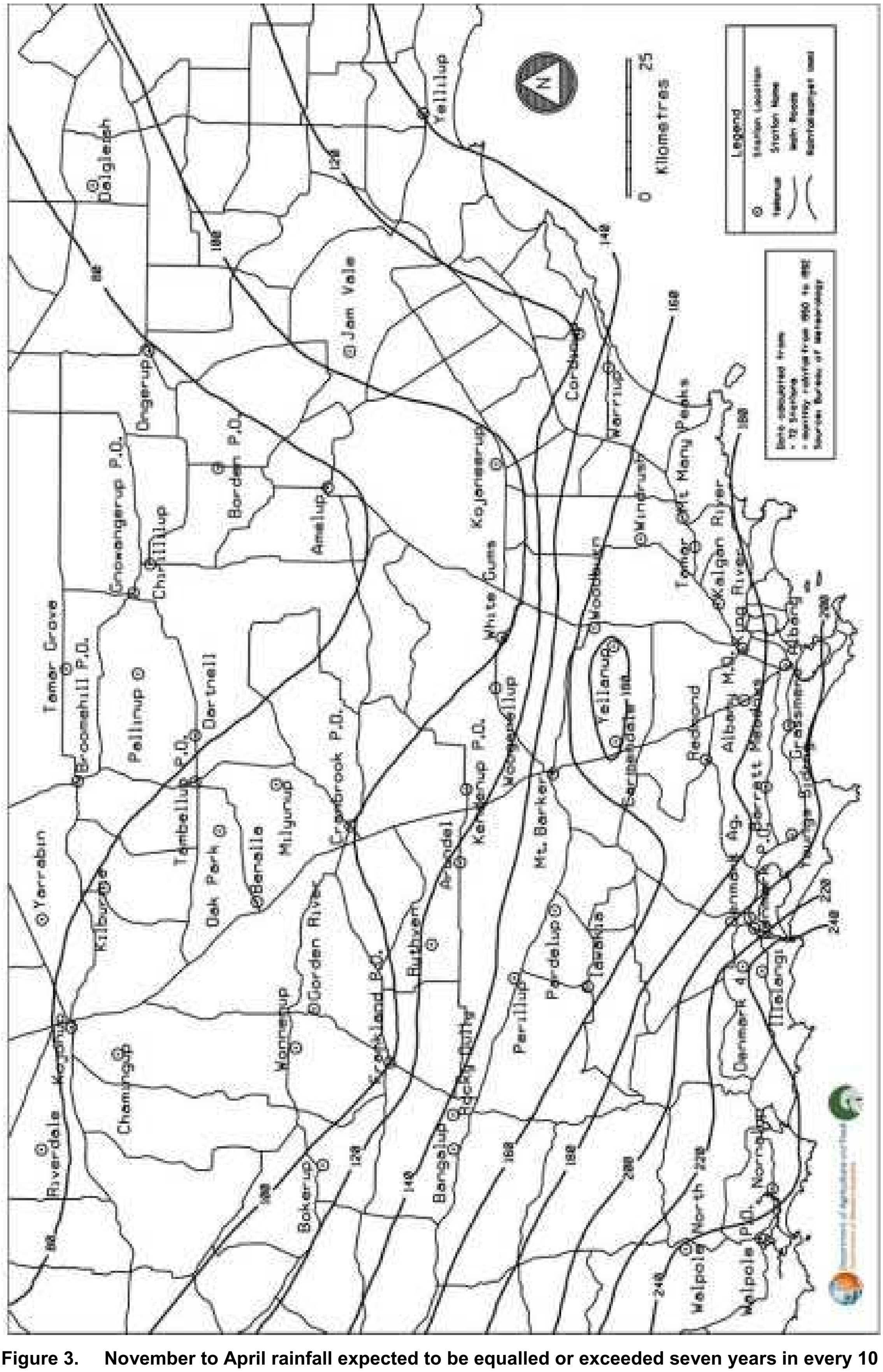

Figure 3. November to April rainfall expected to be equalled or exceeded seven years in every 10 (i.e. In three year out of 10 less than this amount will be received).

5. How much run-off and shallow seepage water can I collect?

Run-off is water flowing in channels over the surface of the ground. Usually it only occurs during, or soon after, rainfall. This water can be collected by shallow grade banks which are not deep enough to reach the clayey subsoil.

Shallow seepage is water-moving downslope within the soil profile. This flow can continue for months over winter and early spring. This water can be collected by seepage interceptor drains which extend just into the clayey subsoils.

The amounts of each type depend on:

- Intensity of the rainfall – as rain falls more quickly, run-off becomes more important than seepage because the water doesn't have time to soak into the soil. In years with mainly misty rain, there is little run-off into dams. You need well maintained roaded catchments or some form of improved catchment to collect run-off during these years.
- Wetness of the soil – the wetter the soil, the more run-off you can expect during rain (because rain infiltrates wet or saturated soils slowly). Wet soils can provide abundant subsurface seepage between falls of rain. This seepage can be collected with shallow seepage interceptor drains and grade banks.

Farm water supplies

On-farm water supplies are essential to maintaining a productive and profitable enterprise. Water management requires development of reliable on-farm supplies. This involves the assessment of current and future water demands for irrigation, livestock, crop spraying and domestic use. It requires suitably designed storages such as dams to store run-off from catchments, tanks to collect water from roof areas, and soaks or well-designed and equipped bores where suitable groundwater is available.

The Department of Agriculture and Food has publications and free software to assist farmers assess the reliability of on-farm water supplies.

Farm Water Supplies for Dryland Agriculture Kit #3 includes:

Farmnotes

72/2002 – Using windbreaks to reduce evaporation from farm dams
5/2003 – Treatment of leaky dams
34/2004 – Water salinity and crop irrigation
41/2004 – Water quality for farm and garden and household use
42/2004 – Clearing cloudy or coloured water
43/2004 – Water quality for farm domestic and livestock use
44/2004 – Emergency chlorination of farm water
52/2004 – Toxic algal blooms
64/2004 – Rainwater tanks
72/2004 – Designing for reliable water supplies.

Bulletin 4609 – Farm dams in Western Australia

Bulletin 4660 – Roaded catchments to improve reliability of farm dams.

Use www.agric.wa.gov.au to access these and other related publications; e-mail farmwaterinfo@agric.wa.gov.au for the kit or CD; or phone (08) 9368 3710 or fax 9368 3355.

Here are some software packages to help:

Dam Volume Calculator. The life or reliability of a water resource (e.g. farm dam) can be calculated by considering the demand on it for different times of the year and for different numbers of livestock or pumping. This program will enable you to assess the reliability of your farm dams.

DAMCAT 4. This is a simple tool that evaluates the optimal design criteria for agricultural water storage structure (dams). The model uses regional rainfall characteristics, dam capacity, dam catchment area, evaporation losses and water use (stock) to derive the best design combinations for the given location. Use this program to dynamically assess the reliability of different design options for combinations of dams and roaded catchments based on rainfall/run-off thresholds and livestock water requirement.

Raintank2 Calculator. This is a simple model used to evaluate existing systems and future designing requirements. The roof area is rated against the rainfall using a 1-2 mm threshold and a known volume of storage. Use this program to optimise the tank size for your roof area and evaluate existing roof-raintank systems based on water demand and rainfall.

Estimating water yields

Figure 4 shows the amount of run-off that can be expected for different annual rainfall for catchments with and without a defined watercourse (more than 60% cleared) and for small catchments (less than 10 ha) with seepage interceptor drains.

For catchments with a defined watercourse (Figure 4; middle line), the percentage of rainfall that runs off increases with more rainfall (i.e. the line slopes upwards). You can expect only about 20 mm of run-off if the annual rainfall is 500 mm (4%), but 60 mm of run-off from 670 mm of rainfall (9%) and 160 mm of run-off from 900 mm (18%).

Catchments without a watercourse (e.g. areas on a very gentle slope above a hillside dam) produce less run-off (fuzzy lowest line on Figure 4) than those with defined watercourse. Thus only about 12 mm of rain may run off slopes receiving less than 500 mm of annual rainfall.

However, catchments with drains that intercept seepage as well as surface run-off can yield large amounts of water when rainfall exceeds 500 mm (Figure 4, dot and dash line). Thus about 90 mm of rainfall may run off drained slopes which receive 600 mm of annual rainfall (15%). However, about 850 mm of rainfall is required to get a 90 mm yield from catchments which have no drains and no defined watercourse. Shallow drains (which intersect the clay subsoil) can provide abundant water to dams in wet years and at the same time reduce the damage caused by waterlogging and water erosion. They can also improve trafficability for vehicles and spray equipment.

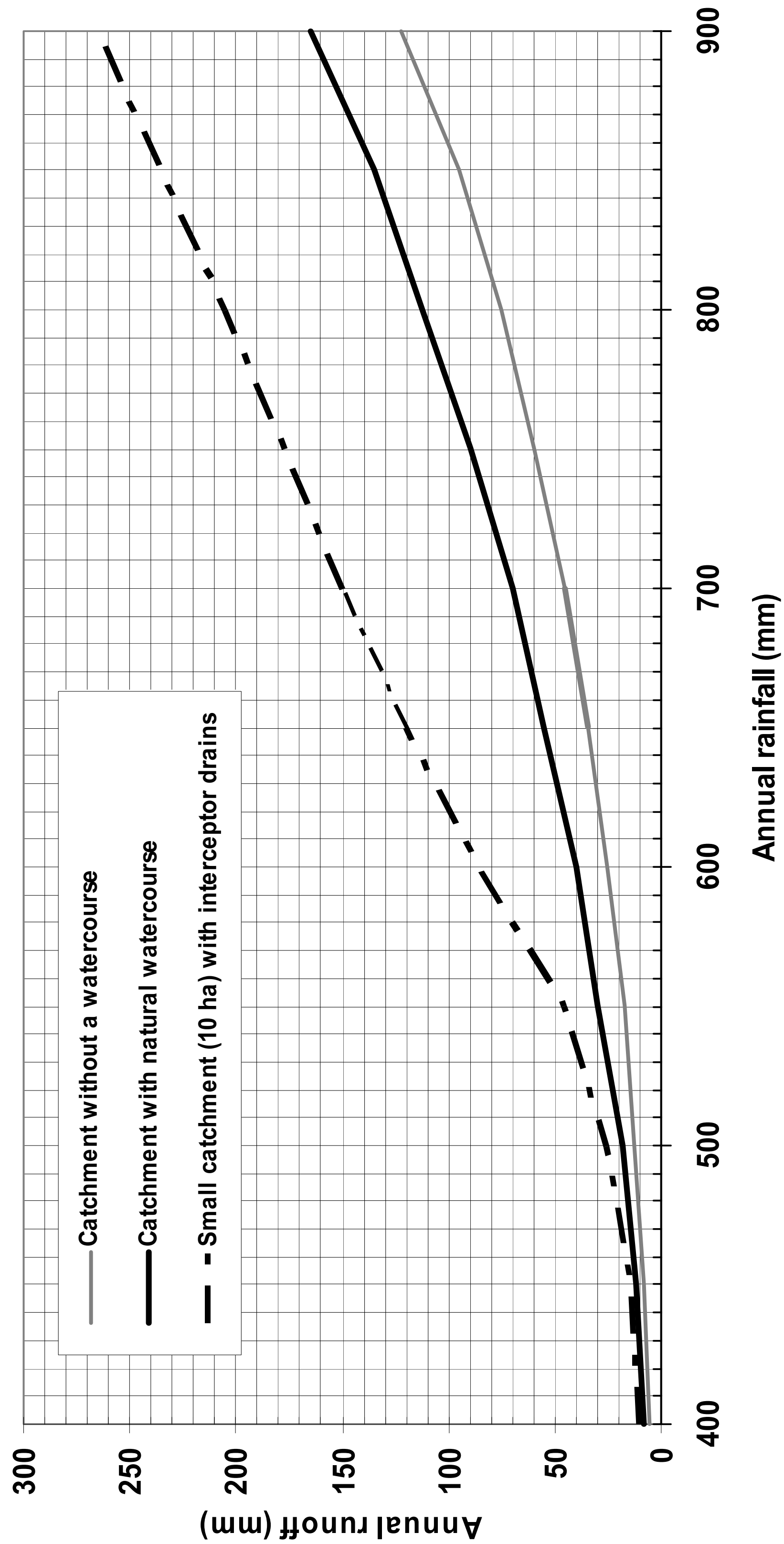

Figure 4. Run-off as function of rainfall for cleared catchments without a watercourse, catchments with a defined watercourse (from Department of Water, Busselton-Walpole Review, unpublished), and small catchments (< 10 ha) with seepage interceptor drains (McFarlane and Cox 1992).

Example 3

How much run-off will a 150 ha catchment with a defined drainage line at Mount Barker produce in a very dry year if the annual rainfall is expected to be exceeded nine years out of 10 (decile 1, the driest of 10 years)?

The catchment area is 150 ha (1,500,000 m^2)

The annual rainfall would be 520 mm or 0.520 m (Figure 2)

The run-off for a year with 520 mm is 24 mm or 0.024 m (Figure 4)

Water yield = 1,500,000 x 0.024 = 36,000 m^3

This means that on average, in nine years out of every 10, the grower can expect the catchment to yield more than 36,000 m^3 and in one year out 10, less than 36,000 m^3 can be expected.

For decile 3 rainfall (620 mm, Figure 1), the run-off would be 45 mm and the water yield 67,500 m^3.

Example 4

How much run-off will a 9 ha catchment with seepage interceptor drains at Redmond produce if the annual rainfall is expected to be exceeded in seven years out of every 10?

Area = 90,000 m^2

Rainfall = 720 mm or 0.720 m (from Figure 1)

Run-off = 160 mm or 0.160 m (from Figure 4)

Water yield = 90,000 x 0.160 = 14,400 m^3

The benefits of using shallow surface drains to harvest water are often overlooked or greatly under-estimated in horticultural and agricultural areas.

Surface and groundwater quality

Figure 5 shows that an area west of Albany (towards Marbellup) and along the Torndirrup Peninsula has been declared a Groundwater Management Area. All wells have to be licensed and there are strict controls on extraction of groundwater for irrigation. Generally, new horticultural developments which would use groundwater in competition with the supply for Albany will not be allowed in this area. The risk of groundwater pollution must be minimised. Contact the Department of Water for further information.

Agricultural areas that may have groundwater of sufficient quality for most horticultural crops and good quality surface water in streams, occur north and west of the restricted area, and extend east along the coast past Manypeaks and Green Range (see Figure 5).

South of Narrikup and around Denmark there are areas with poorer quality groundwater (or difficult to extract at high flow rates) but which have good quality water in streams.

Figure 5 also shows that streams and groundwater in the north of the Great Southern are usually too saline for horticulture. However, it is usually possible to divert sufficient fresh water from surface and shallow subsurface run-off into hillside dams for horticultural crops when the annual average rainfall exceeds 600 mm. It is essential to drill exploratory holes in this area to ensure that there is no saline groundwater under proposed dam sites and that clay with good water-holding properties is available. Channelling of surface water across saline seepages or salt-affected land should be avoided.

Figure 5 is a generalised map and some areas shown as having poor quality groundwater and/or stream water may actually have good quality supplies. Likewise, there may be areas which are shown as having good quality waters which, for local reasons, are too salty for salt-sensitive crops. The map is a guide only and will be updated as better data become available.

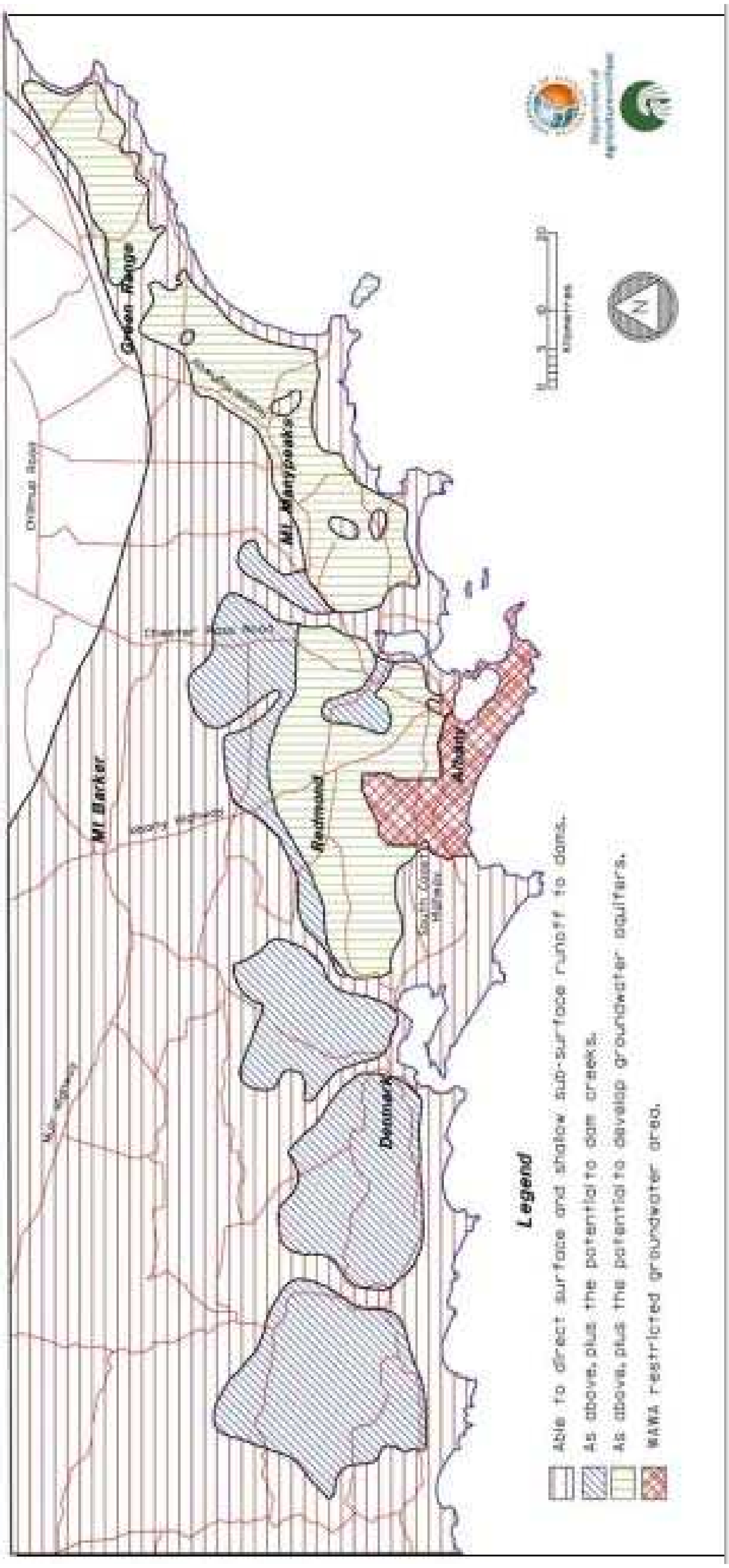

Figure 5. A guide to surface and groundwater resources on the western South Coast of Western Australia.

6. How big do dams and roaded catchments need to be?

Dams should preferably be constructed outside creeklines to reduce problems associated with erosion, sedimentation and structural stability as well as for legal reasons (see Section 9). In addition, lower parts of the landscape are much more susceptible to salinity.

Given the high water yield of drains (Figure 4), some horticulturalists construct long drains which take water to a collector dam from which it is pumped to a higher storage dam and gravity-fed or pumped to irrigated areas.

Roaded catchments can provide run-off to dams from falls of rain as small as 5 mm. For more information refer to Department of Agriculture Bulletins 4609 (Farm dams in Western Australia) and 4660 (Roaded catchments to improve reliability of farm dams).

There is a trade-off between dam size and roaded catchment area. Provided there is room for a roaded catchment, the lowest cost solution depends upon the relative costs of constructing more roaded catchment and building a bigger dam.

If there is not enough room for a roaded catchment, you will need a large dam which fills during wet periods so that there is enough stored water for long dry periods (e.g. 18 months if there is a winter with little or no run-off).

Dam builders may give specifications in cubic yards (or yard as in 'a 10,000 yard dam') rather than cubic metres. Multiply cubic yards by 0.76 to convert to cubic metres and multiply cubic metres by 1.31 to convert to cubic yards.

Example 2 (page 8) showed that we would need about 3,860 m^3 to irrigate a 0.5 ha cherry orchard at Mount Barker. Thus a 1.0 ha orchard would require about 7,720 m^3 and a 1.5 ha orchard about 11,580 m^3. There will be losses from the dam caused by leakage and evaporation, and water may be required for other purposes (e.g. adding fertilisers and chemicals).

A software program called DAMCAT (see page 17) was used to calculate the areas of roaded catchment needed to make sure that there is enough water over a 35-year period (1971 to 2005) to supply 7,720 m^3 of water from a 10,000 $m^{3\ dam}$ and to supply 11,580 m^3 from a 15,000 m^3 dam at Albany, Mount Barker or Denmark (Table 8).

The 10,000 m^3 dam required 3.5 ha of roaded catchment at Albany and Denmark and 4.0 ha at Mt Barker. The larger size at Mt Barker reflects lower rainfall and higher evaporation at the inland site. For the exercise it was assumed that crop requirements were the same in all three areas, whereas crops actually require more water at Mt Barker. It is interesting to note that the years when the dam only just supplied the required amount of water differed in each centre (1972-73 at Denmark and Mt Barker and 1983-84 at Albany).

The 15,000 m^3 dams at all three sites required 5 ha of roaded catchment to supply 11,580 m^3 reliably. The years when supply was only just met were the same for the 10,000 m^3 dam.

These calculations only provide a guide to the required size of both the dam and roaded catchment. The shape of dams affects the amount of water that is lost by evaporation. Deep dams with a small surface area lose less than shallow dams with a large surface area. Factors such as the month when water is required and dam shape can be included in the DAMCAT program to calculate the sizes of dams and roaded catchments for your situation.

Details on water supply issues for hobby farms are contained in Farmnote 73/94 'Water supplies for irrigation on the small farm'.

Table 8. Sizes of dams and roaded catchments required to supply two water demands at Denmark, Albany and Mount Barker

Location	Demand for water (m^3 or kL)	Dam capacity (m^3)	Roaded catchment needed (ha)
Denmark	7,720	10,000	3.5
	11,580	15,000	5.0
Albany	7,720	10,000	3.5
	11,580	15,000	5.0
Mount Barker	7,720	10,000	4.0
	11,580	15,000	5.0

Other Farmnotes which provide details on dam site selection (e.g. the need to avoid salty groundwater and select clays which hold water) and other matters are listed in Section 11.

Increasing run-off to on-farm irrigation dams

In 2003 and 2004 the Department of Agriculture commenced research to increase run-off efficiency of roaded catchments. A trial was set up on a roaded catchment at Frankland to determine the effectiveness of two soil stabilisers in increasing run-off. The treatments were:

1. Control – untreated roaded catchment surface
2. Dustex – calcium lignosulphonate
3. Total ground control (TGC) – acrylic polymer.

Both soil stabilisers significantly increased run-off. Table 9 shows the 2004 results.

Table 9. Run-off from each treatment from 1 May to 31 August 2004

Treatment	Rainfall (mm)	Run-off (mm)	Rain that became run-off
Control	289	107	37%
Dustex	289	133	46%
TGC	289	185	64%

A detailed economic analysis of the benefits of applying chemicals to improve run-off is required for each situation. For more information contact Rod Short, Department of Agriculture and Food, South Perth (Telephone 9368 3333).

7. How do I know if I have fresh groundwater under my property?

Indications of groundwater quality and depth can be gained from Figure 5, which was compiled from drill hole information. The Geological Survey of WA released a hydrogeological map of the Manypeaks-Albany-Denmark-Rocky Gully-Mt Barker-South Stirling area in 1995. This shows the salinity of all known bores in the area. Further details (regolith material encountered, water levels, water supplies, etc.) of the bores can be obtained from the Department of Water and Department of Agriculture and Food.

Asking neighbours what they know about groundwater levels and quality is also worthwhile. Salinity of groundwater at discharge sites (seeps and soaks) may be another good indicator of salinity. As our knowledge of groundwater supplies is limited to the bores that have been drilled so far, it is possible that there are good supplies in some areas.

Groundwater is easy to find, as it is present under most areas. However, finding good quality water in an aquifer which can be pumped economically is much more difficult.

Hydrogeologists from the Department of Water may be in a position to inspect your property and advise on bore siting. Private consultants are also listed in the yellow pages of the telephone book (under Geologists, Civil Engineers or Water Boring).

The Albany Office of the Department of Agriculture and Food has landform maps that help indicate whether fresh groundwater will be present. Air photos are also very useful when selecting drill sites.

Geophysical instruments can measure the conductivity of the ground to different depths. Readings showing high conductivities are associated with saline water.

Water diviners may also offer their services. Some diviners use visual clues based on landforms and may be successful where they have local knowledge about the presence of groundwater. However, there is no known basis for divining and objective tests of divining have shown that the technique performs poorly.

In general, good supplies have been found in:

- Areas with deep basement rocks which contain coarse-grained Tertiary sediments (Werrilup Formation) above bedrock. The closer to the coast, the more likely that the groundwater will be fresh. Close to groundwater catchment divides water will be fresher because it will have been freshly recharged and will not have accumulated much salt in the regolith (see terminology).
- Sandy and spongolite sections of Pallinup Siltstone (sometimes called ‘soapstone’). Spongolite areas often have sinkholes where material which was deposited with the sponge particles has been dissolved. Again, those sediments which are closer to the coast (e.g. south of Hassell Highway) have lower salinities, in soaks downslope of deep sands and gravels.
- Soaks in deep sands that have been deposited at the foot of granitic hills.
- Old sandy river channels which no longer have surface water flowing in them.
- Fractured bedrock associated with major faults and shears.

Areas associated with salty water (and which should be avoided when drilling) include those:

- adjacent to salty creeks and lakes;
- poorly drained, low-lying areas which are a long way from fresh recharge;
- areas with very clayey subsoils (weathered granite and gneiss) because they often store salt, particularly in medium and low rainfall areas.

Once you have decided where to drill, it is necessary to keep a close eye on the material being drilled to see whether:

- it contains water;
- the water is fresh or saline (a portable conductivity meter is useful for this); and
- the material is coarse enough for screening.

Screens need to be able to hold back about 60% of the material. If you use too coarse a screen size, subsoil material can enter the bore and either silt the screen or damage the pump (a common problem in South Coast sediments). If you use too fine a screen, insufficient water will enter the bore. Almost all production bores have a sand envelope (called a gravel pack) added around the screened section to enable a coarse screen to be used. Professional help is needed to select the right screen and gravel pack for each situation.

Some drilling companies will run a geophysical logging tool down the hole to help decide which parts of the hole should be screened. A gamma log shows where sandy and clayey sections are and a conductivity log will indicate where fresh and salty water may be found.

There are good supplies of good water near the South Coast which could be used for horticulture and viticulture. They can often be used in dry years provided groundwater resources are replenished in wet years. Prospective landholders and users should be aware of this need for replenishment.

8. How can I pump the groundwater out?

If a promising section is encountered, it is usual to case and develop the hole (surge with air or water to remove fines from around the slotted area) before test pumping to see how much the water level drops in the bore for different levels of pumping and to see whether the water quality changes.

Commercially-slotted PVC casing can be bought readily. If the water quality is relatively uniform throughout the hole and you are unsure where most of the water is entering the hole, it is best to slot large sections of the hole so that it can all contribute.

Monitor the water level in the hole while pumping at different rates to see which rate is sustainable. Ideally, water levels in small observation bores which are slotted over the same interval as the production bore should be monitored during the test. Professional help is needed for selecting the right screen, gravel pack and pump for each situation.

Observation bores should be located near important production bores to monitor long-term water levels and warn of declines in quantity and quality. They may also be used to reassure surrounding landholders that abstraction of water is not depleting the resource.

9. Who owns the water that flows through and under my property?

Surface waters

The rights of landowners and occupiers to surface water are outlined in the *Rights in Water and Irrigation Act 1914*, administered by the Department of Water. In the Lower Great Southern diverting water from streams and lakes does not require a diversion licence. However, there are certain rights and obligations (defined under Section 2 of the Act), which cover these waters. These rights and obligations are presented on the Department of Water website (www.water.wa.gov.au). The list on the left hand side of this page has links to topics such as allocation and conservation, groundwater, licensing, policy and rural planning.

Licensing – proclaimed and unproclaimed areas (extracts from the website)

1. Proclaimed areas

In proclaimed areas under the *Rights in Water and Irrigation Act 1914* it is illegal to take water from a watercourse or groundwater aquifer without a license. Applications for water licences are made through regional offices. A licence does not guarantee that water is always available to be taken. During drought periods restrictions are applied so that the available water is shared and damage to the water, the resource and users is minimised. Conditions are placed to define how and when water may be taken and to specify obligations the licence holder must meet when using the water.

2. Unproclaimed areas

Water can be taken from watercourses in unproclaimed areas without a licence so long as the flow is not 'sensibly' diminished, affecting the rights of downstream users. If conflicts arise, the Department of Water can issue a direction defining the amount, the purpose and the way water may be taken.

Wetlands and springs distant from creeks

The water in any lake, lagoon, swamp or marsh, the bed of which lies wholly within the boundary of a property and which is not part of a natural water course, may be taken and used by the owner/occupier subject to any requirements under the *Environmental Protection Act 1986* for the protection of wetlands.

Springs which arise on the land of the owner/occupier which are remote from the stream are the property of the landholder if the waters can be intercepted before they enter the natural watercourse or pass through the boundary of the property.

Springs near creeks

Flow arising from springs seeping through the banks and within the bed of the watercourse (including those which arise beneath storages constructed on the watercourse), are part of the natural flow of the stream and come under the provisions of the *Rights in Water and Irrigation Act 1914.*

Riparian rights

Owners or occupiers of land that has a watercourse running through it, or that has a lake, lagoon or swamp partly situated within the property boundaries have certain rights to:

- sufficient water for the domestic and ordinary use of the residents of the property and for watering of livestock;

- water for the irrigation of horticultural crops to the extent that the flow in the watercourse or the water in the wetland is not sensibly diminished;
- water for irrigating a garden up to 2 ha provided the garden is connected to a dwelling and there is no commercial sale of produce if the land passed into private ownership before 1914.

Riparian rights do not apply where there is a foreshore reserve. In these cases, the owner/occupier has to get written approval from the agency in which the reserve is vested before water can be diverted.

Requirement to by-pass low flows

People who divert water from a watercourse, lake, etc. by pumping or by constructing a dam on the stream must make sure that their diversion does not affect existing users and that low flows are by-passed. This means that a new owner cannot buy land above an established property and cut off the stream denying water to downstream users.

The Department of Water encourages owners/occupiers to construct off-stream storages wherever possible. These can store water during periods of high flow, when abstraction is least likely to affect other users, and provides greater security of supply during times of low flow, which must be by-passed.

When a dam on the stream is the only viable option, the dams must have a properly constructed spillway to allow large flows to pass and the ability to by-pass low flows using either an outlet pipe through the dam wall (which is installed during construction) or a permanently secured siphon.

When a person has diverted water to the extent that it interferes with the rights of other users, or that is contrary to public interest, the Department of Water can issue a direction specifying the amount, or how, or for what purpose, the water may be taken.

Legal implications of dams

If a subcatchment containing a dam in the Denmark or Kent Catchments requires any clearing, or if the dam is likely to flood and kill any native vegetation, then a Licence to Clear is needed from the Department of Water.

Stored water should not pond onto adjoining properties (unless there is a written agreement with the owners of the properties) or road reserves.

There must be sufficient room downstream of the dam to return the overflow to the original watercourse within the owners' property, while ensuring that the velocity of the overflow does not erode the bed or banks of the watercourse.

There is no enacted legislation that regulates dam safety and dam construction. Under Common Law, if a dam fails, the owner of the dam is liable for the full cost of all damages including personal injury, property and livestock loss or damage, loss of income, road repairs and restoration of the stream channel. For these reasons professional advice on design and construction should be sought where there is the potential for property damage or loss of human life.

It is strongly recommended that vegetated areas be maintained around streams and dams to act as a nutrient stripping zone and buffer against contamination.

Groundwater

Figure 5 showed the Groundwater Management Area near Albany where groundwater cannot be used without a licence from the Department of Water. As indicated earlier, a large water allocation which compromises the town water supply is unlikely to be granted.

Outside this area, groundwater can be pumped and used provided your extraction does not disadvantage neighbouring bores or groundwater discharge to streams. If your extraction causes financial losses for neighbours, injunctions can be taken out to prevent you pumping and damages obtained through the courts.

Little groundwater is pumped at present (except for small amounts for livestock using windmills) so it is unlikely that legal problems will arise. However, you need to be aware that once a groundwater resource is developed for horticulture, surrounding landholders may decide to follow suit. In areas of dispute, the Department of Water may declare the area and license pumping on the basis of equity, prior use and need.

10. Can I get financial assistance for water supplies?

The type of help available depends on where you live and what you use the water for. Some landholders may be eligible for the Farm Water Grant Scheme 1995. The scheme is currently administered by the Department of Water. The information you need can be found at www.water.wa.gov.au. From the list on the left hand side, select *Rural Water Planning*, then from the drop-down list select *Farm Water Grants*. The section on Farm Water Grants has some information and two PDF files with application forms and more detailed information. There should be contact details for the person managing the program on the forms or in the detailed information.

11. Where can I find out more about water supplies?

The Department of Agriculture and Food in Albany has horticultural development officers, land conservation officers and catchment hydrologists able to help with general enquiries.

For specific investigations of your property you may need to employ a community landcare technician, hydrogeologist, hydrological consultant or agricultural consultant. Lists of these people are held by the Department of Agriculture and Food. The Department of Water may also be able to help.

Further information can be obtained from the following sources, several of which were used when compiling this bulletin:

Department of Agriculture and Food website (www.agric.wa.gov.au).

Information Kit – Farm Water Supplies for Dryland Agriculture Kit #3. Go to www.agric.wa.gov.au to access these and other related publications, or e-mail farmwaterinfo@agric.wa.gov.au for a copy of the kit or CD.

Department of Water website (www.water.wa.gov.au).

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Farmnotes

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12. What does that technical word mean?

Aquifer	– A geological unit including material which can transmit enough water for a bore or well to be useful.
Aquitard	– A geological material which is incapable of transmitting enough water for a bore or well to be useful. Materials with very low permeabilities are called aquicludes.
Decile	– To calculate deciles all the rainfall recordings are ranked, from the lowest to the highest. The list is divided into 10 equal parts and each part is called a decile. Decile 5 is the median (or middle), and there are as many years with less rainfall than that figure as there are years with more rainfall. Decile 1 has one-tenth of all the rainfall recordings less than it, and nine-tenths of them above it (i.e. it is a one in 10 years 'drought').
Developing a bore	– Improving the flow of water to a bore by jetting or surging water through a screen or a slotted section of a production bore to remove fine material from the aquifer near the screen/slots.
Effective evaporation	– The amount that potential evaporation exceeds rainfall.
Exceedence probability	– The likelihood that an event (for example an amount of rain or run-off) will be exceeded in any one year. Thus a 0.3 exceedence probability means that there is a 30% chance that the amount will be exceeded in any one year or in three years out of every 10 on average.
Gneiss	– A metamorphosed rock containing bands of fine and coarse grained minerals.
Gravel pack	– Sand, gravel or aggregate that is placed around the slots or screen of a production bore.
Groundwater	– Water below the surface of the ground which can flow into a well or bore (i.e. it is at a pressure which is greater than atmospheric pressure).
Recharge	– The addition of water to the groundwater, usually via soil but can be via lakes and rivers.
Regolith	– Weathered or unconsolidated material above bedrock.
Roaded catchment	– A 'road' with a clayey surface that carries run-off into a dam. Usually constructed with a grader by bringing clays from subsoil to the surface and forming long, sloping beds or roads.
Screen	– Slotted pipe, or a specially made perforated screen, for holding back material while allowing water to enter a bore.
Shallow seepage	– Water moving laterally through a soil profile, usually on top of a clayey subsoil.
Spongolite	– Rock composed of sponge spicules (needle-like 'spikes').

13. Who else helped to put this bulletin together?

- Funding for this publication was obtained from SCRIPT (South Coast Regional Initiative Planning Team Inc.

- Kevin Shanhun estimated the roaded catchment and dam sizes in Section 6.

- Jill Lisson from Department of Agriculture and Food, Albany, provided the information on farm water supply.

- Wendy Boddington and Geoff Mauger (Department of Water) provided some of the information in Section 9.

- Useful comments were obtained from Greg Luke, Ed Hauck, Kevin Shanhun, Mark Webb and Robin Smith.

- Some information in Sections 9 and 10 was provided by the Department of Water.

- Brett Ward from Department of Water provided the references to its website. Some of the information in Sections 9 and 10 was obtained from there.

- Dr Jo McFarlane provided technical editing assistance.

- Colin McDonald and John Simons from Department of Agriculture and Food reviewed this publication.

- Georgina Wilson from Department of Agriculture and Food, South Perth, reviewed and edited this publication.