GOVERNMENT OF
WESTERN AUSTRALIA

CLEARING PERMIT

Granted under section 51E of the Environmental Protection Act 1986

PERMIT DETAILS

Area Permit Number: CPS 6686/3

File Number: DER2015/001739-1

Duration of Permit: From 12 December 2017 to 12 December 2032

PERMIT HOLDER

Southernrae 1 Pty Ltd

LAND ON WHICH CLEARING IS TO BE DONE

Lot 1790 on Plan 3315, Southern River

AUTHORISED ACTIVITY

The permit holder must not clear more than 4.51 hectares of *native vegetation* within the area cross-hatched yellow in Figures 1 and 2 of Schedule 1.

CONDITIONS

1. Clearing method

(a) The permit holder shall clear only via the method of grazing within the area cross-hatched yellow in Figure 1 of Schedule 1.

(b) The permit holder shall clear via any method within the area cross-hatched yellow in Figure 2 of Schedule 1.

2. Avoid, minimise, and reduce impacts and extent of clearing

In determining the *native vegetation* authorised to be cleared under this permit, the permit holder must apply the following principles, set out in descending order of preference:

(a) avoid the clearing of *native vegetation*;

(b) minimise the amount of *native vegetation* to be cleared; and

(c) reduce the impact of clearing on any environmental value.

3. Weed and dieback management

When undertaking any clearing or other activity authorised under this permit, the permit holder must take the following measures to minimise the risk of introduction and spread of *weeds* and *dieback*:

(a) clean earth-moving machinery of soil and vegetation prior to entering and leaving the area to be cleared;

(b) ensure that no known *dieback* or *weed*-affected soil, *mulch*, *fill*, or other material is brought into the area to be cleared; and

(c) restrict the movement of machines and other vehicles to the limits of the areas to be cleared.

4. Stocking rate

When determining the number of stock occupying the area cross-hatched yellow in Figure 1 of Schedule 1, the permit holder must adhere to the Annexure 1 '*Stocking rate guidelines for rural small holdings, Swan Coastal Plain and Darling Scarp and surrounds, Western Australia*'.

5. Records that must be kept

The permit holder must maintain records relating to the listed relevant matters in accordance with the specifications detailed in Table 1.

Table 1: Records that must be kept

No.	Relevant matter	Specifications
1.	In relation to the authorised clearing activities generally	(a) In relation to the clearing authorised under condition 1(a): (i) the boundaries of the location where stock have access for grazing, recorded using a Global Positioning System (GPS) unit set to Geocentric Datum Australia 1994/2020 (GDA94/20), expressing the geographical coordinates in Eastings and Northings; and (ii) grazing rotation schedules, if applicable. (b) In relation to the clearing authorised under condition 1(b): (i) the method and purpose of the clearing undertaken; (ii) the location where the clearing occurred, recorded using a Global Positioning System (GPS) unit set

No.	Relevant matter	Specifications
		to Geocentric Datum Australia 1994/2020 (GDA94/20), expressing the geographical coordinates in Eastings and Northings; (iii) the date that the area was cleared; and (iv) the size of the area cleared (in hectares). (c) Actions taken to avoid, minimise, and reduce the impacts and extent of clearing in accordance with condition 2. (d) Actions taken to minimise the risk of the introduction and spread of *weeds* and *dieback* in accordance with condition 3. (e) Any changes in stocking rate in accordance with condition 4.

6. Reporting

The permit holder must provide to the *CEO* the records required under condition 5 of this permit when requested by the *CEO*.

DEFINITIONS

In this permit, the terms in Table 2 have the meanings defined.

Table 2: Definitions

Term	Definition
CEO	Chief Executive Officer of the department responsible for the administration of the clearing provisions under the *Environmental Protection Act 1986*.
clearing	has the meaning given under section 3(1) of the EP Act.
condition	a condition to which this clearing permit is subject under section 51H of the EP Act.
fill	means material used to increase the ground level, or to fill a depression.
dieback	means the effect of *Phytophthora* species on native vegetation.
department	means the department established under section 35 of the *Public Sector Management Act 1994* (WA) and designated as responsible for the administration of the EP Act, which includes Part V Division 3.
EP Act	*Environmental Protection Act 1986* (WA)
mulch	means the use of organic matter, wood chips or rocks to slow the movement of water across the soil surface and to reduce evaporation.
native vegetation	has the meaning given under section 3(1) and section 51A of the EP Act.
weeds	means any plant – (a) that is a declared pest under section 22 of the *Biosecurity and Agriculture Management Act 2007*; or (b) published in a Department of Biodiversity, Conservation and Attractions species-led ecological impact and invasiveness ranking summary, regardless of ranking; or (c) not indigenous to the area concerned.

END OF CONDITIONS

Mathew Gannaway
MANAGER
NATIVE VEGETATION REGULATION

Officer delegated under Section 20
of the Environmental Protection Act 1986

30 November 2022

SCHEDULE 1

The boundary of the area authorised to be cleared is shown in the map below (Figure 1).

Figure 1: Map of the boundary of the area within which clearing may occur

The boundary of the area authorised to be cleared is shown in the map below (Figure 2).

Figure 2: Map of the boundary of the area within which clearing may occur

ANNEXURE 1

Stocking rate guidelines for rural small holdings, Swan Coastal Plain and Darling Scarp and surrounds, Western Australia

2-2000

Stocking rate guidelines for rural small holdings, Swan Coastal Plain and Darling Scarp and surrounds, Western Australia

Dennis van Gool

Ken Angell

Lindsay Stephens
Landform Research

MISCELLANEOUS PUBLICATION No. 2/00
ISSN 1326-4168
AGDEX 581

STOCKING RATE GUIDELINES FOR RURAL SMALL HOLDINGS

SWAN COASTAL PLAIN AND DARLING SCARP

WESTERN AUSTRALIA

Dennis van Gool[1], Ken Angell[1] and Lindsay Stephens[2]

[1]Agriculture Western Australia
[2]Landform Research

February 2000

An **AGPLAN**™ product

Acknowledgements

The information in this publication was compiled by Dennis van Gool and Ken Angell, Agriculture Western Australia and Lindsay Stephens of Landform Research. The stocking rate guidelines were prepared for Agriculture Western Australia's Land Use Planning project managed by Ian Kininmonth. Special thanks are extended to Gerry Parlevliet and Noel Schoknecht of Agriculture Western Australia for assistance provided in developing these guidelines. Peter Tille undertook a detailed review of the stocking rate units and many of the survey specific map unit ratings.

Other persons and organisations who assisted by providing information and advice were:

- Agriculture Western Australia - Neil Guise; John Silcock; Brett Vukelic; Eric Wright; Jenny Mercer, Mandy Dearden.
- Shire of Busselton - Iliya Hastings, Chris Ferreira.
- Shire of Murray - Ross Davidson.
- Shire of Serpentine Jarrahdale - Andrew Delmarco.
- Department of Environmental Protection - Jane Taylor.
- Water and Rivers Commission - Alex Marsden.
- Private consultant - Andrew Kikeros.
- Free Range Emu Farm; Ozbred Ostriches; Miandetta Ostrich Farm; Emu and Deer Farms, Bindoon; Neerigen Brook Alpacas; Corporation Park; Yealeringa Lowline Cattle Shed; Clinton Moss, Gingin; Demasc Emu Farm.

Disclaimer

This publication provides guidelines for determining appropriate stocking rates for rural small holdings assuming responsible land and stock management practices will be used. These guidelines apply to landholdings for which planning scheme provisions relate to the stocking and management of land. Proposals to exceed the base stocking rates recommended in these guidelines or established in a planning scheme should be the subject of an approval from the relevant local government authority. Local knowledge or site inspections are normally required to confirm the soil-landscapes and corresponding stocking rates.

Access to information

Copies of this publication are available from:

Publication Sales, Agriculture Western Australia, 3 Baron-Hay Court, South Perth, 6151. Enquiries can be made on fax (08) 9474 2018 or telephone (08) 9368 3729.

CONTENTS

LIST OF TABLES

Figures

1. NEED FOR STOCKING RATE INFORMATION

Small rural holdings are often owned by people who want to pursue a semi-rural lifestyle but who are inexperienced in land management issues. This can result in landholders stocking their properties with animals at rates higher than the land resources can sustain, leading to degradation problems such as soil erosion, water pollution and damage to vegetation. To manage these problems, most local planning schemes contain provisions requiring that stocking rates in special rural and other 'rural residential' zones match those recommended by Agriculture Western Australia.

This document provides information and guidelines to help planners, developers, local authorities and land owners determine the base stocking rates for rural small holdings on the Swan Coastal Plain and Darling Scarp and immediate surrounds. The advice utilises Agriculture Western Australia's rural stocking rate guidelines for rainfed pastures in the high rainfall areas (> 650 mm) in the south-west of Western Australia.

A knowledge of stocking rates and other land management issues can ensure better design of small rural and hobby farm developments at the planning stage. This results from matching the intended land use to the soil type and creating appropriately sized and configured lots. Mismanagement of land resources, stock or property can lead to other problems which are not directly addressed by this document but require consideration particularly during the planning stage or when stocking rates higher than the recommended rate are being contemplated. Examples include issues such as manure handling and stable design. A brief checklist of important considerations is provided as a starting point in Appendix 2. There is also a starting point for horses, a major land use on small holdings in Appendix 1. Section 7 includes the references and lists some additional sources of information.

1.1 Aims of the document

- To provide a method and information for determining the base stocking rate most suited to particular soil-landscapes in 'rural residential' areas.
- To encourage planners, developers and land management assessors to consider stocking rates during the planning process.
- To provide information to local authorities and community members to enable informed decisions on stocking rates to be made.

1.2 What is a rural small holding?

A rural small holding is any block of rural land that is generally used for residential living in a natural bush environment and/or with some level of hobby farm activity. Most local government areas in the south-west have rural small holding zones which are usually referred to as 'rural residential' or 'special rural' zones. Generally, planning scheme controls apply to the stocking of animals and using land for other agricultural activities such as horticulture in these areas.

There are also many rural small holdings located in areas where special planning scheme controls do not currently apply. These are largely a result of unplanned subdivision in rural areas. This is no longer supported as it can result in a number of problems. It removes future options for both urban and agricultural land and may result in land use conflict with bona fide agriculturalists routinely using heavy equipment, creating dust, smoke, odours and using chemicals. It also places a financial burden on local authorities as 'rural residential' owners

expect more urban style services such as sealed roads, well maintained drains, rubbish removal and so forth.

Rural small holdings are normally used for recreation or lifestyle purposes but sometimes include intensive farms, such as orchards or vineyards, organic production or special livestock such as emus or alpacas. They fill a market need for a rural lifestyle close to an urban area. However, in the push for lot yields, many lots may not be large enough to sustain stock without special management. The most common lot size is 1 to 2 hectares but rural small holdings can vary from 0.5 to 40 hectares or more.

Apart from historically unplanned or defacto 'rural residential' areas, planned uses for rural small holdings vary. Some of these uses are not well suited to the keeping of stock. For example, small rural lots are frequently used as buffers between rural and urban land uses. An example is the special rural areas located between urban areas in the South East Corridor Structure Plan (DPUD 1995).

'Rural residential' areas are also used for residential development on land covered by indigenous bush where restrictions on clearing and the keeping of stock are normally applied. An example is the greenbelt rural living areas identified in the Inner Peel Structure Plan (WAPC 1996).

Another major use of rural small lots is for the keeping of stock, especially horses. Although little research has been undertaken, it would appear that in areas where stock is permitted, only half the properties actually carry horses. Horses are commonly owned by families with teenage children. In a group of small rural holdings there is likely to be a period of perhaps 10 to 20 years when the numbers of horses or other stock are at their peak.

In some areas, such as Byford, many horse owners irrigate a portion of their holding. In other areas, such as Gidgegannup, irrigation is much less common. The use of ground or surface water supplies is controlled by the Water and Rivers Commission.

1.3 Stock on the Swan Coastal Plain and surrounding areas

The Swan Coastal Plain is unlike most other areas of the south-west. It has many porous sandy soils with low water and nutrient holding capabilities. In extensive areas the land is poorly drained and it is common for the watertable to lie close to the surface with numerous associated wetlands. Despite the prevalence of sandy soils, this watertable is often perched above a deeper clay or rock layer. Development pressure has led to extensive drainage to allow this land to be used. As a result, dominant environmental problems include nutrient pollution to ground and surface water, wetlands and estuaries. Nutrient pollution is a drainage management issue that goes hand in hand with waterlogging and salinity. The other serious problem is the decline and removal of wetlands and remnant vegetation.

Much of the land is cleared with often only the poorest remaining as bushland. On the Coastal Plain many remnant areas are dry sand ridges, whereas on the scarp, areas of laterite duricrust or steep slopes are the main remaining uncleared private land. Stocking of this remnant bushland is not acceptable because of the poor soil quality and the need for bushland conservation. Some vegetation, or vegetation regrowth, generally of poor quality, survives along roadways, drainage lines and swamps or wetlands.

On the Coastal Plain there are many groundwater resource areas and catchments such as the Peel-Harvey Catchment, Ellen Brook Catchment and the Jandakot Mound where nutrient management is the key issue which will determine stocking rates. For example, Statement of Planning Policy No. 2 for the Peel-Harvey Coastal Catchment, precludes stock on lots of

1 hectare or less. The Management Strategy for the Peel-Harvey Inlet (EPA 1994 - Bulletin 749) has a target estuarine water quality of 0.2 mg/L phosphorus. The Draft Statement of Planning Policy No. 6 for the Jandakot Groundwater Protection Area (Government of Western Australia 1997), restricts nitrogen input to 25 kg or a groundwater concentration of 12.5 mg/L (25% National Health and Medical Research Council limit).

Most of the Coastal Plain is also covered by gazetted groundwater areas. This means that groundwater use for sprinkler irrrigated pastures must be approved by the Water and Rivers Commission. In many areas groundwater use is restricted to 1500 kL per year for a small rural or hobby block of 2 to 5 ha, which is only enough for domestic purposes and a garden area. There are also a number of undergroundwater protection areas identified which restrict a wide range of land uses, and may affect applications for irrigating pastures or activities such as horticulture.

Nowadays, land on or near the Swan Coastal Plain that is close to towns is covered by Planning Schemes or other planning mechanisms that may restrict stocking rates unless approval is given by the local authority or another regulatory body to increase the rate. Approvals to increase the stocking rate are normally only granted if the landholder provides a management plan that prevents soil and vegetation decline as well as minimises nutrient export.

2. STOCKING RATES

2.1 What are stocking rates?

Stocking rates are the numbers of stock, e.g. sheep, cattle, horses, emus or any other type of animal that can consistently be kept on a piece of pasture all year round with minor additional feed and without causing environmental degradation. Environmental degradation could include wind and water erosion, tree decline, increasing levels of nutrients in groundwater and waterways, the spread of weeds into adjoining bushland and soil structure decline. Stocking rates are shown as Dry Sheep Equivalents (DSE) which are the number of adult sheep (wethers) that can be sustained on each hectare all year round.

The stocking rate is most usually associated with broad acre farming practices and thus gives a baseline value for the management of land on small rural holdings. By suggesting a baseline stocking rate for various soil types, and provided related land management issues are addressed, the soil will be protected and the land use can be sustainable.

Stocking rates are largely based on the amount of pasture that each particular type of animal will consume, but are also influenced by feeding patterns, animal weight, foot structure and activity. For example, alpacas have soft pads and are gentler/less destructive on soil structure than hard hooved stock such as sheep and cattle. Sheep may actually pull some annual grasses out of the ground, but emus only tend to nip the tops of the leaves, allowing a higher stocking rate. Horses are much more active than cattle and trampling of pastures may reduce stocking rates slightly.

Emus and ostriches have been included in Table 2 on animal equivalents for the calculation of stocking rates, because they are relatively common in this region. However the animal equivalents shown are conservative because a number of management factors make emus and ostriches significantly different to other grazing animals. It should also be noted that emus require a licence from the Department of Conservation and Land Management. Main stocking rate differences are:

- Emus and ostriches are not purely grazing animals and will require considerable amounts of supplementary feed, even on excellent pastures.
- Emus and ostriches tend to only nip the tops of leaves and combined with supplementary feeding will have a lower impact then hard hooved grazing animals on pastures, hence wind or water erosion may not occur even at fairly high stocking rates. However, the introduced feed means that nutrient export, and related issues such as smells, flies and bacterial contamination of waterways or wetlands may be more prevalent.
- For the purpose of these guidelines it is assumed that mature birds will be kept, and that sufficient space is required for breeding and the rearing of chicks. Mature birds require space to reduce stress levels and to minimise fighting.

2.2 The base stocking rate

The base stocking rate is the number of DSE that would apply to a rural small holding with the lowest level of pasture management in an average year.

The recommended base stocking rate should:

- provide enough feed to maintain animals in good condition;
- avoid soil erosion by providing enough pasture cover to protect the soil throughout the year (management such as stock rotation may be necessary);
- be sustainable through average years.

Assumptions

- Rainfed annual pastures and/or sprinkler irrigation and minimal supplementary feeding (e.g. supplementary feeding may be required in drought years).
- A basic level of pasture management, including knowledge of appropriate fertiliser use, rotational grazing, slashing of the spring flush and hay production.
- Remnant vegetation and wetlands are fenced.
- Access to drainage lines is restricted (some access of cleared drainage lines may be desireable for weed control).
- Design and scheduling of sprinklers, for sprinkler irrigated pastures is adequate.
- Small lots, typically 2 ha, but may vary from 1 to 20 ha. (Small lots have fewer rotational grazing options, such as moving stock to high ground during the winter rains and vice versa during the summer months.)
- Aimed at hobby farms or recreational activities on small holdings which may lead to some supplementary income. Not recommended for assessing major commercial agricultural ventures.

Manure collection may also be required in some situations.

Any increase in the base stocking rates will depend on pasture improvement, farm planning and nutrient management as well as statutory requirements. Proposals to carry stock in excess of the base stocking rate should be the subject of an approval from the relevant local government authority. A stock management plan (see Appendix 2, Increasing stocking

capacity) should form part of the proposal. Very high stocking rates, for example in a feedlot, are considered separately as a noxious industry.

2.3 Stocking rate units

To simplify the calculation of stocking rates the soil-landscape information for the Swan Coastal Plain and Darling Scarp has been divided into 10 stocking rate units with similar soils and similar management requirements.

A general summary of the stocking rate units is included in Section 4. The stocking rates for these units are listed in Table 1.

The stocking rate land units provide a broad overview of similar soils and landscapes on the Coastal Plain. They can be roughly matched to soil-landscape systems (see Maps 2a and 2b and Table 6 in Section 5). This information is appropriate for use at 1:250,000 scale. However, in many cases this information and some knowledge of the property location will be sufficient to determine the base stocking rate.

Much of the area is covered by medium scale soil-landscape maps (see Section 6, Figure 3). These also usually have corresponding reports (referenced in Section 7). The map units in these surveys have been correlated with the closest corresponding stocking rate unit from Section 4. The land qualities that limit the stocking rate are also listed. This level of information is more appropriate for local planning, though the assessment of individual properties would normally still require a brief site inspection to confirm the soil types. An aerial photograph of the property (available over the counter from the Department of Land Administration in Midland) would also be useful to confirm the exact location of features such as drains or remnant vegetation.

Table 1. Base stocking rates for stocking rate units (DSE/hectare)[1]

Stocking rate land unit	Unit code	Recommended dry stocking rate[4]	Recommended irrigated stocking rate[4]
Well drained yellow to brown sands	SR1	6 DSE/ha	20 DSE/ha
Rapidly drained calcareous sands	SR2	2 DSE/ha	Usually not suitable
Rapidly drained pale sands	SR3	2 DSE/ha	10 DSE/ha
Pale sand flats	SR4	6 DSE/ha	20 DSE/ha
Semi-wet soils[2] (swamps and drains) (salty areas)	SR5 SR5.1 SR5.2	6 DSE/ha (0 to 2 DSE/ha) (0 to 2 DSE/ha)	20 DSE/ha (Swamps and salty areas are not usually suitable)
Clay flats	SR6	6 DSE/ha	20 DSE/ha
Loamy flats and terraces	SR7	10 DSE/ha	25 DSE/ha
Gravel slopes (Shallow gravels and ironstone outcrop)	SR8 SR8.1	10 DSE/ha (2 DSE/ha)	25 DSE/ha (Usually not suitable)
Steep slopes[3] (Shallow rocky soils and crests)	SR9 SR9.1	6 DSE/ha (2 DSE/ha)	10 DSE/ha (Usually not suitable)
Loamy slopes	SR10	10 DSE/ha	25 DSE/ha

1 See Table 2 for the animal equivalents.

2 Semi-wet soils range from plains with high seasonal watertables to seasonal drainage depressions, which include seasonal swamps and wetlands. These are rated low or not recommended for stock. Permanent swamps with standing water are usually mapped as water features and are not suitable for stock. Most salty areas are also poorly suited to stock.

3 Shallow rocky soils and crests are rated at 2 DSE/ha.

4 Stock increases in excess of the guidelines require a management plan which includes measures to minimise nutrient export (Appendix 2).

2.4 Animal equivalents

Using Table 2, an equivalent stocking rate for other animals can be determined.

Table 2. Animal equivalents for the calculation of stocking rates

Type of livestock Weight (kg) and animal type	Dry sheep equivalent (DSE)
Sheep	
50 kg Wether, ewe	1.0
40-45 kg Lambing ewe (ewe and lamb)	1.5
75 kg Rams	1.5
Cattle	
425 kg Milking cow	10.0
425 kg Dry cows, yearling, steer or heifer	8.0
300 kg Yearling, heifer	6.0
200 kg Smaller cattle (Dexter, Lowline)	4.0
750 kg Bull, cow with calf	15.0
Cow with young calf	10.0
Horses	
450 kg Light	10.0
1000 kg Draught	20.0
250 kg Pony	5.0
Goats	
30-35 kg Dry Angora	0.7
35-40 kg Cashmere goat	1.0
50-60 kg Dry milk goat	1.5
Milking goat	2.0
Deer	
120 kg Red Deer	2.2
50 kg Fallow Deer	1.0
Other	
55-120 kg Ostrich average (assumes half introduced feed)	1.4
55 kg Emu average (assumes half introduced feed)	0.7
150-210 kg Llama	3.0
60-70 kg Alpaca	0.8

Sources: See acknowledgements and technical publications.

Note: Stocking rates are based primarily on the potential for pasture damage which depends on feeding patterns and foot structure.

A 50 kg wether is the accepted standard for Dry Sheep Equivalents (DSE).

Emus and ostriches are not purely grazing animals and require supplementary feeding, hence estimates are conservative to allow for additional manure on the paddocks.

Emus require a licence from the Department of Conservation and Land Management.

Example: On a property with 22 DSE you could have either 22 sheep, 2 light horses, one draught horse or 31 dry Angora goats, or any combination of these.

3. APPLYING STOCKING RATES TO A PROPERTY

The stocking rate calculation sheet (Table 3a) has been designed to enable the calculation of the dry stocking rate for a particular property. It utilises this report, all available medium scale land resource surveys plus knowledge of the site.

Steps to take

1. Firstly check with your local authority to see if there are any stocking rate restrictions specific to the property. For example the town planning scheme may have conditions such as:

   - no stock on properties less than 1 ha;
   - setbacks to adjacent properties;
   - restrictions on the type of stock.

   The local authority staff will also know if there are other environmental restrictions associated with undergroundwater protection, or the protection of specific wetlands. Restrictions may include:

   - setbacks to drains or wetlands;
   - limitations on stock numbers;
   - restrictions on sprinkler irrigated pastures.

2. Exclude the area of any natural features which cannot be stocked such as wetlands, drains and remnant vegetation which require appropriate setbacks and must be fenced to limit stock access (i.e. ground cover is essential so that some level of water filtration can occur).

3a. Find the map units on the property using available land resource mapping and identify the corresponding stocking rates using the tables in Section 6. Further information about the stocking rate units can also be found in Section 4.

3b. Where the mapping is not immediately accessible, or if the property is not mapped, the stocking rate units can be identified using knowledge of the site, plus Figures 2a and 2b and Table 6 as a guide. There is also extra information about stocking rate units in Section 4.

   Note: The mapping can also help assess seasonal variation which is important when purchasing a lot. For example some properties have excellent pastures in summer, but are severely waterlogged throughout winter.

4. A site visit should be used to confirm the soils on the property, and a site plan should be used to mark major soil changes and features such as vegetation and drainage lines.

5. If irrigated pastures are desired, the Water and Rivers Commission should be contacted to confirm availability of groundwater. Alternatively rainwater tanks may be an option, or in the scarp a farm dam may be feasible. Irrigated pastures require up to 15,000 kL/ha/year.

6. Calculate the total DSE for the area of irrigated pasture by multiplying:
   Area of irrigated pasture in hectares x DSE/ha (for each stocking rate unit)

   Calculate the total DSE for the area of non-irrigated pasture by multiplying:
   Area of non-irrigated pasture in hectares x DSE/ha (for each stocking rate unit)*

7. Exclude setbacks to adjacent properties, plus rock outcrop, driveways, gardens, buildings and other structures.

8. Make a list of all the planning conditions or environmental constraints that have been identified regarding stock being held on the property.
9. The carrying capacity for different animals can be determined from Table 2.
10. A Stock Management Plan may need to be completed (Appendix 2) if higher stocking rates are required.

Table 3a. Stocking rate calculation sheet

Lot number/Location		
Well licence allocation _____ kL/year	**Sufficient water for:** ____ ha (irrigated pastures require up to 15,000 kL/ha/year)	
Irrigated pasture	**Area (hectares)**	**Stock allowed (DSE)**
Stocking rate unit		
Stocking rate unit		
Stocking rate unit		
Non-Irrigated pasture	**Area (hectares)**	**Stock allowed (DSE)**
Stocking rate unit		
Stocking rate unit		
Stocking rate unit		
Total area of pasture and total DSE		
Area of property boundary buffers, plus remnant vegetation wetlands and drains or areas of rock		No stock allowed
Building envelope, driveways etc.		No stock allowed
Total area of property		
Town planning conditions/restrictions		
Environmental requirements		
Conditions imposed		

Table 3b. Example of stocking rate calculation sheet

Lot number/Location	Lot 5 Somewhere Road	
Well licence allocation 22,500 kL/year	**Sufficient water for:** 1.5 ha (irrigated pastures require up to 15,000 kL/ha/year)	
Irrigated pasture	**Area (hectares)**	**Stock allowed (DSE)**
SR1 (well drained yellow to brown sands 20 DSE/ha)	1.0 ha	(1 x 20 DSE) 20 DSE
SR7 (loamy flats and terraces 25 DSE/ha)	0.5 ha	(0.5 x 25 DSE) 12.5 DSE
Irrigated pasture	**Area (hectares)**	**Stock allowed (DSE)**
SR1 (well drained yellow to brown sands 6 DSE/ha)	1.5 ha	(1.5 x 6 DSE) 9 DSE
SR3 (rapidly drained pale sands 2 DSE/ha)	0.5 ha	(0.5 x 2 DSE) 1 DSE
Total area of pasture and total DSE	3.5 ha	42.5 DSE
Area of property boundary buffers, plus remnant vegetation wetlands and drains or areas of rock	2.2 ha	No stock allowed
Building envelope, driveways, etc.	0.7 ha	No stock allowed
Total area of property	6.4 ha	
Town planning conditions/restrictions Remnant vegetation must be fenced.		
Environmental requirements Property is within Peel-Harvey Catchment. 30 metre buffer plus no stock access to seasonal drainage line running along northern boundary and the wetland in the north-east corner.		
Conditions imposed • Permanent fencing around remnant bushland, the wetland, drainage line buffers and property boundary buffers. • Maximum 42 dry sheep or 4 light horses. • Vegetation planted on pale sands (unit SR3) and along boundary to 'rural residential' subdivision must be irrigated during establishment of trees. • $1,000 dollar bond on remedial plantings, repayable after 3 years.		

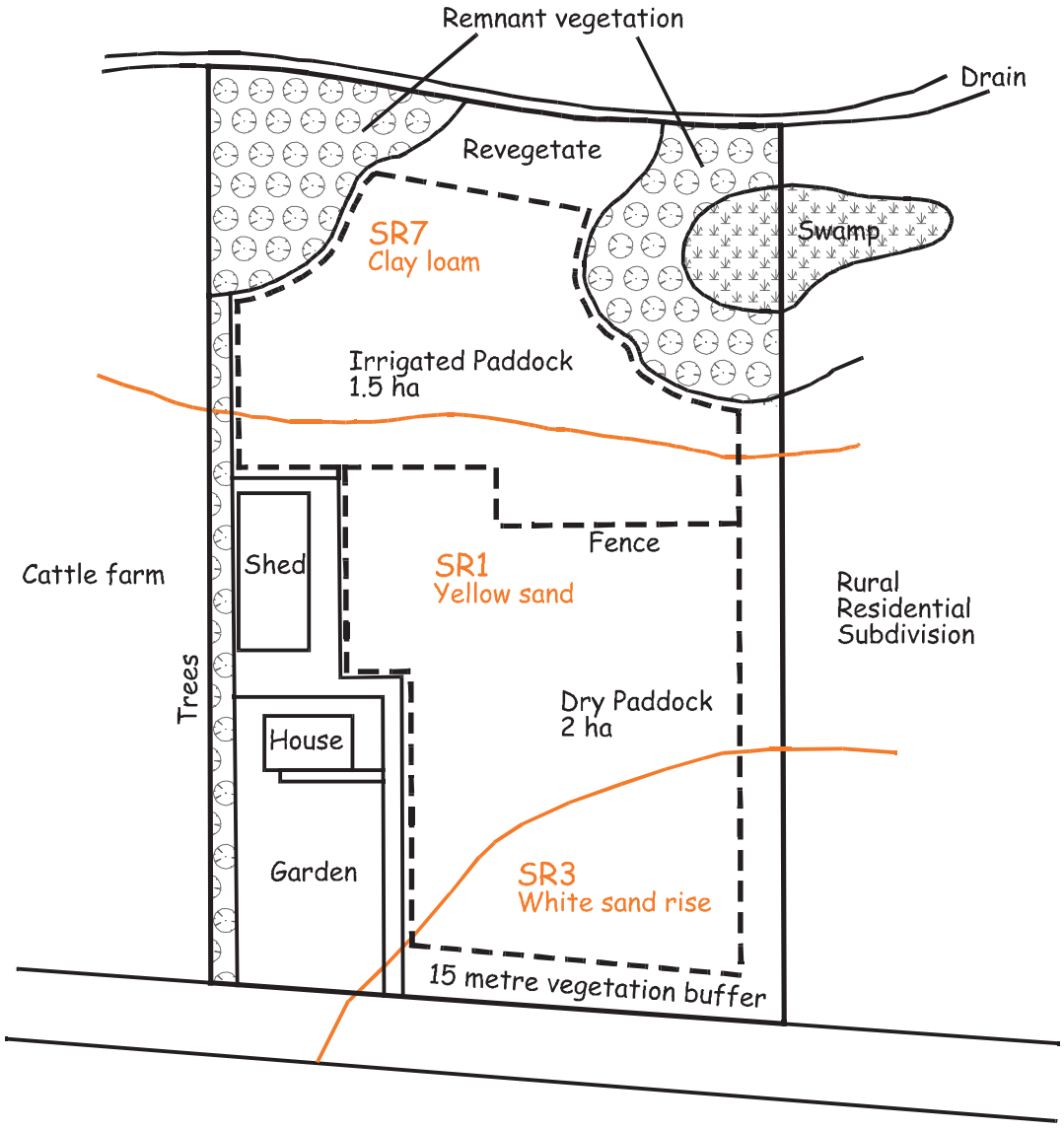

Figure 1. Example site plan - Lot 5 Somewhere Road

Key elements of site plan

- Fifteen metre vegetated buffer on the white sand rise (SR3, rapidly drained pale sands) unit as wind erosion protection, and as a physical border to the 'rural residential' area (includes 3 metre fire break).
- Eight metre wide row of trees on boundary with cattle farm (includes 3 metre fire break).
- Fencing the remnant vegetation, including a small swamp.
- Revegetating a 30 metre buffer to a seasonally flowing stream (as per environmental guidelines).
- Exclusion of shed, tracks and a garden area (again including fire break for shed and house).

Leaves 3.5 ha of useable paddocks

- 1.5 ha irrigated, approximately 1 ha SR7 and 0.5 ha SR1
- 2 ha dry, approximately 1.5 ha SR1 and 5 ha SR3

Approximate useable paddock space for stock, assuming:

- 3 m wide tracks running the full length and twice across the property.
- 2,000 m^2 building envelope and garden.
- 10 metre property boundary buffer (including 3 metre fire break).
- No remnant vegetation or drainage lines on property.

Table 4. Paddock space available on a small lot

Dimensions	Lot area	Approximate paddock area (for stock)
100 x 100 m	1 ha	0.5 ha
100 x 200 m	2 ha	1 ha
200 x 300 m	6 ha	4.5 ha
200 x 500 m	10 ha	8 ha

3.1 Some recommended land use buffer distances

All remnant vegetation, and all buffers shown should be fenced to control or prevent stock access.

Table 5. Recommended land use buffer distances

Wetland	50 m or 1 m AHD (whichever is greater)
Watercourses with permanent water	50 m
Seasonally flowing watercourses	30 m
Watercourses which flow after specific rain events	10 m
Generic industrial buffer for horse stables (primarily as setbacks for residential and 'rural residential' land)	100-500 m depending on size

(From Guidelines for Environment and Planning June 1997)

Other than the setback for horse stables, no other setbacks for low intensity grazing purposes are given, however separation distances in rural living areas are recommended to minimise the potential for land use conflict arising from dust and odour.

3.2 Fencing

Setbacks and buffers recommendations have little effect without the provision of suitable, permanently maintained fencing. There are many fencing options available. Conventional fencing is preferred by the majority of farmers throughout Australia. The main prefabricated fencing materials used are ringlock or hingejoint (Kondinin Group 1994). These fences are

basically a coarse square vertical and horizontal wire mesh where the crossing wires are held by a wire ring (ringlock) or a wire twisted into a type of hinge (hingejoint). The wire mesh is then supported by posts commonly made from wood or steel which for farming are normally spaced up to 10 m apart. However on small holdings fencing costs are perhaps not as critical and a large number of fencing options are possible. The size and design of fences varies greatly according to the animals restrained. For example, deer require a strong fence at least 2 m with small mesh size of 100 mm by 100 mm near the base to prevent young calves escaping or predators entering. Some common fences for other animals include:

Sheep and small stock	5-7 strand ringlock
Cattle	7 strand with barbed wire and/or electric fence
Horses	7 strand height with 'sighter' strands or electric
Ostriches	7 strand and at least 1.5 m high

Electric fencing is excellent for controlling most types of stock and can be used in conjunction with a variety of different fences on property boundaries. Electric fencing on its own is also considered a good, cost-effective option for protecting bushland within a property, as well as the movement of native and feral animals. Hence it is a common choice for landcare-related work, though conventional fences are also used. Conventional internal fences used to protect bushland must be strong enough to prevent animals pushing through to access shade and herbage inside the fence and may therefore be more expensive than property boundary fences. The main drawback with electric fencing is that it must have a reliable power supply and requires constant monitoring to ensure it remains effective.

4. STOCKING RATE UNITS

Stocking Rate Unit SR1: Well drained yellow to brown sands

Land unit description

- Dominant soil in the Spearwood and the Gracetown ridge soil-landscape system, associated with limestone.
- Between the Spearwood and Bassendean Systems, yellow or brown sands commonly have a pale or bleached surface layer and could be hard to distinguish from pale deep sands, which are dominant in the Bassendean Dunes. These soils are sometimes referred to as transient sands 'Karrakata, grey phase' or Jandakot sands.
- Yellow and brown sands are also common in the foothills (Forrestfield System) and occur in pockets in the plateau and valleys adjacent to the Coastal Plain. In these areas it is often associated with variable amounts of gravel, and often has a small, but noticable increase in clay content deeper in the profile.
- Yellow sands may also have pockets of pale leached sands at the base of wetter swales or seepage areas (see SR4).
- Yellow and brown sands may also be associated with pale or grey sands in some plateau and foothills areas (see SR3).
- Well to rapidly drained sands. Dry in summer with maximum watertable usually > 1.5 m from surface.

Main WA soil groups (Schoknecht 1999)

- Yellow deep sand.
- Brown deep sand.
- Smaller areas of Yellow/brown shallow sand and Deep sandy gravel.

Vegetation

- In the Spearwood System characteristic trees include tuart (*Eucalyptus gomphocephala*), marri (*E. calophylla*), jarrah (*E. marginata*), WA peppermint (*Agonis flexuosa*), bull banksia (*Banksia grandis*), shallow sand (*Kunzea ericifolia*). Also common is thicket vegetation on limestone ridges with parrot bush (*Dryandra sessilis*).
- In the Gracetown System characteristic trees include marri (*E. calophylla*), jarrah (*E. marginata*), karri (*E. diversicolor),* WA peppermint (*Agonis flexuosa*), bull banksia (*Banksia grandis*) and (*Dryandra sessilis*).
- In the foothills, valleys and plateau areas jarrah marri forest tends to dominate but is not specific to these soils. *Nuytsia floribunda* is common on the foothills.

Current status

- Because these are considered to be good soils, elevated above the level of the Coastal Plain, with no drainage problems, they tend to be favoured for a wide range of land uses. The Spearwood and Forrestfield Systems are the focus of urban growth corridors, include CALM timber plantations, State Forest and Yalgorup National Park. These soils are also ideal for market gardens and orchards and are favoured for 'rural residential' development. The Gracetown Ridge soil-landscape system has extreme land use pressure for 'rural residential' developments. Recently large residential/tourism-related developments have also begun along this portion of the coast.
- There is considerable hobby farm development, including a significant amount of equestrian activity near Byford and in Mandurah.
- Some areas are cleared for grazing, though many areas on steeper dunes, or with limestone outcrop have significant stands of remnant vegetation.
- On the coast, some limestone and sand lie with Resource and Priority Resource Extraction areas.
- In the foothills areas, some areas are held under mining tenements for mineral sands extraction (Yogannup Formation).

Environmental issues

- High potential for wind erosion.
- The unit has a moderate to high phosphate retention due to depth of sand and the amounts of iron oxide (geothite) present.
- Lake Clifton Management Plan.
- Peel-Harvey Catchment environmental and planning controls.
- Low soil moisture.
- Potential to pollute shallow groundwater (mainly nitrogen), though this soil is not usually prevalent in major groundwater recharge areas.

- Remnant vegetation may contain poorly reserved plant communities at the base of the Darling Scarp.
- Bores restricted to shallow groundwater, normally licensed to 1500 kL/year due to danger of salt water intrusion.

Stocking rates

6 DSE/ha DRY PASTURE
20 DSE/ha IRRIGATED PASTURE

Comment

The loose dry sands are not ideal for grazing stock in summer. However, these soils are well suited to sprinkler irrigation and higher stocking rates can be maintained if a reliable water source is available.

Rocky soils with abundant limestone will have lower stocking rates depending on the amount of rock present.

SR2: Rapidly drained calcareous sands

Land unit description

- Associated exclusively with the youngest coastal dunes, the western most coastal sand dunes and intervening swales. Predominantly on the Quindalup System and the Kilcarnup Dunes between Capes Naturaliste and Leeuwin, also common on the D'Entrecasteaux Dunes east of Augusta.
- Soils usually high in calcium carbonate (20-70%).
- Excessively well drained and very dry in summer with highest watertable > 1.5 m from surface in winter.

Main WA soil groups (Schoknecht 1999)

- Calcareous deep sand.
- Minor areas of Calcareous shallow sand.

Common plant species

- Acacia thicket.
- Coastal scrub and coastal heathland.
- Peppermint scrub or low woodland.

Current status

- Coarse calcareous sands have little agricultural value and low productivity due to excessively rapid drainage and nutrient deficiencies associated with high pH
- Rapid drainage makes these soils well suited to urban developments, and a high proportion of the population of WA is located on the coastal dunes, which also includes the Spearwood Dunes, the Gracetown Ridge and, to a slightly lesser extent, the Bassendean Dunes
- National Parks and Reserves occupy some parts of the coast

Environmental issues

- Very high potential for wind erosion
- Low water retention
- Low nutrient retention particularly phosphorus and nitrogen
- Quindalup has very restricted groundwater limited to a thin lens of fresh water over saline water
- Coastal scrub and heathland has a lower profile than vegetation that includes mature trees. Consequently clearing and degradation of limited areas of coastal vegetation has become a problem.

Stocking rates 2 DSE/ha DRY PASTURE
Not recommended (without stock management plan)

Comment Excessive drainage and wind erosion risk are major constraints, but alkaline (calcareous) sands are also poorly suited to pastures due to poor fertility and high pH.

SR3: Rapidly drained pale sands

Land unit description

- Pale leached or bleached sands are characteristic of the Bassendean System. However, smaller areas of pale deep sands occur in most other soil-landscape systems. These may be wind blown (aeolian) from the Bassendean Dunes, or they may occur in valleys or swales where they have developed due to excessive leaching. These would be semi-wet soils (sheet 5) but may subsequently be transported by wind or water to other locations.
- The pale deep sands are grey surfaced, deep grey or white to pale yellow quartz sands which may have yellow subsoils at a metre or more in depth. Weak iron-organic hardpans often occur at depth. Towards the eastern margin of the dunes pale deep sands commonly overlie alluvial clays. In areas of the Coastal Plain, such as in the foothills, it is common to find small quantities of ferruginous gravels deeper in the profile.
- Very dry in summer with highest watertable normally > 1.5 m from surface in winter.

Dominant WA soil groups (Schoknecht 1999)

- Pale deep sands.

Vegetation

- Pale deep sands in the Bassendean System are associated with banksia woodland (*Banksia attenuata, B. menziesii, B. ilicifolia*), sheoak (*Allocasuarina fraseriana*), jarrah (*Eucalyptus marginata*) and marri are also quite common. Smaller sandy rises (over clay) on the Coastal Plain used to be known as red gum rises and are normally associated with marri and banksia.
- *Banksia* spp. also occur on grey sands on the foothills, but jarrah and marri tend to be more dominant here.
- Pale deep sands in the Spearwood Dunes are often associated with *Kunzea ericifolia.*

Current status

- Eastern most portion of the urban growth corridors along the coastal dunes.
- Large areas of uncleared banksia woodland (Bassendean).
- Resource and Priority sand extraction areas.
- Normally associated with important groundwater recharge areas, including the Jandakot and Gnangara groundwater mounds.

Environmental issues

- Moderate to high potential for wind erosion.
- Low water retention.
- Low nutrient retention particularly phosphorus and nitrogen.
- Banksia Woodland remnants in some areas.
- Wetlands, Peel-Harvey Catchment and groundwater resource areas.
- Buffers required for sand extraction areas.
- Perennial grasses used to improve pasture are very invasive to remnant bushland.
- Protection of groundwater recharge areas and protection of wetland areas, which are normally surface expressions of shallow groundwater.

Stocking rates 2 DSE/ha DRY PASTURE
10 DSE/ha IRRIGATED PASTURE (without stock management plan)

Comment Stock should not be permitted unless irrigation is available for part of the lot.

Nutrient loss, particularly to groundwater, is a likely consequence of irrigation and higher stocking rates unless these areas are carefully managed. Soil amendments and careful fertiliser scheduling are desirable.

SR4: Pale sand flats

Land unit description

- Includes lower dunes, sandplain and better drained swales of the oldest coastal dune system (Bassendean) as well as leached aeolian (wind-blown) low sandy rises blown onto the eastern portions of the Coastal Plain.
- Deep sandy duplex (sand over clay) soils towards the eastern edge of the Bassendean System, and on many portions of the alluvial (water-borne) plain.
- Primarily moderately drained soils. (Poorly drained soils are generally included under semi-wet soils unit SR5, however, the distinction is not usually clear and there may be considerable overlap between these land units.)
- Leached white sand which is frequently waterlogged for short periods in winter. May be slightly peaty.
- May also consist of low lying sand over clay or ferricrete hardpan.
- Watertables may rise to or near the surface for brief periods (commonly several weeks to a month) in winter.

Main WA soil groups (Schoknecht 1999)

- Semi-wet soils.
- Grey deep sandy duplex.
- Pale deep sand.
- Also includes minor areas of Non-saline wet soil and Saline wet soil.

Vegetation

- Flooded gum (*Eucalyptus rudis*) is common where no salinity occurs in the subsoils. Paperbarks (*Melaleuca preissiana*, *M. rhaphiophylla, M. viminaria*) usually dominate the remaining vegetation.
- Coojong - (*Acacia saligna*).
- Heath dominated by *Pericalymma* and *Uipticum spp*.

Current status

- Extensively cleared for summer pasture.

Environmental issues

- Often adjacent to wetlands.
- Despite deep sands additional drainage channels are common.
- Wind erosion on duplex soils.
- Waterlogged in winter.
- Some areas may be prone to flooding.
- High potential for nutrient losses particularly phosphorus. Nitrates are less of a problem because they are denitrified under anoxic conditions in the soils.
- Peel-Harvey Catchment environmental and planning controls.
- Groundwater protection areas.
- Wildlife associated with swamps such as southern brown bandicoots, tortoises, amphibians and bird life.

Stocking rates 6 DSE/ha DRY PASTURE
20 DSE/ha IRRIGATED PASTURE (without stock management plan)

Comment Potential nutrient losses are likely to reduce stocking rates.

Proximity to water bodies, wetlands and remnant vegetation may restrict stocking rates.

Pasture can be improved with perennial clover.

SR5: Semi-wet soils (plus swamps & drains SR5.1 and Salty areas SR5.2)

Unit description

- Semi-wet soils comprise a group of moderate to poorly drained soils with watertables at or near the surface throughout winter. They include most Coastal Plain soils that occur on a level plain with low relief or within slight depressions.
- Several areas poorly suited to stock are distinguishable within this unit. Distinct depressions, such as seasonal swamps, clay pans or wetlands and very wet soils in seepage areas at the base of footslopes, within drainage lines or on valley floors are separated into SR5.1 Salty areas associated with semi-wet soils have been separated into SR5.2. Because these areas are generally smaller, they are not mapped at the soil-landscape system level e.g. 1:250,000 scale, but can be depicted on more detailed mapping e.g. 1:50,000 scale.
- Includes lower swales within the oldest coastal dune system (Bassendean) as well as leached aeolian sands within other land units.
- Includes a wide mixture of soils on the alluvial plain e.g. Pinjarra, Abba, Jindong, Yanga, Guildford Soils include clays, loams and shallow and deep sands over clay.
- Also include wetter areas of Pale sand flats. Leached white sands within distinct depressions are often slightly peaty, and commonly associated with a distinct iron-organic hardpan below the soil. Equally common, the layer that impedes drainage below the sand is an extensive layer of clay. In some cases the impeding layer is very deep and may be difficult to identify, particularly near the margin of the dune system and the plain.

Dominant WA soil groups (Schoknecht 1999)

- Semi-wet and wet soils.
- On the Coastal Plain semi-wet soils are commonly associated with a variety of alluvial soils, including clays, loams, grey deep (and shallow) sandy duplex soils.

Vegetation

- Remnant trees on the Coastal Plain commonly included flooded gum (*Eucalyptus rudis*), paperbarks (*Melaleuca preissiana*, *M. rhaphiophylla, M. viminaria*, *Pericalymma ethpticum* and *Regalia ciliata*).
- Semi-wet and wet soils in the Spearwood System often support coojong, *Kunzea ericifolia* and *Acacia saligna.*
- Clumps of reeds, *Juncus* spp. occur in cleared paddocks.

Current status

- Mostly cleared for summer pasture.
- Some ‘rural residential’ developments.

Environmental issues

- Includes significant areas of wetlands or swamps (i.e. cleared or degraded wetlands).
- Traditionally, because of the build up of organic matter and the occurrence of peaty soils, many wetland areas were cleared and drained for agriculture leaving a legacy of few remaining undisturbed areas and significant nutrient pollution problems in most surface waters and remaining wetland areas.
- Frequently poorly drained, so drainage channels are generally required for most land uses.
- Extensively waterlogged and inundated in winter.
- Some areas prone to flooding.
- High potential for nutrient losses particularly phosphorus. Nitrates are less of a problem because they are denitrified under anoxic conditions in the soils.
- Coastal Lakelands Environmental Protection Policy.
- Peel-Harvey Catchment environmental and planning controls.
- Groundwater protection areas.
- Wildlife associated with swamps such as southern brown bandicoots, tortoises, amphibians and bird life.

Stocking rates 6 DSE/ha DRY PASTURE: Swampy and salty areas (SR5.1 and SR5.2) 0-2 DSE/ha
20 DSE/ha IRRIGATED PASTURE: Swampy or salty areas (SR5.1 and SR5.2) not suitable.

Comment Proximity to water bodies, wetlands and remnant vegetation will require fencing to exclude stock from the margins, which is likely to reduce overall stocking rates. May include wetlands not identified in the coastal lakelands EPP.

Pasture can be improved with perennial clover.

SR6: Clay flats

Unit description

- Alluvial plains and terraces of the main rivers.
- Lagoonal and estuarine sediments.
- Dark brown-black clays which are frequently cracking and dispersive.
- A thin layer of sand may be present over the clay on slight rises.
- Alkaline-acidic, relatively impermeable.
- Saline and calcareous-humic muds, clays and sands.

Dominant WA soil groups (Schoknecht 1999)

- Hard cracking clay.
- Grey non-cracking clay.
- Grey shallow sandy duplex.
- Non-saline wet soil.
- Salt lake soil.

Vegetation

- Marri (*Eucalyptus calophylla*) occur on areas with better drainage, but the domominant plants in most areas are paperbarks (*Melaleuca preissiana, M. rhaphiophylla*) and flooded gum (*Eucalyptus rudis*).
- In saline areas saltwater paperbark (*Melaleuca cuticularis*), rushes, sedges and samphire are common, but flooded gum are absent.
- Areas of very tight clays, with some evidence of salinity in Serpentine-Jarrahdale are dominated by sheoak (*Casuarina obesa)*. To the north, in Gingin, sheoak also occurs, but is typically associated with diatomaceous (fine powdery) material.

Current status

- Mostly cleared and frequently drained.
- Summer grazing, particularly cattle.
- Irrigated pasture in the Harvey area.
- Some estuarine and lagoon areas are reserved.

Environmental issues

- Drainage channels allow nutrients fast access to watercourses.
- Nutrient retention is usually reduced by fast run-off and slow permeability. Nutrient run-off may be higher than for many bleached sands.
- Peel-Harvey Catchment environmental and planning controls.
- Potentially saline soils.
- Groundwater is often brackish or saline and in restricted quantities.
- Proximity to streams, rivers, wetlands and estuaries.
- Soil amendments such as sheeting with sand or addition of gypsum will improve soil.
- Waterlogging and flooding are common in winter.
- Soil structure frequently declines through puddling by stock where soil is damp.

Stocking rates 6 DSE/ha DRY PASTURE
20 DSE/ha IRRIGATED PASTURE

Comment

Higher stocking rates will depend on soil amendments and nutrient management.

Site specific information may be required. Commonly waterlogged in winter and wetter areas may be unsuitable for stock all year round.

Nutrient export can impact on wetlands and estuaries.

SR7: Loamy flats and terraces

Unit description

- Red-brown loams of alluvial flood plains, terraces and plains associated with major rivers and streams.
- Soils vary from sandy loams to clay loams (both vertically and horizontally). Normally the soils are well drained with some perched watertables on flatter areas each winter.
- Tend to be associated with major rivers and streams, including particularly the Harvey and Murray Rivers.
- Minor areas also associated with some smaller streams and in very limited areas adjacent to some of the coastal lakes within the Vasse System.

Dominant WA soil groups (Schoknecht 1999)

- Grey/brown deep loamy duplex.
- Brown loamy earth.

Vegetation

- No particular indicator species, common species are similar to semi-wet soils and clay flats and include: marri (*Eucalyptus calophylla*), flooded gum (*Eucalyptus rudis; Acacia saligna*), paperbarks (*Melaleuca rhaphiophylla* and *M. preissiana*).

Current status

- Mostly cleared for grazing, orchards and vines.
- Also occur in larger areas within the South-West irrigation district.

Environmental issues

- Proximity to rivers and foreshore reserves.
- Foreshore management plans for major rivers will be required.
- Generally high phosphate retention but high potential for losses unless managed.
- Peel-Harvey Catchment environmental and planning controls.
- Fertile soil which is valuable for horticulture, but proximity to drainage needs to be carefully managed.
- Some areas may be subject to flooding.

Stocking rates 10 DSE/ha DRY PASTURE
25 DSE/ha IRRIGATED PASTURE

Comment Potential nutrient losses are the main problem.

Stock access to waterways must be restricted.

SR8: Gravel slopes (SR8.1 Shallow gravels and ironstone outcrop)

Unit description

- Gentle to moderately sloping land (gradients under 15%) with sandy and loamy gravels.
- Dominant soils of the Lateritic Plateaux and Forrestfield System. Also located on the laterite soils of the ridges at the base of the Darling Scarp and on the side slopes of many valleys within the plateau areas.
- Yellow brown gravels with variable amounts of duricrust and laterite. Cemented gravel is commonly present at a depth of 1 to 2 m but may be at the surface.

Dominant WA soil groups (Schoknecht 1999)

- Shallow gravel.
- Duplex sandy gravel.
- Deep sandy gravel.
- Loamy gravel.

Vegetation

- Jarrah-marri woodland. Species include marri (*Eucalyptus calophylla*), jarrah (*Eucalyptus marginata*), bull banksia (*Banksia grandis*) and parrot bush (*Dryandra sessilis*).

Current status

- Partly cleared.

Environmental issues

- High phosphorus absorption.
- Limited shallow groundwater.
- Potential for water to run rapidly from the site with some water erosion.
- Soil depth is restricted by the presence of laterite duricrust (caprock) in some areas.
- Erosion is a potential problem on steeper slopes.
- Remnants on Forrestfield system have high nature conservation values and may need protection from stock.

Stocking rates 10 DSE/ha DRY PASTURE: Shallow gravels and ironstone outcrop (SR8.1) 0-2 DSE/ha.
25 DSE/ha IRRIGATED PASTURE: Shallow gravels and ironstone outcrop (SR8.1) generally not suitable.

Comment The presence of laterite duricrust will restrict pasture growth and stocking rates.

SR9: Steep slopes (SR9.1 Shallow rocky soils)

Unit description

- Moderate to steep slopes (gradients in excess of 15%) of the Darling Plateau.
- Includes minor pockets of rocky and skeletal soils which are poorly suited to stock and distinguished as SR9.1. Because these areas are generally smaller, they are not mapped at the soil-landscape system level e.g. 1:250,000 scale, but can usually be depicted on more detailed mapping e.g. 1:50,000 scale.
- Developed on clay subsoils and basement granite.
- Light coloured to red-brown loams, earths and clays with white kaolin clays at depth.
- Low permeability with rapid run-off.

Dominant WA soil groups (Schoknecht 1999)

- Friable red/brown loamy earth.
- Brown loamy earth.
- Loamy gravel.
- Deep sandy gravel.
- Includes areas of stoney soil and bare rock.

Vegetation

- Steep slopes commonly support jarrah and marri woodlands. Trees include jarrah (*Eucalyptus marginata*), marri (*E. calophylla*), wandoo (*E. wandoo*), yarri (*E. patens*). Common shrubs include hakeas and *grevilleas.*
- In wet areas on the footslopes or valley floors, paperbarks (*Melaleuca preissiana, M. rhaphiophylla*), flooded gum (*Eucalyptus rudis*), and narrow leaf peppermint (*Agonis linearifolia*) are common.

Current status

- Extensive areas occur within State Forest and on the Darling Scarp.
- Other areas mostly cleared and often used for grazing.

Environmental issues

- Susceptible to water erosion under heavy grazing pressure.
- Rapid drainage to stream lines.
- Although the soil is capable of retaining nutrients, run-off reduces the potential for nutrient management.
- High risk of dung being washed into streams and dams.
- Proximity to streams and rivers.
- Frequent soaks and seepages, some of which have elevated salinity.
- Small areas may be waterlogged.
- Susceptible to landslips near seepages on steeper slopes.
- Potential for saline soils in some areas.
- Outcrops of basement granite may restrict the useable area.
- Restrictions for vehicular access due to slope gradients and rock outcrop in some areas.

Stocking rates 6 DSE/ha DRY PASTURE: Shallow rocky soils and crests (SR9.1) 0-2 DSE/ha.
10 DSE/ha IRRIGATED PASTURE: Shallow rocky soils and crests (SR9.1) generally not suitable.

Comment

Stocking rates are low due to steep slopes and high erosion risk. Can be highly productive grazing country if well managed.

Site specific information may be required because of proximity of watercourses, rock outcrops and steep slopes. Generally smaller pockets of rocky soils and crests, which are common in this unit, may not be suitable for any stock.

Susceptible to waterlogging and landslips in some places.

High water erosion potential.

SR10: Loamy slopes

Unit description

- Gentle to moderately sloping land (gradients under 15%) with loamy earths and loamy duplexes.
- Generally well drained soils, commonly with loamy topsoil which occurs in many plateau and valley areas.

Dominant WA soil groups (Schoknecht 1999)

- Friable red-brown loamy earth.
- Brown loamy earth.
- Brown deep loamy duplex.
- Red deep loamy duplex.
- Red loamy earth.
- Loamy gravel.

Vegetation

- Highly variable, but includes jarrah, wandoo and marri forrest which appear to suit soils with higher clay content and poorer internal drainage.

Current status

- Extensive areas occur within CALM State Forest.
- Often used for orchards and lifestyle blocks plus grazing.

Environmental issues

- Generally productive grazing country with soils and issues similar to steep slopes, but water erosion hazard and machinery access are less limiting.
- Some valley floors will contain small portions of semi-wet or wet soils.
- Proximity to drainage lines on valley floors should restrict stock access.

Stocking rates 10 DSE/ha DRY PASTURE
25 DSE/ha IRRIGATED PASTURE (without stock management plan)

Comment Generally soils of high grazing and agricultural value, but this is highly variable due to differences in slope, soils and issues such as water availability which is often restricted to surface water and dam site potential.

5. SOIL-LANDSCAPE SYSTEMS AND STOCKING RATE UNITS

Table 6 summarises the major soil-landscape systems that occur in the region which are illustrated in Figures 2a and 2b.

These broad soil-landscape systems have been correlated to stocking rate units, which are a specific type of land unit which combines general knowledge of the landforms that occur within the systems and the main Western Australian Soil Groups (Schoknecht 1999). Western Australian soil groups provide a simple, non-technical guide to similar groups of soils.

More detailed stocking rates have been applied to all available land resource surveys described in Section 6. Their current availability, their main limiting constraints and a brief introduction to land capability are also described.

Table 6. Stocking rate units within soil-landscape systems (Map legend for Figure 2a and 2b)

General description Soil-landscape systems	**Description**	**Stocking rate units (dominant units in bold, minor units omitted)**	**Information sheet number**	**Base stocking rate (DSE/ha)**	**Irrigated stocking rate (DSE/ha)**
Calcareous coastal dunes: Quindalup, Kilcarnup, part of D'Entrecasteaux	Coastal dunes, with dominant calcareous deep sand, with shallow calcareous sand and yellow or brown sand. Coastal scrub.	**Rapidly drained calcareous sands** Well drained yellow to brown sands	**SR2** SR1	**2** **6**	**Nil** **20**
Yellow dunes and flats over limestone: Spearwood, Gracetown	Dunes and flats overlying limestone, with yellow deep sand, pale deep sand and yellow/brown shallow sand. Tuart forest and woodland on the Swan Coastal Plain, marri-jarrah-karri forest, woodland and coastal heath south of Cape Naturaliste.	**Well drained yellow to brown sands** Rapidly drained pale sands Pale sand flats	**SR1** SR3 SR4	**6** **2** **6**	**20** **10** **20**
Estuarine flats: Vasse	Poorly drained estuarine flats of the Swan Coastal Plain. Tidal flat soil, saline wet soil and pale deep sand. Includes some moderately drained fertile clays and loams. Samphire, sedges and paperbark woodland.	**Semi-wet soils** **Rapidly drained pale sands** Rapidly drained calcareous sands Loamy flats and terraces Clay flats Wet soils	**SR5** **SR3** SR2 SR7 SR6 SR5.1	**6** **2** **2** **10** **6** **2**	**20** **10** **Nil** **25** **20** **Nil**
Siliceous dunes: Bassendean, part of D'Entrecasteaux	Dunes, flats and swampy depression, of the Swan Coastal Plain, with pale deep sands and semi-wet soils dominant. Banksia woodland and heaths on dunes and flats and paperbark woodlands on wetter flats and depressions.	**Rapidly drained pale sands** **Pale sand flats** **Semi-wet soils**	**SR3** **SR4** **SR5**	**2** **6** **6**	**10** **20** **20**
Alluvial sandy plain: Moore River	Level to gently undulating plain being a relict flood plain, partially rejuvenated; sandy duplex, sandy earth, some sandy gravel; alluvium and weathered sandstone.	**Semi-wet soils** **Pale sand flats** Well drained yellow to brown sands Wet soils	**SR5** **SR4** SR1 SR5.1	**6** **6** **6** **2**	**20** **20** **20** **Nil**

Table 6 continued …

Soil-landscape systems	Description	Stocking rate units (dominant units in bold, minor units omitted)	Information sheet number	Base stocking rate (DSE/ha)	Irrigated stocking rate (DSE/ha)
Sandy alluvial plains: Abba Scott River	Poorly drained sandy flats. Wet soils, Semi-wet soils, Grey deep sandy duplex and pale deep sands. Jarrah-marri-paperbark woodland.	**Pale sand flats** **Semi-wet soils** **wet soils** Rapidly drained pale sands	**SR4** **SR5** **SR5.1** SR3	**6** **6** **2** **2**	**20** **20** **Nil** **10**
Foothills: Forrestfield Coombidgee Whicher Scarp	Foothills and rises. Sandy and loamy gravels, deep sands and sandy duplexes. Jarrah-marri forest and woodland.	**Gravel slopes** Well drained yellow to brown sands Rapidly drained pale sands Pale sand flats Semi-wet soils	**SR8** SR1 SR3 SR4 SR5	**10** **6** **2** **6** **6**	**25** **20** **10** **20** **20**
Alluvial plain with sands, loams and clays: Guildford Jindong Pinjarra Yanga	Poorly drained flats. Grey deep sandy duplex soils, loamy earths, cracking clays, often with a self-mulching surface, extensive areas of saline and non-saline wet soils. Jarrah-marri-rudis, sheoak and paperbark woodland.	**Semi-wet soils** **Pale sand flats** Loamy flats and terraces Clay flats Wet soils	**SR5** **SR4** SR7 SR6 SR5.1	**6** **6** **10** **6** **2**	**20** **20** **25** **20** **Nil**
Plateau with laterite and sandplain: Dandaragan Mogumber Regan	Gently undulating plateau with areas of sandplain and some laterite. On Cretaceous sediments. Broad U-shaped valleys 80-150 m deep, smaller V-shaped valleys east of the Gingin Scarp in the south. Soils are formed in colluvium and weathered rock.	**Rapidly drained pale sands** **Well drained yellow to brown sands** Gravel slopes Loamy slopes Steep slopes	**SR3** **SR1** SR8 SR10 SR9	**2** **6** **10** **10** **6**	**10** **20** **25** **25** **10**
Lateritic plateaux on granitic rocks: Darling Plateau Wundowie Cowaramup Uplands	Moderately to strongly dissected lateritic plateau on granite with eastward-flowing streams in broad shallow valleys, some surfical Eocene sediments. Soils are formed in laterite colluvium or weathered in-situ granite.	**Well drained yellow to brown sands** **Gravel slopes** Pale sand flats Semi-wet soils	**SR1** **SR8** SR4 SR5	**6** **10** **6** **6**	**20** **25** **20** **20**

Table 6 continued …

Soil-landscape systems	Description	Stocking rate units (dominant units in bold, minor units omitted)	Infor-mation sheet number	Base stocking rate (DSE/ha)	Irrigated stocking rate (DSE/ha)
Dissected lateritic plateaux on sedimentary rocks: Treeton Hills Yelverton Shelf McLeod	Undulating terrain with remnants of lateritic plateau, with sandy gravels, deep sands, semi-wet soils. Jarrah-marri-wandoo forest and woodland.	**Well drained yellow to brown sands** **Gravel slopes** Semi-wet soils Pale sand flats	**SR1** **SR8** SR5 SR4	**6** **10** **6** **6**	**20** **25** **20** **20**
Granitic valleys: Lowden Murray Bindoon Wilyabrup Valleys Glenarty Valleys	Deep valleys, in the plateau areas, with loamy earths, loamy duplexes, loamy and sandy gravels, stony soils and sandy duplexes. Jarrah-marri forest.	**Loamy slopes** **Gravel slopes** **Steep slopes** Well drained yellow to brown sands Loamy flats and terraces	**SR10** **SR8** **SR9** SR1 SR7	**10** **10** **6** **6** **10**	**25** **25** **10** **20** **25**

6. SOIL-LANDSCAPE MAP UNITS FROM MEDIUM SCALE LAND RESOURCE SURVEYS

Recently updated standards for land evaluation, including land capability have closely aligned land capability for grazing in > 600 mm rainfall areas and stocking rates (See van Gool and Moore 1998). This correlation has helped to identify stocking rates, and the main land resource constraints (limiting factors) that restrict the stocking rates for the map units in the following survey areas.

West Gingin: Smolinski (1997). Scale: 1:50,000.

Notes: This differs from the other maps in that it is a soils only map, not a soil-landscape map. As a result it does not distinguish between minor differences in the landform, although these differences may affect land use. However, because there is a close relationship between soil and landform this should not have a major effect on the interpreted maps for horticulture. As a general guide, it can be expected that 80% or more of the area within any mapping unit will have the capability rating indicated on the map.

North Metropolitan: Combines mapping from McArthur and Mattiske (1985), Wells and Clarke (1986), McArthur and Bartle (1980), Barnesby (unpublished). (This is a small portion of unpublished mapping which runs along the foothills of the Darling Scarp, see notes under aerial photo interpretation.) Scale: 1:50,000.

Notes: This mapping combines information from several sources. It is based mostly on landform. However, most likely due to limited time to complete these surveys, they do not depict many smaller landform features such as inter-dunal swales which are shown on the other 1:50,000 scale mapping and may be of some significance to horticultural (and other) developments. As a general guide, it can be expect that 80% or more of the area within any mapping unit will have the capability rating indicated on the map.

Swan Valley: Moore Campbell-Clause (1991) based on mapping by Pym 1955, Scale: 1:25,000.

Notes: This is the most detailed mapping used in this study. The only warning to those wishing to refer to the original source mapping (Pym 1955) is that the complexity and quantity of mapping units described make this mapping difficult to interpret and use. This has been overcome to a large degree by Moore and Campbell Clause (1991). However many smaller mapping units were not described or rated by Moore and Campbell Clause. These 'missing' units have been added during this study by the authors.

Darling Range: King and Wells (1990). Scale:1:50,000.

Notes: This is an example of the more recent Agriculture Western Australia land resource mapping. The soil-landscape maps are based on the Australian soil and land survey guidelines (Gunn *et al.* 1988). This work was specifically prepared for regional and local strategic planning purposes at 1:50,000 scale and was a test area for the first land capability methodology described by Wells and King (1989). This was updated by van Gool and Moore 1998.

Coastal Plain (from Armadale to Capel): Combines mapping **Peel-Harvey North:** van Gool (1990), which incorporates mapping for Rockingham (Wells, Oma and Richards 1985) and Jandakot (Wells, Richards and Clarke 1986), **Mandurah Murray:** Wells (1989), **Peel-Harvey South:** Van Gool and Kipling (1992), **Harvey to Capel:** Barnesby and Proulx-Nixon (In Prep.). Scale:1:50,000.

Notes: This mapping incorporates eight surveys. An overall report is not yet available however most of the mapping units used are described in detail in the Mandurah Murray land capability study (Wells 1989). The Mandurah Murray mapping is similar to the Darling Range mapping described above.

Busselton Margaret River-Augusta: Tille and Lantzke (1990). Scale: 1:50,000.

Notes: As for Darling Range and Coastal Plain from Armadale to Capel.

Aerial Photo Interpretation (API): Various (see Notes:). Scale: Various.

Notes: Some unpublished gaps in the information which were filled using aerial photo interpretation only. Much of this was compiled by Bev Barnesby (formerly Bev Kipling) for the Ministry for Planning's Metropolitan Rural Policy in 1991. The extra mapping for Armadale was prepared for the Armadale Local Rural Strategy by Martin Wells (Wells 1993). Several small missing portions were also added by the authors.

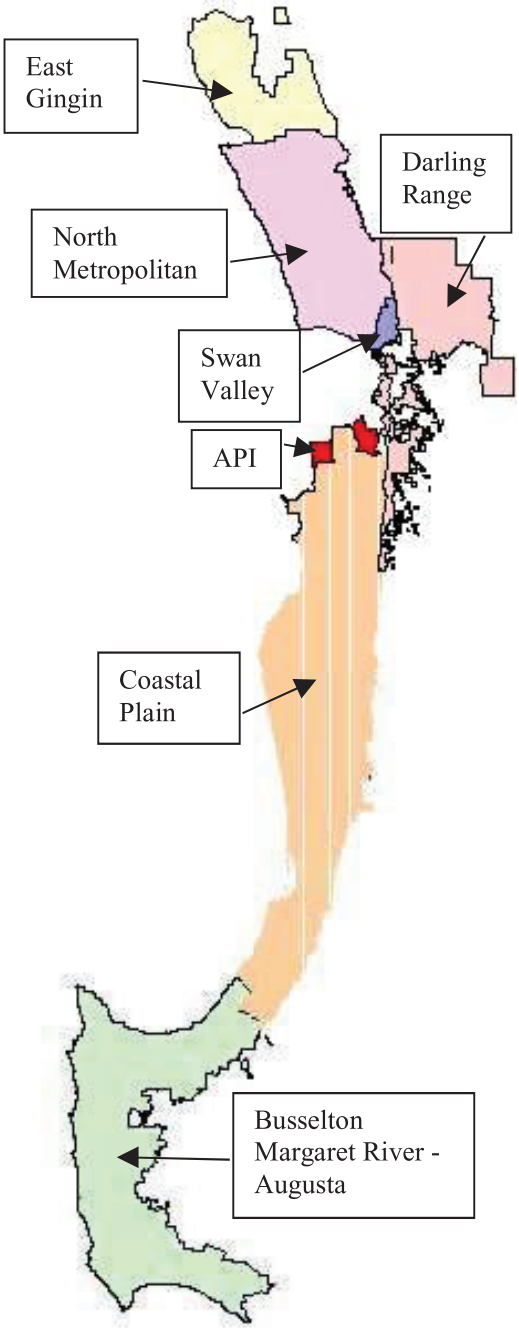

Figure 3. Survey areas with stocking rate information.

6.1 Land qualities considered in the assessment of stocking rates (from van Gool & Moore 1998)

Water repellence, soil structure decline, subsurface compaction and ***subsurface acidification*** all affect pasture production, however they are primarily a broad-acre concern where the cost of amelioration once these problems have occurred is high. They are usually only a minor management concern on small holdings. Water repellence may be an exception because it is related to water erosion and phosphorus export. After summer, with the first rains, sandy areas may experience rapid run-off which could aid water erosion and phosphorus export. These soils eventually do wet up, reducing the problem later in the season. Suitable paddock lay outs (not usually an issue on a small holding) and vegetative filters (e.g. even a grassy berm and/or a slight swale) beside drains will minimise direct nutrient run-off.

Wind erosion must be managed as grazing stock remove pasture cover and loosen topsoil, particularly during drier months, at higher stocking rates or in higher traffic areas such as laneways or under shady trees. Good pasture management, adequate fencing suited to the stock being managed and provision of vegetated wind breaks, as well as keeping within the recommended stocking rates will control wind erosion.

Water erosion is a problem on some soils, particularly where stock preferentially select pockets of remnant vegetation and pasture in and near drainage lines. These areas should be fenced to control access. Controlled access may be desirable to control weeds or fire hazard. Or access may be prevented, for example nature corridors or remnant vegetation.

Phosphorus export is a concern in terms of potential water erosion. Direct washing of manure and fertilisers into streams or wetlands should also be considered. This is considered to be a large problem on the Swan Coastal Plain because of the prevalence of bleached or pale (e.g. Bassendean) sands. In most soils phosphorus is rapidly fixed, but bleached sands can not hold on to phosphorus excacerbating nutrient run-off by so called “soluble phosphorus”. On the positive side, because sands are highly permeable, soil amendment and vegetative filter strips can be exploited to filter nutrients. The effects of erosion and direct surface run-off have been under-rated on the Coastal Plain. It is more difficult to control direct run-off, and phosphorus associated with fine particles of soil from heavy clay soils or severely waterlogged areas (because watertables are so high water still flows above the soil, irrespective of how permeable it is). Direct run-off and poor vegetation cover plus a prevalence of non-wetting sandy topsoils and a general lack of fencing around many drains all serve to make phosphorus pollution one of the major issues in this region.

Unrestricted rooting depth alone is unlikely to be limiting for shallow-rooted pastures. Many shallow areas have very low available water storage, reducing pasture growth and increasing risk of wind and water erosion.

Soil water storage**:** Very low water storage means that pastures dry off rapidly and are removed by stock, increasing the risk of wind and water erosion.

Salinity can be a serious limitation to production, although salt-tolerant pasture species are available. Amelioration may not be possible because saline water could affect adjacent properties, or the groundwater table could be too extensive for local effects. Fortunately salinity tends to be easier to control on the Swan Coastal Plain. Because watertables here are “at equilibrium” - i.e. salinity does fluctuate seasonally, but is not rising overall - salinity and waterlogging are generally treated as the same problem.

pH. Highly acid soils reduce production of most legume species. Management options include growing tolerant species and using acid-tolerant Rhizobia and/or applications of lime.

Very high pH is uncommon in surface soils. On small holdings pH is a relatively minor management consideration.

Waterlogging can limit production, although tolerant pasture species are available. Waterlogging is a major issue on the Swan Coastal Plain which was primarily an extensive wetland area and is now intensively drained. Significant new drainage work is not favoured because it leads to additional phosphorus export and water erosion. As a rule of thumb, there is a direct trade-off between drainage speed and water quality. Hence new or improved drainage with appropriate set backs may be feasible where the waterlogging problem is not too severe, as drainage set backs will reduce the speed at which water is drained but will improve water quality.

A difficulty with small holdings is that management options for issues such as waterlogging are usually restricted. Larger farms will have summer and winter paddocks, where stock can be moved to the appropriate location as the seasons dictate. On a small holding land is likely to be entirely dry or entirely waterlogged, reducing the stock management options available, meaning that both the stocking rates and the design of the property need to be carefully considered.

Soil workability**:** Tractor access for fertiliser topdressing and reseeding may be required. However, on small holdings, this is largely a minor management consideration.

Flood risk only affects the stocking rate if flooding affects pasture production or endangers grazing animals. However, on small holdings, which generally also have associated buildings any flood risk is usually unacceptable. Because this is not considered in the stocking rate, any units subject to any flood risk should be further investigated.

6.2 Swan Coastal Plain soil-landscape survey

Published map unit	Map unit description	Stocking rate land unit	Dry land Stocking rate (DSE/ha)[1]	Land quality considerations[2] (Bold text indicates significant limitations)
B1	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.	SR3	2	**Soil water storage,** Wind erosion
B1a	As for B1, but with a more intensely coloured yellow B horizon occurring within 1 m of the surface; marri and jarrah dominant.	SR3	2	**Soil water storage,** Wind erosion
B1b	Very low relief dunes of undulating sand plain with deep bleached grey sandy A2 horizons and pale yellow B horizons.	SR3	2	**Soil water storage,** Wind erosion
B2	Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.	SR3	2	**Soil water storage**
B2a	As for B2, but with a more intensely coloured yellow B horizon usually well within 1 m of the surface.	SR3	2	**Soil water storage**
B3	Closed depressions and poorly defined stream channels with moderately deep, poorly to very poorly drained bleached sands with an iron-organic pan, or clay subsoil; surfaces are dark grey sand or sandy loam.	Swamp (SR5.1)	2	**Waterlogging risk,** Phosphorus export, pH 0-20 cm
B3a	Broad depression and narrow swales between sand ridges with moderately deep to deep, poor to very poorly drained grey and brown sands with an iron organic (or siliceous) hardpan at generally less than 1 m.	Swamp (SR5.1)	2	**Waterlogging risk,** Phosphorus export
B4	Broad poorly drained sandplain with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay or less frequently a strong iron-organic hardpan.	SR5	6	Phosphorus export, pH 0-20 cm, Waterlogging risk
B5	Shallowly incised stream channels of minor creeks and rivers with soils similar to B4	SR5	6[3]	Phosphorus export, Waterlogging risk
B6	Sandplain and broad extremely low rises with imperfectly drained deep or very deep grey siliceous sands.	SR4	6	Wind erosion, Phosphorus export, Soil water storage
CSs (F6s)	Very low relief 1-5% footslopes with rapidly drained deep bleached grey sands and occasionally deep yellow-brown sands. Minor occurence of gravels.	SR3	2	**Soil water storage,** Wind erosion

Published map unit	Map unit description	Stocking rate land unit	Dry land Stocking rate (DSE/ha)[1]	Land quality considerations[2] (Bold text indicates significant limitations)
CSv (F6v)	Incised stream channels. Moderately drained with soils similar to CSs.	SR5	6[3]	Soil water storage, Phosphorus export
CSw (F6w)	Seasonally inundated swamps, depressions and seepage areas neat the base of the foothills with very poorly drained deep bleached silicious sands.	SR5.1	2	Waterlogging risk, Phosphorus export, Soil water storage
D1 (DR1)	Steeper slopes of scarp face (20-30%) with red and yellow gradational earths and duplex soils with variable depth and common rock outcrop.	SR9, SR9.1	6	Water erosion, Phosphorus export
D2 (DR2)	Moderately inclined slopes (10-20%) with soils and rock outcrop similar to D1.	SR9, SR10	6	Water erosion, Phosphorus export
D3 (DR3)	Deeply incised tributary valleys with steep sideslopes; soils and rock outcrop similar to D1.	SR9, SR9.1	6[3]	Water erosion, Phosphorus export
D4 (DW1)	Gently inclined crests and upper slopes with shallow uniform brownish sands with ironstone gravels and very common block laterite.	SR8, SR8.1	2	**Soil water storage**
D5 (DR5)	Deeply incised river valleys with moderately inclined slopes with deep sandy duplex soils and minor rock outcrop; drainage is generally moderately well to well, with a few swampy depressions or seepage areas.	SR8, SR9, SR9.1 Other	10[3]	
F1a	Gently inclined lower slopes (5-10%) with well drained shallow to moderately deep, very gravelly acidic yellow duplex soils and common laterite.	Other (SR8)	6	Soil water storage
F1b	Gently inclined lower slopes (5-10%) with well drained moderately deep to deep, gravelly acidic yellow duplex soils and rare laterite.	SR8	10	
F1c	Gently inclined lower slopes (5-10%) with well drained deep uniform yellowish brown sands which are generally free of laterite or gravel.	Other (SR1)	6	**Soil water storage,** Wind erosion
F2a	Very gently to gently inclined slopes (2-5%) with well drained shallow to moderately deep, very gravelly acidic yellow duplex soils and common laterite.	Other (SR8, SR8.1)	6	Soil water storage
F2b	Very gently to gently inclined slopes (2-5%) with well drained moderately deep to deep, gravelly acidic yellow duplex soils and rare laterite.	SR8	10	
F2c	Very gently to gently inclined slopes (2-5%) with well drained deep uniform yellowish brown sands which are generally free of laterite or gravel.	Other (SR1)	6	**Soil water storage,** Wind erosion

Published map unit	Map unit description	Stocking rate land unit	Dry land Stocking rate (DSE/ha)[1]	Land quality considerations[2] (Bold text indicates significant limitations)
F3	Very gently inclined (1-3%) lower slopes with deep, imperfectly drained yellow and, less commonly, acidic gley duplex soils.	SR8	10	
F4	Incised stream channels within gentle slopes and with deep acidic yellow duplex soils and sandy alluvial gradational brown earths.	Other (SR8)	6[3]	Phosphorus export, Waterlogging risk
F5	Poorly defined stream channels on lowest slopes and with deep acidic yellow duplex soils and sandy alluvial gradational brown earths.	Other (SR8)	6[3]	Phosphorus export, Waterlogging risk
P1a	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or 'effective duplex') soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity.	SR4, SR5	6	Waterlogging risk
P1b	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or 'effective duplex') soils. Moderately deep pale sand to sandy loam over clay: imperfectly drained and moderately susceptible to salinity in limited areas.	SR4	6	Soil water storage
P1c	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or 'effective duplex') soils. Deep pale brown to yellowish sand to sandy loam over clay; imperfectly drained and moderately susceptible to salinity in limited areas.	SR4	6	Soil water storage
P1d	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or 'effective duplex') soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and moderately susceptible to salinity.	SR4, SR5	6	Salinity risk
P1e	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or 'effective duplex') soils. Shallow pale sand to sandy loam over very gravelly clay; moderately well drained.	SR4	10	
P2	Flat to very gently undulating plain with deep alkaline mottled yellow duplex soils which generally consist of shallow pale sand to sandy loam over clay.	SR4	6	Salinity risk
P2a	As for P2, but there is a silcrete hardpan at 50-100 cm depth generally on top of an olive-grey clay.	Other (SR5.2)	2	**Soil water storage, Salinity risk,** Phosphorous export, Unrestricted rooting depth
P3	Flat to very gently undulating plain with deep, imperfect to poorly drained acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface horizons.	SR5, SR6	6	**Waterlogging risk**

Published map unit	Map unit description	Stocking rate land unit	Dry land Stocking rate (DSE/ha)[1]	Land quality considerations[2] (Bold text indicates significant limitations)
P3a	Flat to very gently undulating plain with deep, poorly to imperfectly gradational or duplex soils, with loam to clay loam surface horizons and subsoils going alkaline.	SR5, SR6	6	**Waterlogging risk**
P4	Poorly drained flats, sometimes with gilgai microrelief and with moderately deep to deep black, olive grey and some yellowish brown cracking clays and less commonly non-cracking friable clays with generally acidic subsoils.	SR5, SR6	6	**Waterlogging risk**
P4a	As for P4, but with a thin veneer of grey sand.	SR6	6	Waterlogging risk
P5	Poorly drained flats, commonly with gilgai microrelief and with deep black-grey to olive-brown cracking clays with subsoils becoming alkaline.	SR5, SR6	6	Waterlogging risk
P5a	As for P5, but with a thin veneer of grey sand.	SR6	6	Waterlogging risk
P6a	Very gently undulating alluvial terraces and low rises contiguous with the plain, with deep moderately well to well drained soils associated with major current river systems and larger streams. Acidic red and yellow duplex soils, less commonly gradational red and yellow earths.	SR6	6[3]	pH 0-20 cm
P6b	Very gently undulating alluvial terraces and low rises contiguous with the plain, with deep moderately well to well drained soils associated with prior stream deposits. Soils are uniform brownish sands.	SR6	6[3]	Soil water storage
P6c	Very gently undulating alluvial terraces and fans. Moderate to moderately well drained uniform friable brown loams, or well structured gradational brown earths.	SR7	10[3]	
P7	Seasonally inundated swamps and depressions with very poorly drained variable acidic mottled yellow and gley duplex soils.	Swamp (SR5.1)	2	**Waterlogging risk,** Phosphorous export
P7a	As for P7 becoming alkaline with depth.	Swamp (SR5.1)	2	**Waterlogging risk,** Phosphorous export
P7b	Seasonally inundated swamps and depressions or seepage areas near the base of the foothills with very poorly drained deep bleached siliceous sands.	Swamp (SR5.1)	2	**Waterlogging risk,** Phosphorous export

Published map unit	Map unit description	Stocking rate land unit	Dry land Stocking rate (DSE/ha)[1]	Land quality considerations[2] (Bold text indicates significant limitations)
P8	Broad poorly drained flats and poorly defined stream channels with moderately deep to deep sands over mottled clays; acidic or less commonly alkaline gley and yellow duplex soils to uniform bleached or pale brown sands over clay.	SR4, SR5	6	Wind erosion, Waterlogging risk
P9	Shallowly incised stream channels of minor creeks and rivers with deep acidic mottled yellow duplex soils.	SR5	6	Waterlogging risk
P9a	Generally shallow incised stream channels of minor creeks and rivers with poorly drained deep mottled yellow duplex soils, becoming alkaline with depth.	SR5	6	Waterlogging risk
P10	Gently undulating to flat terraces adjacent to major rivers, but below the general level of the plain, with deep well drained uniform brownish sands or loams subject to periodic flooding.	SR7	10	
P10a	Flat terraces adjacent to major rivers with deep black cracking clays with alkaline subsoils; soils similar to P5.	SR5, SR6	6[3]	Waterlogging risk
P11	Shallow brown loamy soils or less commonly, very shallow sands over ironstone pavement which is a clear barrier to drainage.	Other	6	Wind erosion, Unrestricted rooting depth, Waterlogging risk
P11a	Shallow sand to sandy loam over lateritic material; imperfect to moderately well drained.	Other	6	Wind erosion, Waterlogging risk
P12	Gently inclined lunettes with deep yellow sands fringing the western side of Benger Swamp on the Pinjarra Plain.	SR6	6[3]	Soil water storage
Qb	Actively eroding, poorly vegetated, blowout with rim and bowl (parabolic) morphology.	Other	Nil	**Wind erosion, Soil water storage**
Qd	Small gently undulating plains (deflation basins) enclosed by discrete parabolic dunes with moderately deep to deep calcareous sands over limestone.	SR2	2	**Soil water storage,** Wind erosion
Qd1	Flat to very gently undulating erosional floor of blowout or sandsheet with medium to coarse (often shelly) sand or calcrete pavement; seasonally waterlogged.	SR2	2	**Soil water storage,** Wind erosion
Qf1	Foredune/blowout complexes (semi-erosional) with very low relief ridge and swale topography and deep uniform calcareous sands.	Other (SR2)	Nil	**Wind erosion, Soil water storage,** Salt exposure

Published map unit	Map unit description	Stocking rate land unit	Dry land Stocking rate (DSE/ha)[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Qf2	Relict foredunes and gently undulating beach ridge plain with deep uniform calcareous sands.	SR2	2	**Soil water storage,** Wind erosion
Qf2a	More prominent relict foredune ridges which occur within unit Qf2.	SR2	2	**Soil water storage,** Wind erosion
Qf3, Qf4	Relict foredunes forming a plain which is topographically lower than Qf2 with prominent ridges and swales. Swamps frequently occupy the swales.	SR2	2	**Soil water storage,** Wind erosion
Qp (Qqp)	Flat to very gently undulating plain with variably leached calcareous sand generally overlying calcrete horizon at 60-90 cm depth (for management purposes similar to Qd).	SR2	2	**Soil water storage,** Wind erosion
Qp1	Complex of nested low relief parabolic dunes with moderate to steep slopes and uniform calcareous sands showing variable depths of surface darkening.	SR2	2	**Soil water storage,** Wind erosion
Qp2	Long walled discrete parabolic dunes with moderate to steep slopes and uniform calcareous sands showing variable depths of surface darkening.	SR2	2	**Soil water storage,** Wind erosion
Qp3	Subdued (small) parabolic dunes on the eastern margins of the dune system with uniform calcareous sands.	SR2	2	**Soil water storage,** Wind erosion
Qs	Actively eroding, poorly vegetated, flat to gently undulating sand sheet with deep uniform calcareous sands.	Other	Nil	**Wind erosion, Soil water storage,** Salt exposure
S1a	Dune ridges with shallow to moderately deep siliceous yellow-brown sands, very common limestone outcrop and slopes 5-15%.	SR1	6	Wind erosion, Soil water storage
S1b	Dune ridges with deep siliceous yellow brown sands or pale sands with yellow-brown subsoil and slopes 5-15%.	SR1	6	Wind erosion, Soil water storage
S1c	Dune ridges with deep bleached grey sands with yellow-brown subsoils, and slopes 5-15%.	SR3	2	**Soil water storage,** Wind erosion
S1d	Dune ridges with moderately deep to deep siliceous yellow-brown sands, rare limestone outcrop and slopes 15-25% occurring on the eastern slipface.	Other (SR1)	2	**Soil water storage,** Wind erosion
S2a	Lower slopes (1-5%) of dune ridge with moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils and minor limestone outcrop.	SR1	6	Soil water storage

Published map unit	Map unit description	Stocking rate land unit	Dry land Stocking rate (DSE/ha)[1]	Land quality considerations[2] (Bold text indicates significant limitations)
S2b	Lower slopes (1-5%) of dune ridge with sallow to moderately deep siliceous yellow-brown sands and common limestone outcrop.	SR1	6	Soil water storage
S2c	Lower slopes (1-5%) of dune ridge with bleached or pale sands with a yellow-brown or pale brown subsoil (like S1c). Usually occurs on the eastern edge of the Spearwood Dunes.	SR3	2	**Soil water storage,** Wind erosion
S3	Inter-dunal swales and depressions with gently inclined sideslopes and deep rapidly drained siliceous yellow-brown sands.	SR1	6	Soil water storage
S3a	Inter-dunal swales and depressions with gently inclined sideslopes with deep bleached grey sands underlain by an orgainic pan or peat deposit.	SR5 (SR5.1)	6	Waterlogging risk
S4a	Flat to gently undulating sandplain with deep, pale and sometimes bleached, sands with yellow-brown subsoils.	SR1	6	Soil water storage
S4b	Flat to gently undulating sandplain with shallow to moderately deep siliceous yellow-brown and grey-brown sands with minor limestone outcrop.	SR1	6	Soil water storage
S4c	Flat to gently undulating sandplain with deep, yellow-brown or dark brown siliceous sands that are seasonally inundated.	SR1, SR5	6[3]	Waterlogging risk
S5	Stony plain with extremely low ridges (relict beach ridges) and shallow to moderately deep siliceous yellow-brown sands.	Other	6	Soil water storage
S6	Flat stony plain with poorly drained shallow siliceous sands and large areas of bare limestone pavement.	Other	2	**Soil water storage, Unrestricted rooting depth**
V1	Saline tidal flats compposed of grey, black and brown foetid muds and humic sandy clays with locally common shell and limestone fragments.	Other	Nil	**Surface salinity, Waterlogging risk, Salinity risk,** Water erosion, Phosphorus export, Soil water storage, pH
V10	Highest level terrace associated with the western margins of Lake Preston and Clifton. Flat to very gently sloping plain (0-2%) of shallow calcareous black sandy loam overlying limestone; may be seasonally waterlogged.	SR7	6[3]	Soil water storage
V2	Samphire covered sand and mud flats marginally higher than V1 and frequently inundated; with deep alkaline alluvial sands and clayey sands.	Other	Nil	**Surface salinity, Waterlogging risk, Salinity risk,** Phosphorus export, Flood risk

Published map unit	Map unit description	Stocking rate land unit	Dry land Stocking rate (DSE/ha)[1]	Land quality considerations[2] (Bold text indicates significant limitations)
V3	Sand flats marginally higher than V2. Frequently inundated; with deep alkaline alluvial sands and clayey sands, commonly supporting stands of *Melaleuca* spp.	Other (SR5.1)	2	**Waterlogging risk,** Phosphorus export, Surface salinity, Flood risk, Salinity risk
V4	Low level storm beach ridges and terraces with shallow to moderately deep uniform alkaline black sandy loams to loams overlying unconsolidated shell beds or clayey marl.	SR5, SR7	6[3]	Waterlogging risk
V4a	Intermediate level terrace fringing lakes. The deep calcareous soils comprise black loams overlying brown to grey silty clay and muddy sands at depth.	SR5, SR7	6[3]	Waterlogging risk
V5	Upper level sandy terrace and gently undulating beach ridges with shallow to moderately deep grey siliceous sands overlying soft shelly limestone or shell beds.	SR4	6[3]	Wind erosion, Soil water storage
V6	Upper level sandy terrace and gently undulating beach ridges with deep grey or bleached pale brown siliceous sands overlying soft shelly limestone.	SR3	2	**Soil water storage,** Wind erosion
V6a	Gently undulating beach ridges similar to V6, but formed from reworked Pleistocene Bassendean sands. Deep bleached grey acidic siliceous sands with iron-organic hardpan.	SR3	2	**Soil water storage,** Wind erosion
V7	Very broad shallow depression with deep, poorly drained, fine textured alkaline estuarine alluvium.	SR5	6	Phosphorus export, Surface salinity, Waterlogging inundation risk, Salinity risk
V8	Flat poorly drained plains forming the margins of the estuarine deposits which border and partially overlie the Pinjarra Plain with variable, moderately deep to deep saline soils. Commonly, these are mottled yellow duplex soils over calcareous sediments or prior soils of the Pinjarra Plain.	SR5	6	Surface salinity, Waterlogging risk, Salinity risk
V9	Areas of former swamps which have been artificially drained, with uniform loamy or peaty soils.	SR5	6[3]	Waterlogging risk

1 These stocking rates are guidelines for small rural holdings only, and do not necessarily apply to broadacre commercial grazing enterprises.
2 See page 34.
3 Proximity to water likely to make portion of map unit unsuitable for stock.

6.3 Swan Valley soil-landscape survey

Published Map unit	Map unit description	Stocking rate unit	DSE/ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Ac	Variable yellow-brown and grey mottled clay.	SR6	6	Soil water storage, Surface salinity, Waterlogging risk, Salinity risk
Acl&Ac	Very shallow brown clay loam or clay over yellow-brown and grey mottled clay.	SR6	6	Surface salinity, Waterlogging risk, Salinity risk
Afs1	Shallow grey-brown sand over mottled clay.	Other (SR5)	6[3]	Soil water storage, Waterlogging risk
Afs2	Shallow brown clayey sand sto sandy loam over variable clays. Commonly has layers of gravels.	SR6	6[3]	Soil water storage, Waterlogging risk
Al	Shallow brown loam over yellow-brown and grey mottled clay.	SR6	6	Surface salinity, Waterlogging risk, Salinity risk
Bas	Moderately deep grey sand over organic hardpan over light brown sand and shallow winter watertable.	SR4, SR5	6	Wind erosion, Soil water storage, Surface salinity, Waterlogging risk, Salinity risk
Bcl	Variable yellow-brown mottled clay. May contain gravels.	SR6	6	Surface salinity, Waterlogging risk, Salinity risk
Bcl&Bc	Shallow yellow-brown clay or clay loam over variable yellow-brown mottled clay. May contain gravels.	SR6	6	Surface salinity, Waterlogging risk, Salinity risk
Bhs	Deep red-brown sand gradually grading to sandy clay loam.	SR7	10	
Bhsl	Deep red-brown sandy loam gradually grading to sandy clay loam.	SR7	10	
Bis	Deep grey sand with shallow winter watertable.	SR4, SR5	6	Wind erosion, Phosphorus export, Soil water storage, Surface salinity,Waterlogging risk, Salinity risk
Bl	Shallow brown clay loam over yellow-brown mottled clay.	SR6	6	Surface salinity, Waterlogging risk, Salinity risk
Bsl	Shallow grey-brown sandy loam over yellow-brown mottled clay.	SR6	6	Surface salinity, Waterlogging/inundation risk, Salinity risk
Ccl	Shallow brown clay loam grading to brown clay over yellow-brown clay.	SR6	6	Wind erosion, Surface salinity, Salinity risk
Cl	Shallow brown loam grading to clay loam over yellow-brown clay.	SR6	6	Wind erosion

1 These stocking rates are guidelines for small rural holdings only, and do not necessarily apply to broadacre commercial grazing enterprises.
2 See page 34.
3 Proximity to water likely to make portion of map unit unsuitable for stock.

Published Map unit	Map unit description	Stocking rate unit	DSE/ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
CP	Thin veneer of sand over clay.	SR6, SR5.1	2	**Waterlogging risk,** Phosphorus export, Soil water storage, Surface salinity, Soil workability, Salinity risk,
Cpt	Clay pit.	Other (SR6)	2	**Waterlogging risk,** Phosphorus export, Soil water storage, Surface salinity, Soil workability, Salinity risk,
Cs	Shallow brown loamy sand over yellow-brown clay.	SR6	6	Wind erosion
Csl	Shallow brown sandy loam over yellow-brown clay.	SR6	6	Wind erosion
DLC	Shallow gritty sandy loam with minor gravels over variable mottled and often gravelly clay. (Drainage line complex).	Other (SR5)	6[3]	Water erosion, Phosphorus export, Flood risk, Waterlogging risk
E	Brown loam to clay loam over basic rocks at shallow depth (scarp face).	SR9, SR9.1	6	Wind erosion, Water erosion, Phosphorus export, Soil water storage, Soil workability
F	Brown clay loam over mottled clay with sandy pockets.	SR6	6	Soil water storage, Surface salinity, Waterlogging risk, Salinity risk
G	Light brown or yellow-brown sand over brown or yellow-brown clay (foothills).	SR8	10	
GC	Brown and yellow-brown mottled clays.	SR6	6	Soil water storage, Surface salinity, Waterlogging risk, Salinity risk
Hgs	Grey to greyish brown gravelly sand over mottled clay.	Other (SR4)	6	Wind erosion
Hgsl	Grey to greyish-brown gravelly sandy loam over mottled clay.	SR6	6	Wind erosion
Hl	Grey-brown loam over mottled clay.	SR6	6	Wind erosion
Hol	Deep brown loam grading to clay.	SR6, SR7	6	Wind erosion
Hos	Very deep brown sand with clay below 1.5 m.	SR4	6	Wind erosion
Hosl	Deep grey-brown sandy loam grading to clay below 1.5 m.	SR4	6	Wind erosion
Hs	Grey to greyish-brown sand with nil to few gravels over mottled clay.	SR4	6	Wind erosion
Hs&CP	Complex of grey-brown sands and clay pans.	Other (SR5.1)	2	**Waterlogging risk,** Phosphorus export, Soil water storage, Surface salinity, Salinity risk
Hs(b)	Brown sand with nil to few gravels over mottled clay.	Other (SR1)	6	Wind erosion
Hs(d)	Deep grey to greyish brown sand with nil to few gravels over mottled clay.	SR4	6	Wind erosion, Soil water storage

Published Map unit	Map unit description	Stocking rate unit	DSE/ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Hs(salty)	Grey to greyish-brown sand with nil to few gravels over mottled clay. Saline.	Other (SR5.2)	2	**Surface salinity, Salinity risk,** Wind erosion
Hsl	Grey-brown sandy loam over mottled clay.	SR6	6	Wind erosion
I	Grey to brownish sands becoming yellow with depth.	SR1	6	Wind erosion
J	Brown sandy loam over a yellow mottled clay and a grey mottled clay.	SR7	6	Wind erosion
Ks	Shallow layer of grey sand over yellow sand (sand dune).	SR1	6	Wind erosion, Soil water storage
Ks(g)	Moderately deep light grey sand over yellow sand (sand dune).	SR3	6	Wind erosion, Phosphorus export
Lg(st)	Grey or grey-brown sands with gravels and quartz stones throughout, over yellow brown clays (foothills).	SR8	10	
Lgs	As for Ls(g) (foothills).	SR8	10	
Lgs(st)	Grey or grey-brown sands with gravels and quartz stones throughout, over yellow-brown clays (foothills).	SR8	10	
Lgsl	Grey or grey-brown gravelly sandy loam over yellow-brown clays (foothills).	SR8	10	
Ls	Grey or grey-brown sands with gravels below 30 cm, over yellow-brown clays (foothills).	SR8	10	
Ls(d)	Deep grey or grey-brown sands with gravels below 60 cm, over yellow-brown clays (foothills).	SR8	10	
Ls(g)	Grey or grey-brown gravelly sands over yellow brown clays (foothills).	SR8	10	
Ls(st)	Grey or grey-brown sands with gravels below 30 cm and some quartz stones throughout, over yellow brown clays (foothills).	SR8	10	
Mogs	Brownish-grey coarse gravelly sand over grey and yellow mottled gritty gravelly clay with lumps of iron cemented material.	Other (SR9)	6	Wind erosion, Soil water storage, Waterlogging risk
Mos	Brownish-grey coarse sand over grey and yellow mottled gritty gravelly clay with lumps of iron cemented material.	SR4	6	Wind erosion, Soil water storage, Waterlogging/inundation risk
Mos(d&sw)	Deep brownish-grey coarse sand with grey surface over grey and yellow mottled gritty gravelly clay with lumps of iron cemented material. Subject to waterlogging.	SR5.1	2	**Waterlogging/inundation risk,** Wind erosion, Phosphorus export, Surface salinity, Salinity risk

Published Map unit	Map unit description	Stocking rate unit	DSE/ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Mos(d)	Deep brownish-grey coarse sand with grey surface over grey and yellow mottled gritty gravelly clay with lumps of iron cemented material.	SR4	6	Wind erosion, Soil water storage, Surface salinity, Salinity risk
Mos(sg)	Brownish-grey coarse sand with subsurface gravels over grey and yellow mottled gritty gravelly clay with lumps of iron cemented material.	SR5	6	Wind erosion, Soil water storage, Waterlogging/inundation risk
Mos(sw)	Brownish-grey coarse sand over grey and yellow mottled gritty gravelly clay with lumps of iron cemented material. Subject to waterlogging.	SR5.1	2	**Waterlogging risk,** Wind erosion, Phosphorus export, Surface salinity, Salinity risk
Mosl	Grey sandy loam over grey, yellow and red mottled gritty clay.	SR6	6	Wind erosion, Soil water storage, Waterlogging risk
Mus	Deep grey sand.	SR4, SR5	6	**Soil water storage** , Wind erosion
Mus(sw)	Swampy deep grey sand.	SR4, SR5	6	Phosphorus export, Waterlogging risk
N	Brown to reddish brown sand over bright brown sandy clay loam and rock after 90 cm (foothills).	SR8	10	
Ogs	Brown loamy gravelly sand with grey surface over yellow-brown gravelly clay (foothills).	SR8	10	
Ogsl	Brown gravelly sandy loam to loam over yellow-brown gravelly clay (foothills).	SR8	10	
Os	Brown loamy sand with grey surface and nil to few gravels over yellow-brown friable clay (foothills).	SR8	10	
Osl	Brown sandy loam to loam over brown gravelly clay (foothills).	SR8	10	
Pc	Shallow brown mottled clay over layers of fine sand and mottled loam.	SR7	10	
Pcl	Shallow brown mottled clay loam over layers of fine sand and mottled loam.	SR7	10	
Pl	Shallow brown mottled loam over layers of fine sand and mottled loam.	SR7	10	
Ps	Shallow brown sand over layers of brown mottled loam and fine sand.	Other (SR5)	6	Soil water storage
Psl	Shallow brown mottled sandy loam over layers of fine sand and mottled loam.	SR4, SR7	6	Soil water storage
Ps-Pc	Complex of mottled sands and clays.	SR5	6[3]	Flood risk
Q	Light grey sand over brown gritty sand with quartz gravel.	Other (SR5)	6	Water erosion, Phosphorus export, Flood risk
R	Black loams and clays over lime.	SR7	10	Waterlogging risk

Published Map unit	Map unit description	Stocking rate unit	DSE/ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Rgs	Grey or grey-brown gravelly sands over yellow to yellow-brown clays (foothills).	SR2	10	
Rs	Grey or grey-brown sands with nil to few gravels over yellow to yellow-brown gravelly clays (foothills).	Other (SR3)	6	Wind erosion, Soil water storage
Rs(d)	Deep grey or grey-brown sands over yellow to yellow-brown gravelly clays (foothills).	SR1	6	Wind erosion, Soil water storage
Rs(s)	Shallow grey or grey-brown sands with nil to few gravels over yellow to yellow-brown gravelly clays. Rock likely after 60 cm (foothills).	SR1	6	**Soil water storage,** Wind erosion
Rs(st)	Shallow grey or grey-brown sands with few gravels and quartz stones throughout over yellow to yellow-brown gravelly clays (foothills).	SR1	6	**Soil water storage**
Rsl	Grey-brown sandy loam over yellow-brown clay, with quartz and feldspar rocks throughout (foothills).	Other (SR8)	6	Wind erosion
RW	River wash.	SR5	6[3]	Flood risk
RW-Pcl	River wash and Pyrton clay loam.	SR5, SR6	6[3]	Flood risk
Scl	Shallow red brown clay loam grading to red clay.	SR7	10	
SD	Grey sandy flats and rises.	SR3	6	**Soil water storage,** Wind erosion
SF	Saline flats.	Other (SR5)	Nil	**Soil water storage, Surface salinity, Salinity risk,** Unrestricted rooting depth, Waterlogging risk
So	Shallow mottled sand to sandy clay loam over tough grey to yellow-brown mottled clay.	Other (SR5.2)	Nil	**Surface salinity, Salinity risk**, Unrestricted rooting depth, Soil water storage, Waterlgging risk
So&Mos (sw)	Complex of rocky swampy sand over clay soils.	SR5.1	2	**Waterlogging risk**, Wind erosion, Phosphorus export, Surface salinity, Salinity risk
Ss	Shallow red-brown sand over red fine sandy clay, grading to red clay.	Other (SR7)	10	
Ssl	Shallow red-brown sandy loam over red-brown clay loam, grading to red clay.	SR7	10	
Ssw	Swamp (salty).	Other (SR5.1)	2	**Waterlogging risk,** Wind erosion, Phosphorus export, Surface salinity, Salinity risk
Sw	Swamp (seasonal).	Other (SR5.1)	Nil	

Published Map unit	Map unit description	Stocking rate unit	DSE/ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Sw(p)	Permanent swamp.	Other (SR5.1)	Nil	
TR	Brown loams and clays over lime.	SR7	10	Waterlogging risk
VC	Variable soils associated with drainage lines.	Other (SR5)	6[3]	Water erosion, Phosphorus export, Flood risk
VC(s)	Shallow soils associated with drainage lines over rock.	Other (SR5)	2[3]	**Soil water storage,** Water erosion, Phosphorus export, Flood risk
W	Shallow grey-brown to light brown sand over yellow-brown or red-brown mottled clay (foothills).	Other (SR6)	6	Water erosion, Phosphorus export
X	Brownish sand over a bright brown sand becoming sticky with depth.	SR1	6	Soil water storage
Y	Light grey sand over dark brown fine clay.	Other (SR7)	10	Waterlogging risk
Z	Light grey-brown to dull brown sand over grey mottled fine clay.	SR4	6	Wind erosion

1 These stocking rates are guidelines for small rural holdings only, and do not necessarily apply to broadacre commercial grazing enterprises.

2 See page 34.

3 Proximity to water likely to make portion of map unit unsuitable for stock.

6.4 West Gingin soil-landscape survey soils only

Published Map unit	Map unit description	Stocking rate unit	DSE/ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
1	Red to yellowish-red weak clayey sands to 150 cm +, commonly associated with limestone.	SR1	6	Wind erosion, Soil water storage
2	Brown siliceous soils.	SR1	6	Wind erosion, Soil water storage
2+3	Co-dominant.	SR1	6	Wind erosion, Soil water storage
2+3_	2 is dominant.	SR1	6	Wind erosion, Soil water storage
3	Yellowish-brown sands.	SR1	6	Wind erosion, Soil water storage
3+4	Co-dominant.	SR1 (SR3)	6	Wind erosion, Soil water storage
3+4_	3 is dominant.	SR1	6	Wind erosion, Soil water storage
4	Pale brown sand to 50 cm overlying brownish-yellow weak clayey sand.	SR1, SR3	6	Soil water storage
4+5	Co-dominant.	SR3 (SR1)	2	**Soil water storage**
4+5_	4 is dominant.	SR1, SR3	2	**Soil water storage**
4_+5	5 is dominant.	SR3	2	**Soil water storage**
5	Pale brown to light grey sand to 90 cm depth overlying brownish-yellow sand to weak clayey sand.	SR3	2	**Soil water storage**
5+6	Co-dominant.	SR3	2	**Soil water storage**
5+6_	5 is dominant.	SR3	2	**Soil water storage,** Wind erosion
5_+6	6 is dominant.	SR3	2	**Soil water storage**
6	Light grey sand to depth between 90-150 cm overlaying pale yellow to yellow sand.	SR3	2	**Soil water storage,** Wind erosion
6+7	Co-dominant.	SR3	2	**Soil water storage,** Wind erosion
6+7_	6 is dominant.	SR3	2	**Soil water storage**
7	Bleached sands.	SR3	2	**Soil water storage**
7+8	Co-dominant.	SR3, SR4	2	**Soil water storage**
7+9	Co-dominant.	SR5, SR3	2	Phosphorus export

Published Map unit	Map unit description	Stocking rate unit	DSE/ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
7_+9	9 is dominant.	SR5 (SR3)	6	Soil water storage
8	Bleached sands with pan.	SR4	6	Soil water storage
8+9	Co-dominant.	SR4, SR5	6	Phosphorus export
9	Humic dark grey swamp soils.	SR5	6	Phosphorus export
10	Brown alluvial sands.	SR4	6	Soil water storage
10+11	Co-dominant.	SR4	6	Soil water storage
11	Pale coloured alluvial sands.	SR4	2	**Soil water storage**
11+9	Co-dominant.	SR4, SR5	10	
12	Dark massive clays.	SR6, SR5	6	pH (acid)
13	Brown duplex soils.	Other (SR7)	10	
14	Brownish-yellow alluvial sands.	SR4	6	Soil water storage
15	Dark brown humic medium to coarse sands to sandy loams overlying gleyed mottled coarse sandy clays between 70-140 cm.	Other (SR7)	10	
17x	Grey brown duplex soils, grey cracking clays and brown massive clays.	SR6, SR7	10	
18x	Dark grey massive clays and dark grey to yellowish brown mottled duplex soils.	SR6	6	Flood risk
19x	Greyish-brown duplex soils and grey to dark grey cracking clays.	SR5.1, SR6	2	**Waterlogging risk,** Phosphorus export, Surface salinity, Flood risk
20x	Greyish brown and gleyed mottled duplex soils.	SR4	6	Flood risk, Waterlogging risk
21x	Greyish brown, brown and gleyed duplex soils.	SR4	6	Surface salinity, Salinity risk
22x	Humic black and grey cracking clays.	SR5.1, SR6	2	**Waterlogging risk,** Phosphorus export, Flood risk
23x	Dark brown silty clays, dark cracking clays and mottled greyish-brown duplex soils.	SR6	10	
24x	Greyish brown duplex soils with acid soil reaction trends.	SR4	6	Phosphorus risk, Waterlogging risk
25x	Humic dark grey swamp soils and dark grey massive clays and dark grey to yellowish-brown mottled duplex soils.	Other (SR5)	6	Flood risk

Published Map unit	Map unit description	Stocking rate unit	DSE/ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
26x	Grey to greyish brown, shallow to moderately deep duplex soils and bleached and coloured siliceous sands overlying mottled clays.	SR4	6	Soil water storage, Waterlogging risk
27x	Red and brown mottled duplex soils.	Other (SR7)	10	
28x	Shallow, grey to black, calcareous loams, clay loams and pedal duplex soils.	Other (SR7)	6	Unrestricted rooting depth, Waterlogging risk
29x	Dark grey to olive grey shallow pedal duplex soils and dark grey cracking clays overlying limestone or marl.	Other (SR6)	6	Unrestricted rooting depth, Surface salinity, Flood risk, Waterlogging risk, Salinity risk
30x	Brown whole coloured or mottled duplex soils overlying siliceous/ferruginous pans.	Other (SR4)	6	Surface salinity, Salinity risk
31x	Very dark greyish brown to dark brown shallow duplex soils overlying siliceous/ferruginous pans.	Other (SR5.1)	2	**Waterlogging risk,** Phosphorus export, Unrestricted rooting depth, Surface salinity, Flood risk, Salinity risk
32x	Shallow to moderately deep greyish brown to yellowish-brown mottled duplex soils and bleached siliceous sands overlying pans and gleyed clays.	SR4	6	Soil water storage, Surface salinity, Waterlogging risk, Salinity risk
33x	Greyish brown to brown shallow duplex soils overlying ferruginous/siliceous pans.	Other (SR4)	6	Unrestricted rooting depth, Surface salinity, Flood risk, Waterlogging risk, Salinity risk
34x	Yellowish brown to brown weak clayey medium to coarse sands to 100 cm+ or overlying moderately deep gleyed mottled clays and moderately deep yellow-brown to gley mottled duplex soils.	SR4	6	Soil water storage
35x	Complex of brown, yellow and bleached sands.	SR4, SR1	6	Wind erosion, Soil water storage
36x	Duplex soils, cracking clays and siliceous sands with acid to alkaline soil reaction trends.	SR6	6	Waterlogging risk
C	Clay.		No data	
Dt	Diatomaceous deposits.		No data	
LAKE	Lake.		Nil	
Ls	Limestone outcrop.		No data	
SWP	Swamp.		Nil	

1 These stocking rates are guidelines for small rural holdings only, and do not necessarily apply to broadacre commercial grazing enterprises.

2 See page 34.

3 Proximity to water likely to make portion of map unit unsuitable for stock.

6.5 Northern metropolitan soil-landscape survey

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
B	Flat terrain fringing water in base of karst depressions; light grey sand with watertable within 2 m; *E rudis*, *B. littoralis* and *Melaleuca* spp. typha spp. near waters edge.	SR4	6[3]	Phosphorus export, Waterlogging risk
DL	Broad, shallow channels, peaty soils, fringe of *Melaleuca* spp. and *E. rudis*; reeds and sedges in central zone.	SR5.1	2	**Waterlogging risk,** Water erosion, Phosphorus export
G	Flat or gently undulating landscape;iron - humus podzols; *Banksia* spp. Low pen woodland with scattered emergent *Eucalyptus calophylla* and *Melaleuca pressiana* dense shrub layer.	SR4	6	Wind erosion, Soil water storage
GG	Flat poorly drained landscape interrupted by broad low sandy rises; soils include shallow sand over ferruginous pan, red loam over limestone and black clay over limestone; *Banksia* spp. woodland on sandy rises scattered *Actinostrobus pyramidalis* on swamp.	Other (SR4, SR5, SR6)	6	Waterlogging risk
J	Poorly drained depressions; humus podzols; scattered *M. preissiana*, *E. rudis* and *Banksia ilicifolia* with a dense shrub layer.	SR4, SR5	6	Phosphorus export, pH, Waterlogging risk
Ja	Low hills and ridges with more than 5 m relief; iron podsols; *Banksia* spp. low open woodland with a dense shrub layer.	SR3	2	**Soil water storage,** Wind erosion
Jas	Ridges with more than 10 m relief; iron podzols; *Banksia* spp. low open woodland with sparse shrub layer.	SR3	2	**Soil water storage,** Wind erosion
Kg	Low hilly to gently undulating terrain; iron podzols; *Banksia* spp woodland with *E.todtiana* and depauperate *E. marginata*; dense shrub layer.	SR1, SR3	6	Wind erosion, Soil water storage
Kls	Low hills and ridges; bare limestone or shallow siliceous or calcareous sand over limestone; dense low shrub dominated by *Dryandra sessilis*, *Melaleuca huegelii* and species of Grevillea.	SR1	6	Soil water storage
Ky	Low hilly to gently undulating terrain; yellow sand over limestone at 1-2 m; *Banksia* spp. woodland with scattered emergent *E. gomphocephala* and *E. marginata* and a dense shrub layer.	SR1	6	Soil water storage
L&Sw	Permanent water in base of karst depressions; Melaleuca spp. and E. rudis. One of water level fluctuation; sedges and reeds in shallow water.	Other	Nil	

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
P	Extensively flat swampy areas; sandy surface with some admixture of diatomite in the surface and organic hardpan below; *E. rudis*, *B. littoralis* and *M. preissiana* around the edges; sedges and reeds with scattered *M. teretifolis* in centre; *Jacksonia furcel.*	SR5.1	2	**Waterlogging risk,** Phosphorus export
Q1	The oldest phase. Dunes or remnants with low relief; soils have organic staining to about 30 cm, overlying pale brown sand, and within definite cementation below 1 m.	SR2	2	**Soil water storage**
Q2	The second phase. A complex pattern of dunes with moderate relief; soils have organic staining to about 20 cm, passing into pale brown sand; some cementation below 1 m.	SR2	2	**Soil water storage,** Wind erosion
Q3	The third phase. Steep irregular dunes with high relief; soils consist of loose sand with little surface organic staining and incipient cementation at depth.	SR2	2	**Soil water storage,** Wind erosion
Q4	The youngest phase. Steep irregular dunes of loose pale brown sand with no soil profile development.	Other (SR2)	Nil	**Wind erosion, Soil water storage,** Salt exposure
Qp	Undulating landscapes with deep calcareous sands overlying limestone; soils have dark grey-brown sand to about 50 cm and then pale brown sand; remnants of hummocks are often present.	Other (SR2(1))	2	Soil water storage
Qs	Undulating landscapes with shallow calcareous sand over limestone and much rock outcrop.	Other (SR2)	2	**Soil water storage,** Phosphorus export
Qu	Presently unstable sand.	Other (SR2)	Nil	**Wind erosion, Soil water storage**
Sp	Irregular banks of karst depressions; some limestone outcrop; shallow brown soils; *Banksia* spp. woodland with emergent *E. gomphocephala* and *E. marginata*; dense shrub layer.	SR1	6	Soil water storage
Wp	Depressions; humus podzols and peats around the edges often with some diatomite zoned vegetation with heath on upper slopes, *Melaleuca* spp. and *E. rudis* at waters edge, reeds and sedges in shallow water.	Other (SR5.1)	2	**Waterlogging risk,** Phosphorus export
Ws	Depressions with free water in winter; humus podzols and peat; dense *M. preissiana*; *M. rhaphiophylla* and *E. rudis* around the edges with reeds and sedges in the centre.	SR5.1	2	**Waterlogging risk,** Phosphorus export

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Wy	A pattern of low sandy rises and many small seasonal swamps; rises have iron-humus or iron podzols and Banksia spp. low open woodland; swamps have surface layer of diatomite over sand; dense *Melaleuca* spp. and *E. rudis* around fringe with sedges in centra.	SR5	6[3]	Waterlogging risk, Phosphorus export
Ya	Flat, poorly drained complex landscape; soils include shallow sand over limestone or ferruginous pan, deep leached sand, and saline soils; dense *Melaleuca* spp. along drainage lines.	SR4	6	Waterlogging risk

1 These stocking rates are guidelines for small rural holdings only, and do not necessarily apply to broadacre commercial grazing enterprises.

2 See page 34.

3 Proximity to water likely to make portion of map unit unsuitable for stock.

6.6 Busselton-Margaret River-Augusta Land Capability Study

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
A	Abba Flats: Flats and low rises with sandy grey-brown duplex (Abba) and gradational (Busselton) soils.	SR4	6	Phosphorus export
A2	Abba gentle slopes; gentle slopes (2-5% gradients) with gravelly sands and grey-brown gradational and duplex soils.	SR4	6	Phosphorus export
Ad2	Abba Deep Sandy Dunes: Gently sloping low dunes and rises (0-5% gradients) with deep bleached sands.	SR3	2	**Soil water storage,** Wind erosion
Adw	Abba Deep Sandy Wet Flats: Poorly drained depressions (mainly in swales). Deep sandy soils with surface organic matter build-up.	SR5	6	Phosphorus export, Waterlogging risk
Af	Abba Fertile Flats: Well drained flats with sandy gradational grey-brown (Busselton) soils, some red-brown sands and loams (Marybrook soils).	SR7	10	
AF	Abba Very Fertile Flats: Well drained flats with deep red-brown sands, loams and light clays, (i.e. Marybrook soils).	SR7	10	
Afw	Abba Fertile Wet Flats: Slight depressions, which are poorly drained in winter, with deep red-brown sands, loams and light clays, (i.e. Marybrook soils).	SR5, SR7	6	Phosphorus export, Waterlogging risk
Av	Abba Vales: Small narrow depressions along drainage lines. Alluvial soils.	SR4	6[3]	Phosphorus export
Avw	Abba Wet Vales: Small narrow swampy depressions along drainage lines. Alluvial soils.	SR5	6[3]	Phosphorus export, Waterlogging risk
Aw	Abba Wet Flats: Winter wet flays and slight depressions with sandy grey brown duplex (Abba) and gradational (Busselton) soils.	SR4, SR5	6	Phosphorus export, Waterlogging risk
Awi	Abba Wet Ironstone Flats: Winter wet flats and slight depressions with shallow red-brown sands and laoms over ironstone (i.e. bog iron ore soils).	Other (SR5.1)	2	**Waterlogging risk, Unrestricted rooting depth, Soil water storage,** Phosphorus export
Awy	Abba Very Wet Saline Flats: Poorly drained depressions with some areas which become saline in summer. Shallow sands over clay subsoils (i.e. Abba clays).	SR5.2	2	**Salinity risk,** Waterlogging risk, Phosphorus export
B	Blackwood Flats: Flats with a variety of deep (mainly sandy) soils.	SR4	6	Phosphorus export
Bd	Blackwood Deep Sandy Flats: Flats and low dunes with deep bleached sands.	SR3	2	**Soil water storage,** Wind erosion

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Bf	Blackwood Fertile Flats: Flats, mainly with deep yellow loamy soils (i.e. Marybrook yellow sandy loam).	SR7	10	
Bvw	Blackwood Wet Vales: Drainage depressions with broad swampy floors. Mixed allyvial and sandy soils.	SR4	6[3]	Phosphorus export
Bw	Black Wet Flats: Flats and slight depressions which are winter wet. Mixed allyvial and sandy soils.	SR5	6[3]	Phosphorus export, Waterlogging risk
Bwy	Blackwood Estuarine Flats: Estuarine flats fringing the Blackwood River near its mouth.	SR5.2	Nil	**Surface salinity, Waterlogging risk,** Phosphorus export, Soil workability, Flood risk
C	Cowaramup Flats and Gentle Slopes: Flats (0-2% gradient) and with gravelly duplex (Forest Grove) and pale grey mottled (Mungite) soils.	SR8, SR4	10	
C2	Cowaramup Gentle Slopes: Gentle slopes (2-5% gradient) with gravelly duplex (Forest Grove) soils.	SR8	10	
Cd2	Cowaramup Deep Sandy Rises: Flats and gently sloping rises (gradients 0-5%), with deep bleached sands. Some areas of low and moderate slopes (gradient 5-15%).	SR3	2	**Soil water storage,** Wind erosion
Cdw	Cowaramup Deep Sandy Wet Flats: Poorly drained flats and depressions with deep organic stained sands.	SR5	6	Waterlogging risk, Phosphorus export
Ci	Cowaramup Ironstone Flats: Flats and gently slopes (0-5% gradient) with some laterite outcrop and shallow gravelly sands over laterite.	SR8.1	2	**Soil water storage,** Unrestricted rooting depth
Cr2	Cowaramup Rocky Gentle Slopes: Flats and gentle slopes (0-5% gradient) with shallow rocky soils and some granite outcrop.	Other (SR8, SR10, SR9.1)	6	
CR	Cowaramup Rock Outcrop: Areas dominated by granitic outcrop.	Other (SR9.1)	2	**Unrestricted rooting depth, Soil water storage**
Cv	Cowaramup Vales: Small, narrow V-shaped drainage depressions with gravelly duplex (Forest Grove) soils.	SR8	10[3]	
Cvw	Cowaramup Wet Vales: Small, broad U-shaped drainage depressions with swampy floors. Gravelly duplex (Forest Grove) soils on sideslopes and poorly drained alluvial soils on valley floor. This unit can be subdivided into the (side) slopes and the (valley) floor.	SR5, SR8	6[3]	Waterlogging ris, Phosphorus export
Cw	Cowaramup Wet Flats: Poorly drained flats and slight depressions with pale grey mottled (Mungite) soils.	SR5	6	Waterlogging risk, Phosphorus export

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
D	D'Entrecasteaux Flats: Interdune flats with deep calcareious sands with organic stained topsoils.	SR2	2	**Soil water storage,** Salt exposure**,** Wind erosion
D5	D'Entrecasteaux Steep Dunes: Steep dunes, sheltered from the prevailing winds, with deep calcareous sands.	SR2	Nil	**Soil water storage,** Wind erosion, Water erosion, Phosphorus export, Soil workability, Salt exposure
Db	D'Entrecasteaux Beaches: Beach and foredunes stretching along the south coast, with deep calcareous sands.	SR2	Nil	**Wind erosion, Soil water storage,** Salt exposure
Dd	D'Entrecasteaux Deep Sandy Flats: Flats with deep bleached siliceous sands.	SR3, SR1	2	**Soil water storage,** Salt exposure**,** Wind erosion
Dd2	D'Entrecasteaux Deep Sandy Gentle Dunes: Gently sloping (2-5% gradient) dunes, sheltered from the prevailing winds, with bleached and yellow-brown siliceous sands, sometimes overlying limestone.	SR1, SR3	2	**Soil water storage,** Salt exposure**,** Wind erosion
Dd5	D'Entrecasteaux Deep Sandy Steep Dunes: Steep dunes (gradient in excess of 15%) with bleached and yellow-brown siliceous sands, sometimes overlying limestone.	Other (SR1, SR3)	Nil	**Soil water storage,** Wind erosion**,** Soil workability, Salt exposure
DE5	D'Entrecasteaux Exposed Steep Dunes: Steep dunes with deep, calcareous sands, exposed to prevailing winds which come off the ocean.	Other (SR2)	Nil	**Wind erosion, Soil water storage,** Soil workability, Salt exposure
Dem5	D'Entrecasteaux Blowouts: Steep bare dunes of mobile pale calcareous sands.	Other (SR2)	Nil	**Wind erosion, Soil water storage**, Salt exposure
Dr	D'Entrecasteaux Rocky Dunes: Dunes with dark calcareous sands containing limestone rubble.	Other (SR2)	6	Wind erosion, Soil water storage, Salt exposure
Drd	D'Entrecasteaux Deep Sandy Rocky Flats: Flats with yellow-brown sands overlying limestone.	SR1	6	Wind erosion, Soil water storage, Salt exposure
G2	Gracetown Gentle Slopes: Gentle slopes (gradients 2-5%) with deep reddish and yellow-brown siliceous sands over limestone (Spearwood Sands). Not exposed to prevailing winds.	SR1	6	Soil water storage**,** Wind erosion
G3	Gracetown Low Slopes: Low slopes (gradient 5-10%) with deep yellow-brown siliceous sands over limestone (i.e Spearwood Sands). Not exposed to prevailing winds.	SR1	6	Water erosion, Phosphorus export, Soil water storage
Ge	Gracetown Exposed Flats: Ridge crest, exposed to prevailing winds, with deep and shallow yellow-brown siliceous sands over limestone (i.e. Spearwood Sands).	SR1	6	Wind erosion, Soil water storage, Salt exposure

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
GEm	Gracetown Blowouts: Small blowouts with deep yellow siliceous sands.	Other (SR1)	Nil	**Wind erosion,** Water erosion, Phosphorus export, Soil water storage, Salt exposure
Gk	Gracetown Karst Areas: Small areas with sinkholes, dolines, limestone scarps and cave entrances.	Other (SR1, SR9.1)	Nil	Water erosion, Phosphorus export, Soil water storage
Gv	Gracetown Valleys: Deepish narrow valleys incised into the Gracetown Ridge.	Other (SR1)	Nil[3]	Wind erosion, Water erosion, Phosphorus export, Soil water storage
H3	Glenarty Low Slopes: Slopes (gradients mainly 5-10%) with a variety of soil types.	Other (SR8)	10	
Hd	Glenarty Deep Sandy Flats: Flats with deep bleached sands.	SR3	2	**Soil water storage,** Wind erosion
Hd3	Glenarty Deep Sandy Slopes: Slopes (gradients mainly 5-10%) with deep bleached sands and quartz grits.	SR3	2	**Soil water storage,** Wind erosion, Water erosion, Phosphorus export
Hdw	Glenarty Sandy Wet Flats: Poorly drained flats and depressions with deep organic stained sands.	SR5	6	Waterlogging risk, Phosphorus export
Hf	Glenarty Fertile Flats: Well drained valley flats and floodplains with deep (often red-brown loamy) alluvial soils.	SR7	10[3]	
Hi3	Glenarty Ironstone Slopes: Slopes (gradients mainly 5-10%) with shallow gravelly sands over laterite.	Other (SR8.1)	2	**Unrestricted rooting depth , Soil water storage,** Water erosion, Phosphorus export,
HR	Glenarty Rock Outcrop: Areas dominated by granitic outcrop.	SR9.1	2	**Unrestricted rooting depth , Soil water storage,** Water erosion, Phosphorus export,
Hv	Glenarty Valleys: Narrow V-shaped open depressions along drainage lines.	SR8	10[3]	
Hvw	Glenarty Wet Valleys: Broad U-shaped drainage depressions with swampy floors.	SR5	6[3]	Waterlogging risk, Phosphorus export
Hw3	Glenarty Wet Slopes: Slopes (graidents mainly 5-10%) with high winter water tables and pale grey mottled (Mungite) soils.	SR5	6	Water erosion, Phosphorus export, Waterlogging risk.
Kb	Kilcarnup Beaches: Beaches and foredunes of calcareous sand, along with west coast.	Other (SR2)	Nil	**Wind erosion, Soil water storage.**
KE	Kilcarnup Exposed Dunes: Steep dunes (gradients usually in excess of 20%) on the west coast, exposed to prevailing winds which come directly off the ocean, with deep pale calcareous sands. Poorly vegetated.	Other (SR2)	Nil	**Wind erosion, Soil water storage,** Salt exposure

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
KEf	Kilcarnup Exposed Dunes (with organic matter build up): Steep dunes (gradients usually over 20%) on the west coast, exposed to prevailing winds which come directly off the ocean. Deep pale calcareous sands with brown topsoils. Well vegetated.	Other (SR2)	Nil	**Soil water storage, Wind erosion**, Water erosion, Salt exposure
KEm	Kilcarnup Exposed Blowouts: Steep bare dunes of mobile pale calcareous sands, on the west coast exposed to prevailing winds directly off the ocean.	Other (SR2)	Nil	**Wind erosion, Soil water storage,** Soil workability, Salt exposure
Kf	Kilcarnup Dunes (with organic matter build up): Steep dunes, (gradients usually over 20%) not exposed to prevailing winds. Deep pale calcareous sands with brown topsoil.	SR2	2	**Soil water storage,** Wind erosion, Water erosion, Salt exposure
Km	Kilcarnup Blowouts: Steep bare dunes of mobile pale calcareous sand, not exposed to prevailing winds.	SR2	2	**Soil water storage,** Wind erosion, Water erosion, Soil workability
Kr	Kilcarnup Rocky Dunes: Low to steep dunes (gradients 5-10%) not exposed to prevailing winds. Dark calcareous sands containing limestone rubble.	SR2	2	**Soil water storage,** Wind erosion
KrE	Kilcarnup Exposed Rocky Dunes: Steep dunes (graidents usually in excess of 20%) with dark calcareous sands containing limestone rubble on the west coast exposed to prevailing winds directly off the ocean.	Other (SR2)	Nil	**Wind erosion, Soil water storage,** Water erosion, Salt exposure
KRE (KREe)	Kilcarnup Exposed Rock Outcrop: Dominantly highly eroded areas where bare limestone has been exposed.	Other (SR2, SR9.1)Other	Nil	**Soil water storage, Wind erosion,** Water erosion, Phosphorus export, Unrestricted rooting depth, Salt exposure
L	Ludlow Flats: Flats and very low dunes. Deep yellow-brown siliceous sands over limestone (i.e. Spearwood sands).	SR1	6	Soil water storage
Lv	Ludlow Vales: Narrow floodplains in small depressions along creeks and rivers. Sandy alluvial soils.	Other (SR1)	6[3]	Soil water storage
Lvg	Ludlow Wet Clayey Vales: Narrow floodplains in small depressions along creeks and rivers. Clayey alluvial soils.	SR6, SR5.2	2[3]	**Salinity risk,** Waterlogging risk, Phosphorus export
Lvw	Ludlow Wet Vales: Narrow swampy small depressions. Sandy soils.	Other(SR5)	6[3]	Waterlogging risk, Phosphorus export
Lw	Ludlow Wet Flats: Flats with poor subsoil drainage in winter. Deep yellow-brown siliceous sands over limestone (i.e. Spearwood Sands).	Other (SR5, SR1)	6	Soil water storage
Lwg	Ludlow Wet Clayey Flats: Poorly drained flats with heavy clayey (Cokelup) soils. Some areas saline in summer.	SR6, SR5.2	2	**Salinity risk,** Waterlogging risk, Phosphorus export

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Lwr	Ludlow Wet Rocky Flats: Flats with high winter water tables and shallow brown and yellow sands over limestone (i.e. Shallow Spearwood sand). Limestone often present on surface.	Other (SR5, SR1)	6	Phosphorus export, Soil water storage
M	Metricup Slopes: Moderate slopes (gradients mainly 10-15%) with gravelly duplex (Forest Grove) soils.	SR8	10	
Mr	Metricup Rocky Slopes: Moderate slopes (gradients mainly 10-15%) with shallow gravelly soils and occasional lateritic and granitic outcrop.	SR9, SR9.1	6	Soil water storage, Water erosion, Phosphorus export, Unrestricted rooting depth
Mv	Metricup Valleys: Valleys with moderately inclined sideslopes and valley floors with relatively steep graidents. Gravelly duplex (Forest Grove) soils.	SR8	10	
Mvr	Metricup Rocky Valleys: Deeply incised valleys with steep sideslopes and valley floors with relatively steep gradients. Shallow gravelly soils and occasional lateritic and granitic outrcrop.	SR9, SR9.1	6	Water erosion, Phosphorus export, Unrestricted rooting depth.
N	Nillup Flats: Flats mainly with pale grey mottled (Mungite) soils.	Other (SR4)	6	Waterlogging risk, Phosphorous export
Nd	Nillup Deep Sandy Flats: Flats with deep bleached sands.	SR3	2	**Soil water storage,** Wind erosion
Ndw	Nillup Wet Deep Sandy Flats: Poorly drained flats with deep organic stained sands.	SR5	6	Waterlogging, Soil water storage, Phosphorus export, Salt exposure.
Nf	Nillup Fertile Flats: Well drained valley flats with deep (often reddish and brown loamy) alluvial soils.	SR7	10[3]	
Ni	Nillup Ironstone Rises: Low rises with shallow gravelly sands over laterite.	SR8.1	2	**Unrestricted rooting depth, Soil water storage**
Nv	Nillup Vales: Small narrow V-shaped drainage depressions.	SR4	6[3]	Waterlogging risk, Phosphorous export
Nvw	Nillup Wet Vales: Small broad U-shaped drainage depressions with swampy floors.	SR5, SR4	6[3]	Waterlogging risk, Phosphorus export
Nw	Nillup Wet Flats: Poorly drained flats with mottled pale grey (Mungite) soils.	SR5	6	Waterlogging risk, Phosphorous export
Q	Quindalup Flats: Flats and low rises with deep pale calcareous sand. This unit also includes a narrow strip of: **Qb** – Quindalup Beach; beach and foredunes of calcareous sand, along the Geographe Bay coastline.	SR2	2	**Soil water storage,** Wind erosion, Salt exposure.

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Q5	Quindalup Dunes: Steep dunes (with gradient mainly around 20%) of calcareous sands.	SR2	Nil	**Soil water storage, Wind erosion,** Water erosion, Phosphorus export, Salt exposure.
Qw	Quindalup Wet Flats: Poorly drained flats around the edge of the Vasse Estuary. Dark calcareous sands and mixed estuarine deposits.	Other (SR4)	6	Waterlogging risk, Phosphorus export, Salinity risk
Qwy	Quindalup Very Wet Saline Flats: Vasse, Wonnerup and Broadwater Estuaries. Low lying depressions which are often underwater in winter and saline in summer.	SR5.2	Nil	**Waterlogging risk,** Phosphorus export, Surface salinity, Flood risk, Salinity risk.
Sd	Scott Deep Sandy Flats: Flats with high winter watertables and deep bleached siliceous sands.	SR4	6	Phosphorus export, Waterlogging risk**,** Wind erosion
Sd2	Scott Deep Sandy Gentle Rises: Low dunes and rises with deep bleached siliceous sands.	SR3	2	**Soil water storage,** Wind erosion
Si	Scott Ironstone Rises: Low rises with shallow sands over laterite.	SR8.1	2	**Unrestricted rooting depth, Soil water storage**
Swd	Scott Deep Sandy Wet Flats: Poorly drained flats with deep organic stained siliceous sands.	SR5	6	Phosphorus export, Waterlogging risk
Swi	Scott Wet Ironstone Flats: Poorly drained flats with shallow sands over laterite (bog iron ore).	Other (SR5.1)	2	**Waterlogging risk, Unrestricted rooting depth, Soil water storage,** Phosphorus export
T	Treeton Steep Slopes: Slopes > 15%. In most cases T3 is the dominant unit present.	SR8	10	
Td3	Treeton Deep Sandy Slopes: Slopes (gradients generally 5-10% but ranging from 2-15%) with deep bleached sands.	SR3	2	**Soil water storage,** Wind erosion
Tf	Treeton Fertile Flats: Well drained valley flats and floodplains with deep alluvial soils, often red-brown loams (i.e. Marybrook soils).	SR7	10	
Tfw	Treeton Wet Fertile Flats: Poorly drained valley flats and floodplains with deep alluvial soils (usually Marybrook soils).	SR5	6	Waterlogging risk, Phosphorus export
Ti3	Treeton Ironstone Slopes: Low slopes (gradients ranging from 2-10%) with shallow gravelly sands over laterite.	SR8.1	2	**Unrestricted rooting depth, Soil water storage,** Water erosion, Phosphorus export
Tv	Treeton Valley: Narrow V-shaped drainage depressions.	SR8	10[3]	
Tvw	Treeton Wet Valleys: Broad U-shaped drainage depressions with swampy floors.	SR5	6[3]	Waterlogging risk, Phosphorus export

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Tw2	Treeton Wet Slopes: Gentle slopes (gradient 2-5%) with high winter watertables and mottled pale grey mottled (Mungite) soils.	SR5	6[3]	Waterlogging risk, Phosphorus export, Water erosion
W	Wilyabrup Slopes: Slopes with gradients generally 5-15%, but ranging from 2-30% and gravelly soils (i.e. Forest Grove and Keenan Soils).	SR8	10	
Wd3	Wilyabrup Deep Sandy Slopes: Low slopes (gradients generally 5-10%) with deep bleached sands.	SR3	2	**Soil water storage,** Wind erosion
We3	Wilyabrup Exposed Slopes: Low slopes (gradients generally 5-10%) exposed to strong winds off ocean.	Other (SR8)	6	Wind erosion
WEw	Wilyabrup Exposed Swamps: Swamps on granitic headland at Cape Leeuwin.	SR5.1	Nil	**Salt exposure, Waterlogging risk,** Phosphorus export
Wf	Wilyabrup Fertile Flats: Well drained valley flats and floodplains with deep alluvial soils, often red-brown loams (i.e. Marybrook soils).	SR7	10[3]	
Wfw	Wilyabrup Wet Fertile Flats: Poorly drained valley flats and floodplains with deep alluvial soils.	SR5	6[3]	Waterlogging risk, Phosphorus export
Wi3	Wilyabrup Ironstone Slopes: Low slopes (gradients generally 5-10%) with shallow gravelly sands over laterite.	SR8.1	2	**Unrestricted rooting depth, Soil water storage,** Water erosion, Phosphorus export,
Wr3	Wilyabrup Rocky Slopes: Low slopes (gradients generally 5-10%) with shallow rocky soils and some granitic outcrop.	Other (SR8, SR9.1)	6	Water erosion, Phosphorus export
WR	Wilyabrup Rock Slopes: Slopes dominated by granitic outcrop.	Other (SR9.1)	2	**Unrestricted rooting depth, Soil water storage,** Water erosion, Phosphorus export,
WrE3	Wilyabrup Exposed Rocky Slopes: Low slopes (gradients mainly 5-10%) with shallow rocky soils and some granitic outcrop, exposed to strong winds off the ocean.	Other (SR9.1)	Nil	**Wind erosion,** Water erosion, Phosphorus export, Soil water storage, Waterlogging risk
WRE	Wilyabrup Granitic Headlands: Areas on the west coast dominated by granitic outcrop.	SR9.1	2	**Soil water storage, Unrestricted rooting depth**, Soil workability, Salt exposure
Wv	Wilyabrup Valleys: Narrow V-shaped drainage depressions.	Other (SR8, SR9.1)	6[3]	Water erosion, Phosphorus export.
Wvw	Wilyabrup Wet Valleys: Broad U-shaped drainage depressions with swampy floors.	SR5	6[3]	Waterlogging risk, Phosphorus export

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Ww3	Wilyabrup Wet Slopes: Low slopes (graidents 5-10%) with high winter watertables.	SR5	6	Water erosion, Phosphorus export, Waterlogging risk
Y	Yelverton Flats and Slopes: Flats and low slopes with mottled pale grey gradational (Mungite) and gravelly duplex (Forest Grove) soils.	SR8, SR4	10	
Yd	Yelverton Deep Sandy Flats and Low Slopes: Flats and low slopes with deep bleached sand.	SR3	2	**Soil water storage,** Wind erosion
Yf	Yelverton Fertile Flats: Valley flats and floodplains with deep alluvial soils, often red-brown loams (i.e. Marybrook soils).	SR7	10[3]	
Yi	Yelverton Ironstone Flats: Flats with shallow gravelly sands over sheet laterite. Laterite outcrop sometimes present.	SR8.1	2	**Unrestricted rooting depth, Soil water storage**
Yv	Yelverton Valleys: Narrow V-shaped drainage depressions and small valleys.	SR8	10[3]	
Yvw	Yelverton Wet Valleys: Poorly drained flats with mottled pale grey (Mungite) soils.	SR5	6[3]	Waterloging risk, Phosphorus export
Yw	Yelverton Wet Flats: Poorly drained flats with mottled pale grey (Mungite) soils.	SR5	6	Waterlogging risk, Phosphorus export
Ywi (YLwi)	Yelverton Wet Ironstone Flats: Winter wet flats with shallow red-brown sandy and loamy soils over sheet laterite (bog iron ore).	Other (SR5.1)	2	**Waterlogging risk, Unrestricted rooting depth, Soil water storage,** Phosphorus export
XX	Distributed Terrain: Areas where the natural land surface has been greatly altered, i.e. areas of landfill, sand mining activity.			

1 These stocking rates are guidelines for small rural holdings only, and do not necessarily apply to broadacre commercial grazing enterprises.

2 See page 34.

3 Proximity to water likely to make portion of map unit unsuitable for stock.

6.7 Darling Range soil-landscape survey

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Bg1	Valleys within Darling Scarp.	SR9	Nil	**Water erosion,** Phosphorus export
Bg2	Valleys within sideslopes of major river valley systems.	SR9	Nil	**Water erosion,** Phosphorus export
C	Crests and upper slopes dominated by granite outcrop and very shallow yellow duplex soils, and yellow and brown massive earths.	Other (SR9.1)	2	**Water erosion,** Phosphorus export, Soil water storage
Ck1	Moderately steep to steep sideslopes with few to commonly occurring areas of rock outcrop. Soils are mainly well drained yellow duplex types. Adjacent to rock outcrop, shallow gravelly earthy and siliceous sands occur.	SR9	6	Water erosion, Phosphorus export
Ck2	Gentle to moderately inclined sideslopes, with similar soils to Ck1.	SR8, SR9	10	
Ck3	Gentle sideslopes with well drained moderately deep gravelly earthy and siliceous sands.	SR8	10	
Ck4	Narrow drainage floors with imperfectly drained yellow or mottled yellow duplex soils.	Other (SR5, SR9)	6[3]	Water erosion, Phosphorus export
D1	Crests and very gently inclined terrain dominated by lateritic duricrust and very shallow gravelly brownish sands, pale brown sands and earthy sands.	Other (SR8.1)	2	**Unrestricted rooting depth, Soil water storage**
D2	Gently undulating terrain with well drained, shallow to moderately deep gravelly brownish sands, pale brown sands and earthy sands overlying lateritic duricrust.	Other (SR8, SR1)	6	Soil water storage
D3	Moderately inclined slopes with well drained shallow to moderately deep gravelly brownish sands, pale brown sands and earthy sands overlying lateritic duricrust.	Other (SR8, SR10)	6	Soil water storage
DS1	Moderately steep to steep upper slopes.	SR9	Nil	**Water erosion,** Phosphorus export
DS2	Moderately inclined lower slopes.	SR10, SR9	6	**Water erosion,** Phosphorus export
F1	Very gently to gently inclined footslopes with deep rapidly drained siliceous yellow brown sands, and pale or bleached sands with yellow-brown subsoil.	SR1, SR3	2	**Soil water storage**
F2	Very gently to gently inclined footslopes with well drained gravelly yellow or brown duplex soils with sandy topsoil.	SR8	10	

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
F3	Very gently to gently inclined footslopes with well drained gravelly yellow or red duplex soils with sandy loam to loam topsoil.	SR10	10	
F4	Gently to moderately inclined breakaway slopes separating Forrestfield from the Swan alluvial terraces. Soils are imperfectly drained yellow or grey gradational earths.	SR8, SR10	10	
F5	Very gently to gently inclined incised drainage channels with poorly drained gravelly yellow or brown duplex soils.	SR5	6[3]	Water erosion, Phosphorus export, Waterlogging risk
F6	Very gently to gently inclined crests and knolls with common lateritic outcrop. Soils are shallow moderately well drained gravelly brownish or earthy sands.	SR8.1	2	**Soil water storage, Unrestricted rooting depth**
F7	Level to very gently inclined alluvial fans with variable imperfectly drained soils comprising layers of sand, sandy loam, clay, grit and weathered granitic detritus.	Other (SR4)	6[3]	Phosphorus export, Waterlogging risk
F8	Moderately inclined footslope areas with moderately well drained gravelly duplex soils similar to those of unit F3.	SR8	10	
F9	Very gently inclined seepage areas and non-incised drainage channels with poorly drained bleached grey sands over an iron-organic hardpan.	SR4, SR5	6[3]	Soil water storage, Waterlogging risk, Phosphorus export
F10	Level to very gently inclined alluvial fans with variable poorly drained soils.	SR4, SR5	6[3]	PH, Waterlogging risk
G (GO)	Level, imperfectly drained swampy margins with deep grey, yellowish brown or brown siliceous or bleached sands.	SR4, SR5	6[3]	Phosphorus export, Soil water storage
Gf1	Plain with moderately well drained yellow duplex or gradational soils with sand to sandy loam topsoil.	Other (SR4, SR7)	10	
Gf2	Plain with imperfectly drained yellow duplex soils with sand to sandy loam topsoil.	SR4, SR5, SR7	6	
Gf3	Plain with poorly drained mottled yellow earths with loamy topsoil.	SR6	6	Waterlogging risk
Gf4	Alluvial fans with variable imperfectly drained soils similar to unit F7.	Other (SR7)	10	
Gf5	Incised drainage channels with poorly drained gradational mottled yellow earths.	SR5	6[3]	Waterlogging risk

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Gf6	Seasonally inundated swamps with very poorly drained uniform non-cracking clays.	SR5.1	2	**Waterlogging risk,** Phosphorus export
Gf7	Minor rises with deep rapidly drained brownish, siliceous or bleached.	SR3	2	**Soil water storage**
Gf8	Plain and broad depressions with poorly drained uniform non-cracking clays.	SR5.1	2	**Waterlogging risk,** Phosphorus export, Soil water storage
Gf9	Minor sandy rises (aeolian deposits) with moderately deep well drained sands overlying gravelly mottled clay.	SR1, SR3	6	Soil water storage
H1	Moderately steep to steep sideslopes and very narrow drainage floors with areas of many rock outcrop.	9.1	Nil	**Water erosion, Unrestricted rooting depth,** Phosphorus export
H2	Moderately inclined sideslopes and lower slopes with few areas of rock outcrop.	SR9	10	
H3	Very gentle to gently inclined valley floors with common rock outcrop.	Other	10[3]	
Ma1	Moderately steep to steep valley sideslopes and narrow incised valley floors.	SR9	6[3]	Water erosion, Phosphorus export
Ma2	Gentle to moderately inclined lower sideslopes.	SR10	10[3]	
Mb1	Undulating broad crests and very gentle upper slopes with common lateritic duricrust outcrop and shallow gravelly sands.	Other (SR8.1)	2	**Soil water storage**
Mb2	Undulating broad crests and very gentle upper slopes with deep loose brownish or pale brownish sands.	Other (SR1)	6	Soil water storage
Mb3	Gently inclined slopes and minor drainage headwaters with deep grey siliceous and bleached sands.	Other (SR3)	2	**Soil water storage,** Phosphorus export
Mb4	Gently to moderately inclined slopes with shallow gravelly sands and few areas of lateritic outcrop.	Other (SR8, SR8.1)	2	**Soil water storage**
Mb5	Level to gently inclined, incised drainage floors with imperfectly drained brownish or pale brown earthy sands that may be saline.	SR5	6[3]	Soil water storage, Salinity risk
Mb6	Level to very gently inclined non-incised drainage floors with imperfectly drained pale sands with yellow brown subsoil over iron-organic hardpan.	SR5	6[3]	Soil water storage
Mb7	Gentle to moderately inclined ridges and spurs at the edge of the plateau surface, with imperfectly drained gravelly yellow duplex soils.	SR8	10	

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Mm1	Gently undulating ridge crests and benches.	Other (SR10)	10	
Mm2	Moderately inclined flanks of ridges and spurs.	Other (SR9, SR10)	6	**Water erosion,** Phosphorus export
My1	Moderately steep to steep sideslopes and very narrow valley floors, with few to commonly occurring areas of rock outcrop.	SR9	Nil	**Water erosion,** Phosphorus export
My2	Moderately inclined to moderately steep sideslopes and narrow valley floors with few areas of rock outcrop.	SR9	6[3]	Water erosion, Phosphorus export
My3	Gently to moderately inclined sideslopes and lower slopes with very few areas of rock outcrop.	SR10	10	
My4	Very gently inclined valley floors, with very few areas of rock outcrop and poorly drained and commonly saline soils.	SR5, SR9	6[3]	Surface salinity, Waterlogging risk, Salinity risk
Pn1	Gently inclined sideslopes with well drained gravelly brownish sands, pale brown sands and earthy sands.	SR8	10	
Pn2	Gently inclined valley headwaters with deep rapidly drained grey, yellowish brown or brown siliceous or bleached sands.	Other (SR1, SR3)	2	**Soil water storage,** Phosphorus export
Pn3	Gently inclined valley headwaters with moderately well drained shallow to moderately deep sands underlain by mottled clay.	Other (SR8)	6[3]	Soil water storage
Pn4	Valley floors with imperfectly drained yellow duplex soils and yellow and brown massive earths.	Other (SR4)	6[3]	Waterlogging risk
Pn5	Broad, level to very gently inclined valley floors with very poorly drained uniform grey or brown clays or clay loams.	SR5.1	2	**Waterlogging risk,** Phosphorus export
Pn6	Level to very gently inclined valley floors with poorly drained saline duplex or gradational soils.	SR5.2	2[3]	**Surface salinity, Waterlogging risk, Salinity risk**
Re1	Gentle slopes with deep, rapidly drained loose brownish or pale sands with a sandy fabric.	Other (SR3)	2	**Soil water storage,** Wind erosion
Re2	Gentle slopes with deep, well drained brownish or earthy sands situated below Re1.	Other (SR1)	6	Soil water storage
Re3	Gentle slopes and spurs with shallow gravelly sands and few areas of lateritic outcrop.	Other (SR8.1)	2	**Soil water storage, Unrestricted rooting depth**

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Re4	Very gently inclined footslopes with deep rapidly drained grey siliceous or bleached sands.	SR3	2	**Soil water storage,** Wind erosion, Phosphorus export
Re5	Level to very gently inclined swampy drainage lines with poorly drained grey siliceous and pale yellow-brown sands.	SR5	6[3]	Waterlogging risk
Re6	Very gently inclined footslope seepage areas with imperfectly drained grey siliceous sands or pale yellow-brown sands.	Other (SR5)	6[3]	Soil water storage**,** Waterlogging risk
Re7	Level to very gently inclined outwash fans with deep, well drained grey siliceous sands or bleached sands overlying clay at depths greater than 1 m.	SR4	6	Soil water storage**,** Phosphorus export
Re8	Moderately steep to steep scarp hillslopes with imperfectly drained yellow duplex and less commonly yellow gradational soils associated with localized areas of siltstone. Minor (few) rock outcrops occur.	SR9	Nil	**Water erosion,** Phosphorus export
Re9	Gentle to moderately inclined footslopes associated with siltstone areas, with soils similar to Re8.	Other (SR8)	10	
Sw1	River margins and low flats with poorly drained variable alluvial soils, subject to frequent flooding.	SR5	6[3]	Flood risk, Waterlogging risk
Sw2	Low level, occasionally flooded, alluvial terraces with imperfectly drained variable alluvial soils with loamy surfaces.	SR7	10[3]	
Sw3	Low level, occasionally flooded, alluvial terraces with imperfectly drained variable alluvial soils with sand to sandy loam surfaces.	SR7	10[3]	
Sw4	Low level, occasionally flooded alluvial terraces with poorly drained variable alluvial soils with dark greyish brown clay loam to clay surfaces.	SR5, SR7	6[3]	Waterlogging risk
Sw5	Swamps within river terraces.	SR5.1	2	**Waterlogging risk,** Phosphorus export
Sw6	Incised drainage channels within river terraces.	SR5	6[3]	Waterlogging risk
Sw7	Mid to higher level terrace with moderately well drained red or brown duplex soils.	SR7	10[3]	
Sw8	Higher level terrace with well drained red earthy sands or brownish sands.	SR1, SR7	10[3]	
Sw9	Higher level terrace with well drained sandy gradational red earths.	SR7	10[3]	
Y1	Gently undulating terrain with well drained moderately deep to deep fine gravelly brownish sands, pale brown sands and earthy sands.	Other (SR8)	6	Soil water storage

Published map unit	Map unit description	Stocking rate unit	DSE/ ha[1]	Land quality considerations[2] (Bold text indicates significant limitations)
Y2	Gently undulating terrain with moderately well drained yellow duplex soils, and yellow and brown massive earths.	SR8	10	
Ya1	Plain with moderately deep poorly drained pale yellow brown sands underlain by mottled clay.	SR4	6	Waterlogging risk
Ya2	Plain and swamp margins with deep poorly drained grey siliceous sand overlying clay.	SR4	6	Waterlogging risk, Soil water storage
Ya3	Seasonally inundated swamps with shallow very poorly drained grey siliceous sand over clay.	SR5.1	Nil	**Surface salinity, Waterlogging risk, Salinity risk,** Phosphorus export
Ya4	Seasonally inundated swamps with very poorly drained alkaline uniform grey clays overlain in places by a thin sand veneer.	SR5.1	Nil	**Surface salinity, Waterlogging risk, Salinity risk,** Phosphorus export
Yg1	Gently to moderately inclined sideslopes with moderately well drained yellow duplex soils, and yellow and brown massive earths.	SR8	10	
Yg2	Very gentle to gently inclined valley headwaters with deep rapidly drained grey, yellowish brown or brown siliceous or bleached sands.	Other (SR1, SR3)	6	Soil water storage, Phosphorus export
Yg3	Very gentle to gently inclined valley headwaters with moderately well drained shallow to moderately deep sands underlain by mottled clay.	Other (SR8)	6[3]	Soil water storage
Yg4	Valley floors with poorly drained mottled yellow duplex soils.	SR5	6[3]	Waterlogging risk**,** Phosphorus export
Yg5	Level to very gently inclined broad valley floors with very poorly drained uniform grey or brown clays or clay loams.	SR5	2[3]	**Waterlogging risk,** Phosphorus export

1 These stocking rates are guidelines for small rural holdings only, and do not necessarily apply to broadacre commercial grazing enterprises.

2 See page 34.

3 Proximity to water likely to make portion of map unit unsuitable for stock.

7. ADDITIONAL INFORMATION AND REFERENCES

Land management information

General guides for small rural holdings include: The *Small Block Manual* (prepared by Mortlock W, 1994 for the Shire of Serpentine-Jarrahdale) and *The land is in your hands – a practical guide for landowners of small rural holdings in Western Australia* (Agriculture Western Australia, 1999). Both these publications are available from Agriculture Western Australia. Farmnotes (F/N), Technical notes (T/N), Bulletins (B/N) and miscellaneous publications (M/P) plus a number of pamphlets are also available from Agriculture Western Australia. Many relevant publications are listed in 7.1 below:

Agriculture Western Australia

3 Baron-Hay Court
SOUTH PERTH WA 6151
Phone: (08) 9368 3729
Fax: (08) 9474 2018

7.1 Land management information *ordered* by land management issue

Subject	Reference	Title
Land clearing	F/N 34/99	Regulation 4, governing land clearing
	Mortlock, W. 1994	Small Block Manual (Mortlock, W. 1994)
Erosion control	F/N 43/99	Windbreaks for horticulture on the Swan Coastal Plain
	M/P 23/97	Preventing soil erosion and soil structure decline - A soil management practices guide for horticultural farmers in the SW high rainfall hills
	F/N 26/93	How to prevent farm track erosion
	F/N 27/93	How to prevent firebreak erosion
	T/N 4/93	The susceptibility of soil to wind erosion
	F/N 31/91	Tree planting for erosion and salt control
	F/N 52/89	Preventing soil erosion and tree damage on small holdings
Fences	F/N 60/99	Preventing tree damage by livestock
	Mortlock, W. 1994	Small Block Manual, help and fact sheets from fencing suppliers and manufacturers.
		Wires and pliers. The farm fencing manual. (Available from the Kondinin Group)
Revegetation	B/N 4174	Tree planting on farms in high rainfall areas
	B/N 4206	Trees for farms
	F/N 37/98	Site preparation for successful revegetation for agricultural regions with less than 600 mm rainfall
	B/N 4729	Streamlining - an environmentally sustainable drainage network for the Swan Coastal Plain
	Mortlock, W. 1994	Small Block Manual

Subject	Reference	Title
Protection of trees	F/N 60/99	Preventing tree damage by livestock
	F/N 52/89	Preventing soil erosion and tree damage on small holdings
	Mortlock, W. 1994	Small Block Manual
Stock management	Mortlock, W. 1994	Small Block Manual
Pasture management	F/N 11/91	Cropping and horticulture
	F/N 6/90	Sprinkler Irrigated pasture for small holdings
	F/N 12/89	Pasture management in the south-west
	B/N 4537	Fertilisers for pastures on sandy soils of the Swan Coastal Plain
	Mortlock, W. 1994	Small Block Manual
	Agriculture Western Australia Booklet	Pasture management for small landholders
Fertiliser	F/N 27/96	Nitrogen fertiliser sources for crops
	B/N 4357	Fertilisers for pastures on sandy soils of the Swan Coastal Plain
	Mortlock, W. 1994	Small Block Manual
		Fertiliser manufacturers/suppliers
Waterlogging, salinity, drainage	F/N 26/94	Notification of intention to drain or pump water in the Peel-Harvey Catchment
	F/N 47/93	Notification of draining or pumping saline land
	F/N 9/91	Water and drainage
	F/N 1/88	Reclaiming saline and waterlogged soils on the Swan Coastal Plain
	Mortlock, W. 1994	Small Block Manual
Property management	F/N 21/98	Manure management on small properties
	F/N 39/93	Calculating the value of rural land
	F/N 8/91	Land use and general property management
	F/N 17/86	Development guidelines for small rural lots
	F/N 19/86	Site evaluations for small rural lot developments
	Agriculture Western Australia	Property Care, A guide to Maintaining and Improving Your Property (T Bell)
	Agriculture Western Australia Booklet	Land management issues in the Swan and Canning Catchment
Weeds		Agricultural Protection Board
	Mortlock, W. 1994	Small Block Manual

Subject	Reference	Title
Water	F/N 22/98	Water supplies on small properties
	F/N 73/94	Water supplies for irrigation on the small farm
	F/N 46/90	Water quality for farm domestic use
	F/N 11/86	Clearing cloudy or coloured water
	F/N 69/78	Water quality for WA farms
	Mortlock, W. 1994	Small Block Manual
Fire	Mortlock, W. 1994	Small Block Manual
		Bushfires Board of Western Australia

7.2 Agriculture Western Australia land resource information

Wells, M.R. and King, P.D. (1989). **Land capability assessment methodology** for 'rural residential' development and associated agricultural land uses. Agriculture Western Australia. (Out of print). Now superceded by:

Van Gool D.and Moore G. (1999). Land evaluation standards for land resource mapping. Guidelines for assessing land qualities and determining land capability in south-west Western Australia. Agriculture Western Australia. Resource management technical report No. 181.

Schoknecht N. (1998). Soil groups of Western Australia. A simple guide to the main soils of Western Australia. Agriculture Western Australia. Resource management technical report No. 171.

Barnesby, B.A., King, P.D. and Prouix-Nixon, M.E. Land resources from **Harvey to Capel** on the Swan Coastal Plain, Two Maps, Agriculture Western Australia.

Campbell-Clause, J. and Moore, G.A. (1991). Land capability study for horticulture in the **Swan Valley**, Agriculture Western Australia.

King, P.D. and Wells, M.R. (1990). **Darling Range** rural land capability study, Agriculture Western Australia.

Smolinski, H. and Scholz, G. (1997). Soil Assessment of the **West Gingin** area, Agriculture Western Australia.

Tille, P.J. and Lantzke, N.C. (1990). **Busselton - Margaret River - Augusta** land capability study, Agriculture Western Australia.

Van Gool, D. and Kipling, B. (1992). Land resources of the northern and southern sections of the **Peel-Harvey Catchment**, Two Maps, Agriculture Western Australia.

Wells, M.R. (1989). Land capability study of the shires of **Mandurah and Murray**, Agriculture Western Australia.

Wells, M.R. and Clarke, A.J. (1986). **Shire of Wanneroo** - a study of land resources and planning considerations. Agriculture Western Australia. Resource management technical report No. 47.

7.3 Other land resource survey references

These published reports were not prepared by Agriculture Western Australia, but may be sourced from libraries, or Agriculture Western Australia. Computer generated prints of the mapping, or digital copies of the maps can be obtained from Agriculture Western Australia.

Barnesby, B.A. (1991). API infill mapping prepared for the metropolitan rural policy (unpublished).

McArthur, W.M. and Bartle, G.A. (1980b). Landforms and soils as an aid to urban planning in the **Perth metropolitan northwest corridor**, Western Australia. Maps (scale 1:25,000, 4 map sheets). CSIRO Australia, Land Resources Management Series No. 5.

McArthur, W.M. and Mattiske, E.M. (1985). The **Gnangara mound** groundwater area landforms, soils and vegetation. Soil-landscape map (scale 1:50,000). Appendix C in *Gnangara mound groundwater resources, environmental review and management programme.* Report by Dames and Moore, November 1986.

Kin, P.G., Byrne, J.D. and Herne, D.E. (1997). Land use effects on the water quality of water discharged to **Ellen Brook**. Final report, May 1997. Report 97/22. CSIRO.

Kin, P.G., Byrne, J.D. and Herne, D.E. (1997). Land use effects on water quality in the **Ellen Brook** catchment: AGNPS model application. Report No. 97/21. CSIRO.

Pym, L.W. (1955). Soils of the **Swan Valley** vineyard area, Western Australia. CSIRO Division of Soils, Soils and Land Use Series No. 15.

7.4 Further reading

Agriculture Western Australia (1994). Emu farming.

Agriculture Western Australia (1993). Farming emus, Farmnote 68/93.

Agriculture Western Australia (1994). Sheep and the hobby farmer. Bulletin 4080.

Armstrong, R.T.F., McDonald, B.J. and Knights, G.I. Raising goats for cashmere and mohair. Dept. Primary Industries Qld.

Birutia, G. (1997). A guide to raising llamas. Storey Communications, Pownal, Vermont USA.

Carter, B. (1966). Llama down under. Agmedia (Vic. Dept Agric.), East Melbourne.

Cliff, A. (1993). Farm animals for gardens and backyards. Aird Books, Melbourne.

Crean, D. and Bastian, G. (1997). Sheep management and wool production. Reed International Australia.

Damerow, G. (1995). A guide to raising chickens. Storey Communications, Pownal, Vermont USA.

Ellis, M. (1996). House cow handbook. Agmedia (Vic. Dept Agric.), East Melbourne.

Foyel, J. (1994). Hoofprints, a manual for horse property management. Primary Industries South Australia.

Garrett, B. Editor (1993). Whole farm planning principles and options. Dept. of Agric. Vic. and Dep. Cons. and Nat. Res. Victoria.

Hinton, D. (1993). Running a small flock of sheep, Agmedia (Vic. Dept Agric.), East Melbourne.

Hoofbeat publication, The green horse. Hoofbeat Publications, Wandi, WA.

Huntington, P. and Cleland, F. (1992). Horse sense. Agmedia (Vic. Dept Agric.), East Melbourne.

Kemp, R. (1997). Exhibition poultry. Kangaroo Press, NSW.

Kondinin Group (1994). Wires and pliers. The farm fencing manual.

Luttmann, G. (1986). Raising milk goats successfully. Williamson Publishing Co., Charlotte, Vermont, USA.

Mason, J. (1996). Farm management. Kangaroo Press, NSW.

McFarlane, A. and McFarlane, G. (1996). Pig keeping on a small scale. Kangaroo Press, NSW.

Mercia, L.S. (1995). Raising your own turkeys. Storey Communications, Pownal, Vermont, USA.

Mortlock, W. (1994). Small block manual. Shire of Serpentine Jarrahdale.

Reading, D. (1981). A guide to keeping poultry in Australia. Viking Penguin Books, Ringwood, Vic.

Vriends, M.V. (Ed) (1987). The new goat handbook. Barrons Munich Germany.

Wallis, C.A. (1996). Running a small beef herd. Agmedia (Vic. Dept Agric.), East Melbourne.

Wilson, J. (1994). Keeping a cow. Kangaroo Press, NSW.

Yabsley, G. (1994). Farming in a small way, NSW Agriculture.

7.5 Technical publications and references

Allen, D. and Jeffery, R.C. (1990). Methods for analysis of phosphorus in Western Australian soils. Chemistry Centre, WA.

Austin, M.P. and Cocks, K.D. (1978). Land use on the south coast of New South Wales. A study in methods acquiring and using information to analyse regional land use options. CSIRO Melbourne.

Dames and Moore (undated). Nitrate management in Jandakot UWPCA. Prepared for the Water Authority of Western Australia.

DPUD (1995). *South-east Corridor structure plan*. Department of Planning and Urban Development (now Ministry for Planning), Perth, WA, Australia.

EPA (1994). Review of Peel Inlet - Harvey Estuary Management Strategy Stage 2, Environmental Conditions. Bulletin 749.

EPA (1997). Final criteria of environmental acceptability for land use within the catchment of Lake Clifton. Bulletin 864.

Foyel, J. (1994). Hoofprints, a manual for horse property management. Primary Industries South Australia.

Gerritse, R.G., Adeney, J.A. and Bates, L.E. (1992). Nutrient inputs from various land uses on the Darling Plateau in Western Australia. CSIRO Report 92/3.

Gerritse, R.G. and Adeney, J.A. (1992). Nutrient exports from various land uses on the Darling Plateau in Western Australia. CSIRO Report 92/41.

Gerritse, R.G. and Adeney, J.A. (1991). A comparison of inputs of nutrients from existing and proposed land use on the 'Chestnuts' Estate in Jarrahdale. CSIRO Divisional Report 91/29.

Govt of Western Australia (1992). Statement of Planning Policy No 2, The Peel-Harvey Coastal Plain Catchment.

Govt of Western Australia (1997). Draft Statement of Planning Policy No 6, Jandakot Groundwater Protection Policy.

Lantzke, N. (1997). Phosphorus and nitrate loss from horticulture on the Swan Coastal Plain. Agriculture Western Australia, Miscellaneous Publication 16/97.

Legislative Assembly of Western Australia (1994). The Select Committee on Metropolitan Development and Groundwater Supplies.

National and Medical Research Council (1996). Australian drinking water guidelines. Canberra, ACT.

Pointke, H.B., Sharma, M.L. and Hosking, J.K. (undated). Effect of irrigated horticultural cropping on groundwater quality Swan Coastal Plain Western Australia. CSIRO Water Resources No. 2.

Van Gool D. and Moore G (1999). Land evaluation standards for land resource mapping. Guidelines for assessing land qualities and determining land capability in south-west Western Australia. Agriculture Western Australia Resource Management Technical Report 181.

WAPC (1996). *Inner Peel Structure Plan*. Ministry for Planning. Perth, WA, Australia.

Wells, M.R. and King, P.D. (1989). Land capability assessment methodology. Land Resource Series No. 1, Western Australian Department of Agriculture.

APPENDIX 1. Stocking rates for horses

Table A1 provides an example of the number of horses that are recommended on various land units for different lot sizes assuming some pasture and stock management. The information is derived using Table 1, in the main body of the report.

A single light horse is equivalent to 10 DSE, hence the only way to keep horses on many small holdings is by using special management, which would normally require a stock management plan and permission from the local government authority.

There are many issues to consider. Just a few include:

- Stable design, including drainage controls for manure.
- Manure handling to avoid odour and stable fly problems.
- The type of horse activity varies from family pet to high value racing or stud horses.
- Access to facilities such as training tracks and bridle paths.
- Aside from manure as a health issue and in terms of nutrient export, woodchips used on bridle paths release toxic tannins which can poison surface water.

Section 7 lists additional information sources. The Water and Rivers Commission is also presently working on guidelines for horses on small rural properties.

Table A.1. Stocking rates for horses

Stocking rate unit	Information sheet	1 ha dry #	1 ha irrig #	2 ha dry	1 ha dry 1 ha irrig	5 ha dry
Well drained yellow to brown sands	1	6 DSE No horse	20 DSE 2 horses	12 DSE 1 horse	26 DSE 2 horses	30 DSE 3 horses
Rapidly drained calcareous sands	2	2 DSE No horse	Not recommended#	4 DSE No horse	Not recommended	10 DSE 1 horse
Rapidly drained pale sands	3	2 DSE No horse	10 DSE 1 horse#	4 DSE No horse	12 DSE 1 horses	10 DSE 1 horse
Pale sand flats	4	6 DSE No horses	20 DSE 2 horses	12 DSE 1 horse	26 DSE 2 horses	30 DSE 3 horses
Semi-wet soils	5	6 DSE No horse	20 DSE 2 horses	12 DSE 1 horse	26 DSE 2 horses	30 DSE 3 horses
Swamps and drains* Salty areas	5.1 5.2	2 DSE No horse	Not recommended#	4 DSE No horse	Not recommended	10 DSE 1 horse
Clay flats	6	6 DSE No horse	20 DSE 2 horses	12 DSE 1 horse	26 DSE 2 horses	30 DSE 3 horses
Loamy flats and terraces	7	10 DSE 1 horse	25 DSE 2 horses	20 DSE 2 horses	35 DSE 3 horses	50 DSE 5 horses
Gravel slopes Shallow gravels and ironstone outcrop	8	10 DSE 1 horse	25 DSE 2 horses	20 DSE 2 horses	35 DSE 3 horses	50 DSE 5 horses
Steep slopes	9	6 DSE No horse	10 DSE 1 horse#	12 DSE 1 horse	16 DSE 1 horse	30 DSE 3 horses
Shallow rocky soils and crests	9.1	2 DSE No horse	Not recommended#	4 DSE No horse	Not recommended	10 DSE 1 horse
Loamy slopes	10	10 DSE 1 horse	25 DSE 2 horses	20 DSE 2 horses	35 DSE 3 horses	50 DSE 5 horses

Calculated using Tables 1 and 2.

In some areas stock are not permitted on lots of < 1 ha.

* Wetlands should be fenced to exclude stock.

Note: For stocking rates in excess of those recommended for dry pasture and dry pasture with some additional feed, a pasture and nutrient management plan may be required depending on the stocking rate unit and site conditions. See section ‘Increasing Stocking Capacity’.

APPENDIX 2. Increasing stocking capacity

A stock management plan should be prepared when stocking a property in excess of the recommended base stocking rates. This should be subject to approval from the relevant local government authority.

The issues listed below are important to any property but are particularly important when developing a management plan to carry stock at rates in excess of the recommended dry land rate.

A stock management checklist of stock management issues is available in Table A2.

The following guidelines apply to stables and areas of increased stocking rates.

Sites considered for higher stocking rates should:

- preferably be confined to the better soils with higher stocking rates;
- not be located on slopes of greater than 10%;
- not be located in areas of shallow groundwater;
- incorporate drainage management that avoids direct run-off to streams or surface water;
- have yards or pens sheeted with compacted earth, sand or sawdust if located on clay soils;
- be located 100 m from streams, wetlands and lakes for intensive stocking;
- have vegetation belts adequately fenced and maintained between drains, lakes, wetlands and watercourses and the area of intensive stocking.

Yards should be constructed so that:

- stormwater cannot come into contact with the yard;
- yards can be regularly cleaned.

Manure should be:

- regularly collected and not allowed to accumulate in yards;
- stored in a dry area protected from run-off, or stored in an area where all leachate is retained by sediment settlement dams or bunds;
- removed off site;
- regularly broken up and spread over pasture, but not near watercourses, if manure is retained on site;
- for more information about fly breeding problems associated with animal manure refer to an information leaflet called ‘Fly Breeding Associated with horticulture and livestock’ by David Cook and Ian Dadour. This is available at Agriculture Western Australia or Health Western Australia.

Table A2. Stock management checklist

This checklist may be helpful to all landholders, is important for those applying to the relevant authorities to stock their land above the base stocking rate.

Lot number, road and location: _____

Lot size: _____

Stocking rate unit: _____

Type and number of stock _____

Checklist

I have:	Not applicable/acceptable	Required
Property management plan		
Fenced buffers, vegetation corridors and rehabilitation		
Protection of waterways		
Water erosion protection measures		
Wind erosion protection measures		
Dust management program		
Management of waterlogged soil		
Pasture management plan (e.g. hay, rotation, slashing)		
Separate stock water supply (scheme, dam, bore, tank)		
Irrigated summer pasture		
Suitable fences for the stock		
Yards or other restraining device for large stock animals		
Fencing of remnant bushland		
Protected trees from grazing		
Managed declared weeds		
Managed environmental weeds		
Soil tests to determine the correct nutrient applications		
Fertiliser/nutrient management plan		
Collection and management of manure/dung		
Management of flies and other nuisance insects		
Management of odour		
Reduced noise impact on adjoining properties		
Satisfactory branding of stock		
Healthy stock		

APPENDIX 3 Additional notes for planners and developers

- The ability of land to accept stock depends on many factors including soil permeability, depth to the watertable, ability of the soil to hold phosphate, potential for erosion and waterlogging, as well as how the soils are managed and the need to maintain adequate vegetation cover.

- Generally pastures can be improved by the introduction of perennial grasses and legumes such as clover.

- Even though nutrient loss is a major concern on the Coastal Plain, pasture improvement requires fertiliser applications. Bare soil is a much higher risk for nutrient loss.

- The nutrient loading on a property is directly related to the amount and type of food brought onto that property, the amount of fertiliser used and small inputs of nitrogen from legume species if present.

- The more fertiliser and feed brought onto a property the greater the risk of nutrient loss.

- Land owners can increase the number of stock owned by agisting stock on part of an adjoining property. This is one simple mechanism that will allow a small rural landholder to own two horses.

- Stocking rate should be determined at the time of subdivision design, taking into account soils and all other environmental and social factors. Areas for grazing should be depicted on development guide plans. The stocking rate could be recorded for each lot as a DSE value to allow purchasers to select the block that allows them to keep their planned stock.

- The low stocking rate of dry leached sands (e.g. Stocking rates units SR2 and SR3) may preclude horses from a 2 hectare lot even with irrigation, unless the animals are stabled and maintained on introduced feed. This exceeds the base stocking rate and will normally require approval from the local government.

- Some planning schemes have minimum lot sizes on which stock can be kept or specify the maximum amount of stock which can be kept.

Suggested planning scheme provisions for stock on rural small holdings

1. Stock may be permitted at the base stocking rate determined by Agriculture Western Australia guidelines.

2. Stock numbers at rates higher than Agriculture Western Australia guidelines may be achieved by agisting stock on adjoining land.

3. Increase in stock as a result of irrigation shall not exceed the allocation of stock based on the proportion of irrigated and non-irrigated land.

4. Stock may only be kept if a water supply other than a domestic supply is available. This could be a dam, access to a waterway, a bore or a second rainwater collection or scheme water.

5. Approval from the Shire should be required prior to keeping stock in excess of the base rate.

6. Areas of remnant vegetation shall be fenced to exclude stock.

7. Stock may only be kept if acceptable fences are in place,:

Sheep and small stock	5-7 strand ringlock
Cattle	7 strand with barbed wire and/or electric fence
Horses	7 strand height with 'sighter' strands or electric
Other stock	As appropriate

8. Wetlands and drainage lines must be fenced, with appropriate setbacks, to restrict stock access.

9. Large stock such as horses or cattle may only be kept if a handling facility such as a yard, stable or restraining device is available.

10. The local government must be notified if stock at rates higher than 2 DSE/ha are kept. This notification may involve commitments and conditions made at the time of notification.

11. Improved pasture must be managed in such a way to minimise nutrient loss at rates no greater than those specified in guidelines prepared by the Water and Rivers Commission or other relevant government agency.

12. Where in the opinion of the local government the continued presence of animals on any portion of land is likely to contribute, or is contributing to unsatisfactory environmental impacts, notice may be served on the owner of the land requiring the removal of the animals for a specified period and the undertaking of remedial works.

    Different stock management systems are possible, depending on the level of pasture improvement, type of animal, feeding regimes and management practices.

APPENDIX 4 Agriculture Western Australia Sustainable Rural Development program policy Stock management on rural small holdings

Agriculture
WESTERN AUSTRALIA

SUSTAINABLE RURAL DEVELOPMENT PROGRAM

Policy Document

Policy No. **SRD/POL/LUP 2D**
Date:
Further information: **Ian Kininmonth (08) 9368 3408**

STOCK MANAGEMENT ON RURAL SMALL HOLDINGS

A policy to ensure that land holdings in rural residential, special rural, special residential and other non-agricultural zones are stocked at levels which are unlikely to result in land degradation and other adverse environmental impacts.

Background

Rural small holdings contained in rural residential, special rural, special residential and other non agricultural zones are often owned by people who want to pursue a rural lifestyle but are inexperienced in land management issues. This can result in overstocking of properties causing land degradation and conflicts with neighbours.

Local and State Government agencies may then be required to resolve the problems at the community's expense.

Rural residential, special rural, special residential and other non agricultural/rural zones are considered to be alternative forms of residential use. As such, local government is considered to be responsible for ensuring and enforcing the responsible management of land resources in these areas.

Most local planning schemes contain provisions on:

- controlling the type, number, location and management of stock in rural residential and other non agricultural/rural zones;
- enabling the local government to order the removal of stock and the undertaking of remedial works where unsatisfactory environmental impacts are occurring or are likely to occur.

In some cases the local planning scheme will state that stocking rates shall not exceed Agriculture Western Australia's standards. These are provided by Farm Note 52/89 *'Preventing Soil Erosion and Tree Damage on Small Holdings'* and the publication *'Stocking Rate Guidelines for Small Rural Holdings'* (in Prep) which updates these standards for the Swan Coastal Plain and Darling Scarp. While the guidelines can be used to advise land holders of appropriate stocking rates for existing lots, they can also be used by local or State

Government agencies when providing advice on new proposals or by private planners and developers when designing new estates.

Policy statement

Agriculture Western Australia will encourage the use of land use planning processes to ensure that land in rural residential areas is not stocked beyond its environmental carrying capacity.

Farm Note 52/89 *'Preventing Soil Erosion and Tree Damage on Small Holdings'* and the publication *'Stocking Rate Guidelines for Small Rural Holdings'* (in Prep) shall be Agriculture Western Australia's standards for stocking rates applying to rural residential and other non agricultural/rural zones.

When designing rural residential estates where it is intended that stock may be kept then developers will be encouraged to:

- identify stock which may be inappropriate for environmental, health or management reasons;
- configure lots to enable the keeping of stock where appropriate; and
- ensure that an adequate water supply is available;
- ensure that stock can be excluded from unsuitable areas e.g. remnant vegetation areas, steep slopes, areas susceptible to waterlogging, areas adjacent to stream lines, drains and water bodies.

Local governments shall be encouraged to include provisions in local planning schemes for:

- controlling the type, number and management of stock; and
- requiring the removal of stock and remedial works where the keeping of stock is, or is likely to contribute to unsatisfactory environmental impacts.

Local governments shall be encouraged to implement strategies which ensure landowners are aware of their obligations relating to the stocking of animals and the management of land resources.

Local governments shall be responsible for providing advice on stocking rates to landowners in rural residential and other non agricultural zones in accordance with the guidelines.

Where a landowner applies to stock land at a rate exceeding the recommended rate then it will be recommended that they prepare a Management Plan (refer to *'Stocking Rate Guidelines for Rural Small Holdings'*). This Management Plan should be assessed by the local government's environmental officer or other qualified person. A report should then be prepared for referral to the Council for a decision.

Where the stocking of land in a rural residential or other non agricultural/rural zones causes or is likely to cause unsatisfactory environmental impacts, then it will be the local government's responsibility to address this.

Agriculture Western Australia will provide specific advice on land management and remedial works to rural small holders on a fee for service basis.

Prepared by: Ian Kininmonth
Land Use Planning Officer

Endorsed by: David Hartley
Executive Director, Sustainable Rural Development Program

Date: 27 August 1999

Toolbox

Stocking Rate Guidelines for Rural Small Holdings. In Prep, Agriculture Western Australia.

This publication provides guidelines to help planners, developers, local authorities and land owners determine the base stocking rates for rural small holdings in rural residential areas, on the Swan Coastal Plain and Darling Scarp. The guidelines can also be used by landowners and land managers seeking to determine appropriate base stocking rates outside these areas.

Pasture Management for Small Landholders, (1998) Agriculture Western Australia

Preventing Tree Damage to Livestock, (1999) Agriculture Western Australia. Farmnote 60/99

Manure Management on Small Properties, (1998) Agriculture Western Australia. Farmnote 21/98

Water Supplies on Small Properties, (1998) Agriculture Western Australia, Farmnote 22/98

Land Management Guidelines List (Section 9 – Appendix 6)

Suggestion Box

Government of Western Australia
Department of Water and Environmental Regulation

Clearing Permit Decision Report

1. Application details and outcome

1.1. Permit application details

Permit application No.:	6686/3
Permit type:	Area Permit

1.2. Applicant details

Applicant's name:	Southernrae 1 Pty Ltd
Application received date:	13 May 2022

1.3. Property details

Property:	Lot 1790 on Plan 3315, Southern River
Local Government Authority:	City of Gosnells
Localities:	Southern River

1.4. Application

Clearing Area (ha)	No. Trees	Method of Clearing	Purpose category:
4.51		Mechanical	Grazing & pasture

1.5. Decision on application

Decision on Permit Application:	Granted
Decision Date:	30 November 2022

Reasons for Decision:

This clearing permit amendment application was submitted, accepted, assessed, and determined in accordance with sections 51E and 51O of the *Environmental Protection Act 1986* (EP Act). It has been concluded that the proposed clearing may be at variance to principles (a), (d), (f), (g) and (h), and is not likely to be at variance to any of the remaining clearing principles.

The Department of Water and Environmental Regulation (DWER) advertised the application for 21 days and no submissions were received.

In making this decision, the Delegated Officer had regard for the site characteristics (see Section 2), relevant datasets (see Appendix B.1), photographs and a land degradation assessment undertaken by the Department of Primary Industries and Regional Development (DPIRD) (see Appendix A), advice received from the Commissioner of Soil and Land Conservation (CSLC), the clearing principles set out in Schedule 5 of the EP Act, relevant planning instruments and any other matters considered relevant to the assessment. The Delegated Officer also took into consideration that the proposed amendment relates only to extending the permit duration by 10 years to 12 December 2032 to allow for ongoing stock grazing at the site.

A review of current environmental information identified that the environmental values present within the permit area remain largely unchanged since the previous assessments of the permit in 2017 and that the permit area contains:

- Suitable habitat for Priority flora species, including individuals of *Jacksonia gracillima* (P3) and *Verticordia lindleyi* subsp. *lindleyi* (P4),
- Suitable habitat for conservation significant fauna,
- Vegetation representative of the Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region (Banksia Woodlands), a state-listed priority ecological community (PEC) and Commonwealth listed threatened ecological community (TEC), and
- 0.04 hectares of vegetation growing in association with a watercourse or wetland.

The Delegated Officer also considered that the proposed amendment may facilitate the introduction and spread of weeds and dieback into adjacent vegetation, including into nearby Bush Forever sites, and that areas immediately surrounding the supplementary stock feeding and watering area may be at risk of land degradation in the form of wind erosion.

The Delegated Officer considered that the majority of the clearing under the proposed amendment will result in the sporadic loss of understorey species, herbs, and grasses through grazing and that mechanical clearing during the extended permit duration is likely to be limited to the maintenance of 0.34 hectares of existing cleared areas. Further, photographs and a land degradation assessment of the site on 12 July 2022 indicate that, with the exception of the area immediately surrounding the supplementary feeding and watering area, the grazing of stock has not significantly impacted the composition or

condition of the vegetation within the permit area over the five-year period since the previous permit was issued in 2017. Therefore, the Delegated Officer considered that the vegetation is capable of regenerating at the current stocking rate to maintain a Good to Excellent (Keighery, 1994) condition. Given nature of the proposed clearing and that no changes to stocking rate are proposed under the amendment, the Delegated Officer determined that the ongoing grazing of the permit area is unlikely to significantly reduce the extent of suitable habitat for flora and fauna, vegetation representative of the Banksia Woodlands ecological community, or riparian vegetation within the permit area or local area, or to significantly contribute to land degradation and the spread of weeds and dieback.

In considering the above, the Delegated Officer determined that the extent to which the impacts of the proposed clearing present a risk to biological, conservation, or land and water resource values remains unchanged from the previous assessments of the permit and can be found in the Decision Reports prepared for CPS 6686/1 and CPS 6686/2. Noting the above, the Delegated Officer considered that the proposed amendment is not likely to lead to an unacceptable risk to environmental values, subject to conditions to:

- avoid, minimise, and reduce the impacts and extent of clearing,
- take hygiene steps to minimise the risk of the introduction and spread of weeds and dieback, and
- ensure stocking rate adheres to the '*Stocking rate guidelines for rural small holdings, Swan Coastal Plain and Darling Scarp and surrounds, Western Australia'* (van Gool et al., 2000).

In addition to extending the permit duration, the Delegated Officer determined that minor amendments to existing permit conditions and the inclusion of recording and reporting conditions were also required to bring the permit in line with current departmental policies and procedures.

2. Site Characteristics

Clearing Description:

The proposed amendment to CPS 6686/2 is for the purpose of extending the permit duration by 10 years to 12 December 2032, to allow for ongoing stock grazing at the site. The vegetation proposed to be cleared under CPS 6686/3 is contained within a single contiguous area (see Figures 1 and 2).

CPS 6686/2 allowed for the clearing of 4.51 hectares of native vegetation within Lot 1790 on Plan 3315, Southern River, for the purpose of livestock management and the establishment of a stock loading/unloading area. The permit holder is authorised to undertake mechanical clearing for stock feeding, fencing, loading and unloading areas within an area of 0.34 hectares on the north eastern boundary of the permit area. Within the remaining 4.17 hectares of the permit area, the permit holder is authorised to clear via stock grazing only.

CPS 6686/2 does not require the permit holder to maintain records of clearing undertaken under the permit. Supporting documentation provided by the permit holder indicates that mechanical clearing on the north eastern boundary of the permit area for the stock feeding, fencing, loading and unloading areas was undertaken in April 2019 and that stock grazing of 15 goats is ongoing (Southernrae 1 Pty Ltd, 2022).

Vegetation Description

The permit area is mapped as Heddle vegetation Southern River complex which comprises open woodland of *Corymbia calophylla* (marri) - *Eucalyptus marginata* (jarrah) - *Banksia* species with fringing woodland of *Eucalyptus rudis* (flooded gum) - *Melaleuca rhaphiophylla* (swamp paperbark) along creek beds (Heddle et al., 1980).

A level 2 flora and vegetation survey of the permit area undertaken by RPS (2012a) identified that the permit area comprises three vegetation types:

- V1: Low open woodland of *Banksia menziesii* and *Banksia attenuata* over open heath to shrubland of *Adenanthos cygnorum* subsp. *cygnorum*, *Xanthorrhoea preissii* and *Eremaea pauciflora* over open low heath of *Scholtzia involucrata*, *Leucopogon conostephioides*, *Melaleuca trichophylla* and *Calytrix flavescens* over open to very open herbland of *Phlebocarya ciliata*, *Patersonia occidentalis*, *Blancoa canescens*, *Dasypogon bromeliifolius* and *Lomandra* spp. over open to very open sedgeland of *Lyginia barbata*, *Schoenus curvifolius* and *Hypolaena exsulca*. V1 is the most dominant vegetation type within the application area,
- V4: Low woodland to low open woodland of *Banksia menziesii* and *B. attenuata* over tall open scrub to tall shrubland of *Jacksonia sternbergiana* and *Adenanthos cygnorum* subsp. *cygnorum* over shrubland of *Xanthorrhoea preissii* and *Stirlingia latifolia* over low shrubland of *Leucopogon conostephioides*, *Hibbertia hypericoides* over open to very open sedgeland of *Lyginia imberbis*, *Hypolaena exsulca*, *Mesomelaena pseudostygia* and *Lyginia barbata*, and
- V5: Open shrubland of *Xanthorrhoea preissii* and *Melaleuca thymoides* over low open shrubland of *Jacksonia gracillima* (Priority 3), *Bossiaea eriocarpa* and

Calytrix flavescens over herbland of *Phlebocarya ciliata*, *Patersonia occidentalis* and *Dasypogon bromeliifolius* over open to very open sedgeland of *Hypolaena exsulca*, *Desmocladus fasciculatus*, *Lyginia imberbis* and *Lyginia barbata* (RPS, 2012a).

Photographs taken by the DPIRD during a site inspection on 12 July 2022 indicate that the vegetation mapping from the 2012 flora and vegetation survey is unchanged and accurately represents the vegetation types within the permit area at present (CSLC, 2022). The vegetation description is considered unchanged from the previous assessments of the permit.

Vegetation Condition

Photographs and a land degradation assessment undertaken by DPIRD on 12 July 2022 indicate that the condition of the vegetation within the permit area ranges from Excellent to Completely Degraded (Keighery, 1994) condition (CSLC, 2022), described as:

- Excellent, described as vegetation structure intact, with disturbance affecting individual species; weeds are non-aggressive species,
- Very Good, described as vegetation structure altered, with obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and/or grazing,
- Good, described as vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and/or grazing,
- Degraded, described as basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and/or grazing, and
- Completely degraded, described as the structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs (Keighery, 1994).

The vegetation condition within the permit area is largely unchanged from the findings of the level 2 flora and vegetation survey undertaken by RPS (2012a) and from the previous assessments of the permit. The photographs taken by DPIRD indicate that the vegetation immediately surrounding the stock feeding and watering area has decreased slightly since the previous assessment of the permit from a Good to Degraded (Keighery, 1994) condition to a Degraded to Completely Degraded (Keighery, 1994) condition (CSLC, 2022). However, the broader permit area remains predominantly in Good to Excellent (Keighery, 1994) condition (CSLC, 2022).

Soil Type

The soil type within the permit area is mapped as the following subsystems:

- Bassendean B2 Phase (212Bs__B2), described as flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m and comprising approximately 70 per cent of the permit area,
- Pinjarra P1b Phase (213Pj__P1b), described as flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplexs) soils. Moderately deep pale sand to loamy sand over clay: imperfectly drained and moderately susceptible to salinity in limited areas and comprising approximately 25 per cent of the permit area,
- Pinjarra, B1 Phase (213Pj__B1), described as extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant and comprising approximately 5 per cent of the permit area (DPIRD, 2022).

Local Area

The local area referred to in the assessment of this application is defined as a 10-kilometre (km) radius measured from the perimeter of the application area.

Figure 1. The area crosshatched yellow indicates the area authorised to be cleared only via the method of grazing under the granted clearing permit.

Figure 2. The area crosshatched yellow indicates the area authorised to be cleared via any method under the granted clearing permit.

3. Avoidance and mitigation measures

While it is acknowledged that the majority of the clearing proposed under the amendment will be through the grazing of stock, the Delegated Officer considers it important for the permit holder to continue to consider, where practical, whether it is still necessary to undertake clearing within the entirety of the area approved under the clearing permit. The Delegated Officer determined that the inclusion of an additional permit condition, requiring the permit holder to have regard to the mitigation hierarchy, would ensure that the amount of native vegetation to be cleared under the amended permit is limited to only the extent necessary and is minimised where possible.

The remaining avoidance and mitigation measures employed by the permit holder are unchanged and can be found in the Decision Reports prepared for Clearing Permits CPS 6686/1 and CPS 6686/2.

4. Assessment of impacts on environmental values

A review of current environmental information indicates that the environmental values present within the existing permit area remain largely unchanged from the previous assessments of the permit and can be found in the Decision Reports prepared for CPS 6686/1 and CPS 6686/2.

Conservation significant flora

In regard to conservation significant flora, a desktop assessment of current databases identified that a total of 90 threatened or priority flora species have been recorded within the local area, comprising 12 Priority 1 (P1) flora, 10 Priority 2 (P2) flora, 30 Priority 3 (P3) flora, 17 Priority 4 (P4) flora, and 22 threatened flora (Western Australian Herbarium, 1998-). Of the 90 conservation significant flora species recorded with in the local area, 65 species were considered during the previous assessments of the permit. According to available databases, there have been no new records of these species within the local area since the previous assessment of the permit was undertaken in 2017.

Of these 65 species, 38 were also specifically considered during a level 2 flora and vegetation survey undertaken in 2012 (RPS, 2012a). A review of the methodology of the 2012 flora survey indicates that the survey timing and methods included sampling within quadrats and relevès, as well as targeted searches for orchids and conservation significant flora between September and November 2012 (RPS, 2012a). The 2012 flora survey was consistent with the most current Environmental Protection Authority (EPA) technical guidance for flora and vegetation surveys at the time and would have been adequate to identify the flora species of concern, if present (RPS, 2012a). The 2012 flora and vegetation surveys did not identify any threatened flora listed under the *Biodiversity Conservation Act 2016* (BC Act) or the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) occurring within the permit area. It is acknowledged that two additional targeted flora surveys were undertaken in 2013 and 2014 to confirm the absence of threatened flora (PGV Environmental, 2013; PGV Environmental, 2014). These surveys also did not identify any threatened flora listed under the BC Act or EPBC Act within the permit area. However, three priority flora species were identified within the broader property during the 2012 flora survey, being *Acacia lasiocarpa* var. *bracteolata* long peduncle variant (P1), *Jacksonia gracillima* (P3), and *Verticordia lindleyi* subsp. *lindleyi* (P4).

During the assessment of the CPS 6686/1, the permit holder amended the application area to remove the identified individuals of *Acacia lasiocarpa* var. *bracteolata* long peduncle variant in the south-eastern portion of the property. As this amendment relates only to extending the duration of Clearing Permit CPS 6686/2 and no changes to the permit area are proposed, the proposed clearing is unlikely to impact on this species and the assessment of impacts to *Acacia lasiocarpa* var. *bracteolata* long peduncle variant is considered unchanged from the previous assessments of the permit.

The 2012 flora and vegetation survey identified 258 individuals of *Jacksonia gracillima* and 24 individuals of *Verticordia lindleyi* subsp. *lindleyi* within the broader property. All 24 recorded individuals of *Verticordia lindleyi* subsp. *lindleyi* occur within the permit area, while individuals of *Jacksonia gracillima* occur both within the permit area and in the south-eastern portion of the property that is not subject to clearing. It is acknowledged that, as the previous survey was undertaken in 2012, the extent of individuals within the permit area may have changed. However, the conservation statuses of *Jacksonia gracillima* and *Verticordia lindleyi* subsp. *lindleyi* are unchanged since the previous assessments of the permit and both species are well-represented in the local area and the greater Perth Metropolitan Region, including a number of records within local conservation estate and Bush Forever sites (RPS, 2012b; Western Australian Herbarium, 1998-). Therefore, while the proposed clearing may result in the loss of individuals of *Jacksonia gracillima* and *Verticordia lindleyi* subsp. *lindleyi*, it is not expected that the proposed clearing represents a significant risk to the continuation of these species. This is unchanged from the previous assessments of the permit.

Of the 25 conservation significant flora species that were not considered during the previous assessments of the permit in 2017, the permit area is considered to contain suitable habitat for 17 species, based on the habitat preferences of these species and available soil and vegetation mapping. However, based on the conservation statuses of these species and their distribution and extent, it is unlikely that the permit area represents significant habitat for these species or would be vital for their continued persistence, if present. Further, although these species were not specifically considered during the 2012 flora and vegetation survey or discussed during the previous assessments of the permit, all are known from records in the local area dated prior to 2017 and the survey timing and effort would have been appropriate for the identification of these species in 2012, 2013 and 2014, if present.

In addition, while it is acknowledged that the permit area is likely to contain suitable habitat for conservation significant flora and individuals of *Jacksonia gracillima* and *Verticordia lindleyi* subsp. *lindleyi*, it is noted that the primary method of clearing is through the grazing of stock. The grazing of stock is unlikely to result in the broadscale clearing of the permit area and impacts to conservation significant flora species and their habitat is likely to be limited to occasional direct impacts from grazing or trampling, particularly noting that the permit holder is also undertaking supplementary feeding of the stock and they are not solely reliant on the vegetation within the permit area as a food source. Further, photographs of the permit area taken by DPIRD during a site inspection on 12 July 2022 indicate that, while the area immediately surrounding the stock feeding and watering area has decreased slightly in vegetation condition, the majority of the permit area remains in Good to Excellent (Keighery, 1994) condition (CSLC, 2022). This implies that the vegetation within the permit area is capable of regenerating at the current stocking rate and

that the grazing of stock has not had a significant impact on vegetation composition or condition over a five-year period since the previous permit was issued in 2017. Given this and that the stocking rate of the site is limited by the '*Stocking rate guidelines for rural small holdings, Swan Coastal Plain and Darling Scarp and surrounds, Western Australia'* (Stocking Rate Guidelines) (van Gool et al., 2000) and is not expected to increase over the extended permit duration, it is not considered likely that the ongoing grazing of stock will result in the loss of the populations of *Jacksonia gracillima* and *Verticordia lindleyi* subsp. *lindleyi* present at the site or to result in the permanent loss of suitable or significant habitat for flora species.

It is also noted that mechanical clearing authorised under the permit is limited to 0.34 hectares on the north-eastern boundary of the permit area, where no conservation significant flora were recorded during the 2012, 2013 or 2014 flora surveys. From a review of aerial imagery, mechanical clearing for stock feeding, fencing, loading, and unloading areas has already been undertaken under the permit and any future mechanical clearing within the permit area under the proposed amendment is likely to be limited to maintaining these cleared areas, which is unlikely to result in the loss of conservation significant flora or their habitats.

Given the above, the Delegated Officer determined that the assessment of impacts to conservation significant flora species remains unchanged and that the proposed amendment is unlikely to result in significant impacts to conservation significant flora or to result in long-term impacts to habitat that is critical for the continuation for any threatened or priority flora species.

Conservation significant fauna

Regarding fauna, a desktop assessment of current databases identified that a total of 57 conservation significant fauna species have been recorded within the local area, including 16 threatened fauna species, 17 priority fauna species, 21 fauna species protected under international agreement, and two other specially protected fauna species (DBCA, 2007-). Of these species, 29 were considered during the previous assessments of the permit and 26 were specifically considered during a fauna assessment undertaken in 2012 (RPS, 2012a). However, according to available databases, all 57 conservation significant species are known from records in the local area dated prior to 2017 and new records of nine species have been recorded in the local area since the previous assessment of the permit in 2017.

The previous assessment identified that 10 conservation significant fauna species had the potential to occur within the permit area based on habitat preferences:

- Baudin's cockatoo (*Zanda baudinii* (previously *Calyptorhynchus baudinii*)) (listed as Endangered under the BC Act and EPBC Act) nests in hollows of mature live or dead trees, including those of marri (*Croymbia calophylla*), jarrah (*Eucalyptus marginata*), and other *Eucalyptus* spp., and primarily feeds on the seeds of marri, but may also forage on the seeds of jarrah and Proteaceous species (*Banksia* spp., *Hakea* spp., and *Grevillea* spp.) (DEC, 2008). The 2012 fauna assessment did not identify any marri or jarrah trees within the permit area, nor any trees of suitable size diameter at breast height (DBH) to develop a nest hollow (RPS, 2012a). While the permit area is not likely to provide breeding or roosting habitat for Baudin's cockatoo, *Banksia menziesii* and *Banksia attenuata* within the V1 and V4 vegetation types are likely to provide secondary foraging habitat for this species.
- Carnaby's cockatoo (*Zanda latirostris* (previously *Calyptorhynchus latirostris*)) (listed as Endangered under the BC Act and EPBC Act) also nests in hollows of mature live or dead trees, including marri, jarrah, and other *Eucalyptus* spp. and forage on the seeds, nuts, and flowers of a variety of plants, including Proteaceous species, as well as *Allocasuarina* and *Eucalyptus* species, marri, and a range of introduced species (Valentine and Stock, 2008). As above, the permit area is not likely to provide suitable breeding or roosting habitat, but *Banksia menziesii* and *Banksia attenuata* within the V1 and V4 vegetation types are likely to provide primary foraging habitat for Carnaby's cockatoo within the permit area.
- Forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*) (listed as Vulnerable under the BC Act and EPBC Act) also nests in hollows of mature live or dead marri, jarrah, and other eucalypt trees and feed predominantly on the seeds of marri and jarrah, which comprise approximately 90 per cent of their diet (DEC, 2008). The permit area is not likely to provide suitable breeding or roosting habitat, but *Banksia menziesii* and *Banksia attenuata* within the permit area are likely to provide secondary foraging habitat for the forest red-tailed black cockatoo.
- Peregrine falcon (*Falco peregrinus*) (listed as other specially protected fauna by DBCA) is associated with a range of habitat types including timbered watercourses, riverine environments, wetlands, plains, open woodlands, and pylons and spires of buildings, but nests on rocky ledges in tall, vertical cliff faces and gorges or in tall riparian trees (Australian Museum, 2021). While the permit area is likely to provide suitable hunting habitat for the peregrine falcon, this species is highly mobile with a large home range and does not rely on specialist niche habitats, so is unlikely to be reliant on the habitat within the permit area.
- Southern death adder (*Acanthophis antarcticus*) (listed as Priority 3 by DBCA) inhabit a wide variety of habitats in association with deep leaf litter, including rainforests, wet sclerophyll forests, woodland, grasslands, chenopod dominated shrublands, and coastal heathlands (Australian Museum, 2020). The permit area is likely to provide suitable habitat for this species.
- Quenda (*Isoodon fusciventer*) (listed as Priority 4 by DBCA) are ground-dwelling marsupials, typically associated with forest or woodlands near watercourses, where understorey consists of dense scrub and leaf litter is abundant (DEC, 2012b). The permit area is likely to provide suitable habitat for this species.
- Carpet python (*Morelia spilota* subsp. *imbricata*) was listed as other specially protected fauna under the Western Australian *Wildlife Conservation Act 1950* during the previous assessments of the permit in 2017 but is no longer listed as a conservation significant fauna species. The species is associated with Banksia woodland, eucalypt woodlands and grasslands in southern Western Australia and eastern South Australia (DEC, 2012a), which is consistent with the permit area.
- Wood sandpiper (*Tringa glareola*) (listed as Migratory and protected under International Agreement under the EPBC Act) is associated with well-vegetated, shallow freshwater wetlands of emergent aquatic plants or grass with taller fringing vegetation (DCCEEW, 2022c). Although the previous assessment identified that the permit area may provide suitable habitat for the wood sandpiper, it is acknowledged that the portion of the permit area that represents wetland habitat associated with the wood sandpiper is limited to 0.04 hectares. Further, the wood sandpiper is a highly mobile species with a large home range and is unlikely to be reliant on the habitat within the permit area.
- Rainbow bee-eater (*Merops ornatus*) (listed as Marine and protected under International Agreement under the EPBC Act) inhabits a range of habitats including open woodlands, forests, heathland, and semi-cleared areas (DCCEEW,

2022b). While the permit area may provide suitable habitat for the rainbow bee-eater, the species is highly mobile with a large home range and is unlikely to be reliant on the habitat within the permit area.
- Black winged stilt (*Himantopus himantopus*) (listed as Marine and protected under International Agreement under the EPBC Act) is associated with wetland habitats, which is restricted to 0.04 hectares within the permit area. The black winged stilt also has a large home range and is highly mobile, so is unlikely to be reliant on the habitat within the permit area.

Of the 28 conservation significant fauna species that were not considered during the previous assessments of the permit in 2017, an assessment of habitat suitability identified that five species have the potential to occur within the permit area:
- Coastal Plains skink (*Ctenotus ora*) (listed as Priority 3 by DBCA) is a poorly recorded short-range endemic (SRE) species associated with sand dunes in remnant vegetation on the Swan Coastal Plain (ALA, 2022a). The sandy Bassendean and Pinjarra soils within the permit area are likely to provide suitable habitat for this species.
- Swan Coastal Plain shield-backed trapdoor spider (*Idiosoma sigillatum*) (listed as Priority 3 by DBCA) is associated with banksia-dominated woodland and heathland in sandy soils on the Swan Coastal Plain and is largely restricted to bushland remnants in the Greater Perth region (Rix et al., 2018). The V1 and V4 vegetation types within the permit area are likely to provide suitable habitat for this species.
- Perth slider (*Lerista lineata*) (listed as Priority 3 by DBCA) is a poorly recorded SRE known from pale sands in banksia or eucalypt-dominated heathlands and shrublands along the Swan Coastal Plain (TSSC, 2020). The V1 and V4 vegetation types and sandy Bassendean and Pinjarra soils within the permit area are likely to provide suitable habitat for this species.
- Black-striped burrowing snake (*Neelaps calonotos*) (listed as Priority 3 by DBCA) is associated with deep sandy soils in banksia and jarrah woodland on the Swan Coastal Plain (ALA, 2022b). The V1 and V4 vegetation types and sandy Bassendean and Pinjarra soils within the permit area are likely to provide suitable habitat for this species.
- Stylet bush cricket (*Throscodectes xiphos*) (listed as Priority 1 by DBCA) is a poorly recorded SRE known only from two locations in Jandakot within areas of banksia-dominated woodland (Jandakot Airport Holdings Pty Ltd, 2016). The V1 and V4 vegetation types within the permit area are likely to provide suitable habitat for this species.

As identified in the previous assessments, the permit area also occurs within a mapped Perth Regional Ecological Linkage (Del Marco et al., 2004) and is likely to contribute to ecological linkage values in the local area.

As outlined in the assessment of impacts to conservation significant flora, it is acknowledged that the primary method of clearing is through the grazing of stock and that mechanical clearing under the amendment is likely to be limited to the maintenance of existing cleared areas. While the permit area is likely to provide suitable habitat for the aforementioned conservation significant fauna species, impacts to fauna habitat resulting from grazing of stock is likely to be confined to occasional direct impacts to understorey species, herbs, and grasses from grazing or trampling. Given the nature of the proposed clearing, it is unlikely that the continued grazing of the permit area will result in the loss of significant foraging habitat for Baudin's cockatoo, Carnaby's cockatoo, or the forest red-tailed black cockatoo, as the primary foraging species present (*Banksia menziesii* and *Banksia attenuata*) are canopy species that are unlikely to be cleared through grazing alone. Regarding ground-dwelling fauna, the continued grazing of the permit area is unlikely to result in the broadscale clearing of understorey species, herbs, or grasses within the permit area, noting that supplementary stock feeding is also being undertaken. Therefore, it is expected that habitat for the southern death adder, quenda, carpet python, Coastal Plains skink, Swan Coastal Plain shield-backed trapdoor spider, Perth slider, black-striped burrowing snake, and stylet bush cricket will remain within the permit area if grazing is continued, and that any individuals present would have ample opportunity to move into adjacent suitable habitat within the permit area that is free from actively grazing stock.

Further, photographs of the permit area taken by DPIRD during a site inspection on 12 July 2022 indicate that the majority of the permit area remains in Good to Excellent (Keighery, 1994) condition (CSLC, 2022), implying that the grazing of stock has not had a significant impact on the availability or quality of fauna habitat over a five-year period since the previous permit was issued in 2017. It is also acknowledged that the stocking rate of the site is limited by the Stocking Rate Guidelines and is not expected to increase over the extended permit duration. Therefore, it is not expected that the continued grazing of the permit area will limit the capacity for fauna to utilise the permit area for foraging and breeding or as an ecological linkage for the extended duration of the permit.

Given the above, the Delegated Officer determined that the assessment of impacts to fauna species remains unchanged from the previous assessments of the permit and that the proposed amendment is unlikely to result in the loss of significant fauna habitat.

Threatened and priority ecological communities

The previous assessments of the permit identified that the V1 and V4 vegetation types, which make up the majority of the permit area, are likely to be representative of the Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region (Banksia Woodlands) ecological community, which is listed as a PEC by DBCA in Western Australia and is federally listed as a TEC under the EPBC Act. Photographs taken by DPIRD during a site inspection on 12 July 2022 indicate that the vegetation composition and condition of the permit area is largely unchanged from the previous assessments of the permit, and it is considered that the vegetation within the permit area remains representative of the Banksia Woodlands TEC and PEC. Given mechanical clearing under the amendment is likely to be limited to maintaining existing cleared areas, it is unlikely that any broadscale clearing of vegetation representative of the Banksia Woodlands TEC and PEC will result from the proposed amendment and clearing is likely to be limited to the sporadic loss of understorey species, herbs, and grasses through grazing.

As discussed in the assessments above, the current photographs of the permit area imply that the grazing of stock has not significantly impacted the condition of the patch of Banksia Woodlands TEC and PEC within the permit area over the five-year period since the previous permit was issued in 2017 and indicates that the Banksia woodland is capable of regenerating at the current stocking rate to maintain a Good to Excellent (Keighery, 1994) condition. Noting that the stocking rate of the site is not expected to increase over the extended permit duration and that supplementary stock feeding is also being undertaken at the site, it is not considered likely that grazing pressure on the patch of Banksia Woodlands TEC and PEC within the permit area will

increase under the proposed amendment. Therefore, ongoing grazing of the permit area is not expected to significantly impact the condition or composition of the patch of Banksia Woodlands TEC and PEC or to reduce the capacity of the patch to regenerate and maintain its current condition.

Given the above, the Delegated Officer determined that the assessment of impacts to TECs and PECs remains unchanged from the previous assessments of the permit and that the proposed clearing is unlikely to result in the loss of a patch of the Banksia Woodlands TEC and PEC or to significantly impact on the local extent any state or federally listed TEC or PEC.

Conservation areas and significant remnant vegetation

The national objectives and targets for biodiversity conservation in Australia has a target to prevent clearance of ecological communities with an extent below 30 per cent of that present pre-1750, below which species loss appears to accelerate exponentially at an ecosystem level (Commonwealth of Australia, 2001). However, the EPA recognises the Perth Metropolitan Region to be a constrained area, within which a minimum 10 per cent representation threshold for ecological communities is recommended (EPA, 2008). The current vegetation extent for the Swan Coastal Plain IBRA Bioregion, the Southern River Complex, and the local area all remain above the 10 per cent threshold for constrained areas (see Table 1 below). Further, as the primary method of clearing is grazing, clearing is likely to be limited to the sporadic loss of understorey species, herbs, and grasses, and it is unlikely that the proposed amendment will result in the loss of an entire remnant of native vegetation. Therefore, the Delegated Officer determined that the proposed amendment is unlikely to significantly impact remnant vegetation extent in an extensively cleared area and that impacts to significant remnant vegetation remain unchanged from the previous assessments of the permit.

Table 1: Vegetation representation statistics (Government of Western Australia, 2019).

	Pre-European extent (ha)	Current extent (ha)	Extent remaining (%)	Current extent in all DBCA managed land (ha)	Current proportion (%) of pre-European extent in all DBCA managed land
IBRA Bioregion*					
Swan Coastal Plain	1,501,221.93	579,813.47	38.62	222,916.97	14.85
Heddle vegetation complex **					
Southern River Complex	58,781.48	10,832.18	18.43	940.36	1.6
Local Area **					
10-kilometre radius	32,037.59	7,918.36	24.72	-	-

*Government of Western Australia (2019a)
**Government of Western Australia (2019b)

As identified in the previous assessments of the permit, the northern boundary of the permit area is adjacent to Bush Forever site 340 and an additional four Bush Forever sites (464, 465, 255, and 413) occur within two kilometres of the permit area. However, as the Bush Forever sites are separated from the permit area by existing fire breaks and access tracks and the permit area is fenced to retain stock, the risk of spread of weeds and dieback into nearby conservation areas is minimal. Further, any mechanical clearing undertaken under the amendment is likely to be limited to maintaining existing cleared areas. Accordingly, the Delegated Officer considers that the assessment of impacts to conservation areas is unchanged from the previous assessments of the permit and that the existing condition for weed and dieback management is sufficient to mitigate any indirect impacts to the environmental values of the nearby Bush Forever sites.

Land and water resources

In regard to water resources, current databases do not indicate any changes in hydrological mapping since the previous assessments of the permit in 2017. The permit area is mapped within the Geomorphic Wetlands Swan Coastal Plain dataset as part of an extensive multiple use category dampland (seasonally waterlogged basin) located in the Bennett Brook consanguineous suite (natural wetland group). However, during the previous assessments of the permit, the permit holder commissioned a wetland boundary assessment and amended the permit area to ensure the maintenance of a 50-metre vegetative buffer to the determined dampland boundary which has been fenced to exclude stock. The impacts to riparian vegetation under the current permit are limited to approximately 0.04 hectares in the south-western portion of the permit area that is dominated by a common wetland species (*Melaleuca thymoides*). As the proposed amendment relates only to extending the permit duration to allow continued grazing of the permit area and no changes to the boundary of the area approved for clearing is proposed, the assessment of impacts to water resources is considered unchanged from the previous assessments of the permit and the proposed clearing is not considered likely to impact vegetation is growing in, or in association with, an environment associated with a watercourse or wetland, surface or underground water quality, or the incidence or intensity of flooding.

According to available databases, no changes in soil mapping have occurred since the previous assessments of the permit in 2017. A land degradation assessment of the permit area identified that there is a low risk of land degradation at the site resulting from salinity, eutrophication and phosphorus export, wind erosion, water erosion, waterlogging, subsurface acidification, and flooding (CSLC, 2022). Advice received from the CSLC indicates that, although the risk of appreciable land degradation occurring as a result of the continued grazing of the site is low, the area immediately surrounding the feeding and watering point has become degraded and there is a risk that this degraded area will increase if the intensity of grazing increases, which could expose the soil to wind erosion (CSLC, 2022). The CSLC advised that as a result, the proposed clearing may be at variance to clearing principle (g) (CSLC, 2022). The CSLC advised that an option to reduce the risk of degradation at the feeding and watering point would be to undertake rotational grazing by periodically moving the feeding and watering areas and fencing off the degraded areas to promote regeneration (CSLC, 2022). However, the CSLC advised that the ongoing grazing of the site under the proposed

amendment was unlikely to increase the risk of land degradation, if the stocking rate of the site does not significantly increase (CSLC, 2022).

Under the conditions of the current clearing permit, the stocking rate of the site is limited by the Stocking Rate Guidelines and it is not expected that grazing intensity within the permit area will increase under the proposed amendment. The Delegated Officer considered that the area immediately surrounding the feeding and watering point was unlikely to regenerate given the current level of degradation and that fencing off this area and moving the feeding and watering point elsewhere would increase the risk of stock degrading adjacent vegetation in Good to Excellent (Keighery, 1994) condition. Given the permit holder is required to apply stocking rates in accordance with the Stocking Rate Guidelines and that stocking rate within the permit area is unlikely to increase, the Delegated Officer considered that the risk of land degradation resulting from the proposed amendment is low and that a requirement to undertake rotational stock grazing is not required in this instance. Given the above, the Delegated Officer considers that the assessment of land degradation risk is unchanged from the previous assessments of the permit and that the ongoing grazing of the site is unlikely to result in appreciable land degradation.

Conclusion

The proposed amendment to CPS 6686/2 is for the purpose of extending the permit duration by 10 years to 12 December 2032, to allow for ongoing stock grazing at the site. Mechanical clearing under the amendment is likely to be limited to the maintenance of existing cleared areas, while the majority of clearing will result in the sporadic loss of understorey species, herbs, and grasses through grazing. A review of current environmental databases indicates that the environmental values within the permit area remain largely unchanged since the previous assessments of the permit in 2017 and it is not considered likely that the ongoing grazing of the permit area will significantly alter the impacts of the clearing approved under CPS 6686/2. Based on photographs and a land degradation assessment of the site on 12 July 2022, the grazing of stock has not significantly impacted the composition or condition of the vegetation within the permit area over the five-year period since the previous permit was issued in 2017 and it is considered that the vegetation is capable of regenerating at the current stocking rate to maintain a Good to Excellent (Keighery, 1994) condition. Given the above and the nature of the proposed clearing, the Delegated Officer determined that the extent to which the impacts of the proposed clearing present a risk to biological, conservation, or land and water resource values remains unchanged from the previous assessments of the permit and can be found in the Decision Reports prepared for CPS 6686/1 and CPS 6686/2.

Planning instruments and other relevant matters.

The clearing permit amendment application was advertised on DWER's website on 7 June 2022, inviting submissions from the public within a 21 day period. No submissions were received in relation to this application.

The City of Gosnells advised that it had no concerns with the proposed amendment to CPS 6686/2 to extend the permit duration for an additional 10 years but provided the following comments:

- The extension to the permit duration should not allow for any further mechanical removal of vegetation without a specific purpose,
- If a fence is not currently installed, a fence should be required to prevent stock from accessing the southern part of the property that does not form part of the existing clearing permit, and
- Given the property is zoned 'Urban deferred' under the Metropolitan Region Scheme, the Department of Planning, Lands and Heritage (DPLH) may be able to comment as to whether the urban deferment may be lifted in the next 10 years while the amended permit is active (City of Gosnells, 2022).

It is acknowledged that the clearing permit only allows mechanical clearing within a specified area of 0.34 hectares on the north eastern boundary of the permit area that is used for stock feeding, fencing, loading and unloading. A review of aerial imagery indicates that mechanical clearing has been undertaken in these areas and any future mechanical clearing under the amendment is likely to be limited to maintaining these cleared areas. It is also understood that the permit area has already been fenced to limit stock access to within the permit area only. The permit area is currently zoned Urban Deferred under the Metropolitan Region Scheme and General Rural under the City of Gosnell's Town Planning Scheme. The Delegated Officer considered that the proposed amendment to extend the permit duration is consistent with the current zoning of the site and that any future changes to zoning would be considered by DWER in the assessment of future amendment proposals, if required. Given the above, the Delegated Officer considers that the comments made by the City of Gosnells have been adequately addressed.

The proposed clearing of 4.51 hectares of native vegetation by grazing and by mechanical clearing for the establishment of stock loading/unloading (and associated infrastructure) on Lot 1790 Passmore Street, Southern River, Western Australia, was referred to the then Department of Environment and Energy (DoEE) (now Department of Climate Change, Energy, the Environment and Water) on 27 March 2018 (reference EPBC 2018/8176). On 21 November 2018, DoEE determined that the proposed action is not a controlled action under section 75 the EPBC Act.

The remaining assessment against planning instruments and other matters is unchanged and can be found in the Decision Reports prepared for Clearing Permits CPS 6686/1 and CPS 6686/2.

Appendix A. Photographs of the vegetation / DWER site inspection report

Figure 3. Area immediately surrounding the supplementary feeding and watering point, looking south from the eastern side of the permit area (CSLC, 2022).

Figure 4. Area immediately surrounding the supplementary feeding and watering point, looking west from the northern side of the feeding and watering point (CSLC, 2022).

Figure 5. Vegetation 50 metres south of the supplementary feeding and watering point (CSLC, 2022).

Figure 6. Vegetation looking west from the southern side of the permit area (CSLC, 2022).

Figure 7. Vegetation looking north from the southern side of the permit area (CSLC, 2022).

Figure 8. Vegetation looking south from the western side of the permit area (CSLC, 2022).

Figure 9. Vegetation looking south from the northern side of the permit area (CSLC, 2022).

Figure 10. Vegetation looking east from the northern side of the permit area (CSLC, 2022).

Appendix B. Sources of information

B.1. GIS databases

Publicly available GIS Databases used (sourced from www.data.wa.gov.au):

- 10 Metre Contours (DPIRD-073)
- Aboriginal Heritage Places (DPLH-001)
- Bush Forever Areas 2000 (DPLH-019)
- Cadastre (LGATE-218)
- Cadastre Address (LGATE-002)
- CAWSA Part 2A Clearing Control Catchments (DWER-004)
- Consanguineous Wetlands Suites (DBCA-020)
- Contours (DPIRD-073)
- DBCA – Lands of Interest (DBCA-012)
- DBCA Legislated Lands and Waters (DBCA-011)
- DBCA Statewide Vegetation Statistics
- Directory of Important Wetlands in Australia – Western Australia (DBCA-045)
- Environmentally Sensitive Areas (DWER-046)
- Flood Risk (DPIRD-007)
- Geomorphic Wetlands, Swan Coastal Plain (DBCA-019)
- Groundwater Salinity Statewide (DWER-026)
- Hydrographic Catchments - Catchments (DWER-028)
- Hydrographic Catchments - Divisions (DWER-029)
- Hydrography, Linear (Hierarchy) (DWER-031)
- Hydrological Zones of Western Australia (DPIRD-069)
- IBRA Vegetation Statistics
- Imagery
- Local Planning Scheme – Zones and Reserves (DPLH-071)
- Native Title (ILUA) (LGATE-067)
- Offsets Register – Offsets (DWER-078)
- Pre-European Vegetation Statistics (DPIRD-006)
- Public Drinking Water Source Areas (DWER-033)
- Ramsar Sites (DBCA-010)
- Regional Parks (DBCA-026)
- Remnant Vegetation, All Areas
- RIWI Act, Groundwater Areas (DWER-034)
- RIWI Act, Surface Water Areas and Irrigation Districts (DWER-037)
- Soil Landscape Land Quality – Flood Risk (DPIRD-007)
- Soil Landscape Land Quality – Phosphorus Export Risk (DPIRD-010)
- Soil Landscape Land Quality – Subsurface Acidification Risk (DPIRD-011)
- Soil Landscape Land Quality – Water Erosion Risk (DPIRD-013)
- Soil Landscape Land Quality – Water Repellence Risk (DPIRD-014)
- Soil Landscape Land Quality – Waterlogging Risk (DPIRD-015)
- Soil Landscape Land Quality – Wind Erosion Risk (DPIRD-016)
- Soil Landscape Mapping – Best Available (DPIRD-027)
- Soil Landscape Mapping – Systems (DPIRD-064)
- Vegetation Complexes - Swan Coastal Plain (DBCA-046)

Restricted GIS Databases used:

- Conservation Covenants Western Australia (DPIRD-023)
- Contaminated Sites Database - Restricted (DWER-073)
- ICMS (Incident Complaints Management System) – Points and Polygons
- Threatened Flora (TPFL)
- Threatened Flora (WAHerb)
- Threatened Fauna
- Threatened Ecological Communities and Priority Ecological Communities
- Threatened Ecological Communities and Priority Ecological Communities (Buffers)

B.2. References

Atlas of Living Australia (ALA) (2022a) *Ctenotus ora (Kay & Keogh, 2012), Coastal Plains Skink*. Available from: https://bie.ala.org.au/species/https://biodiversity.org.au/afd/taxa/14c37a12-473e-480c-a9d5-2f20dadfcd0b (accessed October 2022).

Atlas of Living Australia (ALA) (2022b) *Neelaps calonotus (Duméril, Bibron & Duméril, 1854), Western Black-Striped Snake*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:47207ba8-4d27-4535-8263-1f4ff135be31 (accessed October 2022).

Australian Museum (2019) *Peregrine falcon (Falco peregrinus)*. The Australian Museum, New South Wales. Available from: https://australian.museum/learn/animals/birds/peregrine-falcon/ (accessed October 2022).

Australian Museum (2020) *Common Death Adder (Acanthophis antarcticus).* The Australian Museum, New South Wales. Available from: https://australian.museum/learn/animals/reptiles/common-death-adder/ (accessed October 2022).

Commissioner of Soil and Land Conservation (CSLC) (2022) *Land Degradation Advice and Assessment Report for clearing permit application CPS 6686/3,* received 4 August 2022, Department of Primary Industries and Regional Development, Western Australia (DWER Ref: DWERDT640544).

Commonwealth of Australia (2001) *National Objectives and Targets for Biodiversity Conservation 2001-2005*, Canberra.

Commonwealth of Australia (2022), *Referral guideline for 3 WA threatened black cockatoo species: Carnaby's Cockatoo, Baudin's Cockatoo and the Forest Red-tailed Black cockatoo*. Department of Agriculture, Water and the Environment, Canberra.

Department of Biodiversity, Conservation and Attractions (DBCA) (2007-) NatureMap: Mapping Western Australia's Biodiversity. Department of Parks and Wildlife. Available from: http://naturemap.dpaw.wa.gov.au/ (accessed September 2022).

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2022a) *Species Profile and Threats Database: Tringa glareola — Wood Sandpiper*. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=829.

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2022b) *Species Profile and Threats Database: Merops ornatus — Rainbow Bee-eater*. Available from: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=670.

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2022c) *Species Profile and Threats Database: Tringa glareola — Wood Sandpiper*. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=829.

Department of Environment and Conservation (DEC) (2008) *Forest black cockatoo (Baudin's cockatoo, Calyptorhynchus baudinii, and forest red-tailed black cockatoo, Calyptorhynchus banksii naso) Recovery Plan.* Department of Environment and Conservation, Canberra.

Department of Environment and Conservation (DEC) (2012a) *Fauna profiles: Carpet python, Morelia spilota (Lacépède, 1804)*. Department of Environment and Conservation, Western Australia.

Department of Environment and Conservation (DEC) (2012b) *Fauna profiles: Quenda, Isoodon obesulus fusciventer*. Department of Environment and Conservation, Western Australia.

Department of Primary Industries and Regional Development (DPIRD) (2022) *NRInfo Digital Mapping. Department of Primary Industries and Regional Development*. Government of Western Australia. Available from: https://maps.agric.wa.gov.au/nrm-info/ (accessed September 2022).

Environmental Protection Authority (EPA) (2008) *Environmental Guidance for Planning and Development Guidance Statement No 33*. Environmental Protection Authority, Western Australia.

Government of Western Australia (2019a) *2018 South West Vegetation Complex Statistics. Current as of March 2019*. WA Department of Biodiversity, Conservation and Attractions, Perth. Available from: https://catalogue.data.wa.gov.au/dataset/dbca.

Government of Western Australia. (2019b) *2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of March 2019.* WA Department of Biodiversity, Conservation and Attractions. Available from: https://catalogue.data.wa.gov.au/dataset/dbca-statewide-vegetation-statistics.

Heddle, E. M., Loneragan, O. W., and Havel, J. J. (1980) *Vegetation Complexes of the Darling System, Western Australia*. In Department of Conservation and Environment, Atlas of Natural Resources, Darling System, Western Australia.

Jandakot Airport Holdings Pty Ltd (2016) *Jandakot Airport Conservation Management Plan*, V.12.1. Available from: https://www.jandakotairport.com.au/images/files/Environment/ConservationManagementPlan_v12.1.pdf.

Keighery, B.J. (1994) *Bushland Plant Survey: A Guide to Plant Community Survey for the Community*. Wildflower Society of WA (Inc). Nedlands, Western Australia.

PGV Environmental (2013) *Lot 1790 Passmore Street, Southern River – Targeted Flora Survey*. Letter report, dated 21 October 2013, Reference 10163_001_pvdm.

PGV Environmental (2014) *Lot 1790 Passmore Street, Southern River – Targeted Flora Survey*. Letter report, dated 26 September 2014, Reference 10163_005_pvdm.

Rix, M.G., Huey, J.A., Cooper, S.J.B., Austin, A.D. and Harvey, M.S. (2018) *Conservation systematics of the shield-backed trapdoor spiders of the nigrum-group (Mygalomorphae, Idiopidae, Idiosoma): integrative taxonomy reveals a diverse and threatened fauna from south-western Australia*. ZooKeys, 756, pp. 1–121.

RPS (2012a) *Level 2 Flora and Vegetation Survey and Level 1 Fauna Assessment. Lot 1790 Passmore Street, Southern River. Unpublished report prepared for Castledine Gregor*y. Report No. L11410, Rev 0, December 2012. RPS Environment and Planning, Subiaco, Western Australia (DER Ref: A643812).

RPS (2012b) *Targeted Flora Survey – Bush Forever Sites 340,413,464 and 465, Southern River*. RPS Environment and Planning, Subiaco, Western Australia (DER Ref A732181).

Southernrae 1 Pty Ltd (2022) *Clearing permit amendment application CPS 6686/3 and supporting information*, received 13 May 2022 (DWER Ref: DWERDT603696).

Valentine, L.E. and Stock, W. (2008) *Food Resources of Carnaby's Black Cockatoo (Calyptorhynchus latirostris) in the Gnangara Sustainability Strategy Study Area*. Edith Cowan University and Department of Environment and Conservation. December 2008.

Western Australian Herbarium (1998-*) FloraBase - The Western Australian Flora*. Department of Biodiversity, Conservation and Attractions. Available from: http://florabase.dpaw.wa.gov.au/ (accessed September 2022).