

FINAL REPORT

Benefit-Cost Analysis of the State Barrier Fence

Prepared for

Department of Agriculture and Food

3 Baron-Hay Court
South Perth

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4290 6472

Project Manager:

.....
Bruce Howard
Principal Environmental
Economist

URS Australia Pty Ltd

Project Director:

.....
Dr Don Burnside
Principal Environmental
Scientist

Level 3, 20 Terrace Road
East Perth
WA 6004
Australia
Tel: 61 8 9326 0100
Fax: 61 8 9326 0296

Author:

(Optional)

.....
Bruce Howard
Principal Environmental
Economist

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Executive Summary

The State Barrier Fence (SBF) was built in the early part of the 20th century to protect Western Australia from the western migration of the rabbit. Whilst the fence failed to keep the rabbit out of State the SBF did prove, in later years, to be an effective barrier against migrating emus. Today the SBF spans 1,170km from the Zuytdorp Cliffs north of Kalbarri to Jerdacuttup east of Ravensthorpe and is maintained by the Agriculture Protection Board (APB) and the Department of Agriculture and Food (DAFWA) to minimise the impact of emus on the agriculture region of the state.

Over the past 20 years an increased incidence of wild dog activity adjacent to the SBF from Lake Moore in the Mt Marshall shire to Ravensthorpe and eastwards through the Esperance shire has occurred. This has created an interest within the agricultural industry to investigate the potential of upgrading the SBF to a wild dog fence that would keep both emus and wild dogs out of the agricultural region. This would be achieved by upgrading the existing SBF to a wild dog standard fence, as well as enclosing the two existing gaps in the SBF, one in the Yilgarn shire and the other encompassing the Esperance shire.

This benefit-cost analysis of alternative State Barrier Fence alignments and design specifications used a customized spreadsheet model to undertake the unique requirements of this analysis. This provided the tool to compare the relative merits of a number of fence design and location options. The model was partitioned to provide estimation of:

- Costs of Fence Development, Upgrade and Realignment Options for six fence development options;
- Costs of non-fence control measures such as baiting and trapping, these are varied for each fence development Option;
- Estimates of long term value of agriculture production for each of the three zones along the fence;
- Estimates of impacts caused by emu damage;
- Estimates of impacts caused by wild dog damage; and
- Estimates of impacts caused by kangaroo damage.

The model allowed separate economic analyses to be undertaken for each of three sections of the fence, or for the fence as a whole. The three sub-sections are:

- Kalbarri to Lake Moore;
- Lake Moore to the southern limit of the existing fence near Ravensthorpe; and the
- Esperance extension.

Estimates of capital, construction and maintenance costs for each fence option in each area were linked into the budget analysis. Similarly the costs of non-fence control measures are matched against each fence design option and are linked into the budget.

Damage functions were developed for emus, wild dogs, and kangaroos. The base parameters describe the level of damage that may occur without fencing and non-fence control measures. Ratings of fence and non-fence control measure effectiveness (in combination) in damage reduction are then applied as a rate of damage for each fence design option. The rates of damage were applied separately for each pest animal and reflect impacts on crop and livestock production. Crop losses were estimated against wheat production parameters and stock losses were estimated for a self replacing merino wool flock. Case study productivity values were developed for each of the three lengths of fence.

Executive Summary

The initial requirements of the study, as outlined in the Scope of Works, were to evaluate the following elements:

- the value of two major realignments to the existing State Barrier Fence;
- the value of upgrading the realigned State Barrier Fence to wild dog standard; and to
- the value of the Esperance extension (at wild dog specifications) to the State Barrier Fence.

After consultation with the client five options were developed. A sixth was added after presentation of draft results to the State Barrier Fence Management Advisory Committee (SBFMAC), and the Agriculture Protection Board (APB). The options assessed in this final report were as follows.

- Option 1 – Keep and maintain the existing standard and sub-standard fence.
- Option 2 – Keep the existing fence alignment but upgrade sub-standard sections to Emu Specifications.
- Option 3 – Realign part of the Kalbarri to Lake Moore, and Lake Moore to Ravensthorpe sections and upgrade existing sub-standard sections to Emu specifications.
- Option 4 – Realign part of the Kalbarri to Lake Moore, and Lake Moore to Ravensthorpe sections and upgrade to Wild Dog specifications. Add the Esperance section and fence to Wild Dog specifications.
- Option 5 – Remove the existing fence and replace with additional non-fence control measures.
- Option 6 – Realign part of the Kalbarri to Lake Moore, and Lake Moore to Ravensthorpe sections and upgrade to 10 line Emu specifications with the addition of wild dog netting along the foot of the fence. Add the Esperance section and fence to 10 line Emu specifications with the addition of wild dog netting along the foot of the fence.

The benefit-cost analysis compared the costs of alternative fences and associated non-fence control measures against the benefits provided by reducing the impacts of damage caused by emus, wild dogs, and kangaroos over a 25 year time period. Impacts from each of the pest animals were costed against crop and livestock production values. The effectiveness of alternative fence specifications and alignments were rated by their capacity to reduce pest animal impacts. The total fence costs (capital, works and maintenance), non-fence control costs, and total control costs for each scenario across all three lengths of agricultural boundary were shown to be as follows:

	Fence	Non-Fence Controls	Total
Option 1 - Maintain Existing Fence	\$7.78m	\$6.15m	\$13.93m
Option 2 – Existing Fenceline to Emu Specifications	\$12.43m	\$6.04m	\$18.48m
Option 3 – Fence and Realign to Emu Specifications	\$12.63m	\$5.83m	\$18.45m
Option 4 – Fence to Wild Dog Specifications	\$23.00m	\$3.08m	\$26.09m
Option 5 – No Fence	\$0.00m	\$29.66m	\$29.66m
Option 6 – Realign with Emu Specifications + Dog Netting	\$20.23m	\$3.08m	\$23.31m

The cost of maintaining the existing fence, and non-fence controls was estimated to be \$13.93 million over 25 years. Uniform adoption of a realigned and upgraded emu standard fence along all three lengths of boundary will cost \$18.45 million whilst an emu standard fence with the addition of wild dog netting on the bottom would cost an estimated \$23.31 million. If net benefits suggest it, different specifications might be applied to each length of fence.

Executive Summary

The value of avoided damage from emu, wild dog, and kangaroo impacts with each fence specification varies significantly between species and fence specification. The emu and wild dog damage costs with each fence and non-fence control option across all three lengths of agricultural boundary were shown to be as follows:

	Emu	Wild Dog	Kangaroo
Option 1 - Maintain Existing Fence			
Kalbarri – Lake Moore	\$1.6m	\$0.5m	\$0.9
Lake Moore – Ravensthorpe	\$1.5m	\$3.1m	\$0.5
Esperance Extension	\$9.8m	\$2.3m	\$0.6
Option 2 – Existing Fenceline to Emu Specifications			
Kalbarri – Lake Moore	\$1.1m	\$0.5m	\$0.6
Lake Moore – Ravensthorpe	\$1.0m	\$3.1m	\$0.4
Esperance Extension	\$9.8m	\$2.3m	\$0.6
Option 3 – Fence and Realign to Emu Specifications			
Kalbarri – Lake Moore	\$0.5m	\$0.5m	\$0.3
Lake Moore – Ravensthorpe	\$0.5m	\$3.1m	\$0.2
Esperance Extension	\$9.8m	\$2.3m	\$0.6
Option 4 – Fence to Wild Dog Specifications			
Kalbarri – Lake Moore	\$1.0m	\$0.0m	\$0.1
Lake Moore – Ravensthorpe	\$0.9m	\$0.2m	\$0.1
Esperance Extension	\$0.9m	\$0.1m	\$0.0
Option 5 – No Fence			
Kalbarri – Lake Moore	\$11.0m	\$0.2m	\$1.7
Lake Moore – Ravensthorpe	\$10.1m	\$1.2m	\$1.0
Esperance Extension	\$9.8m	\$0.8m	\$0.6
Option 6 – Realign with Emu Specifications + Dog Netting			
Kalbarri – Lake Moore	\$0.5m	\$0.1m	\$0.1
Lake Moore – Ravensthorpe	\$0.5m	\$0.4m	\$0.1
Esperance Extension	\$0.5m	\$0.3m	\$0.0

The reduction in damage from the existing fence and non-fence controls to that which might be achieved with the emu fence plus wild dog netting (Option 6) are:

- Kalbarri – Lake Moore (emus \$1.1m, wild dogs \$0.4m, and kangaroos \$0.8m),
- Lake Moore – Ravensthorpe (emus \$1.0m, wild dogs \$2.7m, and kangaroos \$0.4), and
- Esperance Extension (emus \$9.3m, wild dogs \$2.0m, and kangaroos \$0.6m).

When all costs and benefits are taken into account the option indicated to provide the highest net present value and benefit-cost ratio was Option 6, Realignment with Emu Specifications plus Dog Netting. Option 4 was also shown to provide positive net returns in the southern two lengths of boundary.

Using the base set of assumptions production and damage parameters the Option 6 fence was indicated as the preferred option in all three lengths of fence-line. It is shown to be marginally better than the existing fence in the northern section, but to provide significant net social benefits in the southern section of the existing State Barrier Fence (NPV \$6.5m, BCR 2.18), and for the proposed Esperance Extension (NPV \$9.1m, BCR 1.97). Sensitivity analysis across a range of parameters indicated the Option 6 fence, Realignment with Emu Specifications plus Dog Netting, to be a robust solution along the two southern sections.

Section 1

Introduction

1.1 Background

The State Barrier Fence (SBF) was built in the early part of the 20th century to protect Western Australia from the western migration of the rabbit. Whilst the fence failed to keep the rabbit out of State the SBF did prove in later years to be an effective barrier against migrating emus. Today the SBF spans 1,170km from the Zuytdorp Cliffs north of Kalbarri to Jerdacuttup east of Ravensthorpe and is maintained by the Agriculture Protection Board (APB) and the Department of Agriculture and Food (DAFWA) to minimise the impact of emus on the agriculture region of the state.

Over the past 20 years an increased incidence of wild dog activity adjacent to the SBF from Lake Moore in the Mt Marshall shire to Ravensthorpe and eastwards through the Esperance shire has occurred. This has created an interest within the agricultural industry to investigate the potential of upgrading the SBF to a wild dog fence that would keep both emus and wild dogs out of the agricultural region. This would be achieved by upgrading the existing SBF to a wild dog standard fence, as well as enclosing the two existing gaps in the SBF, one in the Yilgarn shire and the other encompassing the Esperance shire.

In 2005 the Agriculture Protection Board (APB) formed the State Barrier Fence Management Advisory Committee (SBFMAC) with representation from agricultural, community and other interest groups. SBFMAC's function is to provide the APB and the DAFWA with management options for the existing SBF as well as look at other biosecurity fencing issues within the state, including the Yilgarn and Esperance gaps. One of the first acts of the SBFMAC was to undertake an internal cost benefit analysis (CBA) of the existing State Barrier Fence with the view of reviewing its effectiveness and efficiency as well as to consider alternatives including upgrading the fence design to a fully vermin proof fence and investigate possible extensions to the existing Fence (South Yilgarn, Esperance area).

The completed CBA, whilst lacking in-depth detail, highlighted a positive return on investment. The CBA was then released for a three month public comment period. The majority of comment received was in favour of the CBA proposal to build a wild dog fence that encompassed the entire agricultural region of the state, however as the CBA was not an in-depth study concern was raised that certain aspects had not been addressed including issues such as animal welfare and total expenditure exploration.

As a result of the feedback received a recommendation was presented to the APB that an external and independent analysis of total costs and benefits relating to clearing, building and maintaining a fully vermin proof fence that encompasses all farming land in the South West Land Division be undertaken. This would include an assessment of risks including environmental impacts, native title issues, clearing approvals etc, a full costing of re-vesting of land, clearing of land in areas of realignment and extension and full costing of construction, including river crossings.

1.2 Scope of Services

URS was required to provide a cost benefit analysis that, as a minimum, covered the points taken from the RFQ as presented below.

Section 1

Introduction

1.2.1 Costs

Construction

The cost benefit analysis must provide:

1. Costings and timelines to complete the Yalgoo and Yilgarn realignments and the Esperance extension including;
 - surveying, including addressing native flora and fauna requirements;
 - vesting of a 20 metre wide reserve with the APB (including current land ownership/vesting issues [native title]);
 - clearing of 20 metre wide reserve of all vegetation; and
 - material requirements and construction costs of a fence built to a wild dog standard.
2. Material requirements and construction costs of upgrading approximately 220km of existing 10 line ringlock fencing within the existing SBF to the approved upgrade design.
3. Material requirements and construction costs for replacing (including the removal and disposal of existing fence) all approximately 1,350 km of existing fencing (except 10 line ringlock as stated above) within the existing SBF to the approved wild dog fence design.
4. All fencing replacements and upgrades are to incorporate all costs associated with material and construction, including stock grids (to Main Roads Western Australia standards) where the fence crosses any public road, river/creek crossings and any other unforeseen issue.

Maintenance

The cost benefit analysis must:

1. Using the Queensland, New South Wales and South Australian Dog Fence Boards as references identify annual costs associated to the ongoing maintenance of the entire fence, giving consideration to both external contractors and DAFWA staff. The fence is to be evaluated over a life of 30 years. Consideration is to be given to depreciation of the fence over a standard time.

1.2.2 Benefits

Once the capital cost of erecting a fence to wild dog standard that encompasses the entire agricultural region of the state has been established the benefits associated with having such a fence in place require investigation to enable a rigorous cost benefit analysis to be completed.

Issues to be investigated include:

Wild Dogs

The cost benefit analysis must:

1. Identify potential increased stock carrying capacity along the entire length of new fence due to reduced risk from wild dogs.
2. Identify potential stock benefits due to minimal wild dog activity including;
 - reduced stock deaths;
 - increased lamb/calf weaning percentages and growth rates resulting from much reduced wild dog activity; and

Section 1

Introduction

- potential increased cattle and sheep production from reduced levels of stress to the animals.

Emus

The cost benefit analysis must:

1. Identify grain production impacts relating to;
 - the benefit of the existing SBF compared to the removal of the existing SBF; and
 - potential increased production resulting from the realignment of the Yalgoo section and inclusion of the Esperance and Yilgarn gaps.
2. Potential savings from the damaging impact of emus on farm infrastructure (fences, water points etc),

Kangaroos

The existing SBF has only a limited impact on kangaroo activity on neighbouring farming land due to design constraints. The Yalgoo and Yilgarn gaps and the unfenced border with the Esperance Shire have the combined result of the neighbouring farmers not being afforded any protection from kangaroos. The construction of a fence built to wild dog standard would dramatically reduce kangaroo access to farming lands therefore potentially there may be an increase in productivity on properties adjacent to the fence.

The cost benefit analysis must:

1. Identify the extent of current damage to crops, pastures and infrastructure by kangaroos.
2. Demonstrate the potential benefits that a fence built to wild dog standard, that excludes the majority of kangaroos, would have on neighbouring farm land.

Other issues that need to be considered

The cost benefit analysis must also address the following:

1. Identify who the beneficiaries are on any improvements to the SBF.
2. The quantification of public versus private benefit.
3. The potential social impact on both individuals and the community.
4. Any potential environmental impacts of a fence built to wild dog standard on native species (flora and fauna) both at the local level and during times of migration, including animal welfare implications. Important references are the Department of Environment and Conservation and the Department of Local Government and Regional Development.
5. The comparison of costs of construction and ongoing maintenance of a fence built to wild dog standard versus maintaining the existing barrier fence in its current location and design.
6. Provide a cost and benefit for building and maintaining individual sections of the fence, including the Esperance section, Yilgarn section and Yalgoo section.
7. Identification of the costs associated with maintaining wild dog, kangaroo and emu control to the same level that a wild dog fence would provide.

Section 2

Structure of this Analysis

2.1 Benefit-Cost Analysis

This analysis of alternative State Barrier Fence options was undertaken with a benefit-cost framework. Benefit-Cost Analysis (BCA) provides an accepted method for comparing the economic, social and environmental benefits of alternative investment, in that it provides a framework for comparing cost and benefit flows of alternative investment options through time. It does this by discounting and aggregating future values back to a current or present dollar value.

BCA differs from a financial analysis in that it considers both private and public benefits and costs. The approach of an economic analysis is to compare “with project” scenarios against “without project” scenarios. The without (as is, or do nothing) scenario is the baseline for comparison. It is the difference between the two options that provides the measure of relative merits. In this case the comparison was made between the current fence (or no fence in the case of the Esperance region) and a number of alternative fence alignments and design specifications.

BCA requires the analysis to be conducted over a specific time period usually 20 –30 years. Conducting analysis over time periods greater than this reduces the reliability of the study due to the difficulties associated with predicting future costs and benefits. The process of discounting also tends to reduce the value of impacts that occur further into the future. The timeframe used for this analysis was 25 years.

Outcomes from a BCA are often described in terms of their present value (PV). PV is the equivalent value today of a benefit or cost that occurs at a specified time in the future. It is calculated as the value of a future sum that is discounted at a given discount rate. Net Present Value (NPV) is the present value of all benefits minus the present value of all costs. This is equivalent to the sum of the flow of annual net benefits, each of which is expressed as a present value.

The discount rate can be thought of as the rate of exchange between a value today and a value in the future – it is the rate of time preference. The rate used in the analysis should be regarded as the ‘real’ or inflation-free discount rate. The real rate is approximately equal to the nominal rate minus the rate of inflation. Use of a real rate of discount means that year zero values of benefits and costs can be used throughout the analysis. If the nominal rate were used, benefits and costs would have to be measured in the dollar values in the year they accrue. A discount rate of six per cent was used in the base analysis and sensitivity analysis was undertaken around that value.

2.2 Structure of the Benefit-Cost Assessment Model

A tailored spreadsheet model was developed to undertake the specific requirements of this analysis. This provided the tool to compare the relative merits of a number of fence design and location options. The model is partitioned to provide estimation of:

- Costs of Fence Development, Upgrade and Realignment Options for six fence development options (described in the next section);
- Costs of non-fence control measures such as baiting and trapping, these are varied for each fence development Option;
- Estimates of long term value of agriculture production for each of the three zones along the fence (based on gross margin returns from wheat production and returns from a self-replacing flock);
- Estimates of impacts caused by emu damage;
- Estimates of impacts caused by wild dog damage; and
- Estimates of impacts caused by kangaroo damage.

The model allowed separate economic analyses to be undertaken for each of three sections of the fence, or for the fence as a whole. The three sub-sections are:

Section 2

Structure of this Analysis

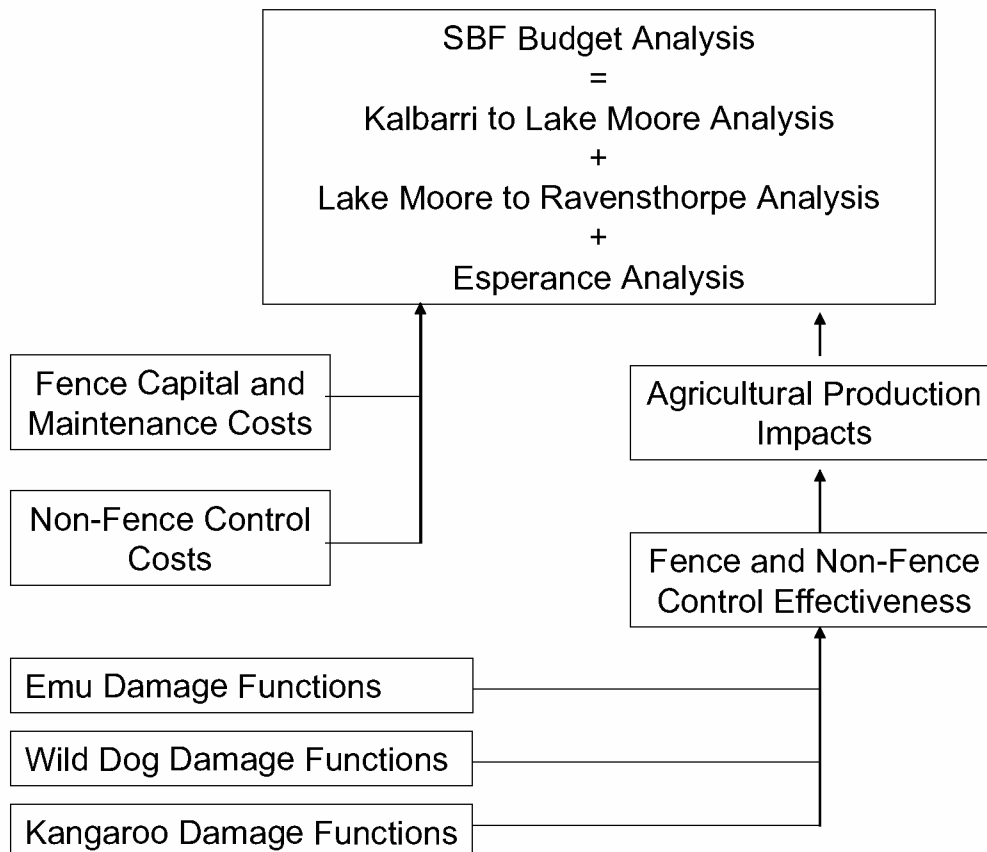
- Kalbarri to Lake Moore;
- Lake Moore to the southern limit of the existing fence near Ravensthorpe; and the
- Esperance extension.

Each of the elements shown above can be attributed or subdivided to provide separate assessments of cost and benefit for each of the three fence lengths. Figure 2-1 below provides an illustration of how each section of the model interlinks and feeds into the budget analysis of effects and net value. These values are estimated for each of the fence design options and are described in the next Section.

The estimates of capital, construction and maintenance costs for each fence option in each area link directly into the budget analysis. Similarly the costs of non-fence control measures are matched against each fence design option and are linked into the budget.

Damage functions were developed for emus, wild dogs, and kangaroos. The base parameters describe the level of damage that may occur without fencing and non-fence control measures. Ratings of fence and non-fence control measure effectiveness (in combination) in damage reduction were then applied as a rate of damage for each fence design option. The rates of damage were applied separately for each pest animal and reflect impacts on crop and livestock production. Crop losses were estimated against wheat production parameters and stock losses were estimated for a self replacing merino wool flock. Case study productivity values were developed for each of the three lengths of fence. The details of data, assumptions and analysis undertaken in each of the sub-models are described in greater detail in following chapters.

Figure 2-1: Structure of Benefit-Cost Assessment Model



Section 2

Structure of this Analysis

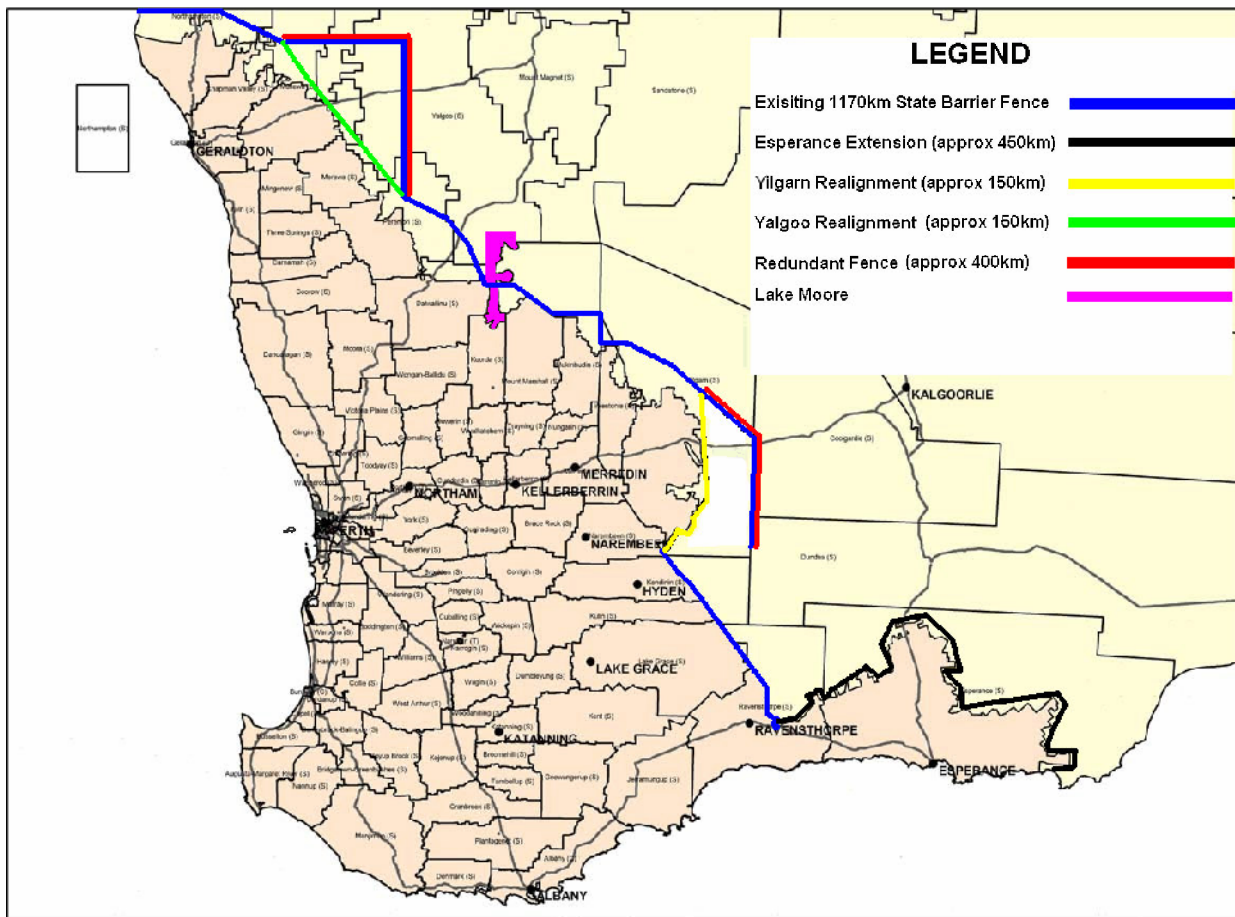
2.3 Alternative Fence Specifications and Alignments

2.3.1 The Existing Fence

The total length of the existing State Barrier Fence is some 1,170 km. This comprises the existing Kalbarri to Lake Moore section which has a length of some 570 kilometres, and the Lake Moore to near Ravensthorpe section which is about 600 kilometres. The coverage of the existing fence and indicative realignments and extensions are indicated by **Error! Reference source not found..** The proposed Esperance extension is 450 kilometres.

The existing fence is comprised of up-to-standard 10 line emu fence, a length of 15 line wild dog fence, and some lengths of what is now sub-standard emu fence. Also, as indicated by Figure 2-2 the fence in two sections deviates some distance from the edge of the agricultural area. This increases the length of fence to be maintained and also means that populations of wild dogs are on the inside of the fence.

Figure 2-2: Map of Existing Fence, Indicative Realignments and Extensions



Section 2

Structure of this Analysis

2.3.2 The Options – Alternative Specifications, Alignments & Extensions

A number of options were put forward for comparison. They vary on the basis of the fence specification (the materials, height, and construction requirements) and capacity to exclude emus and/ or wild dogs and kangaroos, and in their alignment.

The initial requirements of the study, as outlined in the Scope of Works, were to evaluate the following elements:

- the value of two major realignments to the existing State Barrier Fence;
- the value of upgrading the realigned State Barrier Fence to wild dog standard; and to
- the value of the Esperance extension (at wild dog specifications) to the State Barrier Fence.

After consultation with the client five options were developed. A sixth was added after presentation of draft results to the State Barrier Fence Management Advisory Committee (SBFMAC), and the Agriculture Protection Board (APB). The actions required within each option, for each of the three lengths of fence are indicated in Table 2-1. The options assessed in this final report are as follows.

- Option 1 – Keep and maintain the existing standard and sub-standard fence.
- Option 2 – Keep the existing fence alignment but upgrade sub-standard sections to Emu Specifications.
- Option 3 – Realign part of the Kalbarri to Lake Moore, and Lake Moore to Ravensthorpe sections and upgrade existing sub-standard sections to Emu specifications.
- Option 4 – Realign part of the Kalbarri to Lake Moore, and Lake Moore to Ravensthorpe sections and upgrade to Wild Dog specifications. Add the Esperance section and fence to Wild Dog specifications.
- Option 5 – Remove the existing fence and replace with additional non-fence control measures.
- Option 6 – Realign part of the Kalbarri to Lake Moore, and Lake Moore to Ravensthorpe sections and upgrade to 10 line Emu specifications with the addition of wild dog netting along the foot of the fence. Add the Esperance section and fence to 10 line Emu specifications with the addition of wild dog netting along the foot of the fence.

The required actions under each option are shown in Table 2-1. The highlighted distances are the total length of fence of each sub-section for each option. For example, with Option 3, the realigned Kalbarri to Lake Moore section would be some 470 kilometres long (a reduction of 100 Km), it would require the replacement of 230 Km of sub-standard fence to 10 line ringlock, the removal of 370 Km of sub-standard fence, maintenance of 90 Km of the existing 10 line ringlock, and 150 Km of new 10 line emu fence on the realigned section. The realigned section would need to be cleared and is estimated to require six new grids on major roads, one new river crossing, and six new creek crossings. Details of fence specifications and their costs are described in the next chapter.

Section 2

Structure of this Analysis

Table 2-1: Realignment, Upgrade and Expansion Options across three SBF Sub-sections

Fence Options	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension	Total
Option 1 - Maintain Existing Fence	570	600		1,170
existing sub-standard fence (Km)	460	415		875
existing 10 line ringlock fence (Km)	110	110		220
existing 15 line ringlock fence (Km)		75		
Option 2 – Existing Fenceline to Emu Specs.	570	600		1,170
replace sub-standard fence to 10 line ringlock (Km)	460	415		875
sub-standard fence to be removed (Km)	460	415		875
existing 10 line ringlock fence (Km)	110	110		220
existing 15 line ringlock fence (Km)		75		
Option 3 – Fence and Realign to Emu Specs.	470	600		1,070
replace sub-standard fence to 10 line ringlock (Km)	230	265		495
sub-standard fence to be removed (Km)	370	415		785
existing 10 line ringlock fence (Km)	90	110		200
existing 15 line ringlock fence (Km)		75		
new 10 line emu fence on realignment/ ext'n (Km)	150	150		300
new grids	6	6		
new river crossings	1			
new creek crossings	6			
Option 4 – Fence to Wild Dog Specs.	470	600	450	1,520
replace sub-standard with 15 line wild dog (Km)	230	265		495
sub-standard fence to be removed (Km)	370	415		785
existing 15 line ringlock fence (Km)		75		
upgrade 10 line ringlock to wild dog standard (Km)	90	110		200
new 15 line fence on realignment/ extension (Km)	150	150	450	750
new grids	6	6	7	
new river crossings	1		2	
new creek crossings	6		5	
Option 5 – No Fence				
sub-standard fence to be removed (Km)	570	600		1,170
Option 6 – Realign - 10 line + Dog Netting.	470	600	450	1,520
replace sub-standard fence to 10 line ringlock (Km)	230	265		495
sub-standard fence to be removed (Km)	370	415		785
existing 10 line ringlock fence (Km)	90	110		
existing 15 line ringlock fence (Km)		75		75
new 10 line emu fence on realignment/ ext'n (Km)	150	150	450	750
new grids	6	6	7	
new river crossings	1		2	
new creek crossings	6		5	

Section 3

Fence Costs

This Section outlines the construction specifications of alternative fences to meet emu or wild dog specifications. These specifications were used as the basis to determine the costs of fence materials, constructions costs and maintenance.

3.1 Fence Specifications

Specifications were provided to form the basis of costs estimates. Initially three sets of specification formed the basis of analysis. After review of draft results a fourth design option was added. The specifications were for:

- 15 Line Wild Dog Fence;
- 10 Line Emu Fence Design Upgraded to Wild Dog Fence Standard with 2 additional barbed wires added to the top of the existing 10 line ringlock and one barb fence;
- 10 Line Emu Fence Specifications; and
- 10 Line Emu Fence with foot netting attached to the bottom line wire for Wild Dog control (this specification was added after it was considered to provide similar protection as the “wild dog” fences).

3.1.1 15 Line Wild Dog Fence Specifications

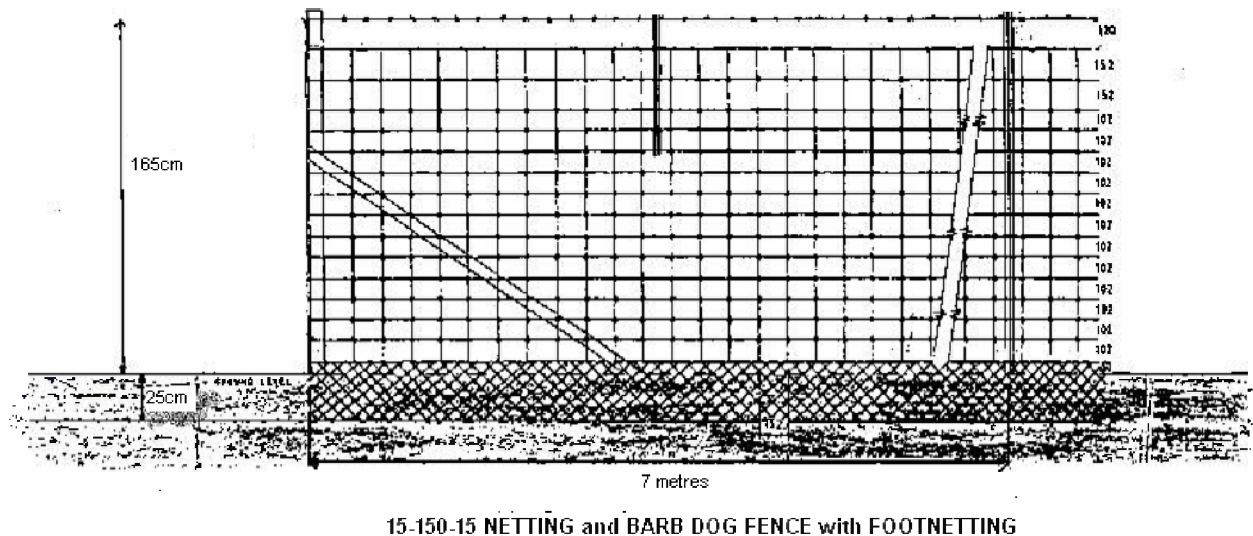
- 15 line prefabricated netting (15-150-15 by 100 metre Lifewire equivalent) with 1 barbed wire (1.8mm, 500 metre rolls, Lifewire equivalent) above the netting to a height of 1.65 metres, strained and tied off at each 200 metre strainer.
- Fabrication to be tensioned to 1.4kn. (300lbs) for each line wire.
- Bottom line wire of the prefabricated netting (15-150-15) to be a constant 50mm above ground level.
- Fabrication rolls to be joined with 15 gripples, leaving a 50mm tail on each wire.
- Foot netting (Lifewire equivalent) is to be attached every 300mm to bottom line wire of the prefabricated netting with clips and buried vertically in line with the standing fence to a depth of 250mm. Foot netting to then be covered to the height of the surrounding ground level.
- Where fence crosses a watercourse foot netting is to be attached as mentioned above and then laid horizontally on the side of the fence that the water course is flowing to and then weighed down continuously with heavy timber or rocks.
- 240cm black steel or galvanised line posts at 7 metre spacing. 15 line fabrication to be tied using tie wire to line posts 5 times, at the top, 4th from the top, 8th from the top, 4th from the bottom and the bottom. Barb wire to be tied off to each line post.
- 63cm droppers to be attached between fabrication and barbed wire at 1 per 7 metre section. Four (4) clips per dropper, one on the barb, one on top line wire and one on 3rd and 5th line wire.
- 2.7 metre drive in angle strainers with struts and ground anchors at 200 metre spacing unless specified otherwise. Prefabricated netting and barbed wire to be tied off to each strainer.

This style of fence is shown in Figure 3-1.

Section 3

Fence Costs

Figure 3-1: Diagram of 15 Line Wild Dog Fence Specifications.



3.1.2 10 Line Emu Fence Design Upgraded to Wild Dog Fence Standard

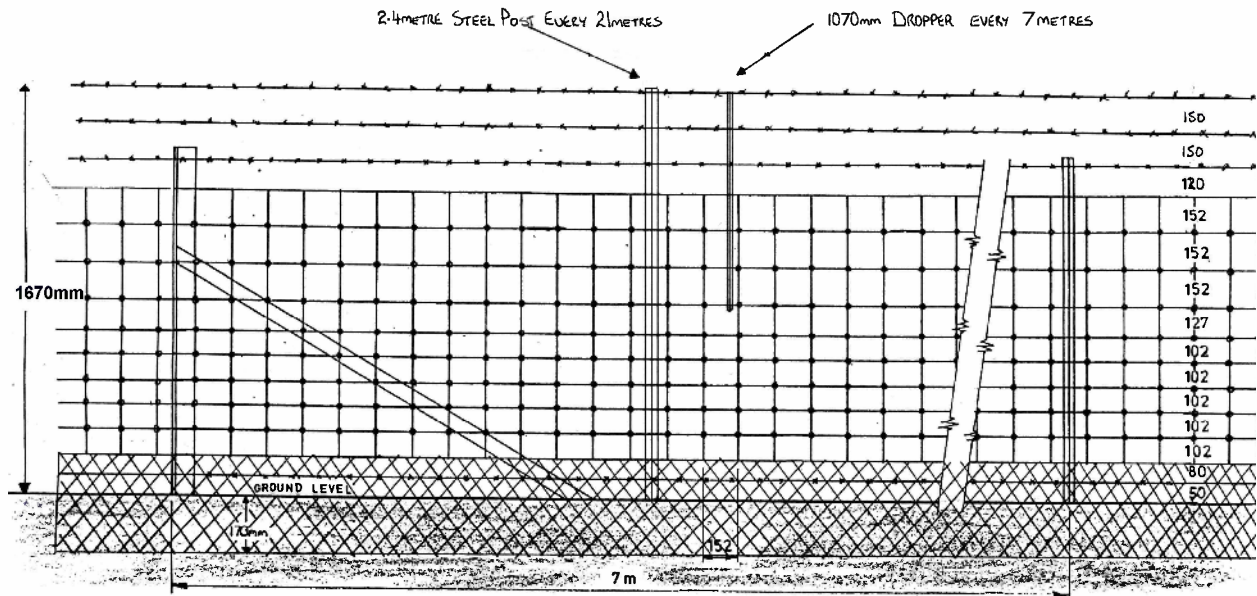
- Two additional 1.8mm (500 metre rolls Lifewire equivalent) barbed wires at 150mm spacings to be added to the top of the existing 10 line ringlock and one barb fence. Wire to be tensioned to 1.4kn. (300lbs) and joined using gripples, leaving a minimum 50mm tail on each wire.
- 2.7 metre drive in angle strainers with struts and ground anchors at 1000 metre spacing unless specified otherwise. Barbed wire to be tied off to each strainer.
- Foot netting is to be attached every 300mm to bottom line wire of the prefabricated netting with clips and buried vertically in line with the standing fence to a depth of 200mm. Foot netting to then be covered to the height of the surrounding ground level.
- Where fence crosses a watercourse foot netting is to be attached as mentioned above and then laid horizontally on the side of the fence that the water course is flowing to and then weighed down continuously with heavy timber or rocks.
- 240cm black steel or galvanised line posts at 21 metre spacing. The 3 barbed wires and 10 line fabrication to be tied off to each line post.
- 107cm dropper every 7 metres and to be attached at each barbed wire as well as between fabrication and barbed wire at 1 per 7 metre section. Five (5) clips per dropper, one on each barb, one on top line wire and one on 4th line wire.

This style of fence is shown in Table 3-1.

Section 3

Fence Costs

Table 3-1: Diagram of 10 Line Emu Fence Design upgraded to Wild Dog Fence Standard



EXISTING 10-110-15 RINGLOCK + FOOTNETTING & BARBS FOR WILD DOGS
MODIFIED TO WILD DOG STANDARDS.

3.1.3 10 Line Emu Fence Specifications

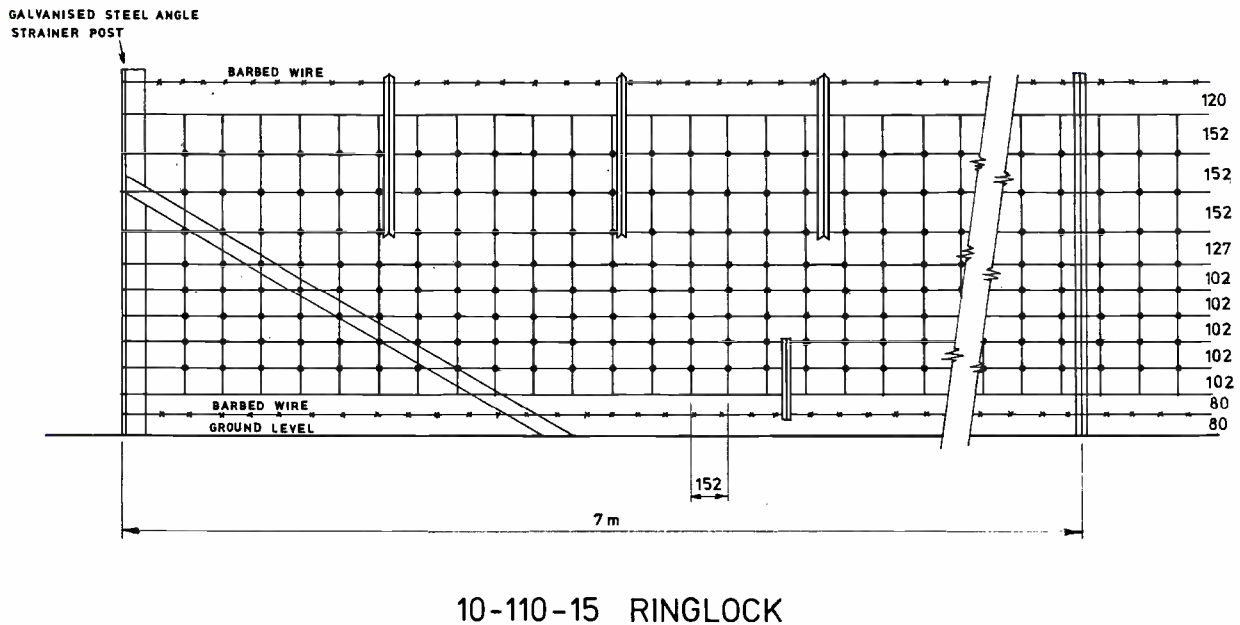
- Ten (10) line ringlock (10-110-15) with top and bottom barbed wire to a height of 1.350 metres, strained and tied off at each 200 metre strainer.
- 2.4 metre drive in angle strainers with struts and ground anchors at 200 metre spacing unless specified otherwise.
- 180cm black steel line posts at 7 metre spacing, with top and bottom barbed wires tied to line posts.
- Fabrication to be tensioned to 1.4kn. (300lbs) for each line wire.
- 10 line fabrication to be tied using tie wire to line posts 4 times, at the top, 4th from the top, 4th from the bottom and the bottom.
- 63cm droppers to be attached between fabrication and top barbed wire at 3 per 7 metre section.
- Fabrication rolls to be joined with 10 gripples, leaving a 50mm tail on each wire.
- End ties at strainers as per attached diagram.
- Steel line posts to be driven into the ground as per attached diagram.
- Fabricated wire to be hung on the northern or eastern side of the fenceline.
- All fencing material will be supplied and delivered to the site by Agriculture Western Australia.

This style of fence is shown in Figure 3-2.

Section 3

Fence Costs

Figure 3-2: Diagram of 10 Line Emu Fence Design



3.1.4 10 Line Emu Fence with Foot Netting for Wild Dogs

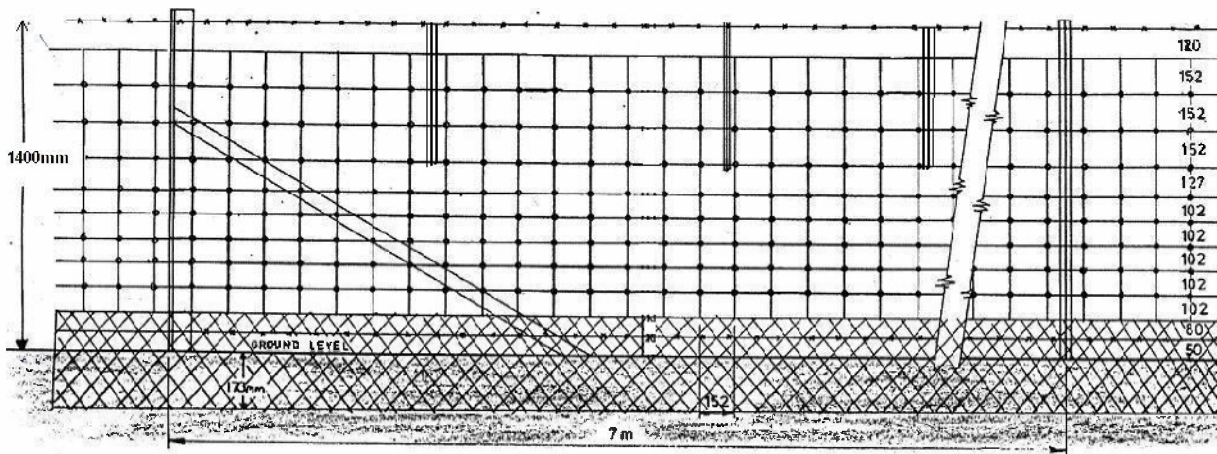
- Ten (10) line ringlock (10-110-15) with top and bottom barbed wire to a height of 1.350 metres, strained and tied off at each 200 metre strainer.
- 2.4 metre drive in angle strainers with struts and ground anchors at 200 metre spacing unless specified otherwise.
- 180cm black steel line posts at 7 metre spacing, with top and bottom barbed wires tied to line posts.
- Fabrication to be tensioned to 1.4kn. (300lbs) for each line wire.
- 10 line fabrication to be tied using tie wire to line posts 4 times, at the top, 4th from the top, 4th from the bottom and the bottom.
- 63cm droppers to be attached between fabrication and top barbed wire at 3 per 7 metre section.
- Fabrication rolls to be joined with 10 gripples, leaving a 50mm tail on each wire.
- End ties at strainers as per attached diagram.
- Steel line posts to be driven into the ground as per attached diagram.
- Fabricated wire to be hung on the northern or eastern side of the fenceline.
- All fencing material will be supplied and delivered to the site by Agriculture Western Australia.
- Foot netting is to be attached every 300mm to bottom line wire

This style of fence is shown in Figure 3-3.

Section 3

Fence Costs

Figure 3-3: Diagram of 10 Line Emu Fence Design with Foot Netting for Wild Dogs



EXISTING 10-110-15 RINGLOCK + FOOTNETTING
 MODIFIED TO WILD DOG STANDARD.

3.2 Fence Costs

Cost estimates for each activity were sourced from fencing contractors and from evidence from fences in Queensland, New South Wales, and South Australia, as well as from our Western Australian experience. Estimates for each activity were developed on the basis of low, high and expected values. The expected values were used in the budget analysis. A summary of materials, works, and maintenance costs are presented below.

3.2.1 Maintenance Costs

Maintenance costs have been obtained from personal comment and data and reports from resources in South Australia Dog Fence Board, The Wild Dog Destruction Board of New South Wales, and Queensland Wild Dog Barrier Fence Board. Each of these states has a Wild Dog Fence that is maintained in different ways – by either sub-contractors or government employees. They also used different methods of construction and financing the operation. Attempts were made to ensure alternative estimates were comparable. Additional comments were obtained from Barry Davies (Department of Agriculture and Food WA) regarding current and required maintenance costs of the existing fence. A summary of annual maintenance costs is shown in Table 3-2.

Section 3

Fence Costs

Table 3-2: Fence Cost Summary – Annual Maintenance Costs

Annual Maintenance Costs	Min	Mean	High
existing sub-standard fence (\$/Km/yr)	\$425	\$500	\$625
existing 10 line ringlock fence (\$/Km/yr)	\$383	\$450	\$563
existing 15 line ringlock fence (\$/Km/yr)	\$425	\$500	\$625
upgrade 10 line ringlock to wild dog standard (\$/Km/yr)	\$388	\$456	\$570
new 10 line emu fence (\$/Km/yr)	\$383	\$450	\$563
new 15 line wild dog fence (\$/Km/yr)	\$388	\$456	\$570
new river crossings (\$/yr)	\$400	\$500	\$1,000
new creek crossings (\$/yr)	\$200	\$250	\$500
dog netting on existing fence (\$/Km/yr)	\$29	\$32	\$38
dog netting on new fence (\$/Km/yr)	\$29	\$32	\$38

3.2.2 Materials Costs

All costs used are per kilometre estimates from suppliers or contractors exclusive of GST. Suppliers were asked to develop quotations for specified products or to use equivalent products if the specified products were not available or if they use a different supplier. Estimates were supplied by: Elders (One Steel and Smorgon Products); Elders (Smorgon Products only Supplied through Elders); Smorgon Steel; and OneSteel. Costs have not been attributed to suppliers to maintain commercial confidence. A summary of material costs is presented in Table 3-3.

Table 3-3: Fence Cost Summary – Capital Materials

Capital Costs – Materials	Min	Mean	High
upgrade 10 line ringlock to wild dog standard (\$/Km)	\$1,875	\$2,025	\$2,325
new 10 line emu fence (\$/Km)	\$4,350	\$5,030	\$5,300
new 15 line fence (\$/Km)	\$6,110	\$6,185	\$6,315
new grids	\$45,000	\$50,000	\$62,500
new river crossings	\$11,250	\$12,500	\$15,625
new creek crossings	\$2,250	\$2,500	\$3,125
material and works – dog netting on existing fence (\$/Km)	\$765	\$850	\$1,063
material and works – dog netting on new fence (\$/Km)	\$450	\$500	\$625

3.2.3 Works Costs

All costs used are per kilometre estimates from contractors exclusive of GST. Estimates were provided by the following fencing contractors: Waikaremoana Rural Contractors; Ray's Contracting; and A&J Rural Contracting. Costs have not been attributed to specific contractors to maintain commercial confidence.

The dog netting that is attached to the bottom of the fence can either be buried or staked horizontally on or just below the surface. Provided estimates suggest the cost of staking the netting to be 15-20% cheaper than burying. The data presented in Table 3-4 below show the cost of staking the netting.

Section 3

Fence Costs

Table 3-4: Fence Cost Summary – Works/ Construction Costs

Capital Costs – Works	Min	Mean	High
sub-standard fence to be removed (\$/Km)	\$0	\$0	\$500
upgrade 10 line ringlock to wild dog standard (\$/Km)	\$2,390	\$3,195	\$4,000
new 10 line emu fence on realignment/ extension (\$/Km)	\$2,100	\$2,950	\$3,500
new 15 line fence on realignment/ extension (\$/Km)	\$3,750	\$4,525	\$5,300
new grids	\$45,000	\$50,000	\$62,500
new river crossings	\$11,250	\$12,500	\$15,625
new creek crossings	\$2,250	\$2,500	\$3,125
new 10 line emu fence on realignment/ extension (\$/Km)	\$2,100	\$2,950	\$3,500
new 15 line fence on realignment/ extension (\$/Km)	\$3,750	\$4,525	\$5,300
clearing for new alignment (\$/Km)	\$1,500	\$2,500	\$3,600

A summary of total material and works costs for alternative fences is provided in Table 3-5.

Table 3-5: Fence Cost Summary – Total Capital Materials and Works Costs

Total Capital and Works Costs	Min	Mean	High
replace sub-standard fence with 10 line ringlock (\$/Km)	\$6,450	\$7,980	\$8,800
replace sub-standard fence with 15 line wild dog (\$/Km)	\$9,860	\$10,710	\$11,615
upgrade 10 line ringlock to wild dog standard (\$/Km)	\$4,265	\$5,220	\$6,325
new 10 line emu fence on realignment/ extension (\$/Km)	\$7,950	\$10,480	\$12,400
new 15 line fence on realignment/ extension (\$/Km)	\$11,360	\$13,210	\$15,215
new grids (\$)	\$90,000	\$100,000	\$125,000
new river crossings (\$)	\$22,500	\$25,000	\$31,250
new creek crossings (\$)	\$4,500	\$5,000	\$6,250

Section 4

Non-Fence Control Measures

4.1 Non-Fence Control Measure Issues

A number of non-fence control measures can be implemented to complement or provide alternatives to barrier fences as a means of reducing agricultural impacts from emus, wild dogs and kangaroos. These measures offer varying degrees of effectiveness in controlling the impact of the three species considered by this report. This analysis incorporates non-fence control measures as an addition to the effectiveness of alternative fence designs, and as a benchmark comparison against the level of control provided by non-fence control measures in the “no fence” option.

The comparison between pest animal species is important in that non-fence control measures can provide notable levels of control against wild dogs but are quite ineffective against large emu migrations. The non-fence control measures that have been costed and incorporated into the damage functions are:

- Trapping and Aerial Baiting of Wild Dogs; and
- Baiting and Shooting of Emus.

Local control of kangaroos is undertaken by shooting. This has not been included in this analysis as it occurs as a means to control local populations that exert pressure from within the boundary of any fence as much as from outside it.

The model considers the costs and effectiveness in damage mitigation of non-fence control measures against the cost and effectiveness of alternative fence designs. The unit cost of each control measure is indicated in Table 4-1. The effectiveness of fence options (discussed in Sections relating to each pest species) incorporates the additional control provided by the levels of non-fence controls that are indicated in Table 4-2.

The levels suggested for Options 1, 2, 3, 4, and 6 are the levels of input that are implemented currently. They are not in any means suggested as the level that is optimal in providing cost-efficient levels of control. The wild dog control inputs suggested for Option 5 (no fence) are considered as being what might be required to provide the maximum level of control that could be achieved with non-fence wild dog control options.

Non-fence emu control options are considered largely ineffective against migrating populations. The levels of indicated control are assumed essentially to combat local incursions of small numbers that might occur on an annual basis.

Table 4-1: Non-Fence Controls – Per Unit Costs

Annual Cost per unit	Min	Expected	High
Doggers (\$/FTE)	\$95,000	\$115,000	\$135,000
Aerial Baiting (\$/baits distributed)	\$0.70	\$1.00	\$1.20
Emu pre-feeding and baiting (person days/ yr)	\$150	\$200	\$250
Emu Shooting (person days/ yr)	\$150	\$200	\$250

Section 4

Non-Fence Control Measures

Table 4-2: Non-Fence Controls – Level of Application per Fence Option

Control Costs	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Option 1 - Maintain Existing Fence			
Doggers (FTE)	0	2	1
Aerial Baiting (baits distributed)	5,000	12,000	12,000
Emu pre-feeding and baiting (person days/ yr)	50	50	100
Emu Shooting (person days/ yr)	50	50	100
Option 2 – Existing Fenceline to Emu Specs.			
Doggers (FTE)	0	2	1
Aerial Baiting (baits distributed)	5,000	12,000	12,000
Emu pre-feeding and baiting (person days/ yr)	40	40	100
Emu Shooting (person days/ yr)	40	40	100
Option 3 – Fence and Realign to Emu Specs.			
Doggers (FTE)	0	2	1
Aerial Baiting (baits distributed)	5,000	12,000	12,000
Emu pre-feeding and baiting (person days/ yr)	20	20	100
Emu Shooting (person days/ yr)	20	20	100
Option 4 – Fence to Wild Dog Specs.			
Doggers (FTE)	0	2	1
Aerial Baiting (baits distributed)	5,000	12,000	12,000
Emu pre-feeding and baiting (person days/ yr)	20	20	20
Emu Shooting (person days/ yr)	20	20	20
Option 5 – No Fence			
Doggers (FTE)	1	6	4
Baiting Buffer Depth (Km)	15	15	15
Baiting Area (Sq Km)	7,050	9,000	6,750
Baits per sq Km (Blanket Baiting)	30	30	30
Total Baits Required	211,500	270,000	202,500
Emu pre-feeding and baiting (person days/ yr)	200	200	200
Emu Shooting (person days/ yr)	200	200	200
Option 6 – Realign with Emu Specs.+Dog Netting			
Doggers (FTE)	0	2	1
Aerial Baiting (baits distributed)	5,000	12,000	12,000
Emu pre-feeding and baiting (person days/ yr)	20	20	20
Emu Shooting (person days/ yr)	20	20	20

Note baiting and dogger effort is halved two years after Option 4 and Option 6 fence is constructed. The first two years are assumed to be required to clear any dogs from the agricultural area side of the fence

Section 5

Emu Behaviour and Impacts

5.1 Emu biology and implications for management

5.1.1 Emu biology

Emu biology in Western Australia has been studied over many years by Stephen Davies, working in the central Murchison area (Mileura Station). Other work has been done in Eastern Australia (see references).

The population dynamics of emus are well understood. It is estimated that the population is normally between 100,000 to 200,000 in WA, but it may be higher after a long run of high rainfall years in the rangelands. The emu population may have increased since European settlement, as a result of the provision of water for domestic stock. The emu's capacity to reproduce rapidly in favourable seasons has also aided its survival, and contributes to the large fluctuation in the size of the population. A pair of emus can produce 5.5 chicks per annum, which can themselves commence breeding at about 20 months of age.

The emu's diet of fruit, seeds, growing shoots of plants, insects, other small animals and animal droppings is strongly seasonally dependent, with flushes in feed supplies after rainy periods, and rapid reductions in dry periods as plants stop growing and reproducing and insect populations contract. Emus also have a high demand for water, drinking between 9 and 18 litres daily. They can go without free water for periods of time, but only if water is obtainable through the feed supply – which will not be the case in extended dry periods. Although the birds can have a lifespan of up to 20 years, a large percentage of birds live much shorter lives due to the fluctuating feed supplies in arid and semi-arid areas. However, although losses are high in extended dry periods, the high reproductive rates enable the population to increase rapidly when seasonal conditions improve.

5.1.2 Population estimates

Specific population estimates were made in WA in the late 1970s, when it was estimated that over 1.48 million km² of the rangelands, there was 0.076 emus per km², or a suggested total population of 109,250. The population was higher in the pastoral areas (0.103 emus/km²) than in unallocated land (0.008 emus/km²). The higher number of emus in rangelands used for grazing sheep has been observed in NSW as well and is attributed to the increased availability of water in pastoral areas, and reduced predation resulting from the control of dingoes.

A study in the rangelands of South Australia through the years between 1978 and 1989 showed that emu group number varied from 0.02 to 0.08 per km², and emu number per group varied between 2.22 and 4.55, depending upon location and year. These studies suggests that the emu density in the pastoral environments north and east of the barrier fence will be between about 0.05 emus per km² and 0.15 emus per km² – with an average of about 0.1. Thus within 500 km of the fence (1,170 km long), there could be at any one time between 30,000 and 90,000 emus resident. However, using the higher numbers from the South Australian study, after a run of good breeding seasons, the population within easy reach of the fence could be as high as 200,000 birds and perhaps higher.

5.1.3 Emu movements

Emus move within a large area according to climatic conditions and to keep in contact with food supplies. If sufficient food and water are available, they will be relatively sedentary. However, when feed supplies become scarce, the birds will move as needed to find suitable conditions. Although commonly termed migratory, this behaviour is better termed 'roaming' or 'nomadic'. They can travel hundreds of kilometres, at about 15 to 25 km per day.

In WA, there is a definite movement of emus southward in winter and northward in summer. At this time, emus will travel up to 1,000 km. This movement is most probably tied to rainfall in that the emus are looking for green feed after summer cyclones in the north, and winter frontal systems in the south. It is believed that they use cloudbanks to navigate towards the feed sources.

Section 5

Emu Behaviour and Impacts

Within this year-to-year nomadic pattern, there are occasional large migrations of emus southwards to the agricultural areas, attracted by the clouds associated with southern frontal systems which pass across the southern extremes of the rangelands. These major incursions mainly impact the northern agricultural regions from Ajana through to Lake Moore. The pre-disposing factors for a major movement southwards would appear to be a series of good seasons in the Southern Rangelands that have allowed an increase in the emu population, followed by a dry period across the region and in the adjacent agricultural areas.

5.1.4 Major movement events

The following descriptions of migration events were provided by Peter Mawson (Department of Environment and Conservation). Unless otherwise referenced they are sourced from uncited agency references.

- The first major problems with emus were recorded in the Upper Chapman district in the early 1920s, where severe damage was caused to wheat crops. The adjacent districts of Northampton and Mingenew were the next to experience problems with emus in the following year. In 1928, 3000-4000 emus were destroyed in the Ajana district.
- The Northampton district suffered several major invasions of emus during the period commencing 1935. During the first invasion, 28,577 birds were destroyed on the south side of the fence while 57,034 were destroyed from August to January on the north side of the No. 3 Fence (total 85,611 emus). In 1936, another invasion occurred and bonus payments were made on 15,121 emu beaks.
- Department of Agriculture records show '...that in the years 1936-37 in areas north of Northampton and in the eastern wheatbelt beyond Merredin there were unprecedented numbers of emus. A bonus was offered for their destruction resulting in over 72,000 being destroyed.'
- During the period 1945-60, bonuses were paid on 284,724 beaks (average 17,795 per annum). Emu bonus payments during the years 1961-73 showed that a total of 52,515 birds were killed inside the Vermin Proof Fences while 109,838 were killed outside (total 162,353, average 12,488 per annum).
- High annual off-take of emus (1945-73 inclusive: total 447,077 emus, average 15,416 per annum) had little or no effect on the long term population levels and did not prevent any subsequent eruptions.
- Data from a report by Long and Tozer (1964) indicate that '... unusual movements of emus were reported in 1936, 1946-47, 1949, 1952, 1957 and 1959. Numbers of emu beaks passed in for bonus payments, also indicate large numbers of birds in the years 1935-36, 1949-50, 1953, 1957-58 and 1960.' (Bonus payments lagged 6-12 months behind the observed large-scale movements of emus.)

Since the completion of the upgraded emu barrier fence across the northern and north-eastern extremities of the wheatbelt in the mid 1960s, significant movements of emus onto the fence have occurred in the following years. Where available, rainfall data are presented for Mullewa, as an indication of seasonal conditions across the lower parts of the Southern Rangeland that are adjacent to Mullewa.

- **1969** – this was a dry year across the Southern Rangelands and agricultural areas, with rainfall at Mullewa of 258 mm, compared to an average of 337 mm, or 25 per cent below average. Further, the previous year had been good across the area, with 550 mm received in Mullewa. In September 1969, the Agriculture Protection Board reported that 'Prompted by seasonal conditions, emus were migrating from as far afield as Wiluna in a south-westerly direction in ever-increasing numbers.' Concern was expressed about random shooting of the birds, and the Board considered that 'with the fences protecting the farms there was no reason to kill the emus at all and the migrating birds were best left to wander along the fence and disperse back into open country later' (APB Press Bulletin 8 September 1969).
- **1971** – above average rainfall was received in Mullewa in 1970 (390 mm), and there was heavy summer rain in March 1971 (126 mm). However from there onwards the year was drier than

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average, which may have encouraged the emus in the adjacent rangelands to migrate. There are no data on the numbers of emus reaching the fence, although it was sufficient to encourage people to shoot the birds. Again random shooting by unauthorised persons was discouraged to prevent cruelty to the birds and damage to the fence.

- **1976** – this was the largest movement of emus onto the fence and is remembered vividly by those involved. The 1974 year was wet (555 mm) and rainfall was marginally above average in 1975 (373 mm). However, the 1976 year was dry throughout the Southern Rangelands. As the dry 1976 winter unfolded, starving emus were dying in the township of Yalgoo, and thousands were reporting being hit by motor vehicles. Emus were ‘everywhere outside the fence’. Towards the end of the year, at least 100,000 birds reached the fence and were doing damage to the fence itself. Although amateur shooting had been discouraged up until this time, the excessive numbers and the damage to the fence resulted in a decision to cull them by shooting. The culling of starving emus outside the fence was demanding work, with 8 shooters reported as destroying 2,500 birds per day (Bob Cornell, reported in the *Geraldton Guardian*). At least 90,000 starving and distressed emus were destroyed by APB staff and farmers under their supervision. Repairs to the fence took many months (based on reports by Ron Diver, APB).
- **1989** – After an above average year in 1988 (431 mm at Mullewa), the rainfall in 1989 was slightly below average (305 mm). However, 125 mm of this fell in May and the subsequent winter and spring were dry. Late in the year, it was reported that there were about 50,000 emus congregated along the barrier fence on Tardie, Yuin, Woolgorong and Boolardoo Stations. While this number was a lot less than in 1976, the fence clearly prevented southwards movement onto farming land in the Yuna- Mullewa areas.
- **1994** – there are no available data on emu numbers in this year. The seasonal sequence leading up to this year was an above average rainfall in 1992 (465 mm), average rainfall in 1993 (340 mm), heavy summer rains in February 1994 (195 mm), followed by a dry winter and spring.
- **1998** – there are no available data on emu numbers in this year. The rainfall data for 1997 and 1998 show that they were nearly average years (324 mm in both years), although there was a period from August 1997 to May 1998 when almost no rainfall was recorded. It can be assumed that it was this dry period that prompted emu migration.
- **2002** – an estimated 50,000 birds moved onto the fence, distributed along its entire length (Barry Davies *pers comm.*). The 2000 year was reasonable (311 mm) but the 2002 rainfall was very low (190 mm). Emus would have been forced to move southwards in search of feed supplies.

5.2 Estimating Emu Damage Costs

5.2.1 Emu interaction at the barrier fence boundary

On the basis of past evidence and inputs from stakeholders consulted for this project, emu density and migration probabilities have been suggested for three classifications of emu migration. The modelled parameters of migration frequency and associated bird densities are summarised in Table 5-1. They are based on the following assumptions:

- One major event, with emu numbers at 60 per km of fence will occur on average every 15 years;
- One moderate event with emu numbers at about 30 per km of fence will occur on average every 10 years; and
- Minor events, with emu numbers at about 15 per km of fence will occur six years out of ten.

Otherwise emu numbers are suggested at less than 5 per km of fence. Frequency and intensity of migrations were assumed to be similar along the length of the agricultural boundary. There are recognised areas of lesser impact but these parameters were assumed to hold across each of the three lengths of agricultural boundary.

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Table 5-1: Emu Density and Migration Probability Parameters

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Emu Density (birds per Km of fenceline)			
- Big Migration	60	60	60
- Moderate Migration	30	30	30
- Minor Year	15	15	15
Annual Migration Probability			
- Big Migration	7%	7%	7%
- Moderate Migration	10%	10%	10%
- Minor Year	60%	60%	60%

Using the parameters shown in Table 5-1 the expected numbers of birds that might potentially enter the agricultural region (with or without a fence) for each of the three levels of migration size were then calculated. These numbers are presented in Table 5-3. The numbers shown in Table 5-3 are those that may actually cause damage after fence and non-fence control measures have reduced the numbers that may cross into the agricultural zone. The assumed effectiveness of fence and non-fence control measures for each fence option is show in Table 5-2. These parameters were developed in conjunction with State agency staff and were supported in the presentation to stakeholders.

Table 5-2: Fence and Non-Fence Control Effectiveness against Emus (% of no control impacts)

	Option 1 - Maintain Existing Fence	Option 2 – Existing Fenceline to Emu Specs.	Option 3 – Fence and Realign to Emu Specs.	Option 4 – Fence to Wild Dog Specs.	Option 5 – No Fence with Non- Fence Controls	Option 6 – Realign with Emu Specs. + Dog Netting
- Big Migration	85%	90%	95%	90%	5%	95%
- Moderate Migration	90%	94%	98%	98%	15%	98%
- Minor Year	95%	97%	99%	99%	50%	99%

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Table 5-3: Expected Annual Emu Migration Numbers

Emu Numbers	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Option 1 - Maintain Existing Fence	570	600	450
- Big Migration	5,130	5,400	25,650
- Moderate Migration	1,710	1,800	11,475
- Minor Year	428	450	3,375
Option 2 – Existing Fenceline to Emu Specs.			
- Big Migration	3,420	3,600	25,650
- Moderate Migration	1,026	1,080	11,475
- Minor Year	257	270	3,375
Option 3 – Fence and Realign to Emu Specs.			
- Big Migration	1,710	1,800	25,650
- Moderate Migration	428	450	11,475
- Minor Year	86	90	3,375
Option 4 – Fence to Wild Dog Specs.			
- Big Migration	3,420	3,600	2,700
- Moderate Migration	428	450	338
- Minor Year	86	90	68
Option 5 – No Fence with Non-Fence Controls			
- Big Migration	32,490	34,200	25,650
- Moderate Migration	14,535	15,300	11,475
- Minor Year	4,275	4,500	3,375
Option 6 – Realign with Emu Specs.+Dog Skirt			
- Big Migration	1,710	1,800	1,350
- Moderate Migration	428	450	338
- Minor Year	86	90	68
No Fence, No Non-Fence Controls			
- Big Migration	34,200	36,000	27,000
- Moderate Migration	17,100	18,000	13,500
- Minor Year	8,550	9,000	6,750

5.2.2 Estimates of area damaged by Emus

The damage these emus might then cause was estimated on the basis of cost per bird (see Table 5-4). Without reliable data to describe damage caused by mobs of alternative size, an approach to describe damage on a per bird basis was used in an effort that it might provide a tangible means of an estimate that could be recognised and comprehended by stakeholders. This approach provided a practical measure that landholders could provide experienced comment on.

Anecdotal information describing behaviour of migrating emu mobs, and the practical lack of control options that landholders can take, is that emus that enter the agricultural areas will not move further than about 10 to 20 kms into farming land. Presumably the hungry birds are normally able to satisfy their dietary needs within that area. Damage was estimated on the basis of likely time a migrating emu will spend in the agricultural area either before it is killed or moves back out, the distance it may travel in that time, and the width of damage it may cause as a result of feeding and the movement through crops.

Assuming an emu destroys a width of about 20 cm during travel, and travels about 4 km a day over a 20 day period, then one emu could knock down/ consume about 1.6 ha of crop in this period. Consensus gained at the presentation of draft data and results to the State Barrier Fence Management Advisory Committee (SBFMAC), and the Agriculture Protection Board (APB) was that emus from a big migration

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will remain in the agricultural area for longer, simply as a result of there being larger numbers to control. In a big migration year they are expected to cause damage for an average of thirty days, this then suggests each bird will inflict some 2.4 hectares of damage.

Table 5-4: Emu Damage Parameters

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Damage per Emu			
- Time in agricultural area big migration (days)	30	30	30
- Time in agriculture area mod. Migration (days)	20	20	20
- Time in agriculture area minor migration (days)	20	20	20
- Daily travel (km)	4	4	4
- Width of damage (cm)	20	20	20
- Area of damage – big migration (Ha)	2.40	2.40	2.40
- Area of damage – mod. Migration (Ha)	1.60	1.60	1.60
- Area of damage – minor migration (Ha)	1.60	1.60	1.60

Stakeholders also suggested that for the most emus will migrate at a time that will cause most damage to standing crops. Because they migrate as seasons in the rangelands turn poor they usually do so at the onset of warmer weather or when crops are generally approaching harvest. A rating of the level of damage was developed (this is described in Chapter 8) along the basis of high, medium and low impacts. This allowed differences in impact to be allocated to pasture and to crop areas. The assumed allocation of damage intensity is described in Table 5-5.

Table 5-5: Pasture and Crop Damage Intensity – Emu Impacts

Damage Intensity Proportion	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Crops	- High	50%	50%
	- Medium	25%	25%
	- Low	25%	25%
Pasture	- High	20%	20%
	- Medium	30%	30%
	- Low	50%	50%

These damage criteria are assumed to have reductions in crop yield and pasture productivity as indicated in Table 5-6.

Table 5-6: Damage Criteria – Emu Impacts on Crop Yield and Pasture Productivity

Damage Criteria	Crop - Yield Reduction	Pasture - Stocking Rate Reduction
High	75%	15%
Medium	30%	10%
Low	10%	5%

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5.2.3 Estimates of Emu damage costs

The cost of damage caused by emus was then estimated by multiplying the expected area of damage by the level of damage, and the estimated value of production generated from crop and pasture in each of the three regions. The value of crop and pasture production and the associated damage values associated with high, mean and low damage are described in Section 8. The expected annual damage cost from emus, under each scenario of fence and non-fence control measures is presented in Table 5-7. These numbers are a mean estimate of damage across the various frequencies and intensities of migration that have been described. These values exclude any damage that may occur to farm fences or vehicles, that would represent an additional cost.

Table 5-7: Expected Annual Damage Cost from Emus (\$)

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Option 1 - Maintain Existing Fence	\$115,890	\$112,569	\$732,899
Option 2 – Existing Fenceline to Emu Specs.	\$75,932	\$73,741	\$732,899
Option 3 – Fence and Realign to Emu Specs.	\$36,679	\$35,604	\$732,899
Option 4 – Fence to Wild Dog Specs.	\$68,667	\$66,605	\$63,834
Option 5 – No Fence	\$785,846	\$763,988	\$732,899
Option 6 – Realign with Emu Specs. + Dog Netting	\$36,679	\$35,604	\$34,133

Section 6

Wild Dog Behaviour and Impacts

This report uses the term 'wild dog' as a collective term for dingoes, hybrids and feral domestic dogs. Thomson and Rose in their 2006 publication "*Wild dog management. Best Practice Manual*" suggest that 'in practical terms, the general biology and behaviour of these canids (member of the dog family) are so similar that it is difficult to distinguish between them'.

6.1 Wild dog biology and implications for management

6.1.1 Social organisation and movements

Dingo behaviour and control technologies have been investigated in two very different bio-physical environments by Peter Thomson and his colleagues in the 1980s (see references). The two environments are the Fortescue River Valley, a mountainous environment with narrow valley floors, hummock grasslands below sparse trees and tall shrubs and ample surface water supplies; and the Nullarbor Plain, a flat-treeless shrubland and arid grassland with limited surface water.

The work has shown that the behaviour of the wild dogs is consistent across these two environments, with the differences in behaviour being related to the opportunities provided by the environment.

Wild dogs are social animals and strongly territorial, in particular the breeding females. In the Fortescue River valley, in a 400 km² area, most wild dogs were members of five discrete packs. Territory size varied between 44.5 and 113.2 km² and there was little interaction between the packs. Individual home ranges were 56 km² for females and 86 km² for males. Lone wild dogs (25% of sightings) occupied large ranges overlapping with the pack territories, and avoided interactions with the packs. Long distance dispersal from home ranges was rare. Dingo population reached a peak of 0.22 dingo per km², but in an area with limited resources, density was only 0.035 per km².

Social organisation was seen to be looser on the Nullarbor Plain, with wild dogs more often observed alone. Although the wild dogs did occupy defined living areas, there was less territoriality than seen in the Fortescue. Further, the wild dogs ranged over larger areas (90 to 300 km²) than in the Fortescue. As water became scarce in this arid environment, movements increased but only 10 per cent of animals moved further than 50 km, with one long journey of 212 km.

6.1.2 General strategy for prevention of predation by wild dogs

Sheep and wild dogs cannot co-exist and therefore sheep paddocks must be kept free of wild dogs if losses are to be avoided. The general strategy is to prevent wild dogs from entering sheep grazing areas. Therefore control must occur before they encounter sheep paddocks.

Studies in Western Australia and in the Eastern States have shown that it is only the wild dogs that are living in or near to sheep grazing areas that pose a threat to sheep welfare. Control activities need to be focused in a 'buffer zone' area that is immediately adjacent to the sheep paddocks. The territorial behaviour of wild dogs makes it possible to maintain a dog-free area within this buffer. If the buffer zone is kept dingo-free, there will be a tendency for wild dogs to relocate into the empty area. However, they will not need to move further into the sheep country, as the buffer will have the resources to sustain them.

Based on the findings in the Fortescue about social organisation and movement, it has been accepted that a buffer zone of 10 to 20 km free of wild dogs is required adjacent to sheep grazing areas. This is equivalent to two home ranges, and is likely to valid for the areas adjacent to the agricultural lands. It is important that this buffer is kept free of wild dogs to avoid movements into the sheep grazing areas and to provide a 'sink' for wild dogs from adjacent home ranges (further away).

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6.1.3 Effectiveness of baiting as a control method

The effectiveness of baiting as a control measure has been assessed. In trials in the Fortescue River valley, fresh meat baits poisoned with compound 1080 killed 100 per cent of the animals at risk, while factory made baits killed 63 per cent. In another trial, 62 per cent of the wild dogs at risk were killed by factory and live baits. Factors causing the variation in bait effectiveness include bait density and distribution, bait type and the age and social status of the wild dogs. Baiting was more effective in killing young wild dogs, and lone wild dogs. The high rate of kill among the latter category is thought to be a result of their general lack of success as hunters. Removal of wild dogs from a target area by baiting led to immigration from neighbouring groups, and rapid breeding amongst those left. However 4 years after the baiting, dingo numbers were still about 30 per cent below the pre-baiting number. Baiting provided protection from predation for adjacent sheep flocks for two years. However, the conclusion is that baiting cannot replace ground control, and baiting, because it does not result in 100 per cent control, will not prevent predation by wild dogs that are already within sheep grazing areas.

6.1.4 Implications for protection from wild dog predation

Based on the density data in the two studies referred to above, an undisturbed population of wild dogs in the buffer zone adjacent to the agricultural areas could be about 0.1 dingo per km², or 2 wild dogs per km of 'agricultural boundary' within 20 km of the boundary (equivalent to one dog per 10 km²). Removal of these wild dogs would provide a 'sink' for wild dogs that are dispersed from populations further away from the agricultural areas.

All options should be considered in a control strategy for wild dogs, including aerial baiting, ground baiting, trapping, shooting and exclusion fencing. The current control techniques in the buffer zone adjacent to the agricultural areas are aerial baiting and trapping. Baiting is normally the most cost-effective, but in the absence of exclusion fencing needs to be supported with trapping to remove wild dogs that do not take baits, and in areas where baiting is not possible (i.e. close to major settlements).

Assuming frequent aerial baiting using fresh meat baits, the buffer area can be maintained with a low population, perhaps down to 0.025 dingo per km of agricultural boundary, or one dog per 50 km² of buffer (if the buffer zone is 20 km deep). Again assuming even distribution of the animals, this still suggests that there could be up to 500 wild dogs at any one time within the area immediately adjacent to the agricultural lands.

Information from the Department of Agriculture and Food is that ground trapping by 2.5 FTEs removes about 100 wild dogs per year. This activity is reactionary, with landholders experiencing predation from dingoes living in the neighbouring bushland and preying on sheep flocks. It has been suggested that this level of control may only be removing the annual population increase and is not sufficient to reduce the long-term population in the buffer zone.

6.2 Estimates of Wild Dog Damage Costs

6.2.1 Wild Dog interaction at the barrier fence boundary

As was the case for emu damage, it was difficult to obtain documented evidence of impacts caused by wild dogs. Individual landholders provided verbal evidence of recent individual cases as it effected their properties but there is a lack of documented longitudinal evidence for any given region. The impacts are real but are difficult to estimate or substantiate on a regional basis.

Without documented data to describe mean aggregate damage at a regional scale, or long term data across representative properties, an approach was taken that used the best indicative regional data and attempted to translate those numbers back to base parameters at a local scale that could then be applied across the alternative fence and non-fence control scenarios. This approach was taken to provide a benchmark that landholders could use to relate their experience against.

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This approach used estimated aggregate losses from the current fence/ no fence situations in each region to calibrate rates of stock losses and lambing impacts at the farm scale. Consultation was undertaken with landholders to indicate potential rates of stock loss, impacts on lambing rates, and other effects that cause productive loss or managerial costs. Consultation was also undertaken to estimate total annual rates of stock loss along the three lengths of agricultural boundary assessed by this study.

These parameters were then used to build aggregate losses at the regional scale for each of the other fence and non-fence control scenarios. Estimates of aggregate stock losses under the current mix of fence and non-fence controls for each region are shown in Table 6-1.

Table 6-1: Current Annual Stock Losses from Wild Dogs on Agricultural Boundary

Estimated Annual Deaths	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance
Option 1 – Existing Fence / Non-Fence Controls	400	2,000	2,000

The approach used to estimate impacts from wild dogs is different to that used for emus. The number of wild dogs in any given area was said not always to correlate with the impacts caused. Individual dogs can behave very differently from each other. One dog may do more damage than 10 others. This is another reason why the methodology to estimate impacts across each of the fence scenarios was based on current loss estimates rather than a first principle approach based on wild dog numbers.

6.2.2 Estimates of area/ stock impacted by Wild Dogs

In the absence of a fence the proportion of the agricultural boundary that is likely to be subjected to incursions by wild dogs was suggested to be about one third or 35% on an annual basis. It was also assumed that on average a wild dog may travel, or operate, up to five kilometres into the agricultural area. There were examples where dogs travelled up to 20 km but 5 km was agreed as a reasonable average. This in combination with the length of boundary subject to wild dog incursions defines the area subject to wild dog impacts on an annual basis.

The effectiveness of the fence and non-fence control options was defined as per Table 6-2. Fencing with 15 line wild dog specifications was suggested to reduce the likelihood of wild dog incursions by 95 per cent. The existing emu fence was said to be 15 per cent effective, whereas the non-fence control measures that are applied without the support of a fence in the Esperance region only reduce the area impacted by wild dogs by 10 per cent. The effectiveness of the emu fence options in the Lake Moore to Ravensthorpe section of the existing fence is higher on average than the Kalbarri to Lake Moore section because there already is some 75 km of wild dog fence in that section.

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Table 6-2: Fence and Non-Fence Control Effectiveness against Wild Dogs (% of no control impacts)

Boundary Length Impacted - Normal Year	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Option 1 - Maintain Existing Fence	15%	25%	10%
Option 2 – Existing Fenceline to Emu Specs.	15%	25%	10%
Option 3 – Fence and Realign to Emu Specs.	15%	25%	10%
Option 4 – Fence to Wild Dog Specs.	95%	95%	95%
Option 5 – No Fence with Non-Fence Controls	70%	73%	70%
Option 6 – Realign with Emu Specs.+ Dog Netting	90%	90%	90%

Given the effectiveness of the alternative fence and non-fence control options then the length (and inferred area) of agricultural boundary likely to be impacted by wild dogs, on average, is indicated by Table 6-3. The area affected is then defined by the proportion of length shown in Table 6-3, multiplied by the length of boundary in each region, multiplied by 5 km (the depth of incursion into the agricultural areas from the boundary).

Table 6-3: Boundary Length Impacted with Alternative Fence and Non-Fence Controls

Fence Option	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Option 1 - Maintain Existing Fence	30%	23%	32%
Option 2 – Existing Fenceline to Emu Specs.	30%	23%	32%
Option 3 – Fence and Realign to Emu Specs.	30%	23%	32%
Option 4 – Fence to Wild Dog Specs.	2%	2%	2%
Option 5 – No Fence with Non-Fence Controls	11%	8%	11%
Option 6 – Realign with Emu Specs.+ Dog Netting	4%	3%	4%
No Fence and no Non-Fence Controls	35%	35%	35%

6.2.3 Estimates of Wild Dog damage costs

Wild dogs cause a number of effects which impact directly in terms of stock deaths and injuries, and impacts on reproduction rates. Other effects which are more difficult to quantify are reduced productivity caused by wild dog harassment, mixed lambing caused by stock crashing through fences and the introduction of rams at inopportune times or to unintended stock, stock losses into the bush or mixing with neighbours flocks, and increased management costs and the emotional strains associated with having injured and suffering stock. The presence of wild dogs can also impact on cropping performance by causing farmers to alter their crop/ pasture rotations. If subjected to ongoing impacts from wild dogs, farmers may choose to avoid running stock within five kilometres or so of the boundary. Reducing the frequency of pastures in a cropping system, does not allow for a disease break between crops and can reduce crop yields. This assessment attempts to cost the impacts of stock deaths, the impacts on reproduction rates, and the costs of crop yield reduction, in systems with reduced disease breaks.

If stock are removed then crop losses might be incurred. This assessment accounts for the lower of the two potential losses when assessing the damage costs on the basis that farmers will logically incur the lower of the two costs when they expect impacts from wild dogs – where they are adjacent to an emu fence or have no fence. In the case where they may neighbour a wild dog standard fence then the impacts on stock losses is taken as the farming system will be geared to using stock up to the protective fence.

The yield reduction, in systems with reduced disease breaks, was assumed at 10 per cent. The impacts on weaning rates and flock death rates were rated across high medium and low damage criteria, they are

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indicated in Table 6-4. This table shows the absolute reductions in flock performance parameters. For example the high impact on weaning rates might reduce weaning rates from 75% to 50%, and average flock death rates from 4% to 16% across the flock. These high rates of impact align with the evidence that was suggested by landholders whose stock had been recently subjected to wild dog attacks.

Table 6-4: Damage Criteria – Wild Dog Impacts on Weaning Rates and Flock Death Rates

Damage Criteria	Weaning Rate Impacts	Flock Death Rates
High	-25%	+12%
Medium	-10%	+8%
Low	-5%	+%

The damage criteria shown in Table 6-4 were then applied with an assumption that the level of damage may occur with equal probability. These impacts were modelled to determine stock losses for self replacing flock structures, at regional stocking rates for known mixes of crop and pasture areas in each of the three regions (see Section 8). Given the assumed area impacted by wild dogs, and the level of damage, total stock losses were then calculated for each region. These were then compared against the total losses suggested by stakeholders in the workshop held with SBFMAC and APB members. The wild dog incidence probability was then adjusted so that estimated losses for Option 1 (the 'as is' scenario) matched the suggested annual losses for each region. Once the model was calibrated for the current scenario the loss parameters could be applied against the fence and non-fence control efficiencies for Options 2 to 6. This process of calibration applied to the stock death estimates. Estimates of impacts on weaning rates were then assumed to occur in the same ratio. The expected annual stock losses (direct kills) in each of the three regions are indicated in Table 6-5.

Table 6-5: Wild Dog Damage Estimates – Expected Annual Stock Losses

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Region
Option 1 - Maintain Existing Fence	400	2,000	2,000
Option 2 – Existing Fenceline to Emu Specs.	400	2,000	2,000
Option 3 – Fence and Realign to Emu Specs.	400	2,000	2,000
Option 4 – Fence to Wild Dog Specs.	24	133	111
Option 5 – No Fence with Non-Fence Controls	141	717	667
Option 6 – Realign with Emu Specs.+ Dog Netting	47	267	222
No Fence and no Non-Fence Controls	471	2,667	2,222

The cost of damage caused by wild dogs was then estimated by adding the costs of increased stock deaths, the reduction in weaning rates, and or the impacts of constraints on cropping rotations. The value of crop and stock production and the associated damage values associated with high, mean and low damage are described in Section 8. The expected annual damage cost from wild dogs across, under each scenario of fence and non-fence control measures is presented in Table 6-6. These numbers are an expected annual cost. They reflect the relative efficiencies of fence and non-fence control measures and the different mixes and values of stock and crop production in each of the three regions that the fence bounds. Note that estimates of damage cost for the 'No Fence with Non-Fence Controls' option are lower than for the current 'Fence and Non-Fence Controls' option. This is because more effective non-fence control measures than are currently employed are considered possible.

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Table 6-6: Expected Annual Damage Cost from Wild Dogs (\$)

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Option 1 - Existing Fence and Non-Fence Controls	\$42,663	\$217,904	\$162,328
Option 2 – Existing Fenceline to Emu Specs.	\$42,663	\$217,904	\$162,328
Option 3 – Fence and Realign to Emu Specs.	\$42,663	\$217,904	\$162,328
Option 4 – Fence to Wild Dog Specs.	\$2,510	\$14,527	\$9,018
Option 5 – No Fence with Non-Fence Controls	\$15,057	\$78,082	\$54,109
Option 6 – Realign with Emu Specs.+ Dog Netting	\$5,019	\$29,054	\$18,036

Section 7

Kangaroo Behaviour and Impacts

7.1 Kangaroo biology and implications for management

The main species of kangaroo in southern Western Australia are the Red kangaroo (*Macropus rufus*) and the Western grey kangaroo (*M. fuliginosus*). Both species are very common in the areas outside the fence, but are less common in agricultural areas as a result of reduced habitat and control by farmers. The red kangaroos are more common in the northern areas, and the western greys are more common in the southern areas.

7.1.1 Kangaroo numbers

Kangaroo numbers fluctuate according to seasonal conditions, with accelerated breeding activity in good conditions, followed by suspension of breeding in poor conditions. It has been observed that the best correlation between animal numbers observed at any point in time, is the amount of green (therefore high quality) grass forage 6 to 12 months before. Population monitoring via aerial strip transect sampling, with application of correction factors is an accepted method for broad scale monitoring of kangaroo numbers. The numbers of the two species occurring in the zones adjacent to the agricultural areas over the period from 1980 to 2000 are shown below.

Kangaroo numbers (and density per km) in the Central Zone of WA, which includes areas adjacent to the agricultural areas from the northern extremity to about Lake Moore and eastwards to the edge of the pastoral areas are shown in Table 7-1. The area of the Central Zone is about 450,000 km².

Table 7-1: Kangaroo numbers and density in the Central Zone

Year	Red Kangaroos		Western grey kangaroos	
	Total number	Per km ²	Total number	Per km ²
1981	258,300	0.57	74,200	0.16
1984	693,600	1.54	88,800	0.20
1987	1,109,400	2.46	35,600	0.08
1990	1,007,100	2.24	171,700	0.38
1993	707,300	1.57	80,100	0.18
1997	578,700	1.29	116,400	0.26
2000	1,163,300	2.58	117,600	0.26
Average	778,243	1.73	97,771	0.22

On the information available, kangaroo numbers in the Central Zone fluctuate considerably around an average of about 2 animals per km², with the range being between 2.6 and 0.75.

Kangaroo numbers (and density per km²) in the Southern Zone of WA, which includes areas adjacent to the agricultural areas from north of Ravensthorpe and eastwards to the edge of the agricultural areas (east of Esperance) are shown in Table 7-2. The area of the Southern Zone is about 300,000 km².

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Table 7-2: Kangaroo numbers and density in the Southern Zone

Year	Red Kangaroos		Western grey kangaroos	
	Total number	Per km ²	Total number	Per km ²
1981	278,200	0.93	599,100	2.00
1984	398,900	1.33	700,100	2.33
1987	355,000	1.18	979,600	3.26
1990	543,800	1.81	1,059,500	3.53
1993	245,800	0.82	812,400	2.71
1996	175,600	0.58	392,300	1.31
1999	282,500	0.94	548,300	1.83
2000	No data	No data	630,545	2.10
Average	325,686	1.08	715,231	2.38

On the information available, kangaroo numbers in the Southern Zone fluctuate considerably around an average of about 3.5 animals per km², with the range being between 5.3 and 1.9. These numbers can be used for estimating the population density in the vicinity of the fence.

7.1.2 Kangaroo behaviour

Kangaroos are territorial, especially females. Red kangaroos typically have a home range of about 10 km, although occasional movements of hundreds of kilometres have been observed. Further recent research in SA using sophisticated statistical analysis has suggested that longer distance movement to areas of higher feed quality may occur. Feed scarcity will increase the degree of movement, up to about 30 km.

These behaviours will limit the degree of movement of kangaroos from pastoral land to adjacent agricultural land, although localised movement to better forage resources in times of declining seasonal conditions can result in very high concentrations of kangaroos on small favoured areas.

7.1.3 Kangaroo harvesting

As a result of the increased availability of water in pastoral areas (including those areas adjacent to the fence), kangaroo numbers are believed to be higher than before European settlement. Both species are harvested commercially and there are approved management plans, which are implemented by the Department of Environment and Conservation. The objectives of commercial harvest include conservation of the species, mitigation of excessive grazing in pastoral lands, and maintenance of a renewable resource. The maximum sustainable yield (on an annual basis) for kangaroos has been variously estimated at between 10 and 20 per cent of the population. The commercial harvest quota in 2004 for WA (and the number harvested) for red kangaroos was 262,000 (232,276) and for western grey kangaroos was 121,000 (105,308).

7.2 Estimates of Kangaroo Damage Costs

7.2.1 Kangaroo interaction at the barrier fence boundary

As presented in preceding sections, the predominant species of kangaroo along the barrier fence alignment are the red kangaroo and the western grey kangaroo. Red kangaroos are more common in the northern areas (as shown by Table 7-1), and the western greys are more common in the southern areas

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(Table 7-2). Both species are relatively sedentary and do not migrate on mass. The reds are likely to move over a larger range after poor seasons and this may then result in larger numbers coming into contact with the barrier fence boundary. This analysis assumed that pressure from kangaroos in the two southern lengths of the fence is constant with a population (in immediately adjacent areas) of some 10 kangaroos per km of fence. For the northern section the additional movement of the red kangaroo is acknowledged by assuming a high density population of 15 kangaroos per km of fence, after poor seasons. The assumed kangaroo population density along the fence and associated probabilities is indicated in Table 7-3.

Table 7-3: Kangaroo Density and Likelihood

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Kangaroo Density (per Km of fenceline)			
- High Density	15	10	10
- Low to Moderate Density	10	10	10
Density Probability			
- High Density	20%	20%	20%
- Low to Moderate Density	80%	80%	80%

7.2.2 Estimates of area impacted by Kangaroos

The approach used to estimate impacts from kangaroos, and the benefit that might be provided with a fence to exclude them along the boundary, was to estimate the effective additional stocking rate pressure they may cause. The cost of that stocking rate was then calculated as the revenue from sheep that it may displace. The kangaroo population (mix of species) was rated at 0.75 dry sheep equivalent (DSE) per animal. The kangaroo DSE equivalents (taking account of alternative kangaroo densities and their probabilities) were used in combination with assumed sheep stocking rates to calculate the area of pasture / crop that would be consumed to provide for the kangaroo stocking level indicated by the population density in each region. This provided the width of impact along the fence. The value of production from this area was used as a measure of impact.

The effectiveness of alternative fence and non-fence control measures were then imposed across this maximum area to indicate the area of impact under each scenario. The assumed effectiveness of each fence scenario is shown in Table 7-4. The resultant area of crop and pasture impacted under each scenario is shown in Table 7-5. Note that this damage estimate is for kangaroos entering agricultural areas from outside the barrier fence boundary, it excludes any damage that might arise from kangaroos from within the boundary.

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Table 7-4: Fence and Non-Fence Control Effectiveness against Kangaroos (% of no control impacts)

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Option 1 - Maintain Existing Fence	65%	65%	35%
Option 2 – Existing Fenceline to Emu Specs.	75%	75%	35%
Option 3 – Fence and Realign to Emu Specs.	90%	90%	30%
Option 4 – Fence to Wild Dog Specs.	95%	95%	95%
Option 5 – No Fence with Non-Fence Controls	35%	35%	35%
Option 6 – Realign with Emu Specs.+ Dog Netting	95%	95%	95%

Table 7-5: Area of Crop and Pasture Damage – Kangaroo Impacts

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Option 1 - Maintain Existing Fence			
- Crop Area (Ha)	559	390	355
- Pasture Area (Ha)	301	210	191
Option 2 – Existing Fenceline to Emu Specs.			
- Crop Area (Ha)	399	278	355
- Pasture Area (Ha)	215	150	191
Option 3 – Fence and Realign to Emu Specs.			
- Crop Area (Ha)	160	111	355
- Pasture Area (Ha)	86	60	191
Option 4 – Fence to Wild Dog Specs.			
- Crop Area (Ha)	80	56	27
- Pasture Area (Ha)	43	30	15
Option 5 – No Fence with Non-Fence Controls			
- Crop Area (Ha)	1,037	724	355
- Pasture Area (Ha)	559	390	191
Option 6 – Realign with Emu Specs.+ Dog Netting			
- Crop Area (Ha)	80	56	27
- Pasture Area (Ha)	43	30	15

7.2.3 Estimates of Kangaroo damage costs

The cost of damage caused by kangaroos was then estimated by multiplying the expected area of damage by the level of damage, and the estimated value of production generated from crop and pasture in each of the three regions. The value of crop and pasture production and the associated damage values associated with high, mean and low damage are described in Section 8. The expected annual damage cost from kangaroos, under each scenario of fence and non-fence control measures is presented in Table 7-6. These values exclude any damage that may occur to farm fences or vehicles, that would represent an additional cost.

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Table 7-6: Expected Annual Damage Cost from Kangaroos (\$)

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance Extension
Option 1 - Maintain Existing Fence	\$64,208	\$41,199	\$47,934
Option 2 – Existing Fenceline to Emu Specs.	\$45,863	\$29,428	\$47,934
Option 3 – Fence and Realign to Emu Specs.	\$18,345	\$11,771	\$47,934
Option 4 – Fence to Wild Dog Specs.	\$9,173	\$5,886	\$3,687
Option 5 – No Fence	\$119,243	\$76,512	\$47,934
Option 6 – Realign with Emu Specs.+ Dog Netting	\$9,173	\$5,886	\$3,687

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The approach used to value the impacts that might arise from emu, wild dog and kangaroo damage comprised the following steps:

- Defining representative agricultural areas and associated production parameters and value, and operating costs of representative crop and livestock production in each representative area; and
- Using representative data to model the economic value of damage to crop and pasture production arising from emu, wild dog and kangaroo impacts.

8.1 Representative Agricultural Areas and Production Parameters

8.1.1 Representative Shire Data

The path of the existing State Barrier Fence, proposed realignments, and the Esperance extension is shown on Figure 2-2. The Shires that the fence passes through from north to south are as follows:

- | | | |
|-------------------|----------------|------------------|
| 1. Northampton | 6. Dalwallinu | 11. Narembeen |
| 2. Chapman Valley | 7. Mt Marshall | 12. Kondinin |
| 3. Mullewa | 8. Mukinbudin | 13. Ravensthorpe |
| 4. Morawa | 9. Westonia | 14. Esperance |
| 5. Perenjori | 10. Merredin | |

A shire was chosen for each length of fence to be representative of the mean agricultural values along that section. Dalwallinu was chosen as the mid-shire on the Kalbarri to Lake More section, Narembeen for the Lake Moore to Ravensthorpe, and Esperance shire for the proposed Esperance fence. Care was taken with the Esperance data to use northern mallee data rather than shire averages which also include the sandplain areas which are quite different.

The representative shires were used as the basis to source land-use data, production histories and operating cost and income data. The source of shire-based data was BankWest Benchmark reports (BankWest 2000, 2001, 2002, 2003, 2004, 2005). These provided time series data for six years between 2000/01 and 2005/06. The Department of Agriculture and Food (Western Australia) publishes series of cropping and livestock gross margin data (Department of Agriculture and Food website). These were used to differentiate between northern mallee farms and sandplain farms in the Esperance region, and to provide specific estimates of variable operating costs for cropping in each defined area.

Price data was converted into 2007 dollar values using the consumer price index. The mean indicators from the time series data were then used as the basis to develop gross margin budgets for representative crop and livestock enterprises in each region. Crop values are based on returns from growing wheat, whilst livestock returns were based on returns from a self replacing merino flock.

8.1.2 Historical Land-use, Production, Income and Operating Costs

The key farm performance indicators from the BankWest Benchmark reports for Dalwallinu, Narembeen, and Esperance Shires are summarised in the following Table 8-1, Table 8-2, and Table 8-3.

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Table 8-1: Historical Production Data, Returns, and Costs (adjusted to 2007 values) – Dalwallinu.

Dalwallinu	00/01	01/02	02/03	03/04	04/05	05/06
Farm Income \$/Eff Ha	\$210	\$247	\$139	\$244	\$222	\$261
Operating Costs \$/Eff Ha	\$172	\$151	\$136	\$134	\$173	\$177
Operating Returns \$/Eff Ha	\$39	\$97	\$3	\$110	\$50	\$82
Operating Profit \$/Eff Ha	\$15	\$74	-\$18	\$88	\$27	\$59
Operating Costs/ Farm Income %	86%	66%	111%	61%	86%	72%
Grain - % of Farm Income	84%	86%	64%	87%	86%	85%
Total cropping area (Ha)	2692	2086	2030	2538	2907	2799
- % of effective area	74%	65%	54%	66%	72%	69%
Wheat Yields (t/Ha)	1.38	1.4	0.29	1.95	1.66	1.82
Total crop costs (\$)	\$164	\$142	\$157	\$142	\$175	\$184
Winter grazed area (Ha)	983	1154	1830	1261	1195	1235
- % of effective area	27%	31%	47%	33%	29%	31%
Income \$/WGHA	\$82	\$66	\$101	\$51	\$124	\$76
Sheep costs (\$/WGHa)	\$73	\$61	\$92	\$35	\$107	\$59
Sheep margin (\$/WGHa)	\$9	\$5	\$9	\$15	\$17	\$17
Wool Cut - Kg/hd	4.8	4.5	5.7	4.8	4.7	4.3
Wool Price \$/kg	\$4.46	\$4.19	\$6.98	\$4.34	\$4.92	\$4.21
Average Sheep Sale Price (\$/hd)	\$32	\$48	\$55	\$70	\$59	\$51
Lamb %	84%	82%	80%	84%	84%	91%
Stocking Rate (shorn sheep/WGHA)	2.6	2.1	1.3	1.6	1.6	1.9

Table 8-2: Historical Production Data, Returns, and Costs (adjusted to 2007 values) – Narembeen.

Narembeen	00/01	01/02	02/03	03/04	04/05	05/06
Farm Income \$/Eff Ha	\$172	\$218	\$205	\$250	\$253	\$222
Operating Costs \$/Eff Ha	\$144	\$130	\$138	\$160	\$172	\$161
Operating Returns \$/Eff Ha	\$27	\$88	\$66	\$91	\$82	\$59
Operating Profit \$/Eff Ha	\$7	\$68	\$43	\$63	\$62	\$35
Operating Costs/ Farm Income %	92%	66%	80%	72%	71%	75%
Grain - % of Farm Income	69%	75%	68%	74%	77%	81%
Total cropping area (Ha)	1638	1469	1928	2071	2032	2169
- % of effective area	60%	59%	65%	69%	61%	62%
Wheat Yields (t/Ha)	1.01	1.7	0.51	2.26	1.64	1.52
Total crop costs (\$)	\$132	\$128	\$116	\$141	\$194	\$178
Winter grazed area (Ha)	1065	946	917	824	1260	1645
- % of effective area	39%	39%	32%	28%	38%	43%
Income \$/WGHA	\$88	\$124	\$131	\$122	\$82	\$78
Sheep costs (\$/WGHa)	\$82	\$72	\$110	\$89	\$57	\$61
Sheep margin (\$/WGHa)	\$6	\$53	\$21	\$33	\$25	\$17
Wool Cut - Kg/hd	4.6	5.4	4.6	4.9	4.4	4.3
Wool Price \$/kg	\$4.85	\$4.09	\$7.21	\$3.48	\$6.10	\$5.14
Average Sheep Sale Price (\$/hd)	\$32	\$49	\$75	\$68	\$42	\$46
Lamb %	82%	67%	44%	83%	75%	87%
Stocking Rate (shorn sheep/WGHA)	3.2	2.6	2.4	4.0	2.1	1.3

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Table 8-3: Historical Production Data, Returns, and Costs (adjusted to 2007 values) – Esperance.

Esperance	00/01	01/02	02/03	03/04	04/05	05/06
Farm Income \$/Eff Ha	\$254	\$345	\$294	\$334	\$360	\$307
Operating Costs \$/Eff Ha	\$172	\$177	\$197	\$225	\$270	\$223
Operating Returns \$/Eff Ha	\$82	\$168	\$97	\$109	\$90	\$84
Operating Profit \$/Eff Ha	\$52	\$136	\$65	\$73	\$52	\$49
Operating Costs/ Farm Income %	73%	52%	71%	70%	75%	73%
Grain - % of Farm Income	70%	76%	70%	78%	76%	72%
Total cropping area (Ha)	1678	1527	1636	1820	1905	1809
- % of effective area	64%	62%	59%	67%	69%	64%
Wheat Yields (t/Ha)	1.89	2.3	1.04	2.77	1.82	2.42
Total crop costs (\$)	\$178	\$182	\$180	\$219	\$253	\$230
Winter grazed area (Ha)	890	956	999	796	901	912
- % of effective area	34%	39%	38%	31%	32%	34%
Income \$/WGHA	\$107	\$226	\$136	\$155	\$178	\$186
Sheep costs (\$/WGHa)	\$67	\$136	\$76	\$102	\$137	\$130
Sheep margin (\$/WGHa)	\$40	\$90	\$59	\$53	\$41	\$56
Wool Cut - Kg/hd	5.7	4.8	4.9	4.7	4.2	4.3
Wool Price \$/kg	\$5.47	\$7.07	\$6.48	\$3.55	\$5.10	\$4.69
Average Sheep Sale Price (\$/hd)	\$30	\$61	\$66	\$74	\$65	\$58
Lamb %	76%	72%	79%	80%	65%	79%
Stocking Rate (shorn sheep/WGHA)	3.3	3.2	3.2	4.2	2.3	2.9

8.2 Modelling Impacts on Agricultural Values

The six years of BankWest Benchmark data for Dalwallinu, Narembene, and Esperance Shires (Table 8-1, Table 8-2, and Table 8-3) was then averaged. These performance indicators (see Table 8-4), along with specific crop yield data for the Esperance mallee areas were then used to develop representative cropping and livestock gross margin models for each of the three regions. Key indicators are highlighted.

Table 8-4: Summary of Production Data, Returns, and Costs – Average across Six Years

	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance
Operating Costs \$/Effective Ha	\$157	\$151	\$210
- % of effective area	67%	63%	64%
Wheat Yields (t/Ha)	1.42	1.44	2.04
Total crop costs (\$)	\$161	\$148	\$207
- % of effective area	33%	37%	35%
Income \$/Winter Grazed Ha (WGHA)	\$83	\$104	\$165
Sheep costs (\$/WGHA)	\$71	\$79	\$108
Sheep margin (\$/WGHA)	\$12	\$26	\$57
Wool Cut - Kg/hd	4.8	4.7	4.7
Wool Price \$/kg	\$4.85	\$5.14	\$5.39
Average Sheep Sale Price (\$/hd)	\$53	\$52	\$59
Lamb %	84%	73%	75%
Stocking Rate (shorn sheep/WGHA)	1.9	2.6	3.2

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8.2.1 Land-use

The mix of crop and pasture (livestock) in each representative area is shown in Table 8-5, these data are summarised from the BankWest shire data. These data were used to determine the areas of crop and number of livestock present in areas along the boundary, and the relative impacts of emus, wild dogs and kangaroos.

Table 8-5: Crop and Pasture Mix in Representative Areas

Crop and Pasture Areas	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance
Crop	67%	63%	64%
Pasture	33%	37%	36%

8.2.2 Modelling Crop Impacts

With data sourced from the BankWest Benchmark reports and the Department of Agriculture and Food cropping gross margin budgets were developed for wheat production in representative areas for the three lengths of fence (see Table 8-6). Once the base gross margin was determined (see the highlighted row), the gross margin with high (75% yield loss), medium (30% yield loss) and low (10% yield loss) impacts were estimated. The range of damage rates were derived from landholder consultations.

The resultant impact costs are the difference between no impact and the high, medium, and low impact levels. The frequency at which the various impact levels might occur was estimated, for example, for emus for each level of migration intensity that might occur. The impact costs were then multiplied of the area in which they were determined to occur for either emu or kangaroo impacts.

Table 8-6: Cropping Production (Wheat) – Gross Margins and Impact Costs

Production Parameters	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance
Gross price (\$/tonne)	\$190	\$190	\$190
Net price (\$/tonne)	\$149	\$133	\$145
Yield (tonnes/Ha)	1.42	1.44	1.70
Gross Income (\$/Ha)	\$211	\$192	\$247
Total variable costs (\$/Ha)	\$161	\$144	\$170
Gross Margin (\$/Ha)			
High Impacts (75% yield loss)	-\$128	-\$114	-\$129
Medium Impact (30% yield loss)	-\$28	-\$23	-\$14
Low Impact (10% yield loss)	\$29	\$29	\$52
No Impact	\$51	\$48	\$76
Impact Cost (\$/Ha)			
High Impacts (75%)	\$178	\$162	\$206
Medium Impact (30%)	\$78	\$71	\$90
Low Impact (10%)	\$21	\$19	\$24

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8.2.3 Modelling Livestock Impacts

With data sourced from the BankWest Benchmark reports and the Department of Agriculture and Food livestock (self replacing merino flock) gross margin budgets were developed for sheep production in representative areas for the three lengths of fence (see Table 8-7). Once the base gross margin was determined (see the highlighted rows), a gross margin with high, medium and low impacts were estimated. Impacts were determined for wild dog effects on death and weaning rates, and for emu and kangaroo impacts on pasture productivity.

High wild dog impact assumed a reduction in the weaning rate of 25 per cent and an increase in the death rate of 12 per cent over the assumed base level. Medium wild dog impact assumed a reduction in the weaning rate of 10 per cent and an increase in the death rate of 8 per cent over the assumed base level. Low wild dog impact assumed a reduction in the weaning rate of 5 per cent and an increase in the death rate of 4 per cent over the assumed base level. The range of damage rates were derived from landholder consultations.

The livestock model adjusted livestock sales and shearing numbers to reflect different mortality and reproductive rates. High emu or kangaroo impact assumed a reduction in pasture productivity of 15 per cent, medium impact was 10 per cent, and low impact was 5 per cent.

The resultant impact costs are the difference between no impact and the high, medium, and low impact levels. The frequency at which the various impact levels might occur was estimated for each pest animal, as per Sections 5, 6, and 7.

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Table 8-7: Livestock and Wool Production – Gross Margins and Impact Costs

Production Parameters	Kalbarri – Lake Moore	Lake Moore - Ravensthorpe	Esperance
Weaning rate	80%	75%	75%
Death rate	4%	4%	4%
Winter stocking rate (DSE/winter grazed ha)	1.9	2.6	4.0
Average flock wool cut (kg/hd greasy)	3.75	3.95	3.95
Average sale price (\$/hd net of freight and charges)	\$40.20	\$25.50	\$25.50
Wool price (\$/kg greasy net taxes & selling costs)	\$4.90	\$5.50	\$5.50
Gross Income (\$/Ha)	\$84	\$105	\$162
Total variable costs (\$/Ha)	\$72	\$79	\$104
Wild Dog Impacts			
Gross Margin (\$/Ha)			
High Impacts (weaning -25%, deaths +12%)	-\$10	\$4	\$24
Medium Impact (weaning -10%, deaths +8%)	\$1	\$15	\$40
Low Impact (weaning -5%, deaths +4%)	\$6	\$21	\$49
No Impact	\$12	\$26	\$57
Impact Cost (\$/Ha)			
High Impacts (weaning -25%, deaths +12%)	\$23	\$22	\$34
Medium Impact (weaning -10%, deaths +8%)	\$12	\$11	\$18
Low Impact (weaning -5%, deaths +4%)	\$6	\$5	\$8
Emu and Kangaroo Impacts			
Gross Margin (\$/Ha)			
High Impact (pasture productivity - 15%)	\$9	\$19	\$47
Medium Impact (pasture productivity – 10%)	\$10	\$22	\$50
Low Impact (pasture productivity - 5%)	\$11	\$24	\$53
No Impact	\$12	\$26	\$57
Impact Cost (\$/Ha)			
High Impact (pasture productivity - 15%)	\$3	\$7	\$11
Medium Impact (pasture productivity – 10%)	\$2	\$5	\$8
Low Impact (pasture productivity - 5%)	\$1	\$2	\$4

Section 9

Social and Environmental Effects

9.1 Social Impacts and Values

Community and landholder reactions to approaches to emu, kangaroo, and wild dog control and the methods used to achieve control are highlighted by the following collection of opinions, policy statements and newspaper articles. They reflect some community and landholder values and provide a useful baseline to judge the merits of fence or other methods of control of emus, kangaroos, and wild dogs especially. The decision to use fences as a control measure as opposed to lethal control measures is not just an economic decision. Community values may add to, or detract from, the merits of alternate options. These values have not been costed as such but they add weight to the value of fences as a means of control.

9.1.1 Landholder Impacts and Values

One of the questions asked during the landholder consultation was 'What causes you more economic cost, emus or wild dogs?' Landholders uniformly responded that emus cause more economic damage. However, it is the impact of wild dogs that are the greatest cause of concern to landholders. This is because of the emotional stress and impact on farm management decisions that are caused by wild dogs. Farmers are strongly affected by the distress and injury that wild dogs can inflict upon livestock. People hate seeing their stock suffer as a result of wild dog injury and harassment. Landholder reactions to address the cause of the problem may be disproportionate to the economic losses caused by wild dogs, but that is because this can be a very emotional issue.

Responses to impacts caused by emus are less passionate, and cause less stress to landholders. This is probably because they are more directly economic as they cause damage to crops. No doubt when they occur they may cause financial stress, but it is also possible that this can be reduced with crop insurance. Kangaroo impacts also seem to cause less emotional stress. Impacts are relatively low, and because they are more consistent (the kangaroos are always about) they are considered to be part of the operating environment – they belong.

9.1.2 Community Values

ACF Dingo Policy

One useful reflection of community attitudes is the Australian Conservation Foundation (ACF) Dingo policy (ACF Dingoes, Policy Statement No. 42). This policy states:

- 'No killing without proper justification - Although wildlife protection legislation in Australia allows for the limited killing of protected wildlife under permit, this should only be done with proper justification (such as verified loss of stock to dingoes).
- Development of non-lethal control measures - Non-lethal methods should be developed and implemented where dingo populations require control including:
 - careful zoning of land use around forests, national parks, etc where dingo conservation is a management objective (eg sheep grazing should be kept away from the boundaries), and well-designed and carefully located exclusion fencing.
- Broad-scale and indiscriminate control measures not to be employed - Broad-scale and indiscriminate lethal 'wild dog' control measures should not be employed, especially the widespread use of leghold traps, nooses and the aerial broadcasting of non-specific and highly toxic baits, because such methods are unnecessarily cruel and cause substantial losses of non-target species.'

Section 9

Social and Environmental Effects

In essence this policy suggests a preference for exclusion fencing and aversion to lethal control measures.

Newspaper References on Wild Dog Control

'Fox on the run as dingo's day dawns', Richard Macey, July 11, 2007, Sydney Morning Herald

DINGOES should be reintroduced into NSW to protect native animals from feral foxes, cats and dogs, a scientist said yesterday. Farmers could protect their stock from marauding dingoes by using donkeys, llamas and alpacas as 'watch animals', said Chris Dickman, an ecologist at the University of Sydney.

Speaking at a biodiversity and extinction conference at the University of NSW, Professor Dickman also proposed abolishing sheep farming in marginal country, and using the properties to harvest kangaroos instead. He said Australia had one of the worst records for protecting native mammals. A 'rough estimate' could put the rate of extinction at about 700 times the natural rate.

He proposed reintroducing dingoes to NSW national parks, starting with Sturt National Park in the far west. Picking off foxes, dogs and cats, the dingoes would give threatened native wildlife a chance to recover. Professor Dickman conceded 'it would not be a popular idea ... there is no doubt dingoes are hated with a passion' in rural Australia.

US farmers were using donkeys, llamas and alpacas to fend off wolves and coyotes. 'A small number of donkeys would be very effective as guard animals. Two or three is probably all you would need. They think they are part of the flock,' he said, adding they could kick attackers. Governments would need to compensate farmers for stock lost to dingoes, just as many US farmers were compensated for losses to native wild animals.

'Dingoes touted as wildlife's saviour', By ABC Science Online's Dani Cooper, Posted 12 July 2007

Dingoes should be reintroduced into large tracts of Australian sheep grazing country to control feral animals that would otherwise threaten native fauna, a wildlife expert says. Professor Chris Dickman, of the Institute of Wildlife Research at the University of Sydney, also says it may be time to consider pulling down the dingo fence that was built in the 1880s to keep dingoes from livestock in south-east Australia.

He says Australians, particularly the livestock farming community, need to rethink their attitude towards the country's native dog. In a range of papers to be presented this week at the Biodiversity Extinction Crisis Conference in Sydney, Professor Dickman and his colleagues argue the dingo is critical to saving threatened native species and restoring biodiversity in areas that have been devastated by drought and sheep farming.

Professor Dickman says Australia has the world's highest rate of mammal extinction with 27 species and sub-species lost since European settlement in 1788, 'which is as much as the rest of the world combined in the same period'. Research shows two introduced predators, the red fox and feral cat, are the main cause of many extinctions and reductions in mammal species and that dingoes keep down their numbers.

'Where dingoes occur in big numbers, cats and foxes don't,' Professor Dickman says.

THE WA Dingo Association is calling for a ban on aerial baiting for vermin control in a radical bid to save Australia's native dog from extinction. Jim Kelly, PerthNow, October 15, 2007

Association president Nic Papalia says dingoes are being driven to extinction and is leading a push to have them listed as an endangered species. Mr Papalia said the animals which once roamed the country are now restricted to remote habitats where they are under threat from aerial baiting programs using poisons such as 1080. 'Aerial baiting is eco-vandalism,' he said. 'Dingoes play an important role in the eco-system and are essential in the wild for the survival of small native species such as bilbies, quolls, rare wallabies and possums. In areas where the dingo has been exterminated, aggressive predators, such as foxes and wild cats, have wiped out these significant species. Mr Papalia said high profile tragedies on Fraser Island and the Azaria Chamberlain case had prejudiced attitudes towards the dingo, which remains the only Australian species listed as vermin. He said Australia holds the world record for mammal extinctions, losing 20 species in the past 200 years. 'It would be an abomination if dingoes were added to this list' he said.

Section 9**Social and Environmental Effects****9.2 Environmental Impacts****9.2.1 Impacts of the State Barrier Fence on Non-Target Native Species**

Peter Mawson (Department of Environment and Conservation, *pers. comm.*) suggests there is little adverse impact on non-target native species. None of the larger terrestrial species are migratory, and smaller local species such as reptiles have no difficulty in passing through the fence.

Section 10

Financial and Economic Analysis

10.1 Cost of Control Options

10.1.1 Costs of State Barrier Fence Options

The aggregate capital and works, and maintenance costs for the three lengths of State Barrier Fence, and the fence as a whole are presented in Table 10-1. The cost of each option is shown as the present value (PV) of cost over a 25 year period, and as a cost per km of fence. The length is assumed to be either the length of fence or the length of agricultural boundary in the case of the Esperance options without fence.

Total costs over 25 years, for example, are some \$23.0 million or \$15,100 per km for the wild dog specifications (15 line) and \$7.8 million or \$4,800 per km to maintain the existing fence. Note that these costs don't reflect the different levels of protection they may provide. They are based on the per unit and works costs presented in Section 3.

Table 10-1: Capital and Works, and Maintenance Costs of State Barrier Fence Options

	Capital & Works		Maintenance		Total	
	PV (\$m)	\$/km	PV (\$m)	\$/km	PV (\$m)	\$/km
Option 1 - Maintain Existing Fence						
Kalbarri – Lake Moore	\$0.00	\$0	\$3.79	\$6,644	\$3.79	\$6,644
Lake Moore - Ravensthorpe	\$0.00	\$0	\$3.99	\$6,651	\$3.99	\$6,651
Esperance Extension	\$0.00	\$0	\$0.00	\$0	\$0.00	\$0
Total	\$0.00	\$0	\$7.78	\$4,801	\$7.78	\$4,801
Option 2 – Existing Fenceline to Emu Specs.						
Kalbarri – Lake Moore	\$3.67	\$6,439	\$2.57	\$4,501	\$6.24	\$10,939
Lake Moore - Ravensthorpe	\$3.31	\$5,517	\$2.89	\$4,815	\$6.20	\$10,332
Esperance Extension	\$0.00	\$0	\$0.00	\$0	\$0.00	\$0
Total	\$6.98	\$4,309	\$5.45	\$3,367	\$12.43	\$7,676
Option 3 – Fence and Realign to Emu Specs.						
Kalbarri – Lake Moore	\$3.69	\$7,851	\$2.14	\$4,549	\$5.83	\$12,400
Lake Moore - Ravensthorpe	\$3.91	\$6,517	\$2.89	\$4,815	\$6.80	\$11,332
Esperance Extension	\$0.00	\$0	\$0.00	\$0	\$0.00	\$0
Total	\$7.60	\$5,000	\$5.03	\$3,307	\$12.63	\$8,307
Option 4 – Fence to Wild Dog Specs.						
Kalbarri – Lake Moore	\$5.19	\$11,043	\$1.99	\$4,240	\$7.18	\$15,282
Lake Moore - Ravensthorpe	\$5.62	\$9,367	\$2.70	\$4,496	\$8.32	\$13,862
Esperance Extension	\$5.59	\$12,422	\$1.91	\$4,250	\$7.50	\$16,672
Total	\$16.41	\$10,796	\$6.59	\$4,337	\$23.00	\$15,133
Option 5 – No Fence						
Kalbarri – Lake Moore	\$0.00	\$0	\$0.00	\$0	\$0.00	\$0
Lake Moore - Ravensthorpe	\$0.00	\$0	\$0.00	\$0	\$0.00	\$0
Esperance Extension	\$0.00	\$0	\$0.00	\$0	\$0.00	\$0
Total	\$0.00	\$0	\$0.00	\$0	\$0.00	\$0
Option 6 – Emu Specs. & Dog Netting						
Kalbarri – Lake Moore	\$3.93	\$8,362	\$2.29	\$4,862	\$6.22	\$13,224
Lake Moore - Ravensthorpe	\$4.18	\$6,967	\$3.15	\$5,249	\$7.33	\$12,215
Esperance Extension	\$4.57	\$10,156	\$2.11	\$4,699	\$6.68	\$14,855
Total	\$12.68	\$8,342	\$7.55	\$4,967	\$20.23	\$13,309

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10.1.2 Costs of Non-Fence Control Options

The aggregate non-fence control costs for the three lengths of State Barrier Fence, and the fence as a whole are presented in Table 10-2. The cost of each option is shown as the present value (PV) of cost over a 25 year period, and as a cost per km of fence. The length is assumed to be either the length of fence or the length of agricultural boundary in the case of the Esperance options without fence.

The level of control cost doesn't reflect an optimal level of protection. They are not in any means suggested as the level that is optimal in providing cost-efficient levels of control. The wild dog control inputs suggested for Option 5 (no fence) are considered to be what might be required to provide the maximum level of control that might be achieved with non-fence wild dog control options. All costs are based on per unit costs presented in Section 4.

Table 10-2: Non-Fence Control Costs on State Barrier Fence Alignment

	Non Fence Controls	
	PV (\$m)	\$/km
Option 1 - Maintain Existing Fence		
Kalbarri – Lake Moore	\$0.34	\$594
Lake Moore - Ravensthorpe	\$3.55	\$5,917
Esperance Extension	\$2.26	\$5,029
Total	\$6.15	\$3,797
Option 2 – Existing Fenceline to Emu Specs.		
Kalbarri – Lake Moore	\$0.28	\$499
Lake Moore - Ravensthorpe	\$3.50	\$5,827
Esperance Extension	\$2.26	\$5,029
Total	\$6.04	\$3,731
Option 3 – Fence and Realign to Emu Specs.		
Kalbarri – Lake Moore	\$0.18	\$375
Lake Moore - Ravensthorpe	\$3.39	\$5,646
Esperance Extension	\$2.26	\$5,029
Total	\$5.83	\$3,833
Option 4 – Fence to Wild Dog Specs.		
Kalbarri – Lake Moore	\$0.10	\$214
Lake Moore - Ravensthorpe	\$1.94	\$3,228
Esperance Extension	\$1.05	\$2,324
Total	\$3.08	\$2,028
Option 5 – No Fence		
Kalbarri – Lake Moore	\$5.51	\$11,720
Lake Moore - Ravensthorpe	\$14.09	\$23,487
Esperance Extension	\$10.06	\$22,358
Total	\$29.66	\$19,514
Option 6 – Emu Specs. & Dog Netting		
Kalbarri – Lake Moore	\$0.10	\$214
Lake Moore - Ravensthorpe	\$1.94	\$3,228
Esperance Extension	\$1.05	\$2,324
Total	\$3.08	\$2,028

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Financial and Economic Analysis

10.1.3 Combined Fence and Non-Fence Control Costs

The aggregate fence and non-fence control costs for the three lengths of State Barrier Fence, and the fence as a whole are presented in Table 10-3. The cost of each option is shown as the present value (PV) of cost over a 25 year period, and as a cost per km of fence. The length is assumed to be either the length of fence or the length of agricultural boundary in the case of the Esperance options without fence.

Total costs over 25 years, for example, are some \$26.1 million or \$17,200 per km for the wild dog specifications (15 line) and \$13.9 million or \$8,600 per km to maintain the existing fence. The option to achieve wild dog control with the addition of dog netting on the bottom of the 10 line emu fence costs \$23.3 million. This suggests a saving of some \$2.8 million or about \$1,900 per km over the 15 line wild dog specification option. The no-fence scenario is likely to cost more than the fence options as the costed non-fence control options (largely for wild dog control only) are more expensive than the capital development costs associated with all the fence options.

Table 10-3: Aggregate Fence and Non-Fence Control Costs

	Fence PV (\$m)	Non-Fence PV (\$m)	Total	
			PV (\$m)	\$/km
Option 1 - Maintain Existing Fence				
Kalbarri – Lake Moore	\$3.79	\$0.34	\$4.13	\$7,239
Lake Moore - Ravensthorpe	\$3.99	\$3.55	\$7.54	\$12,568
Esperance Extension	\$0.00	\$2.26	\$2.26	\$5,029
	\$7.78	\$6.15	\$13.93	\$8,599
Option 2 – Existing Fenceline to Emu Specs.				
Kalbarri – Lake Moore	\$6.24	\$0.28	\$6.52	\$11,439
Lake Moore - Ravensthorpe	\$6.20	\$3.50	\$9.70	\$16,159
Esperance Extension	\$0.00	\$2.26	\$2.26	\$5,029
	\$12.43	\$6.04	\$18.48	\$11,406
Option 3 – Fence and Realign to Emu Specs.				
Kalbarri – Lake Moore	\$5.83	\$0.18	\$6.00	\$12,774
Lake Moore - Ravensthorpe	\$6.80	\$3.39	\$10.19	\$16,978
Esperance Extension	\$0.00	\$2.26	\$2.26	\$5,029
	\$12.63	\$5.83	\$18.45	\$12,141
Option 4 – Fence to Wild Dog Specs.				
Kalbarri – Lake Moore	\$7.18	\$0.10	\$7.28	\$15,496
Lake Moore - Ravensthorpe	\$8.32	\$1.94	\$10.25	\$17,090
Esperance Extension	\$7.50	\$1.05	\$8.55	\$18,996
	\$23.00	\$3.08	\$26.09	\$17,162
Option 5 – No Fence				
Kalbarri – Lake Moore	\$0.00	\$5.51	\$5.51	\$11,720
Lake Moore - Ravensthorpe	\$0.00	\$14.09	\$14.09	\$23,487
Esperance Extension	\$0.00	\$10.06	\$10.06	\$22,358
	\$0.00	\$29.66	\$29.66	\$19,514
Option 6 – Realign with Emu Specs.+Dog Netting				
Kalbarri – Lake Moore	\$6.22	\$0.10	\$6.32	\$13,438
Lake Moore - Ravensthorpe	\$7.33	\$1.94	\$9.27	\$15,443
Esperance Extension	\$6.68	\$1.05	\$7.73	\$17,179
	\$20.23	\$3.08	\$23.31	\$15,337

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10.1.4 Annual Cost of Capital, Maintenance and Non-Fence Control Costs

The total capital, maintenance and non-fence control costs are presented as an annuity cost per kilometre in Table 10-4. This is the annual payment per km of fence that would be required to meet the total costs over 25 years. An interest rate of six per cent has been used (being the same as the discount rate used in the overall analysis). These costs provide a basis to assess any cost-sharing arrangements.

Table 10-4: Annual Fence and Non-Fence Control Costs (\$/Km)

	Capital Costs	Maintenance Costs	Control Costs	Total
Option 1 - Maintain Existing Fence				
Kalbarri – Lake Moore	\$0	\$520	\$46	\$566
Lake Moore - Ravensthorpe	\$0	\$520	\$463	\$983
Esperance Extension	\$0	\$0	\$393	\$393
Option 2 – Existing Fenceline to Emu Specs.				
Kalbarri – Lake Moore	\$504	\$352	\$39	\$895
Lake Moore - Ravensthorpe	\$432	\$377	\$456	\$1,264
Esperance Extension	\$0	\$0	\$393	\$393
Option 3 – Fence and Realign to Emu Specs.				
Kalbarri – Lake Moore	\$614	\$356	\$29	\$999
Lake Moore - Ravensthorpe	\$510	\$377	\$442	\$1,328
Esperance Extension	\$0	\$0	\$393	\$393
Option 4 – Fence to Wild Dog Specs.				
Kalbarri – Lake Moore	\$864	\$332	\$17	\$1,212
Lake Moore - Ravensthorpe	\$733	\$352	\$253	\$1,337
Esperance Extension	\$972	\$332	\$182	\$1,486
Option 5 – No Fence				
Kalbarri – Lake Moore	\$0	\$0	\$917	\$917
Lake Moore - Ravensthorpe	\$0	\$0	\$1,837	\$1,837
Esperance Extension	\$0	\$0	\$1,749	\$1,749
Option 6 – Realign with Emu Specs.+ Dog Netting				
Kalbarri – Lake Moore	\$654	\$380	\$17	\$1,051
Lake Moore - Ravensthorpe	\$545	\$411	\$253	\$1,208
Esperance Extension	\$794	\$368	\$182	\$1,344

10.1.5 Control Effectiveness versus Fence and Non-Fence Control Costs

The assumed levels of effectiveness of emu, wild dog and kangaroo control are compared against the budgeted fence and non-fence control costs of each option in Table 10-5. For example, the wild dog control provided by Option 6 (90%) is assumed to be not quite as good as the 15 line wild dog fence (95%), but because the fence is not as high it is less prone to be pushed over by emus. Consequently it is assumed to offer better emu control - 95% as opposed to 90% with the 15 line fence.

Per km costs and estimated effectiveness of the existing fence option provide an interesting comparison of the costs and levels of control provided by the existing strategies on the three lengths of agricultural

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boundary. The non-fence control expenditure in the Esperance region is about 70% of that spent along the Kalbarri to Lake Moore section yet it provides less than a tenth of the protection against emus, and possibly less protection against wild dogs.

Table 10-5: Control Effectiveness Verses Fence and Non-Fence Control Costs

	Cost \$/km	Effectiveness of Control		
		Emu – Big Migration	Wild Dogs	Kangaroos
Option 1 - Maintain Existing Fence				
Kalbarri – Lake Moore	\$7,239	85%	15%	65%
Lake Moore - Ravensthorpe	\$12,568	85%	25%	65%
Esperance Extension	\$5,029	5%	10%	35%
Option 2 – Existing Fenceline to Emu Specs.				
Kalbarri – Lake Moore	\$11,439	90%	15%	75%
Lake Moore - Ravensthorpe	\$16,159	90%	25%	75%
Esperance Extension	\$5,029	5%	10%	35%
Option 3 – Fence and Realign to Emu Specs.				
Kalbarri – Lake Moore	\$12,774	95%	15%	90%
Lake Moore - Ravensthorpe	\$16,978	95%	25%	90%
Esperance Extension	\$5,029	5%	10%	35%
Option 4 – Fence to Wild Dog Specs.				
Kalbarri – Lake Moore	\$15,496	90%	95%	95%
Lake Moore - Ravensthorpe	\$17,090	90%	95%	95%
Esperance Extension	\$18,996	90%	95%	95%
Option 5 – No Fence				
Kalbarri – Lake Moore	\$11,720	5%	70%	35%
Lake Moore - Ravensthorpe	\$23,487	5%	70%	35%
Esperance Extension	\$22,358	5%	70%	35%
Option 6 – Realign with Emu Specs.+Dog Netting				
Kalbarri – Lake Moore	\$13,438	95%	90%	95%
Lake Moore - Ravensthorpe	\$15,443	95%	90%	95%
Esperance Extension	\$17,179	95%	90%	95%

10.2 Net Value of State Barrier Fence Options

The net value of each option in each section of the fence is displayed in Table 10-6. This shows the control costs (total of fence and non-fence as per Table 10-3), and the cost of emu, wild dog, and kangaroo impacts.

- The total cost column indicates the sum of control costs and the impact cost from each pest animal.
- NPV is the net present value of an option when compared against the existing fence (or no fence in the case of Esperance).
- BCR is the benefit cost ratio when comparing the difference in control costs, and damage costs between the existing fence and the existing fence/ non-fence situation.

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Benefit-Cost Analysis Decision Rules

NPV, BCR and IRR are benefit-cost analysis (BCA) indicators. They provide the basis of decision rules which should be interpreted as follows:

- **Net Present Value (NPV)** - The prime decision rule in benefit-cost analysis is that a program or project should, subject to budget constraints, be accepted if the PV of benefits exceeds the PV of its costs. That is, the program's NPV is greater than zero. If more than one option provides a positive NPV then the BCR of each option should then be compared.
- **Benefit: Cost Ratio (BCR)** - The BCR of a program is calculated by dividing the PV benefits by the PV of its costs ($BCR = PV \text{ benefits} / PV \text{ costs}$). A program with a BCR greater than one is acceptable because the PV of benefits exceeds the PV of costs. A benefit: cost ratio of 1.3 indicates that \$1.30 PV of benefit is received for each \$1.00 PV of cost. The BCR is a useful adjunct to the NPV but it should not be used as the sole decision rule because it may give an incorrect ranking if the projects differ in size.
- **Internal Rate of Return (IRR)** - The internal rate of return is the rate in which the present value of benefits equals the present value of costs. It is the rate in which the project's net benefits grow. If the IRR is greater than the rate of borrowed funds, the project should be supported. If the IRR is less than the rate of borrowed funds the project cannot be supported on economic grounds.

Preferred Options for each Section of Fence

Using the BCA decision rules this analysis suggests the following for each section of fence:

- **Kalbarri – Lake Moore.** Only one option is shown to provide better NPV than to maintain the existing fence. Realigning and re-fencing with 10 line plus dog netting (Option 6) provides a small net benefit of \$200,000, with a BCR of 1.08. This suggests this option is only marginally better than the existing fence option. The S6 fence is more expensive but this is offset by additional emu protection (\$1.1 million), wild dog protection (\$400,000), and reduced loss from kangaroos which is estimated at \$800,000. Without the suggested additional protection from kangaroos, as a result of the wild dog netting, the existing fence would remain the preferred option. Otherwise realignment and fencing to emu specifications (S3) would provide a near to break-even alternative.
- **Lake Moore – Ravensthorpe.** Two options present positive NPVs. Realigning and fencing to 15 line wild dog standard (S4), and 10 line emu standard plus wild dog netting (S6). The highest NPV is provided by S6, which at \$2.5 million is \$1.2 million better than the S4 option. This is because the S6 option is \$1.0 million cheaper in terms of construction, maintenance, and non-fence control costs. It is also suggested to provide an additional \$400,000 worth of emu damage protection, but \$200,000 less wild dog protection. The S6 option is suggested to provide a BCR of 2.42. This suggests strong social returns on the required investment. Implementation of S4 is estimated to generate a BCR of 1.47 which is also a high return on investment.
- **Esperance Extension.** Similarly two options present positive NPV. Realigning and fencing to 15 line wild dog standard (S4), and 10 line emu standard plus wild dog netting (S6). The highest NPV is provided by S6, which at \$6.5 million is \$1.1 million better than the S4 option. This is because the S6 option is \$800,000 million cheaper in terms of construction, maintenance, and non-fence control costs. It is also suggested to provide an addition \$400,000 worth of emu damage protection, but \$200,000 less wild dog protection. The S6 option is suggested to provide a BCR of 2.18. This suggests strong social returns on the required investment. Implementation of S4 is estimated to generate a BCR of 1.86 which is also a very high return on investment.

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Table 10-6: Net Value of State Barrier Fence Options (\$m)

	Control Costs	Emu Impacts	Wild Dog Impacts	Roo Impacts	Total Costs	BCR	NPV
Kalbarri – Lake Moore							
S1 - Existing Fence	-\$4.1	-\$1.6	-\$0.5	-\$0.9	-\$7.2		\$0.0
S2 – Existing to Emu Specs.	-\$6.5	-\$1.1	-\$0.5	-\$0.6	-\$8.8	0.34	-\$1.6
S3 – Realign to Emu Specs.	-\$6.0	-\$0.5	-\$0.5	-\$0.3	-\$7.3	0.93	-\$0.1
S4 – Wild Dog Specs.	-\$7.3	-\$1.0	\$0.0	-\$0.1	-\$8.4	0.61	-\$1.2
S5 – No Fence	-\$5.5	-\$11.0	-\$0.2	-\$1.7	-\$18.3	-7.06	-\$11.1
S6 – Emu + Dog Netting	-\$6.3	-\$0.5	-\$0.1	-\$0.1	-\$7.0	1.08	\$0.2
Lake Moore - Ravensthorpe							
S1 - Existing Fence	-\$7.5	-\$1.5	-\$3.1	-\$0.5	-\$12.7		\$0.0
S2 – Existing to Emu Specs.	-\$9.7	-\$1.0	-\$3.1	-\$0.4	-\$14.2	0.31	-\$1.5
S3 – Realign to Emu Specs.	-\$10.2	-\$0.5	-\$3.1	-\$0.2	-\$13.9	0.53	-\$1.2
S4 – Wild Dog Specs.	-\$10.3	-\$0.9	-\$0.2	-\$0.1	-\$11.4	1.47	\$1.3
S5 – No Fence	-\$14.1	-\$10.1	-\$1.2	-\$1.0	-\$26.4	-1.09	-\$13.7
S6 – Emu + Dog Netting	-\$9.3	-\$0.5	-\$0.4	-\$0.1	-\$10.2	2.42	\$2.5
Esperance Extension							
S1 - Existing Fence	-\$2.3	-\$9.8	-\$2.3	-\$0.6	-\$15.0		\$0.0
S2 – Existing to Emu Specs.	-\$2.3	-\$9.8	-\$2.3	-\$0.6	-\$15.0		\$0.0
S3 – Realign to Emu Specs.	-\$2.3	-\$9.8	-\$2.3	-\$0.6	-\$15.0		\$0.0
S4 – Wild Dog Specs.	-\$8.5	-\$0.9	-\$0.1	\$0.0	-\$9.6	1.86	\$5.4
S5 – No Fence	-\$10.1	-\$9.8	-\$0.8	-\$0.6	-\$21.2	0.19	-\$6.3
S6 – Emu + Dog Netting	-\$7.7	-\$0.5	-\$0.3	\$0.0	-\$8.5	2.18	\$6.5

The net value of the options indicated to provide positive NPV are shown in Table 10-7. These numbers are the difference between the displayed option and the existing situation (S1). These results also include IRR estimates. Notably S6 on the Esperance Extension provides a higher IRR than S6 on the Lake Moore to Ravensthorpe length of fence but a lower benefit cost ratio. This suggests benefits will accrue quicker on the Esperance section.

This result needs to be understood and interpreted within the context of how emu benefits were estimated. Benefits of avoiding emu migrations are incorporated as the average benefit each year. In reality the benefit may occur as a large value in one year which could be in year one or otherwise. The IRR result may not therefore be relevant as the timing of the flow of benefits may be different to the way they have been evaluated.

Using the base set of assumptions production and damage parameters the Option 6 – Emu specification plus dog netting is indicated as the preferred option in all three lengths of fence-line. It is shown to be marginally better than the existing fence in the northern section, but provides significant net social benefits in the southern section of the existing State Barrier Fence, and for the proposed Esperance Extension.

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Table 10-7: Net Value of Preferred Options in each Zone (\$m)

	Control Costs	Emu Impacts	Wild Dog Impacts	Roo Impacts	BCR	NPV (\$m)	IRR
Kalbarri – Lake Moore							
S6 – Emu + Dog Netting	-2.2	1.1	0.5	0.8	1.08	0.2	6.6%
Lake Moore - Ravensthorpe							
S4 – Wild Dog Specs.	-2.7	0.6	2.9	0.5	1.47	1.3	8.7%
S6 – Emu + Dog Netting	-1.7	1.0	2.7	0.5	2.42	2.5	12.7%
Esperance Extension							
S4 – Wild Dog Specs.	-6.3	8.9	2.1	0.6	1.86	5.4	17.1%
S6 – Emu + Dog Netting	-5.5	9.3	2.0	0.6	2.18	6.5	22.2%
Whole Fence							
All Option 6	-9.4	11.5	5.2	1.8	1.97	9.1	14.4%

10.3 Implications of Changed Agriculture and Wild Dog Pressures

Two changing trends that may influence future benefits from the State Barrier Fence were suggested by stakeholders. They were:

- Increased wild dog pressure in the northern section of the existing fence (Kalbarri – Lake Moore); and
- Reduced returns from cropping resulting in shifts in land-use from cropping to livestock along the Kalbarri to Lake Moore section.

The effects of these possible shifts were modelled by changing land-use to 35 per cent cropping and 65 per cent pasture (reversal of current situation), reducing crop and pasture yields by 10 per cent, and increasing the rate of wild dog losses to match that assumed for Esperance and the southern section of the existing SBF.

The results shown in Table 10-8 now indicate two options providing positive NPV - Realigning and fencing to 15 line wild dog standard (S4), and 10 line emu standard plus wild dog netting (S6).

The highest NPV is still provided by S6, which at \$1.3 million is \$1.0 million better than the S4 option – and \$1.1 million more than under the base parameters. Although benefits from avoiding emu damage are less with reduced cropping in the region, this is more than offset by the benefits of wild dog control. The S6 option is suggested to provide a BCR of 1.58. This suggests good social returns on the required investment.

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Table 10-8: Net Value of State Barrier Fence Options (\$m)

	Control Costs	Emu Impacts	Wild Dog Impacts	Roo Impacts	Total Costs	BCR	NPV
Kalbarri – Lake Moore							
S1 - Existing Fence	-\$4.1	-\$0.8	-\$2.9	-\$0.4	-\$8.2		\$0.0
S2 – Existing to Emu Specs.	-\$6.5	-\$0.5	-\$2.9	-\$0.3	-\$10.2	0.16	-\$2.0
S3 – Realign to Emu Specs.	-\$6.0	-\$0.2	-\$2.9	-\$0.1	-\$9.3	0.45	-\$1.0
S4 – Wild Dog Specs.	-\$7.3	-\$0.5	-\$0.2	-\$0.1	-\$8.0	1.08	\$0.3
S5 – No Fence	-\$5.5	-\$5.3	-\$1.0	-\$0.8	-\$12.6	-2.18	-\$4.4
S6 – Emu + Dog Netting	-\$6.3	-\$0.2	-\$0.3	-\$0.1	-\$7.0	1.58	\$1.3

10.4 Sensitivity Analysis

10.4.1 Implications of Reduced Agriculture Production

The effect of reduced agriculture productivity was modelled by reducing crop and pasture yields by 10 and 20 per cent across all regions. The results shown in Table 10-9 indicate the existing fence to be the best option for the northern section of the SBF with a 10 per cent yield reduction. The 10 line emu standard plus wild dog netting (S6) remains the best option for the southern section of the SBF and the Esperance Extension even with a 20 reduction in agricultural productivity.

Table 10-9: Implications of Reduced Agriculture Production

	10 % Productivity Decline		20 % Productivity Decline	
	BCR	NPV (\$m)	BCR	NPV (\$m)
Kalbarri – Lake Moore				
S1 - Existing Fence		\$0.0		\$0.0
S2 – Existing to Emu Specs.	0.31	-\$1.7	0.27	-\$1.7
S3 – Realign to Emu Specs.	0.84	-\$0.3	0.74	-\$0.5
S4 – Wild Dog Specs.	0.55	-\$1.4	0.49	-\$1.6
S5 – No Fence	-6.36	-\$10.2	-5.65	-\$9.2
S6 – Emu + Dog Netting	0.97	-\$0.1	0.86	-\$0.3
Lake Moore - Ravensthorpe				
S1 - Existing Fence		\$0.0		\$0.0
S2 – Existing to Emu Specs.	0.28	-\$1.6	0.25	-\$1.6
S3 – Realign to Emu Specs.	0.48	-\$1.4	0.42	-\$1.5
S4 – Wild Dog Specs.	1.32	\$0.9	1.17	\$0.5
S5 – No Fence	-0.98	-\$13.0	-0.88	-\$12.3
S6 – Emu + Dog Netting	2.18	\$2.0	1.94	\$1.6
Esperance Extension				
S1 - Existing Fence		\$0.0		\$0.0
S2 – Existing to Emu Specs.		\$0.0		\$0.0
S3 – Realign to Emu Specs.		\$0.0		\$0.0
S4 – Wild Dog Specs.	1.67	\$4.2	1.49	\$3.0
S5 – No Fence	0.17	-\$6.4	0.15	-\$6.6
S6 – Emu + Dog Netting	1.97	\$5.3	1.75	\$4.1

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10.4.2 Implications of Discount Rate

Discount rate is the rate at which future values are discounted to present. This analysis was undertaken using “real” rather than “nominal” values so the discount rate used reflects a rate of time preference. It is not adjusted to account for inflation as real values are used throughout the analysis.

The effect of discount rate was modelled. The results shown in Table 10-9 indicate the existing fence to be the best option for the northern section of the SBF with an 8% discount rate. The 10 line emu standard plus wild dog netting (S6) option in the northern section is sensitive to a discount over 6%. In the southern section of the SBF and the Esperance Extension the 10 line emu standard plus wild dog netting (S6) remains the best option even with a discount rate of 10%. In these regions the S6 option is robust to changes in discount rate. The IRR results shown above indicate it will remain the preferred option even at a discount rate of 12%.

Table 10-10: Implications of varying Discount Rates

	Discount Rate				
	4.0%	5.0%	6.0%	8.0%	10.0%
Kalbarri – Lake Moore					
S1 - Existing Fence	0	0	0	0	0
S2 – Existing to Emu Specs.	-1,280	-1,440	-1,580	-1,814	-1,999
S3 – Realign to Emu Specs.	479	152	-132	-598	-959
S4 – Wild Dog Specs.	-543	-904	-1,217	-1,731	-2,130
S5 – No Fence	-13,364	-12,173	-11,146	-9,483	-8,213
S6 – Emu + Dog Netting	878	496	165	-378	-798
Lake Moore - Ravensthorpe					
S1 - Existing Fence	0	0	0	0	0
S2 – Existing to Emu Specs.	-1,230	-1,368	-1,488	-1,690	-1,849
S3 – Realign to Emu Specs.	-819	-1,047	-1,246	-1,573	-1,828
S4 – Wild Dog Specs.	2,553	1,865	1,270	299	-450
S5 – No Fence	-16,451	-14,984	-13,720	-11,673	-10,110
S6 – Emu + Dog Netting	3,732	3,049	2,458	1,496	755
Esperance Extension					
S1 - Existing Fence	0	0	0	0	0
S2 – Existing to Emu Specs.	0	0	0	0	0
S3 – Realign to Emu Specs.	0	0	0	0	0
S4 – Wild Dog Specs.	7,477	6,354	5,383	3,804	2,593
S5 – No Fence	-7,542	-6,869	-6,290	-5,352	-4,635
S6 – Emu + Dog Netting	8,592	7,455	6,471	4,873	3,646

10.4.3 Damage Rate Crossover Values

Cross over values indicate the point where the preferred option changes as a result of changing one of the input parameters. The rates of damage from emus and wild dogs were reduced to see if the result was sensitive to the assumed rates. The results shown in columns one and two in Table 10-11 are where the emu and wild dog parameters are changed one at a time, not simultaneously. The third column shows where both are changed at the same rate together.

Table 10-11 shows how much these rates would need to change in order to change the preferred option. Where damage from each is varied singularly, the S6 option in the northern section of the fence is

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sensitive to changed parameters. For example, if the rate of emu damage is reduced to 75% of the assumed base rate then the preferred option is the existing fence (S1). Selection of S6 in the Lake Moore to Ravensthorpe section, and in the Esperance Extension is insensitive to changes in either source of damage.

Where both rates are reduced together, a 10% reduction is required to switch to S1 in the northern section of the fence, reinforcing the marginal nature of the S6 result. The other two regions require major reduction is assumed damage rates before another option is shown as preferred (S1 in all cases).

Table 10-11: Damage Rate Crossover Values

	Emu Damage	Wild Dog Damage	Combined
Kalbarri – Lake Moore	Reduce damage rate to 85%of base rate - S6 to S1	Reduce damage rate to 75%of base rate - S6 to S1	Reduce damage rates to 90%of base rates - S6 to S1
Lake Moore - Ravensthorpe	Remains S6 even with zero damage from emus	Reduce damage rate to 10%of base rate - S6 to S1	Reduce damage rates to 35%of base rates - S6 to S1
Esperance Extension	Reduce damage rate to 30%of base rate - S6 to S1	Reduce damage rate to 0%of base rate - S6 remains preferred option	Reduce damage rates to 45%of base rates - S6 to S1

10.4.4 Fence Costs Crossover Values

Table 10-12 shows how much fence capital, works and maintenance cost estimates would have to change before the preferred option changes. Costs for each option were varied by the same amount. If all costs were increased by 105% then on the northern section of the fence S1 becomes the preferred option. On the southern section and the Esperance Extension costs would need to increase by 170% and 195% respectively before S1 becomes the preferred option. S6 is robust as the preferred option along these lengths of the agricultural boundary.

Table 10-12: Fence Cost Crossover Values

	Fence Costs
Kalbarri – Lake Moore	Increase fence cost estimates by 105%of base rate - S6 to S1
Lake Moore - Ravensthorpe	Increase fence cost estimates by 170%of base rate - S6 to S1
Esperance Extension	Increase fence cost estimates by 195%of base rate - S6 to S1

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11.1 Benefit-Cost Analysis Summary

The benefit-cost analysis compared the costs of alternative fences and associated non-fence control measures against the benefits provided by reducing the impacts of damage caused by emus, wild dogs, and kangaroos over a 25 year time period. Impacts from each of the pest animals were costed against crop and livestock production values. The effectiveness of alternative fence specifications and alignments were rated by their capacity to reduce pest animal impacts.

These values were all defined for each alternative fence along three lengths of agricultural boundary: Kalbarri to Lake Moore, and Lake Moore to Ravensthorpe (which are part of the existing State Barrier Fence), and the possible Esperance Extension. The fence, non-fence and total fence and non-fence control costs for each scenario across all three lengths of agricultural boundary were shown to be as follows:

	Fence	Non-Fence Controls	Total
Option 1 - Maintain Existing Fence	\$7.78m	\$6.15m	\$13.93m
Option 2 – Existing Fenceline to Emu Specifications	\$12.43m	\$6.04m	\$18.48m
Option 3 – Fence and Realign to Emu Specifications	\$12.63m	\$5.83m	\$18.45m
Option 4 – Fence to Wild Dog Specifications	\$23.00m	\$3.08m	\$26.09m
Option 5 – No Fence	\$0.00m	\$29.66m	\$29.66m
Option 6 – Realign with Emu Specifications + Dog Netting	\$20.23m	\$3.08m	\$23.31m

The cost of maintaining the existing fence, and non-fence controls was estimated to be \$13.93 million over 25 years. Uniform adoption of a realigned and upgraded emu standard fence along all three lengths of boundary will cost \$18.45 million whilst an emu standard fence with the addition of wild dog netting on the bottom would cost an estimated \$23.31 million. If net benefits suggest it, different specifications might be applied to each length of fence.

The value of avoided damage from emu, wild dog, and kangaroo impacts with each fence specification varies significantly between species and fence specification. The emu and wild dog damage costs with each fence scenario across all three lengths of agricultural boundary were shown to be as follows:

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	Emu	Wild Dog	Kangaroo
Option 1 - Maintain Existing Fence			
Kalbarri – Lake Moore	\$1.6m	\$0.5m	\$0.9
Lake Moore – Ravensthorpe	\$1.5m	\$3.1m	\$0.5
Esperance Extension	\$9.8m	\$2.3m	\$0.6
Option 2 – Existing Fenceline to Emu Specifications			
Kalbarri – Lake Moore	\$1.1m	\$0.5m	\$0.6
Lake Moore – Ravensthorpe	\$1.0m	\$3.1m	\$0.4
Esperance Extension	\$9.8m	\$2.3m	\$0.6
Option 3 – Fence and Realign to Emu Specifications			
Kalbarri – Lake Moore	\$0.5m	\$0.5m	\$0.3
Lake Moore – Ravensthorpe	\$0.5m	\$3.1m	\$0.2
Esperance Extension	\$9.8m	\$2.3m	\$0.6
Option 4 – Fence to Wild Dog Specifications			
Kalbarri – Lake Moore	\$1.0m	\$0.0m	\$0.1
Lake Moore – Ravensthorpe	\$0.9m	\$0.2m	\$0.1
Esperance Extension	\$0.9m	\$0.1m	\$0.0
Option 5 – No Fence			
Kalbarri – Lake Moore	\$11.0m	\$0.2m	\$1.7
Lake Moore – Ravensthorpe	\$10.1m	\$1.2m	\$1.0
Esperance Extension	\$9.8m	\$0.8m	\$0.6
Option 6 – Realign with Emu Specifications + Dog Netting			
Kalbarri – Lake Moore	\$0.5m	\$0.1m	\$0.1
Lake Moore – Ravensthorpe	\$0.5m	\$0.4m	\$0.1
Esperance Extension	\$0.5m	\$0.3m	\$0.0

The reduction in damage from the existing fence and non-fence controls to that which might be achieved with the emu fence plus wild dog netting are:

- Kalbarri – Lake Moore (emus \$1.1m, wild dogs \$0.4m, and kangaroos \$0.8m),
- Lake Moore – Ravensthorpe (emus \$1.0m, wild dogs \$2.7m, and kangaroos \$0.4), and
- Esperance Extension (emus \$9.3m, wild dogs \$2.0m, and kangaroos \$0.6m).

When all costs and benefits are taken into account the option indicated to provide the highest net present value and benefit-cost ratio was Option 6, Realignment with Emu Specifications plus Dog Netting. Option 4 was also shown to provide positive net returns in the southern two lengths of boundary.

Using the base set of assumptions production and damage parameters the Option 6 fence was indicated as the preferred option in all three lengths of fence-line. It is shown to be marginally better than the existing fence in the northern section, but to provide significant net social benefits in the southern section of the existing State Barrier Fence (NPV \$6.5m, BCR 2.18), and for the proposed Esperance Extension (NPV \$9.1m, BCR 1.97). Sensitivity analysis across a range of parameters indicated the Option 6 fence, Realignment with Emu Specifications plus Dog Netting, to be a robust solution along the two southern sections.

11.2 Beneficiaries: Public or Private Benefit

The assessment of emu, wild dog and kangaroo behaviour describes behavioural variations which impact on how damage is caused, where it is caused and how it is costed. This has some effect on how the mixture of public and private benefits might be understood. The benefit-cost analysis showed the mixture and magnitude of damage avoided by different fences varies across the three species as well. Along the

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Esperance extension the majority of benefits are expected to arise from emu control, whereas along the Lake Moore to Ravensthorpe section that majority of additional benefits are suggested to come from wild dog control.

Wild dog impacts were shown to be largely confined to within five km 'inside' of the agricultural boundary. Kangaroo impacts from animals outside the boundary entering farming land are much less than that – with the incursion distance confined usually to several hundred metres. Therefore, these impacts will be expected to occur primarily on the properties that are adjacent to the fence alignment. It follows that a barrier fence will provide a direct benefit against wild dog and kangaroo impacts to properties directly neighbouring the fence.

The situation for emus is likely to be different. Emus, especially with big migrations, exhibit very different behaviour. They are suggested to travel up to four km per day within farming land where there is ample forage, and may remain in these areas for 30 days or so. Even without travelling in straight lines into the agricultural area there is potential for them to migrate across three or four farm boundaries. Control at the boundary benefits the properties adjacent to the fence and potentially those within 20 to 30 km of the fence. However, it might be expected that greatest impacts will occur on areas closer to the agricultural boundary and diminish as emus disperse of a greater area.

Pannell (2008) defines private net benefits as those where benefits minus costs accrue to the private land manager as a result of proposed changes in land management. He also suggests private benefits are broader than financial benefits, and include the broad range of factors that influence the relative advantage of the new land use options (as perceived by the landholders) such as risk, complexity, social considerations, personal attitude to the environment, and farming-systems impacts of the land-use. Public net benefits are defined by Pannell (2008) as those where benefits minus costs accruing to everyone other than the private land manager.

These definitions suggest benefits from a State Barrier Fence accrue to private landholders, if not in entirety then certainly in the majority. Benefits estimated as part of this assessment should be defined as private. Any public benefits might be additional and are suggested to be minimal in magnitude.

The question of public or private benefit generally arises with respect to cost-sharing arrangements. The mix of net public and private benefits contribute to negotiated cost sharing. This report was not required to undertake a cost sharing analysis but it offers issues that might be considered in developing one.

Wild dog and kangaroo benefits are largely private and will generally accrue to landholders neighbouring a barrier fence. Emu benefits are likely to accrue to a broader set of landholders but will still primarily be private in nature. Differences between landholders may occur in the area of non-fence control costs. If landholders adjacent to the boundary incur more non-fence control costs, which benefit other landholders, then it might be reasonable they incur a smaller proportion of any fence costs. How cost may be shared can be guided by cost-share principles.

Another issue that might be considered is the fact that current landholders along the three sections of potential barrier fence have purchased and or operated their properties under a different set of attributes. Landholders along the two northern sections purchased their properties at a value that would have reflected the existing level of emu control. Landholders along the Esperance section have purchased their properties at a price that reflects the management costs and impacts arising from emu and wild dog damage. Landholders along the fence will receive not only benefits from additional pest animal control, but also capital benefits in the form of higher property values associated with reduced operating costs.

11.3 Cost share Implications

Cost sharing between stakeholders is used to provide a means to achieve investment in projects that deliver net social benefits that might otherwise not be achieved if the full cost is apportioned to one party. Cost sharing may also be appropriate to overcome barriers to investment or inappropriately directed investment caused by market failures such as insufficient, inadequate or costly information, public goods,

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and externalities. This section briefly describes principles on which cost-sharing arrangements are commonly based, and how they may be applied in a practical and relevant manner to the barrier fence.

11.3.1 Cost share principles

There are two broad principles for determining the allocation or sharing of costs — ‘polluter pays or ‘beneficiary pays’. The two principles have different efficiency and distributional effects.

Polluters Pays

The notion that if ‘you make a mess you clean it up’ has been enshrined in the ‘polluter-pays’ principle for environmental protection. Requiring polluters to pay is often regarded as being the fairest and most equitable policy. It is also the most efficient policy when the principle can be applied to stop pollution before it occurs, or to control it within acceptable limits.

The polluter-pays principle requires polluters to be effectively identified and their pollution measured, monitored and levied. If this is the case then it is sensible that that polluter-pays principle should take precedence over the beneficiary-pays principle for sharing the funding of management measures. The polluter-pays principle provides an economic disincentive to pollute.

The polluter-pays principle is difficult to apply when there are high costs of identifying the polluters and monitoring the damage they cause. This may be a case in point for ‘non-point’ pollution arising, for example, from drainage activities. This principle does not apply in the case of the barrier fence.

Beneficiaries Pay

Paying a price that reflects the social value of goods and services received provides an economically efficient allocation of resources. Governments and public authorities recognise the importance of efficient use of scarce resources and that services provided by public authorities should be paid for by beneficiaries of those services. The beneficiary-pays principle has been adopted by many authorities for determining who should meet the costs of the works undertaken as part of land and water planning, and for any subsequent investment in on-ground works. Hajkowicz and Young (2000) and Aretino, (2001) defined a number of rules for the application of the beneficiaries pay principle.

- Direct and indirect beneficiaries should share costs.
- Governments should only provide funds where they generate net public benefits and where (environmental management) would not already occur. To ensure accountability and to avoid establishing perverse incentives, such investment of public funds needs to meet other criteria, including that:
 - public payments are clearly linked to the delivery of outcomes;
 - funding does not cover costs related to private benefits (although there may be some exceptions), and
 - funding achieves value for money by maximising the social benefits received for each dollar of funding.
- Government’s share need not be equal to the full public benefits generated. Governments need contribute only the minimum necessary to trigger appropriate environmental management by the private sector.
 - While it may be difficult to determine this incentive in advance, one way may be by calling for tenders or bids (auctions) for the voluntary provision of environmental services. This may help governments achieve value for money by allocating its funds to issues and providers that deliver the greatest environmental gain for a given cost.

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The basic tenet of cost share is that it is a negotiated process. This analysis suggests strong private benefits would be received by landholders along the southern section of the existing SBF and along the proposed Esperance extension. Marginal benefits are suggested for upgrading the northern section of the SBF, but show strongly that it should be maintained. Because of different net returns, and mixes of benefit from emus, wild dogs, and kangaroos the theoretical sharing arrangements between landholders, and between landholders and the community might be different for each section.

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Limitations

URS Australia Pty Ltd (URS) or Insert name of correct entity has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Department of Agriculture and Food and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 5 April 2007.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between 14 May 2007 and November 2007 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A

Acknowledgements

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- Ray Batt, Ray's Contracting, raythefencer@bigpond.com
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References: Biological

- ABC Science Online (2000). *Emu chicks emerging*. Scribble Gum, Australian Broadcasting Corporation. www.abc.net.au/science.scribblygum/August2000/default.htm
- Australian Museum (undated). *Emu Dromaius novaehollandiae*. Fact Sheet. www.amonline.net.au/birds/factsheets/emu.htm
- Caughley, G. and Grice, D.A. (1982). A correction factor for counting emus from the air and its application to counts in Western Australia. *Australian Wildlife Research* **9**, 253-260.
- Davies, S.J.J.F. (1976). The natural history of the Emu, compared to other ratites. pp. 109-122. *Proceedings of the 16th International Ornithological Congress*, Australian Academy of Sciences, Canberra.
- Dawson, T.J., Herd, R.M. and Skadhauge, E. (1983). Water turnover and body water distribution during dehydration in a large arid-zone bird, the Emu, *Dromaius novaehollandiae*. *Journal of Comparative Physiology* **153**(2), 235-240.
- Department of Agriculture (2001). *The State Barrier Fence of Western Australia – CENTENARY 1901 - 2001*. Government of Western Australia
- Department of Conservation and Land Management (2002). *Red kangaroo (Macropus rufus) Management Plan for Western Australia 2003-2007*. Government of WA.
- Department of Conservation and Land Management (2002). *Western Grey kangaroo (Macropus fuliginosus) Management Plan for Western Australia 2003-2007*. Government of WA.

Appendix A

Acknowledgements

- Department of Environment and Conservation (2007). *Management Plan for the commercial harvest of kangaroos in Western Australia 2008-2012 (Draft)*. Government of Western Australia
- EconSearch Pty Ltd, (2000). *Economic Assessment of the Wild Dog Barrier Fence*. Report for Department of Natural Resources, Queensland, October 2000.
- Grice, D, Caughley, G. and Short, J. (1985). Density and distribution of emus. *Australian Wildlife Research* **12**, 69-73.
- Pople, A., Cairns, S. and Grigg, G. (1991). Distribution and abundance of emus *Dromaius novaehollandiae* in relation to the environment in the South Australian pastoral zone. *Emu* **91**, 222-229.
- Pople, A. and Grigg, G. (1999). *Commercial harvesting of kangaroos in Australia*. Report prepared by the University of Queensland for Environment Australia
- Pople, A.R., Phinn, S.R., Menke, N., Grigg, G.C., Possingham, H.P. and McAlpine, C. (2007). Spatial patterns of kangaroo density across the South Australian pastoral zone over 26 years: aggregation during drought and suggestions for long distance movement. *Journal of Applied Ecology* **44**, 1068-1079
- Rural Management Partners (2004). *Economic assessment of the impact of dingoes/wild dogs in Queensland*, report prepared for Department of Natural Resources and Mines
- Stanley, J., Herbert, J. and Strong, K. (2001). Untitled Department of Natural Resources paper describing operational costs of the Queensland Wild Dog Barrier Fence (WDBF) and the management alternatives for continued maintenance and reconstruction.
- Thomson, P.C. (1986). The effectiveness of aerial baiting for the control of dingoes in North-Western Australia. *Australian Wildlife Research* **13**, 165-176.
- Thomson, P. and Rose, K. (2006). *Wild dog management. Best Practice Manual*. Bulletin 4677, Department of Agriculture and Food. Agriculture Protection Board of WA.
- Thomson, P.C. and Marsack, P.R. (1992). Aerial baiting of dingoes in arid pastoral areas with reference to rabies control. *Bureau of Rural Resources Proceedings* **11**, 125-134
- Thomson, P.C., Rose, K. and Kok, N.E. (1992a). The Behavioural ecology of dingoes in North-Western Australia. IV. Social and spatial organisation, and movements. *Australian Wildlife Research* **19**, 543-563.
- Thomson, P.C., Rose, K. and Kok, N.E. (1992b). The Behavioural ecology of dingoes in North-Western Australia. V. Population dynamics and variation in the social system. *Australian Wildlife Research* **19**, 565-584.
- Thomson, P.C., Rose, K. and Kok, N.E. (1992c). The Behavioural ecology of dingoes in North-Western Australia. VI. Social and spatial organisation and movements. *Australian Wildlife Research* **19**, 565-584.

References Economic

- Aretino, B., Holland, P., Matysek, A. and Peterson, D. (2001). Cost Sharing for Biodiversity Conservation: A Conceptual Framework. Productivity Commission Staff Research Paper, AusInfo, Canberra.
- EconSearch Pty Ltd, (2000). *Economic Assessment of the Wild Dog Barrier Fence*. Report for Department of Natural Resources, Queensland, October 2000.
- Hajkowicz, S. and Young, M. D. (2000). An economic analysis and cost sharing assessment for dryland salinity management. Report for Primary Industry and Resources SA prepared by Policy and Economics Research Unit, CSIRO Land and Water.
- Jerry Stanley, Jim Herbert, and Kevin Strong (2001). Untitled Department of Natural Resources paper describing operational costs of the Queensland Wild Dog Barrier Fence (WDBF) and the management alternatives for continued maintenance and reconstruction.
- Pannell, D.J. (2008). Public benefits, private benefits, and policy intervention for land-use change for environmental benefits, Land Economics (forthcoming).
- Rural Management Partners (2004). *Economic assessment of the impact of dingoes/wild dogs in Queensland*, report prepared for Department of Natural Resources and Mines