Preparing Road Reserve Asset Management Plans

Milestone 9 of the Road Reserve Asset Management Plan (RRAMP) project

Western Australian Local Government Association

science+design

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Table of Contents

List of Figures

List of Tables

List of Images

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Executive Summary

INTRODUCTION

Ecoscape, Wajon and Associates and ShawMac (the Project Team) were commissioned by the Western Australian Local Government Association (WALGA) to produce a Road Reserve Asset Management Plan (RRAMP), a guide for Local Governments to strategically manage their road and associated infrastructure assets while conserving the environmental value of their roadside vegetation.

The objectives of the RRAMP are to:

- document road and associated infrastructure plans and operational needs;
- consolidate environmental conservation planning, focussing on road reserve conservation needs;
- identify environmental conservation and infrastructure conflicts;
- set up a consolidated strategy and plan of action which resolves strategic conflicts in order to meet both transport and conservation objectives; and
- establish a guide to enable resolution of potential conflicts between transport and conservation objectives.

ROAD ASSET MANAGEMENT AND NATIVE VEGETATION CONSERVATION

In some cases, Local Governments are the custodians of the last remnants of native vegetation where past State and/or Commonwealth Government policy and agricultural practice has resulted in the over-clearing of large areas. Local Governments are responsible for the management and conservation of vegetation within road corridors, which can represent a significant proportion of the remnant vegetation within their municipality. Simultaneously, Local Governments are responsible for the management and upgrading of their road infrastructure to meet safety concerns and traffic demands. This can sometimes require clearing of vegetation within the corridor. There is a need for Local Governments to balance both requirements.

THE RRAMP PROCESS

The RRAMP has been developed by the Project Team to assist Local Governments to manage these sometimes competing demands. The RRAMP process was conducted in seven stages. The first two stages examine the features of the road and infrastructure. The Road Asset Environment is first described in Stage 1 to gather information of the road to identify what road hazards are present. A Road Hazards score (R) is then calculated in Stage 2 to determine the need for road works to remove or minimise the hazard/s. A map is also prepared to indicate the location and severity of the road hazard/s.

Stage 3 examines whether any clearing of vegetation is required. If so, the adjacent roadside vegetation is then evaluated in accordance with the *Environmental Protection Act 1986* (EP ACT) Ten Clearing Principles in Stage 4 and a Vegetation Value score (V) is then calculated in Stage 5. A map is prepared to indicate the locations and significance of the vegetation.

Stage 6 integrates the R and V scores into an Action Matrix which then selects a list of “balanced” actions that may assist in addressing the road works needs while conserving the significant vegetation. The Road Hazard and Vegetation Maps are intersected to determine if any road hazards

lie within or immediately adjacent to significant vegetation. Stage 7 then uses all of the collated information and decisions to develop a final Road Works Plan.

ASSESSMENT TOOL

The Project Team developed the Assessment Tool spreadsheet to guide Local Government officers through the seven RRAMP stages by:

- collating all necessary information into one document;
- determining whether a Clearing Permit is required;
- providing calculators to determine the Road Hazard (R) and Vegetation Value (V) scores;
- automatically selecting an Action Domain based on the R and V scores; and
- having a filter list to present the selected list of possible actions.

The document may also be submitted to the Department of Environment and Conservation (DEC) to demonstrate what information has been collated and how an action has been selected to address road hazards while minimising impacts on native vegetation.

ASSESSMENT OF RRAMP PROCESS

Some Local Governments lack the necessary resources to effectively manage their road and environmental assets. The main deficiencies are information, software and trained staff.

There are two main databases currently available to assist Local Governments – the Shared Land Information Platform (SLIP) and the Road Management Program (ROMAN).

The RRAMP is in its infancy and has only been tested against a few sample projects. The Process and Assessment Tool needs to be further tested by Local Governments against a wider range of roads. Feedback should be collected by WALGA to improve both aspects.

RECOMMENDATIONS

A total of 24 recommendations are made across seven themes to assist Local Governments in developing effective RRAMPs, which are summarised in Table 1.

Table 1: List of recommendations for Local Governments to produce effective RRAMPs

NO.	RECOMMENDATIONS
1	**LOCAL GOVERNMENTS STRATEGIES AND POLICIES**
1.1	That Local Governments prepare a written short to medium term road works plan.
1.2	That Local Governments prepare an environmental policy and strategy.
1.3	That Local Governments collect, store and use more comprehensive data on their road assets.
1.4	That Local Governments collect, store and use more comprehensive data on their environmental assets.
2	**SUPPORT FOR LOCAL GOVERNMENTS**
2.1	That Local Governments obtain access to high speed or broad band internet capability to be able to access Google Earth and Google Street View.
2.2	That Local Governments obtain GIS capability to interpret data and produce maps.
2.3	That training be provided to Local Government employees on the environmental values of roadsides, and techniques to protect and enhance roadsides during road works.
2.4	That training be provided to Local Government employees on databases such as ROMAN and SLIP.
3	**FUNDING FOR LOCAL GOVERNMENTS**
3.1	That road funding programs incorporate environmental considerations into the design, construction and upgrade of roads.
4	**SUPPORT FOR STATE GOVERNMENT DEPARTMENTS**
4.1	That additional funding be allocated to the Roadside Conservation Committee to undertake roadside vegetation surveys and assessments.
5	**CURRENT INFORMATION DATABASES NEED TO BE FURTHER DEVELOPED**
5.1	That the ROMAN and SLIP databases be further developed to become more user friendly and to hold additional local-scale information that is available to Local Governments.
6	**THE RRAMP NEEDS TO BE TRIED AND REFINED**
6.1	That the RRAMP process be further tested by a variety of users with specific comments and suggestions fed back to WALGA.
6.2	That WALGA review the feedback and coordinate the improvement of the RRAMP process and Assessment Tools.

1.0 Introduction

1.1 Background

Ecoscape, Wajon and Associates and ShawMac (the Project Team) were commissioned by the Western Australian Local Government Association (WALGA) to produce a Road Reserve Asset Management Plan (RRAMP), a guide for Local Governments to strategically manage their road and associated infrastructure assets while conserving their environmental value of their roadside vegetation.

The project was divided into ten milestones, the first of which was to conduct in-depth interviews with several Local Governments (including two pilot programs) and investigate how they manage their road works and roadside vegetation. The collated information would then support the subsequent milestones, namely to:

- develop a medium-term Road and Infrastructure Program (RIP) for the two pilot programs (Milestone 2);
- determine, compile and supply all available environmental and other relevant data to the Local Governments to assist with their RIPs (Milestone 3);
- perform a gap analysis of what necessary data is missing and recommend how this may be acquired (Milestone 4);
- develop medium-term Vegetation and Infrastructure Management Plans for the pilot programs (Milestones 5 to 8); and
- develop a model for other Local Governments to develop their own RRAMPs (Milestones 9-10).

The following report summarises the findings of Milestones 1 to 8. It is a draft report that discusses a strategy for Local Governments to consolidate road infrastructure and environmental objectives and provide a mechanism to achieve a balance between the need for road infrastructure and the conservation of environmental assets.

1.2 The Roles of Local Government

1.2.1 NATURAL RESOURCE MANAGEMENT

Local Government is responsible for undertaking, managing, supporting and in some instances, regulating a wide range of activities that may impact upon natural resource management (NRM). The sector also has a key role to play in translating the natural resource management policies of Commonwealth and State Governments, to local and on-ground projects.

Local Governments are:

- Land managers;
- Providers of roads, paths, community buildings, recreation facilities and services, social services, drainage, sewerage, water supply, power supply, telecommunications and many other services;
- Responsible for the management of some 123,000 kilometres of the Local Road network, being about 70% of the total road network; and
- Regulatory agencies for fire management, road transport, land use and development, health and safety and a range of other functions.

The principal functions of Local Government in relation to natural resource management include the following:

- **management of community lands** and public open space (playing fields, parks, and reserves, bushland);
- **vegetation management** (roadside vegetation, noxious weeds);
- **biodiversity conservation and landscape management** (threatened species conservation, rehabilitation of degraded sites, feral animal control);
- **water management** (water quality monitoring, stormwater drainage and harvesting, water efficiency measures);
- **coastal zone management;**
- **land use planning** (Local Planning Schemes and Strategies, Local Biodiversity Strategies, zoning, land use controls, etc.);
- **land management** (acid sulphate soil controls, management of contaminated sites, prevention of soil erosion / degradation / salinity);
- **construction and maintenance of infrastructure** (roads, drainage systems, recreation/leisure facilities);
- **community support; and**
- **water supply** and **wastewater** (sewerage) management (in some areas).

Some Local Governments, particularly in the Wheatbelt, are custodians of the last remnants of native vegetation where past State and Commonwealth Government policy and agricultural practice has resulted in the over-clearing of large areas. Remnant vegetation within the road reserves often provides a valuable function in connecting fragmented landscapes and conserving local biodiversity. Remnant vegetation in road reserves may also represent the last of the original endemic native vegetation and may contain conservation significant flora and fauna. It is for this reason that road works that involve the clearing of vegetation needs to be in compliance with the WA *Wildlife Conservation Act 1950, the Environmental Protection Act 1983 (EP Act)*, and the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

1.2.2 LOCAL GOVERNMENT ACT 1995

The Western Australian *Local Government Act 1995*, Section 1.3 states:

"(2) This Act is intended to result in -

- better decision-making by Local Governments;
- greater community participation in the decisions and affairs of Local Governments;
- greater accountability of Local Governments to their communities; and
- more efficient and effective Local Government.

(3) In carrying out its functions, a Local Government is to use its best endeavours to meet the needs of current and future generations through integration of environmental protection, social advancement and economic prosperity."

Therefore, Local Governments in Western Australia have a legislative responsibility to their communities to consider the environmental, social and economic implications of all their decisions and activities and to manage the environment accordingly. They also have legislative responsibility to include their community in decision-making around the management of their natural resources.

1.2.3 ROLES AND RESPONSIBILITIES

Local Governments' activities in natural resource management vary considerably across the State depending on their natural environment, pressure for development and community interest. As a result the impact of any environment legislation varies considerably.

The key natural resource management legislation that impacts on Local Government is listed in **Table 2**. Guidelines and Standards that direct the legislation are presented in **Appendix Two**.

Table 2: Key Natural Resource Management State Acts that Impact on Local Governments

Legislation	Local Government and natural resource management focus
Land Administration Act (1997)	Local Governments have responsibility for the land vested in them including; vegetation in reserves and transport corridors; beaches to the low-tide mark; waterways in reserves, including lakes, streams, wetlands; and public open space.
Environmental Protection Act (1986)	Defines the need for environmental impact assessment and is the means by which development proposals likely to have significant impacts are refused or required to be modified. Under the Act is the *Clearing of Native Vegetation Regulations 2004* which has significant relevance to Local Government around activities such as clearing for road construction and maintenance, gravel pits, rural bus stops and land use planning.
Wildlife Conservation Act (1950)	Protects flora and fauna native to WA; it is illegal to destroy or remove native flora or fauna from original habitat without a license. Any class or description of protected flora or fauna is likely to become extinct or is rare or otherwise in need of special protection, may be declared by the Minister that class or description of flora / fauna is rare flora/ fauna for the purposes of this section throughout the State. This requires Local Governments to be aware of, and preserve declared rare flora/ fauna on land they manage.
Planning and Development Act (2005)	New or amended local planning schemes are referred to the EPA, which will determine if the scheme must be assessed for environmental impacts (according to the EP Act s.48). The Act also requires that upon creation of a scheme, a local planning strategy also be created.
Biosecurity and Agriculture Management Act (2007)	Replaces the Agriculture and Related Resources Act 1976 (AARR Act) and 16 others. Local Government can control declared plants and declared animals on and in relation to land under its control. The Local Government can also make local laws around pest plants.
Soil and Land Conservation Act (1945)	Relates to the conservation of soil and land resources, and to the mitigation of the effects of erosion, salinity and flooding.

1.3 Native vegetation and roads

Trees and other non-frangible (non-breakable) objects such as signs or light poles alongside a road can increase the probability and severity of a crash and reduce the chance of a vehicle recovering and getting back on the road. Roads have therefore usually been constructed with a lateral verge or Recovery Zone (formally called a Clearance Zone) that is clear of non-frangible trees and other objects.

The Recovery Zone is designed to provide a measure of safety while respecting environmental concerns and private property. The width of Recovery Zones has varied over time and throughout the world, initially ranging from 1 to 4 metres. More recently, the width of Recovery Zones along major high speed rural roads in Australia has been increased to 9 metres (Austroads 2008). Accepted practice provides a range of Recovery Zone widths that are largely dependent on speed limit and vehicle volumes. However, it is acknowledged in the Austroads guideline that the first 4-5 metres provides the majority of the benefit of Recovery Zones, so that there would appear to be some scope for judgement and risk assessment to decide how wide the Recovery Zone should be.

The adequacy and validity of the Recovery Zone concept as a means of addressing roadside safety is increasingly being questioned and studies have supported this (Oxley et al 2004). Consequently, a risk-based approach and case-by-case analysis should be used in setting guidelines for Recovery Zone widths on particular sections of roadway. Such an approach could result in a diversity of widths or types of vegetation along roadsides, with improved outcomes for safety as well as biodiversity and community amenity.

Main Roads Western Australia (MRWA) recognised the necessity to assess the need for removal of vegetation, especially trees, along existing rural roads, and prepared the "Guideline for Assessing Trees within Recovery Zones on Established Roads" (MRWA 2006) as a draft document. The principle was to assess the real risk to safety of trees close to the road way, including the economic cost of death or serious injury, and balance this with an assessment of the biodiversity, conservation and aesthetic value of each individual tree before deciding whether or not to remove it.

It should also be noted that the roadside proximity and beauty of Western Australia's native flora, country roads draws large numbers of tourists to these areas

There are many examples of roads with vegetation, in particular mature trees, close to the side of the road that illustrate the ability of roads to meet both safety, tourism and conservation objectives. Such examples include the following:

- Tuart Road in the Ludlow Forest, near Busselton;
- Mount Shadford Road, Denmark;
- Boranup Forest road, Margaret River; and
- Ruabon Road, Busselton.

Photos of the example roads with adjacent vegetation are presented in **Appendix Three**.

1.4 RRAMP Strategy

1.4.1 AIMS OF RRAMP STRATEGY

The aim of the RRAMP project is to identify the processes and resources required to achieve a balance between infrastructure requirements and environment conservation, develop tools that help address this, summarise the lessons learned and a way forward.

The objectives of the RRAMP are to:

- document road and associated infrastructure plans and operational needs;
- consolidate environmental conservation planning, focussing on road reserve conservation needs;
- identify areas where both environmental conservation and infrastructure needs exist; and
- set up a consolidated strategy and plan which balances transport and conservation objectives.

1.4.2 LOCAL GOVERNMENT PLANNING

Local Governments need to identify Road Transport Objectives to manage their vegetation and road assets. Works may be strategically planned through various drivers, such as:

- Strategic transport;
- Economic transport;
- Social needs; and
- Asset management.

Local Government may react to these drivers through their own operations and planning activities. Examples include:

- Road safety;
- Emergency management;
- Asset preservation and renewal;
- Community service standards; and
- Social connectivity.

Activities may be also implemented through liaison with State government agencies. Local Governments are able to influence State Government strategies and initiatives in which both the roadside vegetation may be conserved and road works better planned. Examples include:

- The Department of Transport's Strategic Plan 2010-2014;
- The Department of Planning's Regional Development Schemes;
- Office of Road Safety's Towards Zero: road safety strategy 2009; and
- MRWA's Remote Community Access Program.

A diagram outlining road work drivers and input opportunities is presented in **Appendix One**.

1.4.3 SUMMARY OF RRAMP PROCESS

The RRAMP process is also structured towards a strategic approach across a regional level. It is to assist Local Governments in planning a three to five year set of probable and priority works. This will help them identify what clearing may result, and therefore what clearing permits may be required to complete this work.

The RRAMP process undergoes seven stages. The first two stages examine the features of the road and infrastructure. The Road Asset Environment is first described to gather information on the location, status, ownership, traffic type, and traffic history of the road. This information is used to identify what road hazards are present. A Road Hazard Score (R) is then calculated, and this is used to determine the need for road works to remove or minimise the hazard/s. A map is also prepared to indicate the location and severity of the hazard/s.

The third stage examines whether any clearing of vegetation is required. Under most circumstances, a clearing permit is required. If, under special circumstances, a clearing permit is not required or if

no vegetation is to be cleared, a road works plan may then be developed to remove or minimise the hazard/s (see stage 7).

If vegetation clearing is required, the adjacent roadside vegetation is then evaluated (Stages 4 and 5). Vegetation is assessed according to the principles contained within schedule 5 of the *EP Act 1986*. A Vegetation Value score (V) is then calculated to determine the importance of the vegetation. The information gathered can then be used to support a clearing application. A map is prepared to indicate the locations and importance of the significant vegetation.

Stage 6 involves "balancing" the needs for the road works against the significance of the vegetation. The R and V scores are integrated into an Action Matrix where the differing scores offer a list of actions that may assist in addressing the road works needs while conserving the significant vegetation. The Road Hazard and Vegetation maps are intersected to find any road hazards lying within or immediately adjacent to significant vegetation.

Stage 7 is the development of a Final Road Works Plan that can balance road and conservation needs. The RRAMP Process is illustrated in **Figure 1.**

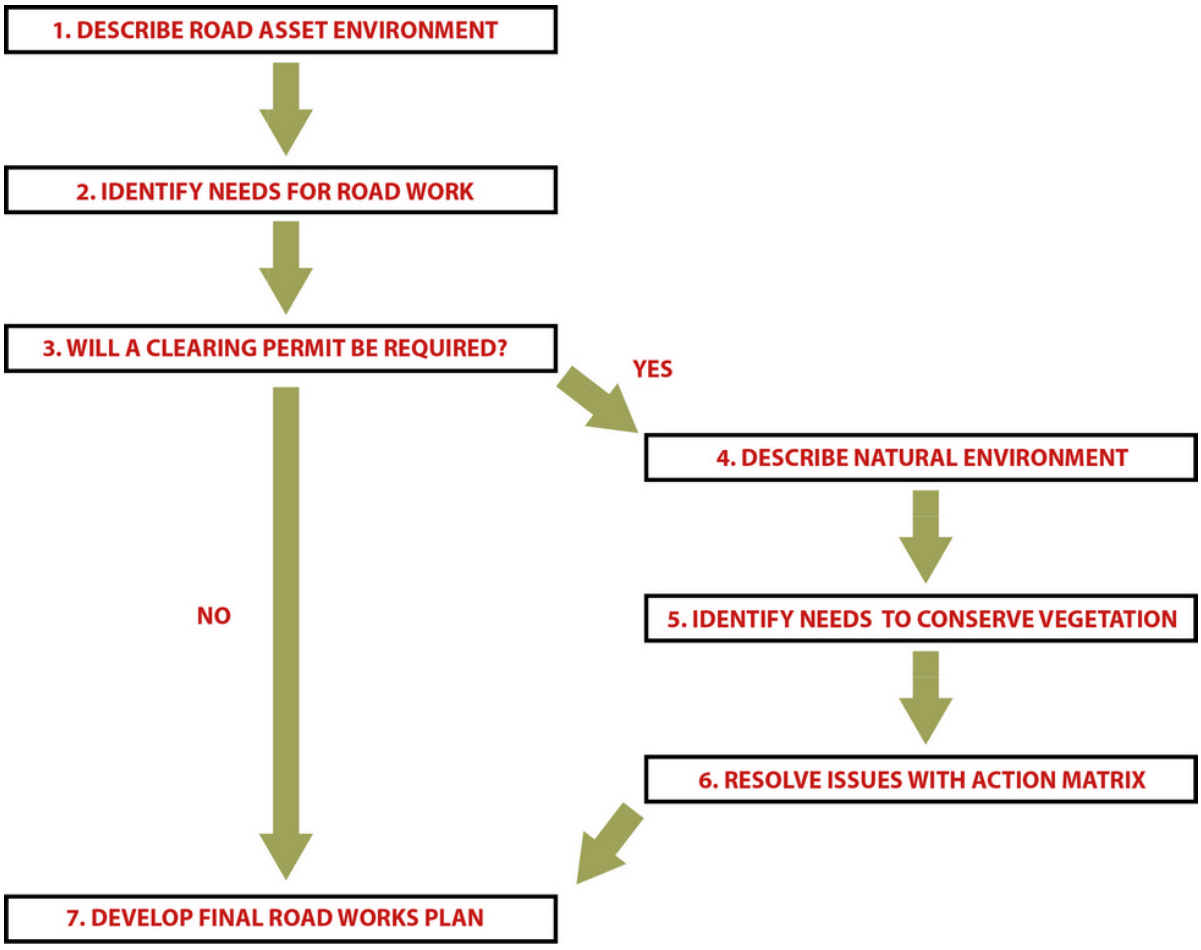

Figure 1: RRAMP Process

The seven stages are further described in **Section 3**. The list of actions is detailed in **Section 4**.

1.4.4 RRAMP AND CLEARING PERMIT APPLICATIONS

The preparation of a RRAMP does not remove the need for clearing permits. However, the RRAMP may be used to:

1. identify whether native vegetation needs to be cleared;
2. identify whether a clearing permit is required;
3. determine how to minimise the
   a) amount of vegetation to be cleared
   b) clearing of valuable vegetation; and
4. identify suitable offset areas or activities that may be required to compensate for clearing that is required.

In this respect, the RRAMP may be used to help:

- reduce the number of clearing permits that need to be submitted to the DEC, potential impact;
- increase the likelihood of DEC granting a clearing permit, as the Local Government should have submitted clearing plans that avoid high value bushland;
- ensure all necessary information is provided to assist the DEC with their decision-making process; and
- reduce conditions set by the DEC (e.g. amount of offsets), as the clearing of native vegetation will be minimised.

1.5 Scope of this Report

The scope of this report is as follows:

- describe how to prepare a RRAMP and how to balance infrastructure and environmental needs;
- describe the tool used to meet both transport and conservation objectives;
- present a concise summary of impediments and enablers encountered;
- identify any strategies that were successful in leading to improved outcomes;
- discuss alternative approaches to the provision of new, or upgrade of existing, road infrastructure;
- prepare a breakdown of the time taken to compile the RRAMPs for each pilot project; and
- present a realistic assessment of resource requirements, costs and benefits of the proposed RRAMP process in comparison to other potential approaches.

1.6 Limitations Statement

There were several limitations imposed on the development of this report and the overall project, which are detailed below:

1. At the time of analysis, the data presented in the Road and Infrastructure Program (RIP) reports prepared for the Shires of Esperance, Pingelly, Wickepin and Cuballing had not been validated by the Shires. Consequently some of the data used to develop the RIPs and RRAMPs may not reflect the current situation and therefore may need to be adjusted.

2. Much of the information needed to undertake road infrastructure and environmental assessments was not obtainable or was not sufficiently detailed. There were budget limitations which restricted the purchase of information, such as aerial imagery. The ROMAN I database contained little relevant information and in all cases was not being used to

generate five year work programmes. Much of the available information was at a regional scale, meaning little detailed analysis could be conducted on a roadside scale. Some data sources were also several years old. Some datasets may also be incomplete (e.g. known locations of significant flora). This is further discussed in the Gaps Analysis report (Ref: 7657-2525-10R).

3. There were also restrictions on the level of detail at which the work to develop RIPs and RRAMPs as part of this project could be conducted. The work could thus only be conducted as a desktop assessment, as no field visits were possible to ground truth the findings. This meant that the RIPs and RRAMPs could not present solid conclusions and recommendations for each proposed road project. Instead, the RIPs and RRAMPs may only present a collation of feasible options that each Local Government Works Manager should consider and pursue further in deciding the most suitable outcome.

4. The Assessment Tool was developed as part of this project to help find a balance between the proposed road works and vegetation conservation and to provide a candidate list of actions for the Local Government to consider. The Assessment Tool is new and largely untested outside this project. Extensive time and effort has been put in by the Project Team into creating this Tool. However, the calculations may be subjective and further scrutiny and use of the Tool is required to determine whether the criteria are comprehensive, suitable, relevant and measurable, and whether it can be used by Local Government staff. Consequently, some items in the calculations may still need to be adjusted.

2.0 RRAMP Process

The following stages describe how to conduct a RRAMP assessment of proposed road works. It has been written to use in conjunction with the RRAMP Assessment Tool spreadsheet.

2.1 Stage 1: Describe Road Asset Environment

The road asset environment is first assessed to determine the features of the road proposed to be upgraded. Information collated includes:

- location and extent;
- ownership and status;
- current traffic volume and type;
- horizontal and vertical geometry, cross section and departures from standards and / or guidelines;
- future expected traffic volume and type; and
- any history of crashes.

The data required to describe the Road Asset Environment are as follows:

- road information;
- cadastre and planning, contour, elevation and transport datasets;
- gravel pit and roads surface spatial data;
- aerial photography; and
- environmental assets.

The data can be obtained from the following sources:

- ROad MANagement database programme (ROMAN);
- Landgate Shared Land Information Platform (SLIP);
- Google Earth (free);
- Google Street View (free);
- Local Government GIS datasets; and
- Nearmap (free).

How to access or locate the data sources are summarised in **Table 4** in **Appendix Four**. The information required to describe the Road Asset Environment is summarised in **Table 5** in **Appendix Four**.

2.2 Stage 2: Identify Needs for Road work

2.2.1 IDENTIFY ROAD HAZARDS

The collated information is then assessed to identify any road hazards that may be present. Potential contributors to hazards include:

- high traffic flow;
- roadside objects, such as trees and infrastructure that may be hit if a vehicle leaves the road;
- the design speed of the road being lower than the zoned speed limit;
- deficiencies in vertical and horizontal geometry, such as a substandard bend or crest in the road;
- inadequate number of lanes;
- inadequate width of lanes;
- inadequate shoulder width;
- inadequate or deficient sight distance; and
- poor pavement and / or seal condition.

2.2.2 CALCULATE ROAD HAZARD SCORE

The warrants for the proposed road works should be evaluated by assessing the Road Hazard (R) associated with the existing road. This involves undertaking an assessment of each different section of the existing road and allocating each different section an R score according to the road's design, features and condition.

The R scores are calculated using the Assessment Tool according to the severity of identified road hazards. Separate scoring systems have been developed for sealed and unsealed roads, to assess their different features. The R score is calculated by summing the scores for all characteristics and then dividing the score with a "normalising factor" to obtain a value between 1 and 4. This figure is then rounded to a single figure (e.g. an average score of 1.923 would be rounded to 2). The R score indicates the hazard as follows:

- 1 (Very Low);
- 2 (Low);
- 3 (High); or
- 4 (Very High).

A high score indicates that the hazards assessed potentially pose a high risk and corrective works are important, whereas a low score indicates that the hazards assessed pose a lower risk and more flexibility in choosing corrective works may exist. A low hazard and would require little work to upgrade.

There is a possibility that applying a normalising factor would result in an important or essential single characteristic not being adequately recognised if there were no other significant characteristics. In the case of the R score:

- no individual hazard is considered to be such that a significant single deficiency would override all other considerations;
- those hazards that are considered serious were accorded a greater weight in the score; and

- even a very low R score does not preclude any works; it simply means that the range of options is more limited and more consideration should be given to options that do not remove vegetation.

It should be noted that the R score cannot factor in external circumstances such as the following:

- the vehicle condition (eg bald tyres) or vehicle make (e.g. passenger vehicle vs. 4WD on a gravel road);
- the driver's condition (e.g. tired, inattentive or under the influence of alcohol or drugs) or safety (e.g. wearing seatbelts);
- if the driver is inexperienced or reckless (e.g. speeding); and
- severe weather.

The full list of characteristics for R values and their associated scores for sealed roads and unsealed roads are presented **Tables 6 and 7** in **Appendix Four**.

2.2.3 MAP ROAD HAZARDS

The locations and extent of the identified road hazards should be clearly mapped and labelled. The following hazards are recognised as being high and should be clearly indicated if present:

- roadside hazards within the recovery zone;
- deficient sight distance – both vertical and horizontal;
- inadequate number of lanes; and
- inadequate lane width and shoulder width.

2.3 Stage 3: Will a Clearing Permit be required?

If the road is proposed to be upgraded, it is necessary to determine whether a clearing permit is required. The following situations do not require a Clearing Permit:

1. no vegetation to be cleared;
2. removal of encroaching vegetation from the road footprint;
3. removal of vegetation in an area has been cleared within the previous ten years; and
4. removal of damaged vegetation (e.g. after a severe storm).

If the proposed road works meet one or more of these criteria, a Clearing Permit is not required and the Local Government may proceed to stage 7 of the RRAMP process. In all other cases, it is required to submit a Clearing Permit and to undertake RRAMP Stages 4 to 6.

It should be remembered that clearing vegetation for safety reasons is still subject to DEC approval. Activities such as clearing in the line of sight area are not exempt under the *Environment Protection Act (1986)* and DEC (2008) *Guidance Statement No. 33* if that area has not been cleared within the previous ten years. No such clearing should be undertaken until the DEC has been informed and has approved of the clearing. Any persons or organisation conducting clearing without DEC approval risks severe penalties.

2.4 Stage 4: Describe Natural Environment

2.4.1 NATURAL FEATURES

If a Clearing Permit is required, it is important to examine the adjacent roadside vegetation that may need to be cleared or disturbed during the proposed road works. Specific information should be collated to enable the proposed clearing to be assessed against the Clearing Principles as listed in the *Clearing Regulations 2004*.

Native vegetation should not be cleared if:

1. it comprises a high level of biological diversity;
2. it comprises the whole, or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia;
3. it includes or is necessary for the continued existence of, rare flora;
4. it comprises the whole or part of, or is necessary for the maintenance of a Threatened Ecological Community;
5. it is significant as a remnant of native vegetation in an area that has been extensively cleared;
6. it is growing, or in association with, an environment associated with a watercourse or wetland;
7. the clearing of the vegetation is likely to cause appreciable land degradation;
8. the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area;
9. the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water; or
10. the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.

2.4.2 ENVIRONMENTAL DATASETS

The following datasets may be accessed to provide information on the natural environment of the study area:

- Department of Sustainability Environment Water Population and Communities (DSEWPC) *Protected Matters Search Tool;*
- Department of Environment and Conservation (DEC) *Naturemap;*
- DEC *Threatened Species and Ecological Communities database;*
- Landgate *Comprehensive, Adequate and Representative (CAR) Conservation Reserve* dataset;
- Landgate *Shared Land Information Platform* (SLIP) website;
- Department of Water (DOW) *Geographic Data Atlas; and*
- Roadside Conservation Committee (RCC) Roadside Surveys.

The DSEWPAC *Protected Matters Search Tool* generates a report on matters of national environmental significance or other matters protected by the EBPC Act (1999) within the area of interest.

The DEC *Nature Map* is a useful tool which can be used to generate a report to identify flora and fauna species within a defined search area. It also gives the DEC listing for conservation significant fauna.

Similarly, the DEC *Threatened Species and Ecological Communities database* can be accessed to determine the locations of any known threatened and priority flora, fauna and ecological

communities within a defined search area. The DEC Species and Communities branch should be contacted to access this information.

The Landgate *CAR Conservation Reserve* dataset is used to determine the representation of vegetation types and is available to download from the SLIP website. A login name will be required which can be obtained online.

The Landgate *SLIP* website provides information on the likelihood of land degradation. SLIP provides a wide range of data including soil types, wetlands, hydrology, topography, flood risk and native vegetation extent.

The DOW Water *Geographic Data Atlas* is a free interactive website that allows people to download geographic data and includes the Water Information Network (WIN). Data includes groundwater, surface water and WIN sites.
The RCC has been coordinating conservation assessments of roadside vegetation of WA Local Governments for more than 15 years. In recent years, these surveys have also incorporated weed presence in roadsides. The aim is to survey and map all roadsides throughout all Local Government areas in the south-west land division. More than 60 Local Governments have been mapped up to November 2012. These surveys may assist in providing valuable information on the roadside vegetation in areas of proposed road works, particularly in identifying vegetation with significant conservation value.

A full list of datasets that can be used to determine if a proposal would be at variance with any of the clearing principles are listed in **Tables 8** in **Appendix Four**. It includes the approximate costs to access each dataset. The access or contact details for these datasets are presented in **Table 4** in **Appendix Four**.

2.5 Stage 5: Identify Needs to Conserve Vegetation

2.5.1 VEGETATION VALUE (V)

The value of the roadside vegetation along each different section of the existing road should be assessed and each different section assigned a Vegetation Value (V) score according to its natural features and environmental significance. These features are aligned to the DEC (2009) *Ten Clearing Principles*. Social values could also be scored (e.g. heritage, visual amenity). Like Road Hazard Value, the score is calculated by normalising the score to between 1 and 4.

Several of the vegetation features are also allocated additional factors to fully detail all the issues involved with that feature. The total score is increased if the proposed vegetation contains or might contain any of these factors. For example, for the “Impact on Conservation Area” feature, if the roadside vegetation was the sole corridor to a conservation area, an additional five points were given.

There is a possibility that applying a normalising factor would result in an important or essential single characteristic not being adequately recognised if there were no other significant characteristics. This is addressed in the case of the V Value score where if a certain characteristic was deemed to be at the highest level of impact (and protection was essential), the vegetation would automatically score the maximum value. Situations that score a maximum score of 4 were when the vegetation:

- was listed as world heritage – nationally listed or National Park;
- contained threatened flora;
- contained threatened fauna;
- contained threatened ecological communities (TECs); or
- had <1% remaining of a vegetation community.

The full list of characteristics for Vegetation Values and their associated scores are presented in **Table 9** in **Appendix Four**.

2.5.2 MAP SIGNIFICANT ENVIRONMENTAL FEATURES

The locations and extents of the significant environmental features should be clearly mapped and labelled. Any feature that was listed a maximum score of 4 should be clearly indicated as highly significant.

2.6 Stage 6: Resolve Issues with Action Matrix

2.6.1 DEVELOP LIST OF ACTIONS

An Action Matrix is used to assign the Road Hazard (R) and Vegetation Value (V) scores to a particular domain. The matrix domain indicates a series of actions that may be feasible and should be considered by the Works Manager when designing the proposed road works in a manner that would minimise any impact on the adjacent roadside vegetation. The Action Matrix groups the actions into a total of 11 domains, labelled A to K (**Figure 2**).

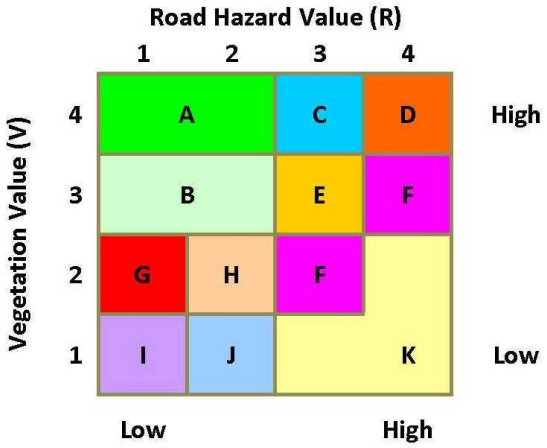

Figure 2: Action Matrix

A total of 31 actions are allocated across the Domains. The options are developed along eight themes:

1. Reduce likelihood of vehicle leaving road and severity of crash;
2. Reduce likelihood of vehicle leaving road by improving road/ infrastructure;
3. Reduce severity of clearing and risk of crash;
4. Reduce likelihood and severity of clearing by changing table drain design;
5. Reduce severity of clearing through selective clearing;
6. Reduce likelihood and severity of clearing and risk of crash by realigning road;
7. Reduce risk and severity of crash; and
8. Potential additional options.

The possible actions are influenced by the R and V scores. The number of possible actions:

- are greatest when R and V are both high, as a wide range of actions should be considered to protect the important vegetation whilst improving road safety;
- decrease when R is low and V is high, as actions are eliminated if they result in considerable clearing of vegetation not warranted by the low level of risk;
- decrease further when the R and V are both low, as actions are eliminated if they are considered to be not warranted in conserving low value vegetation; and
- are least when the R is high and the V is low, as only a few actions are considered to be practical or warranted in these situations.

For example, if R is 3 (High) and the V is 1 (Very Low), the Action Matrix would select Domain K. The actions offered under Domain K would provide two alternatives to clearing the whole alignment that would not compromise the high importance of addressing the identified road hazards.

Alternatively, if the R is 1 (Very Low) and the V is 3 (High), the Action Matrix would select Domain B. The actions offered under Domain B offer 16 actions that will result in no or little clearing of vegetation and would still address the identified minor road hazards.

The Action Matrix selection process is presented in **Table 10** in **Appendix Four**. All of the actions are fully described in **Section 3**.

2.6.2 INTERSECT ROAD HAZARD AND SIGNIFICANT ENVIRONMENTAL FEATURE MAPS

The two maps should be overlaid to allow a spatial interpretation of where the road hazards and significant environmental features are located. The Intersect Map should reveal which significant environmental features:

1. are located far enough from the road hazards that they will not be affected by road works;
2. are near the road hazards and may be slightly impacted by the road works; and
3. are immediately adjacent to or within road hazards and would be greatly impacted from road works.

In the cases of points 2 and 3, the maps will also indicate whether any conflicts between environmental features and road hazards are highly significant. This analysis will assist the Local Government in choosing which of the actions selected by the Action Matrix are most appropriate.

2.7 Stage 7: Develop Final Road Works Plan

A final Road Works Plan may now be completed, which integrates the findings of the previous stages and explains how the road works may address the road hazards while simultaneously minimising the impact to significant vegetation. The Plan will allow the DEC to understand what issues have been identified and how they have been addressed.

The Final Road Works Plan should include:

- findings from the RRAMP Assessment Tool spreadsheet including
  - Road Hazard and Vegetation Value Scores
  - the Action Matrix list of actions

- the following maps
  - Road Hazard
  - Significant Environmental Feature
  - Intersect
  - Final Road Works

- the selected action and approach.

3.0 Actions to resolve conflicts

The following section discusses road work actions and how they may improve road safety and function while minimising the need to clear vegetation. It also discusses how to use offsets to mitigate the impacts of clearing vegetation, and where a Local Government may locate suitable offsets within their municipality.

3.1 Introduction

REDUCING RISK OF CAR ACCIDENTS

The Monash University Accident Research Centre (Oxley et al 2004), reports that of the numerous measures to reduce run-off-road crashes outlined above, the greatest potential for reducing serious injuries resulting from single-vehicle crashes in rural areas comes from the following:

1. speed limit reductions especially along roads of curved alignment and/or with hazardous roadsides, because of the powerful relationship that exists between vehicle speeds and crash and injury risk for all crash types, especially single-vehicle crashes;

2. crashworthy roadside barriers such as wire rope barriers erected over extended lengths of rural roadway because of the extreme difficulty in preventing a substantial number of drivers and riders in high-speed rural environments from leaving roadways; and

3. skid resistant pavements and shoulder sealing with tactile edge-lining; because they assist a sizable proportion of the drivers and riders of errant vehicles to regain control of their vehicles without entering the roadside and, desirably, without striking, unnecessarily, any immovable objects.

OFFSETS AND ASSET ENHANCEMENT

Where road works result in clearing of vegetation, especially where that clearing potentially is at variance with any of the Ten Clearing Principles, offsets may be required. Offsets should be strategic and should add value, with the objective of a no net loss of vegetation. Where possible, offsets should enhance the existing vegetation assets by restoring degraded vegetation, especially recently disturbed vegetation such as those associated with gravel pits. Offsets should also create or enhance corridors between islands of vegetation, especially between vegetation in good condition and vegetation in reserves or under conservation.

3.2 Potential Road Work Actions

The range of measures that can be taken to upgrade a road in order to improve road safety and function while minimising the need to clear vegetation were derived from a number of sources including the following:

- AustRoads guidelines;
- MRWAexperience, practice and guidelines;
- Local Government best practice; and
- Road safety and accident literature, especially that of the Monash University Accident Research Centre (Oxley et al 2004).

1. REDUCE LIKELIHOOD OF VEHICLE LEAVING ROAD AND SEVERITY OF CRASH

a) Reduce speed limit

On straight or curved sections of rural road, a substantial proportion of drivers leave the roadway as a result of temporary deficits in functional performance. Much effort has been given to developing and implementing treatments to address the consequences of such deficiencies. AustRoads (2008) recommends that advisory speed signs be erected where hazards exist. Thus, recommended reduced speeds on curves and other hazardous road features are commonly signed; however these speed signs are advisory only and are not regulatory speed limits. On entrances to towns speed zones are frequently reduced by regulatory signage.

Additional treatments to reduce speeds and speeding could typically include the following (Oxley et al 2004):

- traffic calming on the approaches to and within rural towns, including pavement narrowing, refuge islands, road surface alterations, raised road surfaces, hazard marker posts, countdown signs, chicanes and transverse lines;
- perceptual countermeasures, comprising transverse pavement markings, physical roadway design to enforce speed reductions, peripheral lane-edge and herringbone markings, centre-line marking, other edge-line markings, enhanced post curvature treatments (with and without ascending height posts) and hatched median treatments; and
- vehicle-activated signs to advise of travel speed.

Of the numerous measures outlined above, the greatest potential for reducing serious injuries resulting from single-vehicle crashes in rural areas comes from speed limit reductions, especially along roads of curved alignment and/or with hazardous roadsides, because of the powerful relationship that exists between vehicle speeds and crash and injury risk (Oxley et al 2004). However as the Commissioner of MRWA is the authority for approving speed zones on all roads, the implementation of regulatory speed zones is subject to the review and approval of that authority.

The most effective of the perceptual treatments are transverse lines with reduced spacing, chevrons with increasing angles and hatched areas at the edge of the road.

Similarly the Commissioner of MRWA is the authority for approving signs and lines on all roads, and the implementation of signs and lines is subject to review and approval of that authority.

There are a number of locations around Western Australia, such as Wanneroo Road / Indian Ocean Drive near the entrance to Yanchep National Park, and Caves Road between Yallingup and Margaret River, where advisory signs with reduced recommended speeds have been erected because of the presence of trees close to the road.

2. REDUCE LIKELIHOOD OF VEHICLE LEAVING ROAD BY IMPROVING ROAD / INFRASTRUCTURE

a) Improve quality of pavement and edges / shoulders

Monash University Accident Research Centre (Oxley et al 2004) make the point that pavement resealing can cut casualty crash frequencies by 44%, while shoulder sealing can reduce the frequency of casualty crashes by 25 - 30%.

b) Install (more) guideposts (reflective delineation)

Delineation is an important component of the geometric design feature of roads, which assists drivers manoeuvre their vehicles along road lengths and through intersections safely (Oxley et al). It consists of a system of reflectors, posts and painted lines along the road network. For instance, painted edge-lines and reflectorised posts delineate the edge of the travelled way and are marked to discourage travel on road shoulders and to make driving safer and more comfortable. It should be

noted that longitudinal line marking (centre line and edge line) is only appropriate on roads having a minimum seal width, and as such in some cases widening may be required to accommodate line marking.

Oxley et al (2004) make the observation that implementation of low-cost perceptual countermeasure treatments such as enhancing (decreasing) the spacing of guideposts can bring about an unobtrusive change of up to five percent in speed at some locations and may be appropriate at hazardous locations such as curves and intersections. Oxley et al (2004) indicate that post-mounted delineators on rural roads reduce the incidence and severity of crashes. Guide-posts with reflectors appeared to enhance static direction judgement at night and increasing the number of posts on the outside of the bend appeared to improve the driver's judgement.

Road improvements are standard treatments advocated by AustRoads (2008), the NSW Road and Traffic Authority and VicRoads (Wooldridge 2010). Several of the suggested actions are only applicable to sealed roads, but installing (or installing more) guideposts along the road are applicable to both sealed and unsealed roads.

c) Install guideposts (reflective delineation) adjacent to trees

Installing guideposts on or before trees is applicable to both sealed and unsealed roads and is advocated by AustRoads (2008), the NSW Road and Traffic Authority and VicRoads (Wooldridge 2010).

d) Reinstate / apply edge lines and centre lines

According to the Monash University Accident Research Centre (Oxley et al 2004), effective measures to reduce single-vehicle crashes include improved delineation of edge lines, centre lines and lane lines. Reported crash reduction ranges from no effect up to 36%, but there are suggestions of crash increases on narrow roads carrying low volumes of traffic so they are possibly only effective on roads with high traffic volumes, fewer lane-keeping errors with wide and high contrast line markings. However, Oxley et al (2004) also report that installation of raised reflective pavement markers can result in crash reductions of between 15 and 18%.

e) Install audible / tactile edge line

According to the Monash University Accident Research Centre, one of the most beneficial measures for reducing serious injuries resulting from single-vehicle crashes in rural areas is shoulder sealing with tactile edge-lining such as 'Wake-up' pavements and shoulder rumble-bars; because they assist a sizable proportion of the drivers and riders of errant vehicles to regain control of their vehicles without entering the roadside. Tactile edge-lining can reduce casualty crash frequencies by between 9% and 21% (Oxley 2004).

f) Widen or extend the seal to include the shoulder of the road

Monash University Accident Research Centre make the point that pavement widening can cut casualty crash frequencies by 31%, while shoulder sealing can reduce the frequency of casualty crashes by 25 - 30% (Oxley et al 2004).

g) Put up signs warning of trees close to the road

AustRoads (2008) recommends that warning signs be erected where hazards exist. There are a number of locations around Western Australia, such as Wanneroo Road / Indian Ocean Drive near the entrance to Yanchep National Park, and Caves Road between Yallingup and Margaret River,

where there are signs advising of the presence of trees close to the road. This is because the numerous large trees along the road provide an ambience that visitors and travellers value.

3. REDUCE SEVERITY OF CLEARING AND RISK OF CRASHES

a) Install safety barriers along verge or around individual trees

Safety barrier systems are proving to be an effective means of reducing the incidence and severity of run-off-road crashes. If roadside hazards cannot be removed, or adequate recovery zones cannot be created, consideration should be given to the installation of some physical barrier (Oxley et al 2004). Road safety barriers can be installed around specific trees to absorb the energy of the vehicle so that injuries are prevented or greatly reduced.

The main types of barrier systems available are flexible wire rope barriers, semi-rigid W-beam barriers and rigid concrete barriers. They each have different properties including impact on vehicle and occupants, deflection, reflection and cost. While conventional barrier systems have performed well for the occupants of passenger cars, their effects on the safety of other road user groups are not well understood (Oxley et al 2004). Motorcyclists in particular are very concerned about the potential injuries associated with interacting with wire rope barriers (Larrson et al 2003).

Monash University Accident Research Centre (Larrson et al 2003) discusses installation of wire rope barriers in both the median and in the verge along rural high speed roads in Victoria. They anticipate that this would reduce the road toll by up to 75% while saving a large number of trees from being removed. They assert that the safety benefits of large-scale use of flexible barriers are overwhelming, and despite some issues relating to their use, the opportunity exists to reduce dramatically the incidence of single-vehicle fatalities.

MRWA endorse the use of wire rope barriers and consider they are the preferred barrier type because they have the lowest severity associated with an impact. The critical consideration in the use of such systems is adequate room to allow for deflection of the barrier and a suitable traversable area (slope of 1 in 10 or flatter) over this width of deflection (MRWA Document D11#38472, Revision 1A, 12 April 2011).

Wire rope barriers currently cost approximately $65 - 115/m but could cost as little as $30/m when used on a large scale (Candappa et al 2009).

Use of safety barrier systems, especially wire rope barriers, is increasing on Western Australian roads. Recent examples include the Kwinana Freeway extension, Mandurah Entrance Road and Old Coast Road.

4. REDUCE LIKELIHOOD AND SEVERITY OF CLEARING BY CHANGING TABLE DRAIN DESIGN

a) Realign table drain around trees where possible

Several Local Governments retain trees in normal table drain alignments by deviating the table drain around the back of the tree and retaining the tree. Examples include the upgrade of the Cunderdin-Quairading Road by the Shire of Cunderdin where table drains meander around trees.

b) Use excavators to create table drains rather than graders

Smaller machinery such as backhoes rather than graders should be used to create table drains where it is not desired or necessary to remove trees. Smaller machinery is more flexible and can be used to deviate table drains around the backs of trees thereby retaining the trees. Several Local Governments, such as the Shire of Cunderdin in its recent upgrade of the Cunderdin-Quairading

Road, use excavators/backhoes to manoeuvre around trees and in areas where a grader could not get access.

c) Construct offshoot or cut-off drains instead of widening table drains

Offshoot or cut-off drains are open drains used to carry stormwater from table drains into catch drains or to allow the stormwater to flow overland away from the road. Installation of cut-off drains allows the table drain to be smaller and may reduce the need for clearing. MRWA and many Local Governments commonly use cut-off drains. Examples include the Cunderdin-Quairading Road recently upgraded by the Shire of Cunderdin.

Cut-off drains should be designed and constructed with minimum clearing to prevent weed growth on their batters. This could be achieved by scraping off the topsoil before cutting the V-drain, and then re-spreading a thin layer of topsoil over the new batters. This would allow native vegetation to regenerate in the cut-off drain, rather than weeds.

d) Increase the table drain batter slopes from 4:1 (recoverable) to 3:1 (traversable) to decrease width (both fore slope and back slopes)

MRWA guidelines (Document 67-08-62D, Revision 2B, 10 June 2006) suggest the desirable roadside slope of a table drain is 6:1 and a maximum slope is 4:1. The backslope of the table drain may be varied from 4:1 to almost vertical. A flat section may be introduced at the bottom of the drain.

However, MRWA guidelines (Document 67-08-62D, Revision 2B, 10 June 2006) suggest desirable slopes of 2:1 for normal cut batters and 3:1 for fill batters in sandy soil, with steeper slopes up to 2:1 to suit environmental, services or geotechnical constraints. ARRB recommends a maximum slope of 3:1 (Anderson 2006).

Thus, where table drains are shallow, both batter slopes can be increased from 4:1 to 3:1 or 2:1 without significant risk of scouring, in order to decrease the drain width and reduce the amount of vegetation requiring to be cleared.

e) Reduce width and depth of table drain and flatten slopes

Where the soil adjacent to roads is relatively permeable, or storm volumes are low, table drains could be shallow and narrow, and batter slopes could be increased from 1:4 to 1:3 or 2:1 without significant risk of scouring, in order to decrease the drain width and reduce the amount of vegetation requiring to be cleared.

f) Eliminate table drain

Where the soil adjacent to roads is very permeable, such as sandy soils, there is little need for table drains since stormwater shedding from the road rapidly infiltrates into the groundwater. MRWA WA and many Local Governments commonly use direct infiltration strategies.

g) Retain frangible vegetation on back slopes

Vegetation on the back slopes of table drains assists in reducing erosion and does not impede the function of the drain. Retaining the vegetation, especially frangible (i.e. breakable) vegetation such as understorey and less rigid trees such as some banksias and sheoaks, therefore has benefits for maintenance and biodiversity.

5. REDUCE SEVERITY OF CLEARING THROUGH SELECTIVE CLEARING

a) Prune trees at edge of formation both horizontally and vertically

Horizontal and vertical pruning of tree branches rather than completely removing trees close to the pavement to create a safe corridor for large vehicles, to minimise the impact of fallen limbs and to improve line of sight is common practice among all roads agencies. For example, the Shire of Cunderdin used this practice extensively in the recent upgrade of the Cunderdin-Quairading Road. A drawback of this strategy is that the aesthetic cathedral-like appearance of a road could be diminished.

b) Reduce recovery zone widths

One treatment to improve the safety of roadsides that has received much attention worldwide is the provision of a recovery zone as large as practically possible by removing or relocating obstacles. The provision of a recovery zone facilitates drivers maintaining or regaining control of their vehicle, or an opportunity to substantially reduce speed before they strike rigid structures. Objects causing the most severe injuries in run-off-road crashes are trees and poles, bridges, culverts and embankments, with collisions with trees making up the major part of the injury problem in rural areas. Removal or relocation of trees and poles to provide recovery zone distances of between 1.5 and 10 m can reduce crash and injury risk substantially (estimates range from 13% to approximately 60%).

However, a recent study by Oxley et al (2004) of median encroachments by the drivers of vehicles travelling on high-speed roads concluded that the Victorian guidelines for the median width above which no median barrier is required (15 m) frequently did not prevent a vehicle passing through the median and potentially colliding with vehicles travelling in the opposite carriageway. Therefore, 9 m (either to the left or right of the carriageway) may not be adequate for a person to regain control of their vehicle before reaching the far boundary of the recovery zone. In some cases, the contact speeds with rigid objects beyond the recovery zone may exceed the capacity of vehicles with the highest standards of crashworthiness to protect their occupants. In these situations the provision of a recovery zone by removing trees close to the edge of the road may have limited benefit.

The minimum width for a recovery zone to effectively reduce severe injury crashes is 4 - 5 m, as that is where the most significant benefit is gained (Oxley et al 2004, MRWA 2003). However, there are potentially additional benefits in having recovery zones of at least 9 m on the sides of rural roads having a speed limit of 80 km/h or higher, with a 9 m recovery zone being considered sufficient space for most drivers to either return to the road, or to bring their vehicle to a safe stop (Oxley et al 2004).

However, MRWA suggests a 4 m minimum clearance where traffic volume is less than 1000 vehicles per day (MRWA 2003). Thus, where the likelihood of running off the road is evaluated as relatively low either because the road is relatively wide, the surface is in good condition, or the traffic volumes are low, there may be a justification to retain trees located 3 - 4 m or more from the side of the road. This approach was taken by the Shire of Cunderdin recently during upgrading of the Cunderdin-Quairading Road when they decided to leave large Eucalypts within 3 m of the edge of the pavement.

c) Clear only at intersections/ driveways

A significant benefit is derived from clearing where the line of sight can be enhanced, such as intersections and driveways. Clearing to provide line of sight should be selective, and may involve only removing trees if the remaining vegetation is low-growing, or may involve removing shrubs while retaining the trees if the tree branches are sufficiently high to not impede adequate vision. This practice is common in many Local Governments and was used by the Shire of Cunderdin in the upgrade of the Cunderdin-Quairading Road.

It should be noted that clearing in the line of sight line area at intersections (ie an area between the edge of a stretch of road and a line of sight necessary for the safe use of the stretch of road) is not an exempt activity under the EP Act (1986) and *EP (Clearing of Native Vegetation) Regulations 2004* if that area has not previously been cleared within the previous ten years.

d) Clear only at bends

A significant benefit is derived from clearing where the line of sight can be enhanced, such as at bends and along curves. Clearing to provide line of sight should be selective, not excessive, and may involve only removing trees if the remaining vegetation is low-growing, or may involve removing shrubs while retaining the trees if the tree branches are sufficiently high to not impede adequate vision. This practice is common in many Local Governments and was used by the Shire of Cunderdin in the upgrade of the Cunderdin-Quairading Road.

It should be noted again that clearing in the line of sight line area at bends (ie an area between the edge of a stretch of road and a line of sight necessary for the safe use of the stretch of road) is not an exempt activity under the *EP Act (1986)* and *EP (Clearing of Native Vegetation) Regulations 2004* if that area has not been cleared within the previous ten years.

e) Review the longitudinal profile of the road to reduce cut / fill requirements

Removing crests on roads to improve sight lines can result in significant clearing due to the consequent need for cut batters. Alternatives may include reducing vertical design speed to limit the amount of crest removed, or to sightly widen the road or the seal and provide adequate centre line and edge markings with guide posts. This strategy was used on the Roe Highway Stage 7 near South Street, Kwinana Freeway extension near Paganoni Reserve, and Paganoni Road upgrade in Karnup.

f) Construct passing pockets

Passing pockets are short sections of road similar to but shorter than passing lanes, along narrow sections of primarily unsealed roads in which a vehicle can drive or stop to allow an approaching large vehicle such as a truck, bus or harvester to pass safely.

Passing pockets should:

- be constructed in degraded or less dense vegetation to minimise clearing requirements;
- be staggered on both sides of the road to provide opportunity for passing from either direction, sufficiently long (where possible) to minimise the need to completely stop;
- have adequate lines of sight so that they could be seen from a distance; and
- be appropriately signposted.

An example of a passing pocket is in the Shire of Plantagenet where two wider “pull over” sections before and after large karri trees along the section of Millinup Road from Woodlands Road to Wansborough Walk have been constructed to allow vehicles to pass safely while protecting the karri trees on both sides of the road.

g) Remove trees only while leaving the understorey

Single-vehicle, run-off-road crashes where vehicles strike non-frangible, rigid, fixed objects such as trees, poles or culverts contribute to a large proportion of rural road death and serious injuries. Typical criteria for recovery zones are therefore that trees with a diameter greater than 100 mm need to be removed to eliminate the hazard, although these criteria do not take into account the higher frangibility of trees such as sheoaks and banksias which could potentially be retained.

Nevertheless, if trees were removed from the recovery zone, while leaving understorey shrubs, not only would the probability of impact with non-frangible, rigid, fixed objects close to the road decrease, but the understorey would also slow the vehicle down to reduce the probability of the vehicle hitting trees further from the road. Where the understorey is in good condition, removing the trees would still allow the majority of the biodiversity of the roadside vegetation to be retained. It would also stabilise the soil and prevent the introduction of weeds. Conversely, where trees are a dominant or in some cases sole component of the roadside vegetation, or where they are a significant aesthetic component of the road, the removal of trees could result in a very barren landscape and therefore a loss of biodiversity.

6. REDUCE LIKELIHOOD AND SEVERITY OF CLEARING AND RISK OF CRASH BY REALIGNING ROAD

a) Realign road by clearing on one side of the existing transport corridor, the side with the overall poorest quality vegetation

Where there is a choice, and clearing is required to widen the road formation, it is preferable to widen the road on one side of the alignment. The clearing should occur on the side of the alignment with the lesser quality and/or narrowest vegetation. This would retain the widest vegetation corridor possible to enhance vegetation survival and regeneration, and to provide a safe corridor for fauna movement. In addition, there may be less animal strikes as wildlife is less likely to cross the road to get to vegetation on the other side. MRWA and many Local Governments, including the Shire of Pingelly and Shire of Cunderdin, already employ this technique.

b) Avoid clearing an unmade road reserve adjacent to an approved subdivision in an already cleared area

The Roadside Conservation Committee (2010) has written to Local Government planning officers suggesting that where possible, new roads should be built on already cleared land rather than in uncleared or “unmade” road reserves. This is a particular opportunity where new developments, or subdivisions, are being proposed which may result in major upgrades to the road network. Consideration of roadside vegetation in the development or subdivision plan at an early stage can result in improved outcomes for biodiversity conservation and community values by retaining the vegetated land in the uncleared road reserve as public open space.

c) Construct some or all of the road, or construct a new lane, in a cleared area such as a paddock

Many bends have been straightened by constructing a new alignment though a paddock. Recent examples include the Cunderdin-Quairading Road upgraded by the Shire of Cunderdin and the Great Northern Highway between Muchea and New Norcia.

d) Consider other alternative alignments

There are often opportunities to construct an upgraded road on a new alignment that reduces the amount of clearing while improving safety by eliminating dangerous curves. Such a strategy was used for the upgrade of Great Northern Hwy between Bindoon and New Norcia, and for Muir Highway near Mt Barker. Another example is the upgrade of the Cunderdin-Quairading Road in which a vegetated bend was preserved by re-directing the road through an adjacent cleared paddock.

In some cases, and with the agreement of neighbouring farmers, new lanes could be constructed in adjacent cleared paddocks, utilising the existing road way as one of the two divided lanes separated by the vegetation in one of the verges. This has the benefit of retaining vegetation while increasing the width of each travelling lane.
Locations where there are substantial stretches of median containing remnant vegetation including large trees are the New Perth Bunbury Hwy and the Old Coast Road near Lake Clifton.

7. REDUCE RISK AND SEVERITY OF CRASH

a) Clear whole alignment

This action should only be chosen when all other actions either prove ineffective in addressing the road safety risk or the vegetation is completely degraded.

8. EXTRA OPTIONS TO CONSIDER

a) Construct the road using pervious pavement to avoid or reduce the need for additional clearing for drainage infrastructure

The use of pervious pavements as an alternative to clearing to provide drainage infrastructure may be a viable option where vegetation values are high. Pervious pavements allow rainfall to infiltrate through the road pavement and thus manage water as part of an ecological system rather than a nuisance to be drained away. Pervious pavement materials include open graded asphalt, porous concrete blocks and no-fines concrete. Most pervious pavement has generally been confined to light traffic areas (e.g. car parks) using concrete blocks, although some roads have also been built using continuous pervious pavements, mostly in the USA and Europe. The City of Canning is undertaking a trial of pervious concrete pavement at its works depot and along a residential street to manage flooding.

Pervious pavements provide the following benefits:

- do not interrupt natural drainage flow, either vertically (infiltration) or horizontally (cross flow);
- have reduced clearing footprint as a result of reduced drainage infrastructure;
- avoid or reduce the cost of drainage infrastructure;
- result in reduced weed growth on the side of the pavement resulting in possible reduced collisions with native animals and reduced death and serious injury to either humans or animals;
- purify rainwater/road generated drainage which could be captured for direct use at low cost;
- Permecocrete pervious pavements made with magnesium oxide sequester carbon; and
- Permecocrete pervious pavements are safer because they are drier, brighter and have more traction.

b) Install median

Measures that make a fundamental improvement in the inherent safety of rural roads with respect to head-on crashes include physical separation of traffic directions such as medians to separate opposing vehicle directions along undivided rural roads. Monash University Accident Research Centre make the point that medians can cut casualty crash frequencies by 61% (Oxley et al 2004). However, it should be noted that this option requires extra road reserve width and could result ing more clearing of vegetation.

c) Install wire rope barrier in median

Measures that make a fundamental improvement in the inherent safety of rural roads with respect to head-on crashes include physical separation of traffic directions such as the use of crashworthy barrier systems on medians to separate opposing vehicle directions along undivided rural roads (Oxley et al 2004).

Crashworthy barrier systems include the '2+1' road configuration with wire rope barriers introduced in recent years in Sweden. In this system, a passing lane is created in the centre of the road between the opposing travel lanes, and is used as a passing lane that alternates about every 1 to 1.25 km between the two directions of travel. Such roadways can be built within existing roadway rights of way. Such systems, because of the difficulty in predicting where head-on crashes will occur, would need to be installed over extended lengths (i.e. tens or hundreds of kilometres) of rural roadway.

Recent US research indicates that well designed and maintained safety barriers are effective overall in reducing casualty crash severity. In Sweden, the use of wire-rope safety barriers has also been effective and associated with the removal of solid objects and other engineering treatments along more than 200 km of road has proven to be a low-cost approach to improving safety, compared to other options such as conversion to four-lane roadways (Oxley et al 2004).

3.3 Offsets and asset enhancement

Where road works result in clearing of vegetation, especially where that clearing potentially is at variance with any of the Clearing Principles, offsets may be required. Offsets should be strategic and should add value, with the objective of a no net loss of vegetation. Where possible, offsets should enhance existing vegetation assets by protecting them in perpetuity, restoring degraded vegetation, especially disturbed vegetation such as those associated with gravel pits, and should create or enhance corridors between islands of vegetation, especially between vegetation in good condition and vegetation in reserves or under conservation.

Offsets could thus include the following:

- revegetate any historical gravel pits that have been created within vegetated areas for which this has not been a condition of approval for clearing;
- revegetate degraded road verges;
- revegetate under-utilised internal roads;
- revegetate and fence riparian areas;
- create vegetated links through private property;
- undertake weed control in Local Government reserves;
- fence high quality private vegetated areas to prevent stock and unauthorized access and protect the vegetation; and
- purchase and covenant private vegetated land to protect it in perpetuity.

4.0 Assessment of the RRAMP process

The following section discusses the findings of the Project Team in undertaking Milestones 1 to 9 and comments on the development of the RRAMP process.

4.1 Enablers and Impediments

4.1.1 ENABLERS ENCOUNTERED WHEN DEVELOPING THE RRAMP

1. Development of a RRAMP Assessment Tool spreadsheet

The concept of a graph or matrix to classify roads according to their hazard and vegetation value, and using this to guide appropriate actions, was inspired by a report on environmental clear zones on rural roads by ARRB on behalf of the NSW Roadside Environment Committee (McRobert et al 2005). The Project Team used this approach to develop an Assessment Tool to guide Works Managers through the RRAMP process by:

- collating all necessary information into one document;
- determining whether a Clearing Permit is required;
- providing calculators to determine the Road Hazard (R) and Vegetation Value (V) scores;
- automatically selecting an Action domain based on the R and V scores; and
- having a filter list to present the selected list of possible actions.

The document may also be submitted to DEC to demonstrate what information has been collated and how an action has been selected to address road hazards while minimising impacts on vegetation.

2. Using Google Street View for "virtual drives" along roads

To complement the data that is available, Google Street View is a very useful tool to assess road width, seal, condition and surrounding vegetation and environmental features such as river crossings. It can be very time consuming to virtually "drive" along long stretches of road, but this process is probably quicker and more convenient than actually driving. Google Street View is available for a large number of country roads except minor roads. It should be noted that the date of photography in Street View is unknown and as such may not show actual current conditions.

3. Using MRWA video footage of roadsides for virtual drives along roads

MRWA makes video records of country roads in order to rapidly assess the roadside vegetation condition. The methodology of image capture is similar to Google Street View; a vehicle drives along the subject roads and mounted cameras capture video images. Again this form of assessment can be very time consuming, but probably quicker and more convenient than driving. In addition, the date of the recording should also be available, so it can be easily determined whether the footage shows the current conditions.

The Project Team were not aware this resource would be available from MRWA and therefore have not considered this method in the RRAMP process. If the footage was made available for specific road sections this could reduce the assessment time and RRAMP process. This information is

potentially highly valuable in assessing road project areas. Local Governments should consider requesting MRWA to supply the video footage for their RRAMP assessments.

4. Other benefits of RRAMP

Using the proposed RRAMP process has the following benefits:

1. reduction in time and effort for both Local Government and DEC in submitting and processing multiple clearing permits;
2. reduction in clearing costs as the amount of clearing required may be reduced over standard approaches;
3. potential for a reduction in hospitalisation and trauma costs if the most effective engineering solutions have been implemented to reduce death and serious injury;
4. a more considered approach to clearing resulting in a greater retention of biodiversity;
5. a greater likelihood of, and more rapid, approval of clearing permits by the DEC, with reduced time and work involved in answering questions or revising proposals;
6. a strategic approach to the provision of offsets which results in offsets that are sustainable, meaningful and connected;
7. reduction in costs of implementing offsets as fewer offsets will be required because less, and less significant, vegetation will be cleared; and
8. the opportunity to engage with the local community to provide valued input.

4.1.2 DIFFICULTIES ENCOUNTERED WHEN DEVELOPING THE RRAMP

1. Collating Information

The Project Team prepared the RRAMPs using information held by others, including the specific Local Government, Landgate and the DEC. The Project Team found it difficult to obtain much of the information required from the Local Governments, including the actual location, length, width, seal and condition of roads to be upgraded as part of a forward planning programme. Typically this was due to Local Governments not having any detailed road works strategy over a short to medium-term period, but instead having a “wish” list of road work projects that were either deemed to have a high priority or needed to be completed in the following few years. Indications were that an authorities list of projects could suddenly change in reaction to outside factors such as crashes, grain carting options and adverse weather. Projects may also be subject to funding restrictions and clearing permit applications.

This project was conducted as a desktop assessment. To obtain more accurate, current and detailed information would require field visits which were not part of this project, and if required would be expensive. Similar constraints would apply to RRAMPS prepared in-house by Local Governments.

2. Validation of data

In developing the RRAMPs, the Project Team interpreted the proposed road works information supplied by the Local Governments, either in writing or during meetings. However, this interpretation has not been formally validated by any of the Local Governments. Consequently some of the data used to develop the RRAMPs may not reflect the current situation in the Local Governments.
These issues will not exist if / when RRAMPS are prepared in-house by each local government.

3. ROMAN Database

ROMAN I, the current road management database used by all Local Governments to record road condition and upgrades, was of limited value because of the limited data stored in the program. Most of the Local Governments indicated that ROMAN I is only used to support funding applications and not to plan road maintenance work or vegetation clearing. ROMAN II, which is due to be released shortly, is designed to be more user-friendly and to hold more information and therefore could be more useful for Local Governments. However, Local Governments generally consider ROMAN II to be very expensive and will require extensive training of staff in its use. As such there is the view that many Local Governments will not use the programme to plan future road works, except possibly for sealed roads.

Much of the necessary environmental information was not available, obtainable or if available, was not detailed. The availability of data varied considerably between Local Governments, with the Wheatbelt Local Governments which are resource poor having very little data or ability to obtain it, while the larger Local Governments have significant resource capability and access to in-house datasets.

4. SLIP database

A range of environmental data is available through Landgate's Shared Land Information Platform (SLIP). However, some users commented that they often encountered problems when trying to use the SLIP, such as the login not working or slow data transfer, which caused frustration due to the lack of time available to spend on these tasks. Further, much of the available information from SLIP or the DEC is at a regional scale, meaning little detailed analysis can be conducted on a roadside scale. Some datasets are also several years old and possibly obsolete, while others may be incomplete (eg known locations of significant flora).

5. Obtaining detailed and accurate aerial imagery

There are often budget limitations which restrict the purchase of more detailed and up to date aerial imagery through Landgate, such as with this project. Some aerial imagery is available through Google Earth and Nearmap, however photography can also lack detail or be out of date.

6. Lack of feedback on RRAMP Assessment Tool

Unfortunately, the Project Team received little feedback from Local Governments regarding the suitability or feasibility of the list of suggested actions generated by the Assessment Tool that would meet the need to improve road safety and function while minimising the need to clear vegetation. Typically, the feedback related to cost issues rather than effectiveness or benefits.

Similarly, there was little feedback on the accuracy of the Road Hazard / Vegetation Value matrix and the assigning of actions to particular domains. Further use is required to determine whether the criteria are comprehensive, suitable, relevant and measurable. Consequently, the applicability and usefulness of the Action Matrix needs to be tested by a range of users.

7. Time

The number of hours taken for the Project Team member to develop the Pilot program RRAMPs is presented in **Table 3**. It has been itemised for each milestone.

Table 3: Total hours spent by Project Team to develop Pilot RRAMPs

Milestone	Total
1 In Depth Interviews	159
2 Five Year Road and Infrastructure Program	206
3 Collation of Data and Map Production	98
4 Gap Analysis	74
5 Five Year Infrastructure and Native Vegetation Management Plan	258
6 Feedback from Committee	42
7 Public Consultation Workshop	18
8 Feedback from Consultation Process	22
TOTAL	**877**

The workload was far greater than anticipated as:

- there was much more effort involved in collating and processing information;
- there was also difficulty in organising phone interviews with Local Governments;
- a second face to face interview was required with the pilot Local Governments after it was realised they did not have any detailed works plans;
- travel time for the Esperance face to face interviews and public consultation workshops were extended as a result of limited flights;
- forward works programmes were not available from most Local Governments and additional time was required to develop draft recommended programmes
- time was required to develop the RRAMP Assessment Tool, which was not part of the original scope;
- a greater amount of time was required to do the mapping and spatial analysis; and
- several additional meetings were required with the Steering Committee to discuss the identified difficulties and progress.

4.2 Strategic Management of Roadside Vegetation

The management of native vegetation during the provision of new, or upgrade of existing, road infrastructure can be approached through strategic (whole or part of a LG area) or specific area (road by road) approach.

The more strategic approaches, aside from the RRAMP process proposed here, include the following:

a) Prepare an inventory of environmental assets, such as roadside vegetation, of the entire Local Government area, including a listing of flora, vegetation associations and fauna based upon survey or at a minimum based on inspection. Use this to prepare a list of assets ranked by quality or significance, from which a strategic plan or set of objectives can be created to retain and / or enhance particular assets.

b) Undertake flora, vegetation association and fauna surveys of areas associated with road works 12 - 18 months in advance of the need to undertake the works.

Both options (a) and (b) would provide more adequate data that would fit into the proposed RRAMP process described in this report. These additional data would enable a more reliable assessment to be made of the value of the environmental assets likely to be directly affected by the proposed road works. In turn, this would enable a more realistic appraisal to be made of the location of the proposed road works in the Action Matrix, and thus what actions are appropriate to improve road safety and function while minimising the need to clear vegetation.

A strategic/purpose permit can remain current for five years and reduces the need to apply to the DEC for permits for each road or clearing requirement.

4.3 Cost of preparing a RRAMP

The actual dollar costs of undertaking the RRAMP process described in this report are difficult to estimate because they would vary widely between Local Governments. The actual costs would depend on the number and experience of the people undertaking the planning, design and site inspection of the proposed road works, on the number of road projects proposed, on the scale and difficulty of obtaining road and environmental asset data, and on the experience and efficiency of the personnel acquiring and assessing the data.

It is acknowledged that the capital cost of implementing some of the suggested potential alternative actions, such as safety barriers, wider sealed shoulders or pervious pavement, may be significant.

Nevertheless, the strategy proposed for the preparation of a RRAMP of using available data and local knowledge combined with a site visit by personnel appropriately qualified or skilled in engineering and environmental science means that this strategy to planning and designing road works is considerably less expensive than undertaking formal vegetation, flora and fauna surveys, though these may be required later. However, the cost of undertaking environmental surveys should be put in the context of undertaking geotechnical or engineering surveys and designs. Both are required to provide lasting, well-designed natural and built infrastructure solutions.

4.4 Gaps analysis of resources required to prepare a RRAMP

The following section discusses limitations that are likely to affect Local Government's capability to prepare RRAMPs.

4.4.1 LOCAL GOVERNMENT RESOURCES

The RRAMP process proposed here is primarily desktop-based, relying on available electronic or written information. Consequently all Local Governments require the following resources:

- computers with Adobe and Java software enabling view of SLIP portal data;
- adequate Geographic information systems (GIS) and drafting software (eg ArcGIS, Arc Explorer and AutoCAD);
- an internet connection to access online datasets (eg SLIP, Google Street View, Google Earth, Nearmaps, DOW Geographic Data Atlas);
- other relevant environmental and road databases and datasets (eg DEC Threatened Species and Ecological Community Database request, Landgate aerial imagery, ROMAN); and
- access to road design guidelines, standards and technical criteria

Many Local Governments cannot afford to have all of these resources- in particular software programs, data and access to trained drafting/mapping staff.

4.4.2 LOCAL GOVERNMENT STAFF SKILLS AND KNOWLEDGE

Local Governments also need qualified staff who are knowledgeable and trained in:

- GIS;
- drafting;
- environmental science;
- road engineering;
- clearing permits and other environmental legislation;
- operating the online databases; and
- general computer usage.

Interviews with the selected Local Governments have revealed that few Western Australian Local Governments can afford all or even most of the resources and staff listed above. Major shortfalls were GIS capability and knowledge in environmental science. Some Local Governments address this shortfall by hiring consultants with the capability, although this is often limited by funds.

The proposed RRAMP process relies to a considerable extent on experience and local knowledge. For example, an engineer familiar with the attributes of the road under consideration must be able to assess the Road Hazard score by considering elements such as design speed, horizontal and vertical geometry which contribute to the Road Hazard score as these factors are subjective and judgement-based based on sound knowledge of technical guidelines and design standards.

The person evaluating the Road Hazard score should be familiar with the road on which the road works are proposed, or be able to visit the road or use Google Street View, to make an informed and un-biased assessment of the location and severity of roadside hazards, design deficiencies and other factors contributing to risk. The person designing the road works should also be familiar with, and able to supervise the designing and implementing alternative road side designs and strategies.

Also, detailed information specific to the road on which the road works are proposed should be obtained because the available environmental data are often at a regional scale and consequently the level of detail is too broad. Site environmental information can be gathered by the person evaluating the Vegetation Value score as they will be familiar with the road project area, through either site visits or by using Google Street View. This person should have some environmental background or training to be able to make an assessment of the quality and type of vegetation.

Aside from undertaking the Vegetation Value assessment of the proposed road project area, the environmental officer should have an understanding of, and a Strategic Vision for, the environmental assets of the Local Government. This would enable the identification of offsets if required, to compensate for the vegetation that may be cleared.

Thus, potentially two people with different skills may be required to prepare a RRAMP. It would be beneficial to undertake a formal vegetation survey of the road project area. However, the use of Google Street View, local knowledge and an ability to use the GIS datasets available, would be sufficient to undertake at least an initial assessment. If the initial assessment indicates considerable conflict between environmental and road values is likely, then a decision can be made to undertake a more detailed vegetation assessment.

4.4.3 LOCAL GOVERNMENT FUNDING

Lack of funding and capacity will be the prime difficulties for Local Governments in preparing a RRAMP. Local Governments have a finite funding base from rates and levies supplemented from time to time by grant funds. In rural areas with low rate bases, financial capacity is often inversely proportional to the amount of roads and native vegetation needing to be managed.

4.4.4 EXISTING ASSET MANAGEMENT PROGRAMMES

1. Road Management Program (ROMAN)

ROMAN II, an upgrade to ROMAN I, is currently being distributed to Local Governments. The new program contains a spatial component that allows the roads to be viewed on a map which allows for interpretation of the data. The program has great potential and could be used for the management of roads and conservation assets as it can include environmental information such as soils, topography, vegetation communities and significant flora. This would provide Local Governments a greater ability to manage their roads and environmental assets and to prepare RRAMPs.

2. Shared Land Information Platform (SLIP)

SLIP provides a single point of access to authorative location information from a range of state government sources. This online spatial database can supply Local Governments that have limited GIS capability. The main benefits of SLIP for Local Governments include the following:

- the consolidation of data into one central database;
- the ability to link data into GIS; and
- free download of selected layers.

5.0 Conclusion

5.1 Findings

Strategic planning is the key to successful delivery of safe, sustainable, biodiverse roads and roadsides. Information, understanding and expertise are key elements in undertaking strategic planning. Larger Local Governments frequently have the staff, skill and funding to undertake the required detailed planning. However this is mostly not the case with smaller, regional Local Governments who have few skilled staff or funds to manage a road network with significant biodiversity along the road sides.

In the RRAMP process, detailed information about road and natural assets would contribute to a better decision making process. But even with the relatively inadequate or broad-scale information which is currently available within Local Government and the SLIP database, a basic on-site assessment by appropriate, local, knowledgeable and experienced personnel can be used to support valid decision making. Where required, or as part of project execution, more information should be obtained to validate the decision and assist with detailed design in order to obtain the best outcome.

In order to improve road safety while conserving biodiversity, Local Government road engineers and environmental scientists need to identify and embrace alternative solutions. Some alternative solutions are included in the RRAMP Action Matrix developed as part of this project, but as our technology and understanding grow, others will become evident. Innovative and bold solutions will be required to both improve road safety and retain important environmental assets.

Some of these solutions will require additional capital over traditional solutions. But the long term benefits and costs savings in terms of better roads, reduced human tragedy and a resilient, productive, attractive environment will also be significant. Consequently, every attempt should be made to encourage and support solutions that will both improve road safety and retain important environmental assets.

The preparation of RRAMPs strategically for several Local Governments in an area at the same time, could provide cost benefits, look at the longer-term strategic needs (eg road upgrades across Local Government boundaries) and opportunities (eg offsets across Local Government boundaries). This may prove to be a more cost effective use of state resources in supporting Local Governments and providing a clear and consistent strategic approach to road and roadside vegetation conservation planning.

5.2 Recommendations

Recommendations to enable the proposed RRAMP process to deliver on its expectations of improving road safety while retaining important environmental assets are discussed in the following section.

5.2.1 RRAMP TESTING AND REFINEMENT

The RRAMP process and the associated RRAMP Assessment Tool have only been tested on a few example projects within the pilot programs. Consequently, the system requires further field testing to find any shortfalls to further refine the process.

Recommendations to improve the RRAMP process are:

1. The RRAMP process needs to be tried by a variety of different users with specific comments and suggestions fed back to WALGA.
2. The RRAMP Assessment Tool needs to be tried by a variety of different users with specific comments and suggestions fed back to WALGA.
3. WALGA needs to review the feedback and coordinate the improvement of the RRAMP process and Assessment Tools.

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Roadside Conservation Committee (2010), Letter to Western Australian Local Government planners.

Wooldridge, C (2010), Addressing run-off-road crashes on rural roads. Insurance Commission of Western Australia Road Safety Forum 2010.

Appendix One: Strategic Drivers and Input Opportunities

Figure 3: Road work drivers and influence opportunities for Local Governments

Appendix Two: Guidelines and Standards

ROAD AND TRANSPORT INFRASTRUCTURE

A list of standards and guidance documents that should be consulted when designing or upgrading transport infrastructure are presented below.

Austroads

- Austroads (2000). Use of Recycled Materials and the Management of Roadside Vegetation on Low Trafficked Roads (AP-R154-00)
- Austroads (2003). Environmental Considerations for Planning and Design of Roads (AP-R217-03)
- Austroads (2003). Guide to the geometric design of rural roads
- Austroads (2005). Road Safety in Rural and Remotes areas of Australia (AP-R273-05)
- Austroads (2006). Guide to Road Safety Part 1: Road Safety Overview
- Austroads (2006). Guide to Road Safety Part 5: Road Safety for Rural and Remote Areas (AGRS05-06)
- Austroads (2008). Road Surface Characteristics and Crash Occurrence: A Literature Review (AP-T-96-08)
- Austroads (2009). Evaluation of the Safety Impact of Centre-of-the-road Wire Rope Barrier (WRB) on Undivided Rural Roads (AP-T135-09)
- Austroads (2009). Guide to Road Safety Part 8: Treatment of Crash Locations (AGRS08-09)
- Austroads (2009). Guide to Road Transport Planning (AGRTP-09)
- Austroads (2010). Guide to Road Design Part 3: Geometric Design (AGRD03-10)
- Austroads (2010). Guide to Road Design Part 5: Drainage Design (AGRD05-10)
- Austroads (2010). Guide to Road Design Part 6: Roadside Design, Safety and Barriers (AGRD06-10)
- Austroads (2010). Road Safety Engineering Risk Assessment Part 5: Review of Crashes on Unsealed Roads (AP-T150-10)
- Austroads (2010). Road Safety Engineering Risk Assessment Part 8: Rural Head-on Crashes (AP-T153-10)
- Austroads (2010). Road Safety Engineering Risk Assessment Part 9: Rural Intersection Crashes (AP-T154-10)
- Austroads (2011). Innovative Road Safety Measures to Address Fatigue: Review of Research and Results from a Treatment Trial (AP-R379-11).
- Austroads (2011). Safe Intersection Approach Treatments and Safer Speeds Through Intersections: Phase 2 (AP-R385-11)
- Austroads. (2006-09) Guide to Road Design Part 1 to 8 (AGRD Set)

- Austroads. (2006-09) Guide to Road Safety Part 1 to 9 (AGRS Set)
- Austroads. (2006-12) Guide to Pavement Technology Part 1 to 10 (AGPT Set)

Main Roads Western Australia

- MRWA (2005). Roadways. Document 67-08-62 Rev 2A
- MRWA (2006). Guideline for Assessing Trees within Recovery Zones on Established Roads
- MRWA (2006). Selection of Cross Sectional Elements (Document 67-08-62D, Revision 2B, 10 June 2006)
- MRWA (2010). List of Codes, Design Guides and Reference Materials. Document D08#40679 Rev 3F

Other Guidelines and Statements

- ARRB (2009). Unsealed roads manual. Guidelines to good practice. 3rd edition March 2009-08-19
- Institution of Engineers, Australia (1987). Australian Rainfall & Runoff - A Guide to Flood Estimation, Pilgrim, DH, (ed).

VEGETATION CONSERVATION

Other standards and guidance documents that should be consulted in terms of identifying significant vegetation are presented below.

EPA Position Statements

- EPA (2000) Position Statement No. 2 - *Environmental Protection of Native Vegetation in Western Australia*
- EPA (2002) Position Statement No. 3 - *Terrestrial Biological Surveys as an Element of Biodiversity Protection*

EPA Guidance Statements

- EPA (2004) Guidance Statement No. 51 – *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessments in Western Australia*
- EPA (2004) Guidance Statement No. 56 – *Terrestrial Fauna Surveys for Environmental Impact Assessments in Western Australia*
- *EPA (2006)* Guidance Statement No. 6 – *Rehabilitation of Terrestrial Ecosystems*
- EPA (2007) Guidance Statement No. 19 - *Environmental Offsets*
- EPA (2008) Guidance Statement 33 - *Environmental Guidance for Planning and Development*

Appendix Three: Examples of vegetation adjacent to roads

Tuart Road, Ludlow Forest, Busselton (Google Street View)

Tuart Road, Ludlow Forest, Busselton

Valley of the Giants, Walpole (Google Street View)

Boranup Forest, Margaret River

Abbeys Farm Road, near Yallingup (Google Street View)

Appendix Four: RRAMP Process

Table 4: Access and Contact Details for Reference Datasets

Dataset	Access/ Contact
DSEWPC *Protected Matters Search Tool*	http://www.environment.gov.au/epbc/pmst/index.html
DEC *Nature Map*	http://naturemap.dec.wa.gov.au/default.aspx
DEC *Threatened Species and Ecological Communities database*	Fauna – fauna.data@dec.wa.gov.au Flora – flora.data@dec.wa.gov.au Ecological Communities – communities.data@dec.wa.gov.au Information Sheet – http://www.dec.wa.gov.au/content/view/5379/2231/
DOW *Geographic Data Atlas*	http://www.water.wa.gov.au/idelve/dowdataext/index.jsp
Google Earth	http://www.google.com/earth/index.html
Google Maps and Street View	http://maps.google.com.au/maps?hl=en&tab=wl http://maps.google.com/help/maps/streetview/
Landgate *CAR Conservation Reserve*	https://www2.landgate.wa.gov.au/web/guest/downloader.
Landgate *SLIP*	http://spatial.agric.wa.gov.au/slip/products_view.asp
Nearmap	https://www.nearmap.com/welcome-new
RRC Roadside Vegetation Conservation Value	RCC Technical Officer, Ms Kylie Payne kylie.payne@dec.wa.gov.au

Table 5: Reference Sources to describe Road Environment

ROAD ENVIRONMENT	REFERENCE
1. LOCATION AND EXTENT	
a) Location	Shire
b) Extent	Shire
2. ASSET OWNERSHIP AND STATUS	
a) Ownership	ROMAN database
i) Private road	
ii) Local Gov road	
iii) State Gov road	
iv) Federal Gov road	
v) Other	
b) Status	Shire
i) Structure and Condition	
- Seal width	Site measurement
- Pavement width	Site measurement
- Formation width	Site measurement
3. TRAFFIC	
a) Volume (number)	
- Current	Site measure / estimate
- Future/ Foreseen	Estimate
b) Traffic Type	
i) Current	
- Local/ passenger	Site measure / estimate
- Permit vehicles	Site measure / estimate
- School buses	Site measure / estimate
- Farm equipment	Site measure / estimate
- Trucks/ Haulage	Site measure / estimate
- Other (Specify) _____	Site measure / estimate
TOTAL	
c) Future/ Foreseen	
- Local/ passenger	Estimate
- Permit vehicles	Estimate
- School buses	Estimate
- Farm equipment	Estimate
- Trucks/ Haulage	Estimate
- Other (Specify) _____	Estimate
TOTAL	
d) History	
a) 5 year crash history	MRWA database
i) Off road crashes - hit object	MRWA database
ii) Head on	MRWA database
iii) Right angle	MRWA database
iv) Other	MRWA database
4. OTHER	
a) Describe	Shire
b) Describe	Shire
c) Describe	Shire

Table 6: Road Hazard Factors and Scores for Road (Sealed Road)

FACTOR		SCORE
Traffic flow – current or predicted future	<800	2
	800-1,000	1
	1,000-2,500	3
	>2,500	4
Roadside Hazards	Hazard within 3 metres; Crash severity high	8
	Hazard 3-6 metres; Crash severity high	6
	Hazard within 3 metres; Crash severity moderate	5
	Hazard 3-6 metres; Crash severity moderate	3
	Hazard within 3 metres; Crash severity slight	2
	Hazard 3-6 metres; Crash severity slight	1
Terrain	Flat	1
	Rolling	2
	Mountainous	3
Sight distance	Compliant	0
	Partly deficient	2
	Deficient	5
Design speed relationship to zoned speed	10km/h above zoned speed	1
	Equals zoned speed	2
	10km/h below zoned speed	3
	20km/h below zoned speed	4
Deficiency in Vertical Geometry	Fully compliant	1
	Largely compliant	2
	Partly compliant	3
Deficiency in Horizontal Geometry	Fully compliant	1
	Largely compliant	2
	Partly compliant	3
Number of lanes	Adequate	0
	Not adequate	10
Lane width	>3.5 metres	1
	3.0-3.5 metres	2
	<3.0 metres	3
Sealed shoulder width	>1.5 metres	1
	0.6-1.5 metres	2
	<0.6 metres	2
Seal condition	Good condition	1
	Medium condition	2
	Poor condition	3
Maximum Sealed Road Hazard Score (R)		**49**

Table 7: Road Hazard Factors and Scores for Road (Unsealed Road)

FACTOR		SCORE
Traffic flow – current or predicted future	<800	2
	800-1,000	1
	1,000-2,500	3
	>2,500	4
Roadside Hazards	Hazard within 3 metres; Crash severity high	8
	Hazard 3-6 metres; Crash severity high	6
	Hazard within 3 metres; Crash severity moderate	5
	Hazard 3-6 metres; Crash severity moderate	3
	Hazard within 3 metres; Crash severity slight	2
	Hazard 3-6 metres; Crash severity slight	1
Terrain	Flat	1
	Rolling	2
	Mountainous	3
Design speed relationship to zoned speed	10km/h above zoned speed	1
	Equals zoned speed	2
	10km/h below zoned speed	3
	20km/h below zoned speed	4
Sight distance	Compliant	0
	Partly deficient	2
	Deficient	53
Deficiency in Vertical Geometry	Fully compliant	1
	Largely compliant	2
	Partly compliant	3
Deficiency in Horizontal Geometry	Fully compliant	1
	Largely compliant	2
	Partly compliant	3
Pavement width	> 10.0 metres	1
	7.0 - 10.0 metres	2
	< 7.0 metres	3
Surface condition	Good condition	1
	Medium condition	2
	Poor condition	3
Maximum Unsealed Road Hazard Score (R)		**36**

Table 8: Reference sources to describe the natural environment

NATURAL ENVIRONMENT	REFERENCE	Approx. cost
10 CLEARING PRINCIPALS		
(a) Biodiversity		
Datasets required for base level information on biodiversity		
Declared Rare and Priority Flora	DEC data request	$300 + gst
Threatened Ecological Communities	DEC data request	$200 + gst
Threatened and Priority Fauna	DEC data request	$200 + gst
Vegetation type and condition	Site survey	Cost will be variable
Additional datasets		
aerial imagery	Landgate, SLIP, Google Earth, Near Maps	Purchase from Landgate or free to view on Google Earth and Nearmap
location of World Heritage Areas, National Parks, Nature Reserves and ESAs	DEC, SLIP	Free to view on SLIP
total vascular plant taxa (species, subspecies and varieties) inventory	DEC Florabase, SLIP	Free to view
vascular plant taxa diversity for each ecological community	DEC Florabase, SLIP	Free to view
total vertebrate and invertebrate fauna taxa (genera, species and subspecies) inventory	DEC Nature Map	Free to view
number of ecological communities (fauna communities (assemblages))	site survey	Cost will be variable
macrohabitat diversity	site survey	Cost will be variable
(b) Fauna habitat		
Datasets required for base level information on fauna habitat		
protected or threatened fauna, priority fauna or fauna otherwise of significance	DEC Threatened species and community database	$200 + gst
EPBC protected matters search tool	DSEWPC website report	Staff time
NatureMap search tool	report	Staff time
fauna habitat i.e presence of breeding, sheltering or feeding sites for protected fauna	Site survey	Cost will be variable
Additional datasets		
location of Environmentally Sensitive Areas	DEC, SLIP	Free to view on SLIP
corridor of linked vegetation	DAFWA, SLIP	Free to view on SLIP
native vegetation extent	DAFWA, SLIP	Free to view on SLIP
native vegetation extent by type	DAFWA, SLIP	Free to view on SLIP
(c) Flora		
Datasets required for base level information on flora		
protected or threatened flora, priority flora or flora otherwise of significance	DEC Threatened species and community database	$200 + gst
EPBC protected matters search tool	DSEWPC website report	Staff time
Additional datasets		
presence of habitat for protected flora	site survey	Cost will be variable
corridor of linked vegetation	DAFWA, SLIP	Free to view on SLIP
native vegetation extent	DAFWA, SLIP	Free to view on SLIP
native vegetation extent by type	DAFWA, SLIP	Free to view on SLIP

NATURAL ENVIRONMENT	REFERENCE	Approx. cost
(d) Threatened Ecological Community		
presence of Threatened Ecological Community (TEC) and Priority Ecological Community (PEC)	DEC Threatened species and community database	$200 + gst
EPBC protected matters search tool	DSEWPC website report	Staff time
presence of Environmentally Sensitive Area	DEC, SLIP	Free to view on SLIP
(**e) Extent of clearing**		
aerial imagery	Landgate, SLIP, Google Earth, Near Maps	Purchase from Landgate or free to view on Google Earth and Nearmap
native vegetation extent	DAFWA, SLIP	Free to view on SLIP or purchase dataset from DAFWA
CAR database	SLIP download	Free
(f) Proximity of Water		
aerial imagery	Landgate, SLIP, Google Earth, Near Maps	Purchase from Landgate or free to view on Google Earth and Nearmap
presence of Environmental Protection Policy or conservation category lake	DEC/EPA, SLIP	Free to view on SLIP
presence of Environmentally Sensitive Area	DEC, SLIP	Free to view on SLIP
presence of significant wetland	DEC, SLIP	Free to view on SLIP
RAMSAR wetlands	DEC, SLIP	Free to view on SLIP
presence of rivers and creeks	DOW, SLIP	Free to view on SLIP
(g) Effect on land degradation		
contours	SLIP, Google Pro, Landgate	Free to view from SLIP or purchase from Landgate
land use capability	DAFWA, NRM, SLIP	Free to view from NRM SLIP
groundwater salinity	NRM SLIP	Free to view from NRM SLIP
salinity risk	DAFWA, SLIP	Free to view from NRM SLIP
subsurface compaction	DAFWA, SLIP	Free to view from NRM SLIP
water erosion	DAFWA, SLIP	Free to view from NRM SLIP
subsurface acidification	DAFWA, SLIP	Free to view from NRM SLIP
water repellency	DAFWA, SLIP	Free to view from NRM SLIP
(h) Impact on Conservation Area		
aerial imagery	Landgate, SLIP, Google Earth, Near Maps	Purchase from Landgate or free to view on Google Earth and Nearmap
cadastre	SLIP	Free to view on SLIP
location of World Heritage Areas, National Parks, Nature Reserves and ESAs	DEC, SLIP	Free to view on SLIP
location of DEC managed land	DEC, SLIP	Free to view on SLIP
location of Shire Reserves	DEC, SLIP	Free to view on SLIP

NATURAL ENVIRONMENT	REFERENCE	Approx. cost
corridor of linked vegetation	DAFWA, SLIP	Free to view on SLIP
Land for Wildlife or Conservation Covenant Land	DEC	Free on DEC website
Conservation Covenant Land	National Trust of Australia (WA)	Free on National Trust website
Woodland Watch site	Florabase	Free to view on Florabase
Bush Forever site	SLIP	Free to view on SLIP
(i) Impact on Water Quality		
contours	SLIP, Google Pro	Free to view on SLIP or purchase from Landgate
Water Information Network (WIN) database of surface water quality	DOW, SLIP	Free to view on GDA and SLIP
Water Information Network (WIN) database of ground water quality	DOW, SLIP	Free to view on GDA and SLIP
salinity risk	DAFWA, SLIP	Free to view on SLIP
water erosion	DAFWA, SLIP	Free to view on SLIP
subsurface acidification	DAFWA, SLIP	Free to view on SLIP
water repellency	DAFWA, SLIP	Free to view on SLIP
phosphorus export risk	DAFWA, SLIP	Free to view on SLIP
presence of Acid Sulfate Soils	DEC, SLIP	Free to view on SLIP
(j) Impact on flooding		
aerial imagery	Landgate, SLIP, Google Earth, Near Maps	Purchase from Landgate or free to view on Google Earth and Nearmap
presence of wetlands	DEC/EPA, SLIP	Free to view on SLIP
presence of rivers and creeks	DOW, SLIP	Free to view on SLIP
flood risk	DAFWA, NRM SLIP	Free to view on SLIP
Water Information Network (WIN) database of ground water levels	DOW	Free to view on GDA
Floodplain mapping	Shire	Free to view on SLIP
water logging	NRM SLIP	Free to view on SLIP
soil landscape systems	DAFWA, SLIP	Free to view on SLIP
SOCIAL AND HERITAGE FACTORS		
a) History and Heritage		
Indigenous artefacts Registered Heritage site	DIA database	Free to obtain online
Registered ethnographic site	DIA database	Free to obtain online
Stored data	DIA database	Free to obtain online
Site of European Heritage (eg school, building)	Shire, Heritage Council of WA database, Australian Heritage Database (DSEWPC)	Free to obtain online
Site of other historical significance	Shire	Staff time
b) Amenity and Character		
High Visual amenity / beauty	Shire, site survey	Cost will be variable
Unusual Landscape Character	Shire, site survey	Cost will be variable
Local tourist spot	Shire	Staff time

Table 9: Roadside Vegetation Factors and Scores for Road

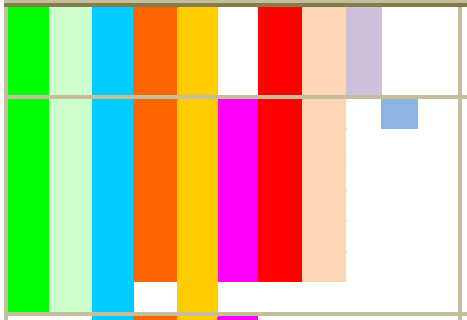
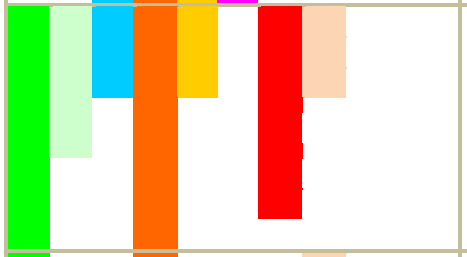
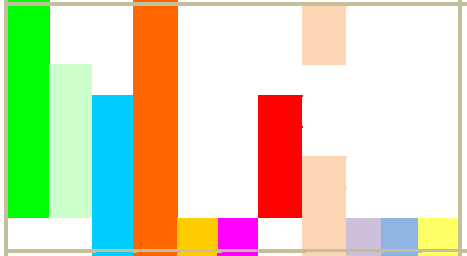
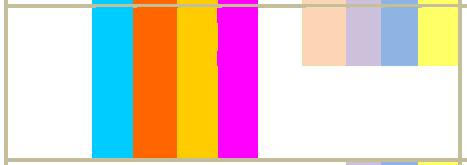
FACTOR		SCORE
10 CLEARING PRINCIPLES		
a) Biodiversity	World heritage - nationally listed	Auto Max Value Score
	Nature reserve	9
	> 250 species	8
	>100 species	6
	> 50 species	4
	< 50 species	2
	0 species (cleared)	0
	Factor 1 - Relative value	
	Higher quality than nearby vegetation	5
	Not higher quality	0
b) Fauna habitat	Threatened fauna	Auto Max Value Score
	Priority 1 fauna	9
	Priority 2 fauna	8
	Priority 3 fauna	7
	Priority 4 fauna	6
	Priority 5 and other significant fauna	5
	No significant fauna	0
	Factor 1 - Corridors	
	Ecological corridors, stepping stones are present	5
	None are present	0
	Factor 2 - Breeding habitat	
	Presence of breeding habitat for threatened fauna	5
	No breeding habitat present for threatened fauna	0
	Factor 3 - Isolated population	
	Local isolated population of fauna present	5
	No local isolated population of fauna present	0
c) Flora	Threatened flora (EPBC or DEC)	Auto Max Value Score
	Priority 1 flora	8
	Priority 2 flora	6
	Priority 3 flora	4
	Priority 4 flora	2
	Priority 5 and other significant flora	1
	No significant flora	0
	Factor 1 - Special species	
	Special species present	5
	No special species present	0
	Factor 2 - Presence of habitat	
	Habitat for threatened species present	5
	No habitat for threatened species present	0

FACTOR		SCORE
d) Threatened Ecological Community	TEC on site	Auto Max Value Score
	Environmentally Sensitive Area	8
	TEC within 1 km	7
	PEC on site	5
	PEC within 1 km	3
	Other significant community	2
	No TEC, PEC or other significant community within 1 km	0
e) Extent of clearing	<1% remaining	Auto Max Value Score
	<2% remaining	9
	<5% remaining	8
	<10% remaining	7
	<30% remaining	6
	<50% remaining	3
	<80% remaining	1
	Factor 1 - Remnant vegetation	
	Large remnant in otherwise cleared landscape	5
	Consistent with adjacent landscape	0
f) Proximity of Water	Containing EP Lake, ESA, Protected, significant or conservation category	10
	Located within wetland buffer	8
	Located in minor wetland or creek	6
	Isolated riverine or wetland trees	3
	No proximity to water	0
g) Effect on land degradation	On a slope >1:3	10
	On a slope >1:6	5
	On a slope >1:10	1
	Factor 1 - Soil type	
	Site is predominantly sandy soil	5
	Site is predominantly soil type other than sandy soil	0
	Factor 2 - Soil acidity	
	Soil pH <4	5
	Soil pH <5	3
	Soil is non acidic	0
	Factor 3 - Salinity risk	
	High salinity risk	5
	Moderate salinity risk	3
	Low salinity risk	1
	No salinity risk	0

FACTOR		SCORE
h) Impact on Conservation Area	Adjacent to National Park or Nature reserve	10
	Adjacent to Shire reserve	8
	Adjacent to Land for Wildlife or Conservation Covenant Land	6
	Not adjacent to reserve	0
	Factor 1 - Corridor	
	Through sole corridor to conservation area	5
	N/A	0
i) Impact on Water Quality	On a slope >1:3	10
	On a slope >1:6	5
	On a slope >1:10	1
	Factor 1 - Soil type	
	Site is predominantly sandy soil	5
	Site is predominantly soil type other than sandy soil	0
	Factor 2 - Soil acidity	
	Soil pH <4	5
	Soil pH <5	3
	Soil is non acidic	0
	Factor 3 - salinity risk	
	High salinity risk	5
	Moderate salinity risk	3
	Low salinity risk	1
	No salinity risk	0
	Factor 2 - Nutrients	
	Likely to result in nutrient export	5
	Not likely to result in nutrient export	0
	Factor 3 - ASS	
	In estuarine or swampy area likely to generate acid	5
	Not in estuarine or swampy area likely to generate acid	0
j) Impact on flooding	Area or nearby area suffers from flooding	10
	Water table within 1 m of surface	4
	Clay soils	2
	Not affected by flooding, high water table or clay soils	0
SOCIAL AND HERITAGE FACTORS		
History and Heritage	Contains Indigenous artefacts Registered Heritage site	10
	Registered ethnographic site	5
	Contains stored data	4
	Site of European Heritage (eg school, building)	5
	Site of other historical significance	3
	No significance	0

FACTOR		SCORE
Amenity and Character	High Visual amenity / beauty	10
	Unusual Landscape Character	5
	Local tourist spot	5
	No value	0
Maximum Total Vegetation Value Score		**434**

Table 10: Options for road work design to minimise clearing of vegetation

A	B	C	D	E	F	G	H	I	J	K	THEME	ACTION
											1. Reduce likelihood of vehicle leaving road and severity of crash	a) Reduce speed limits to reduce the risk of errant driving or the impact of any collision with roadside hazards
											2. Reduce likelihood of vehicle leaving road by improving road/ infrastructure	a) Improve quality of pavement and edges/shoulders
												b) Install (more) guideposts (reflective delineation)
												c) Install guideposts (reflective delineation) adjacent to trees
												d) Reinstate/apply edge lines and centre lines
												e) Install audible / tactile edge line
												f) Widen or extend the seal to include the shoulder of the road
												g) Put up signs warning of trees close to road
											3. Reduce severity of clearing and risk of crash	a) Install safety barriers along verge on stretches of road or around individual trees located close to the travelling lane
											4. Reduce likelihood and severity of clearing by changing table drain design	a) Realign table drains around trees where possible
												b) Use excavators to create table drains rather than graders
												c) Construct drainage offshoots instead of widening table drains
												d) Increase table drain batter slopes from 1:4 (recoverable) to 1:3 (traversable) to decrease width (both fore slope and back slopes)
												e) Reduce table drain width, depth and flatten slopes
												f) Eliminate table drain
												g) Retain frangible vegetation on back slopes
											5. Reduce severity of clearing through selective clearing	a) Prune trees at edge of formation, both horizontally (eg overhanging branches) and vertically (eg encroaching branches)
												b) Reduce recovery zone widths (eg retain trees >2 m from edge of road)
												c) Clear only at intersections / driveways
												d) Clear only at bends
												e) Change the longitudinal profile of the road to reduce cut / fill requirements
												f) Construct passing pockets
												g) Remove trees only while leaving the understory (ie retain frangible vegetation)
											6. Reduce likelihood and severity of clearing and risk of crash by realigning road	a) Realign road by clearing on one side of the existing transport corridor, the side with the overall poorest quality vegetation
												b) Avoid clearing an unmade road reserve adjacent to an approved subdivision in an already cleared area
												c) Construct some or all of the road, or construct a new lane, in a cleared area such as a paddock
												d) Consider other alternative alignments
											7. Reduce risk and severity of crash	a) Clear whole alignment
											8. Extra options to consider	a) Construct the road using pervious pavement to avoid or reduce the need for additional clearing for drainage infrastructure
												b) Install median
												c) Install wire rope barrier in median or centre line