7 REVIEW OF FIELD DATA

There is only limited information available regarding research into the use and effectiveness of road design modifications for fauna. Published research investigating modifications in Australia is generally difficult to find and varies greatly in the degree of detail and the methodologies employed.

Overseas studies have been largely undertaken to prevent road mortalities of large animals that are also likely to injure vehicle occupants during collisions, and therefore the designs are of little relevance to Australian roads. In particular, other than macropods and perhaps wombats, Australian mammals are smaller and less likely to cause serious injuries to vehicle occupants. As such, modification to designs on Australian roads, are more focused on conserving threatened or locally restricted species.

At present, the most significant item of Australian literature regarding the use of culverts by fauna has been published by the Australian Museum Business Services as AMBS Consulting (1997). This survey involved a study of three culverts under the F3 Freeway between Sydney and Newcastle. The study included examination of the fauna surrounding the underpass, the species using the underpass and the influence that the design and features of each culvert may have on fauna movement.

In 1996, Kinhill Pty Ltd conducted a study of the culverts along three sections of motorway located in the Sunshine Coast region of south-east Queensland. Although unpublished, the data obtained during this survey provides an indication of the species likely to use culverts for movement in south-east Queensland, and the effectiveness of culverts that have been modified for fauna movement.

Collation of the data from these two studies (in addition to results obtained from species-specific assessments) provides an indication of which species utilise certain culvert types, and which modifications to culvert surrounds are likely to encourage fauna movement through the culverts. A detailed statistical comparison of data could not be undertaken as a result of variations in the recording of data, the experimental design employed and the methodology used in the surveys. However, as a general guide, this data will assist in identifying conditions that appear to facilitate fauna movement through underpasses and culverts and areas which may benefit from more research.

Findings from targeted field surveys currently being undertaken by the Queensland Department of Main Roads and other road authorities, will be compiled and presented in the second volume of this series. Field surveys have and will continue to be developed to test the preliminary findings provided in this volume.

7.1 GENERAL DESCRIPTION OF THE DATA

A summary of the raw data from field surveys conducted by AMBS Consulting (1997) and Kinhill Pty Ltd (1996) is presented in Appendices A and B. A general description of this data is included below. Interpretation of the data has been undertaken using total number of species or percentages of total records. This has been undertaken to allow comparison between the two different data sets.

To further aid interpretation of this data, fauna species recorded during both surveys are grouped into faunal types as identified on Table 7.1. In general, the fauna in each category would have similar requirements in culvert design and modification.

Table 7.1 Categories of animals used for interpretation of field data

Faunal type	Animals included within category
Small terrestrial mammal	Ground-dwelling species including rodents (both native and introduced), antechinus* and dunnarts
Medium-sized terrestrial mammal	Ground-dwelling species including echidnas, bandicoots and quolls
Large terrestrial mammal	Ground-dwelling species including kangaroos, wallabies and wombats
Semi-arboreal mammal	Tree-dwelling species which move across the ground including possums and koalas
Arboreal mammal	Tree-dwelling species which usually move through the canopy, rarely moving on the ground, including gliders
Bat/flying-fox	Flying mammal species including microchiropteran bats and flying-foxes
Reptile	Ground or tree-dwelling reptiles including all snakes and lizards
Bird	Predominantly ground-dwelling birds species with only incidental records of flying bird species
Amphibian	Ground or tree-dwelling frogs and toads
Introduced predator	Introduced ground dwelling carnivores namely cats, dogs and foxes

* *Antechinus spp. are generally considered to be terrestrial, but may be semi-arboreal or exclusively arboreal in particular conditions. For this investigation these animals are considered to be terrestrial.*

7.1.1 AMBS Consulting (1997)

AMBS Consulting examined three culverts which are further described in Table 7.2. All culverts were located under the F3 Freeway north of Sydney and were of a similar length.

Table 7.2 Description of culverts studied by AMBS Consulting 1997

Location of culvert	Culvert type	Dimensions	Presence of wildlife fencing	Vegetation type in vicinity	Presence of water
Mooney Mooney	Elongated pipe installed specifically as a tunnel for fauna movement*	10 m diameter	Yes	Low open forest	No water present
Sparks Road	3 cell box culverts	3 m wide x 1.5 m high	No	Melaleuca, woodland, cleared pasture dry open forest	Standing water at eastern end. Access by small fauna not obstructed
Palmers Road	4 cell pipe	1.5 m diameter	No	Regenerated vegetation, particularly sedges and shrubs within approaches to pipes	Some standing water on western side

* *Referred to as a fauna tunnel in this report.*

Details of species in the surrounding environment were obtained by AMBS Consulting (1997) from database information from the New South Wales National Parks and Wildlife Service, close examination of the surrounding habitats including terrestrial and arboreal trapping, spotlighting, searches for indicators and identification of road-kills. Animals inside the culverts were identified using infra-red photography. Variations in the number of entrances at each site has probably led to an under-representation of fauna records within the culverts as the camera was only installed in one cell.

A comparison between the number of species recorded in the surrounding environment and the number of species recorded utilising the culverts are listed in Table 7.3. Investigations of these culverts found that more than twice the number of species was recorded in the surrounding environment as was recorded using the culvert. This is only a general estimate for mammals as surveys for reptiles, amphibians and birds were not undertaken. Records of these animals largely come from incidental use of the culvert by these fauna types or identification of road kills. Bats were not surveyed.

Table 7.3 Comparison of species number (including introduced species) recorded in the surrounding environment and within each culvert (from AMBS Consulting 1997)

Fauna type	Mooney Mooney		Sparks Road		Palmers Road	
	General population	Culvert	General population	Culvert	General population	Culvert
Small terrestrial mammal	8	3	4	3	5	2
Medium-sized terrestrial mammal	5	3	1	-	5	3
Large terrestrial mammal	9	2	3	1	5	1
Semi-arboreal mammal	3	1	2	-	3	-
Arboreal mammal	5	-	3	-	4	-
Bat/flying-fox	-	-	-	-	-	-
Bird	2	1	3	-	4	-
Reptile	-	3	3	1	-	2
Amphibian	-	-	-	1	-	1
Introduced predator	3	3	3	1	3	2
Total number of species	**35**	**16**	**22**	**7**	**29**	**11**

7.1.2 Kinhill Pty Ltd (1996)

Kinhill Pty Ltd (1996) conducted surveys of culverts and underpasses along three stretches of road on the Bruce Highway in the Sunshine Coast area of south-east Queensland. In general, each section of highway had numerous cross drainage structures of varying sizes and types. An indication of the size and type of structures along each section of road is provided in Table 7.4.

Table 7.4 Structure size and type along sections of the Bruce Highway (from Kinhill Pty Ltd 1996)

	Number of sites				
Location	**Small pipe <0.5 m d**	**Large pipe >0.5 m d**	**Small box <1.2 x 1.2m**	**Large box >1.2 x1.2 m**	**Bridge**
Nambour Bypass section	4	3	-	-	2
Cooroy Bypass section	3	5	-	4	-
Sunshine Coast Motorway section	6	-	3	5	-
Total	**13**	**8**	**3**	**9**	**2**

The survey methodology to detect species occurring in the surrounding environment included small terrestrial mammal trapping, spotlighting, interpretation of indicators (such as tracks and scats) and identification of road-kills. Investigation inside the culverts included small mammal trapping and identification of indicators inside the structures. Trapping within the culverts was generally not representative of the size of the opening. For example, the same number of traps (generally around 2 or 3), were used to survey both a pipe of 40 cm diameter and a bridge 10 m wide. As such, comparison between some sites provides only a guide.

Comparison between the number of species using the culverts and the number of species recorded in the surrounding population is listed in Table 7.5. Results from both AMBS Consulting (1997) and Kinhill Pty Ltd (1996) estimate that approximately half the number of species recorded within the surrounding environment are recorded utilising the culverts.

Table 7.5 Comparison of species number (including introduced species) recorded in the surrounding environment and within the culverts from Kinhill Pty Ltd (1996)

Fauna type	Nambour Bypass section		Cooroy Bypass section		Sunshine Coast Motorway section	
	General population	Culvert	General population	Culvert	General population	Culvert
Small terrestrial mammal	6	3	6	3	6	3
Medium-sized terrestrial mammal	2	1	1	1	1	1
Large terrestrial mammal	1	-	2	2	1	1
Semi-arboreal mammal	2	-	1	-	1	-
Arboreal mammal	2	-	1	-	-	-
Bat/flying-fox	1	-	1	-	-	-
Bird	1	1	4	-	2	2
Reptile	1	1	1	-	4	-
Amphibian	1	1	1	-	-	1
Introduced predator	1	2	1	2	-	1
Total	**18**	**9**	**19**	**8**	**15**	**9**

The data provided by AMBS Consulting (1997) and Kinhill Pty Ltd (1996) has been further analysed to assist in the identification of particular features of culverts which appear to facilitate fauna movement. This included investigations of the suitability of culvert type and size, influence of associated vegetation and wildlife fencing and impacts upon fauna movement by wet or dry passage. The findings of these investigations are provided below.

7.2 CULVERT SIZE AND TYPE

The size and type of culverts can influence which animals will use the passage. It is generally considered desirable that culverts should be large enough to allow natural movement of a variety of animals. The majority of studies indicate that small mammals can readily use any sized culverts, but large mammals are restricted by the size of the opening.

AMBS Consulting (1997) used infra-red photography to examine three relatively large culverts under the F3 Freeway, including a specifically designed fauna tunnel (Mooney Mooney site). All three culverts chosen for the study were 1.5 m, or taller to allow movement of larger species including

wombats and macropods. Representation of each faunal type as a percentage of total fauna records obtained for each culvert location is included in Table 7.6.

Table 7.6 Percentage of fauna type photographed in each culvert (from AMBS Consulting 1997) presented as a percentage of total for each culvert

	Culvert location and description		
Faunal type	**Mooney Mooney 10 m dia. Tunnel (%)**	**Sparks Road 3 m x 1.5 m box culvert (%)**	**Palmers Road 1.5 m dia. reinforced concrete pipe (%)**
Small terrestrial mammal	32	65	29
Medium-sized terrestrial mammal	28	-	69
Large terrestrial mammal	18	3	-
Semi-arboreal mammal	2	-	-
Arboreal mammal	-	-	-
Bat/flying-fox	-	-	-
Birds	7	-	-
Reptiles	7	9	-
Amphibians	-	6	-
Introduced Predator	6	17	2
Total	**100**	**100**	**100**

Kinhill Pty Ltd (1996) studied a total of 35 culverts. Unfortunately, the same number of traps were used at all sites, without consideration of the variations in the size of the culvert openings. This therefore bias' the results in the favour of smaller culverts. The culverts were divided into four categories based on size and type. Representation of each fauna type as a percentage of total fauna records obtained for each culvert type for this data set are presented in Table 7.7.

Table 7.7 Fauna types either trapped or identified from tracks and scats (dung) in each structure type (from Kinhill Pty Ltd 1996) presented as a percentage of total for each culvert

	Structure			
Faunal type	**Small pipe <0.5 m diameter (%)**	**Large pipe >0.5 m diameter (%)**	**Small box <1.2 x 1.2 m (%)**	**Large box >1.2 x 1.2 m (%)**
Small terrestrial mammal	61	57	75	76
Medium-sized terrestrial mammal	10	14	8	4
Large terrestrial mammal	-	7	-	10
Semi-arboreal mammal	-	-	-	-
Arboreal mammal	-	-	-	-
Bat/flying-fox	-	-	-	-
Birds	5	-	-	-
Reptiles	2	7	-	-
Amphibians	15	-	8	-
Introduced Predator	7	15	9	10
Total	**100**	**100**	**100**	**100**

A brief discussion of the implications of results from the above data sets are provided below. The usage of culverts by each fauna type have been outlined separately as each animal has different requirements and preferences for culvert size and type. All numbers quoted in the following section refer to Tables 7.6 and 7.7.

7.2.1 Usage of culverts by faunal type

Small terrestrial mammals

Small ground-dwelling mammals were commonly recorded in all culverts examined by AMBS Consulting (1997) and Kinhill Pty Ltd (1996). Numbers varied between 29% of all animals recorded at the Palmers Road underpass to 76% of all animals recorded in large box culverts. The data reflects the ability of small mammals to use culverts of any type, but both studies recorded the highest number of small mammals in large box culverts.

Medium-sized terrestrial mammals

Numbers of medium-sized ground-dwelling mammals varied between 4% in large box culverts (Kinhill Pty Ltd 1996) and 69% in a 1.5 m reinforced concrete pipe (at Palmers Road; AMBS Consulting 1997). Variations in this data are likely to be due to less reliable identification methods by Kinhill as only prints were used to identify animals other than small terrestrial mammals as opposed to the infra-red camera used at Palmers Road. In addition, AMBS Consulting's data was also influenced by 212 Long-nosed Bandicoots (*Perameles nasuta*) being photographed at this one site. It is highly likely that many of these records were of the same animal.

Medium-sized mammals were recorded in all culvert types. However, low percentages were recorded in large box culverts (0% by AMBS Consulting (1997) at Sparks Road and 4% by Kinhill Pty Ltd (1996)).

Large terrestrial mammals

Culvert use by large mammals is generally restricted by size. Eighteen percent of fauna using the tunnel at Mooney Mooney were large mammals including wombats and macropods. Large mammals constituted 3% of the fauna use in the box culvert at Sparks Road and no animals were recorded in the pipe at Palmers Road. Kinhill Pty Ltd (1996) showed that large mammals only utilised the larger structures.

Semi-arboreal mammals

Only one record of an animal in this category was recorded. An Eastern Pygmy Possum (*Cercartetus nanus*) was photographed in the fauna tunnel at Mooney Mooney. The use of culverts by these animals is largely unknown. It is, however, generally considered that large structures (in excess of 6 m wide by 3 m high) promote passage of individuals in this fauna type.

Arboreal mammals

No arboreal mammals were recorded using culverts during either survey, although both studies indicated that gliders were observed in the surrounding environments during spotlighting.

Bats/Flying-foxes

The use of culverts by these species was not investigated.

Birds

Bird records are largely incidental and are comprised mainly of birds that spend a large portion of their time on the ground. AMBS Consulting (1997) had 13 records (7% of the fauna recorded) of the Wonga Pigeon (*Leucosarcia melanoleuca*) at Mooney Mooney. Kinhill Pty Ltd (1997) has records of the White-faced Heron (*Ardea novaehollandiae*) and Bush Thick-knee (*Burhinus grallarius*) comprising 4% of the total fauna using small pipes. No specific bird surveys of the surrounding environments were undertaken.

Reptiles

Reptiles were recorded in low numbers in both studies. However, no specific surveys were undertaken to study reptiles.

Amphibians

Three native frogs were recorded using the fauna tunnel at Mooney Mooney and only the introduced Cane Toad (*Bufo marinus*) was recorded using culverts in the Kinhill Pty Ltd (1996) study. Amphibians are not usually guided into culverts by wildlife fencing and therefore the majority of amphibian records are incidental and are probably a reflection of frog habitats being present in the vicinity of the culverts. Kinhill's (1997) study included some wet culverts which has possibly increased the likelihood of Cane Toads using culverts in these areas.

Introduced predators

The introduced predators Cat, Dog and Fox were a relatively large component of the fauna using culverts. This included the box culvert at Sparks Road (17%; AMBS Consulting 1997) and small pipes (7%), small box culverts (9%) and large pipes (10%). The high number at Sparks Road is possibly due to the location of this culvert near a rural setting.

7.2.2 Faunal diversity

The number of different fauna species recorded in the three culverts studied by AMBS Consulting (1997) is included in Table 7.8.

Table 7.8 The number of fauna species (including introduced species) recorded in each culvert during the survey (from AMBS Consulting 1997)

	Culvert location and description		
	Mooney Mooney 10 m dia. tunnel	**Sparks Road 3 m x 1.5 m box culvert**	**Palmers Road 1.5 m dia. reinforced concrete pipe**
Number of fauna species recorded in culvert	17	7	10

As shown in Table 7.8, the highest faunal diversity was recorded in the specifically designed fauna tunnel at Mooney Mooney. Records from this site included many uncommon species including Wombats (14 records), Echidnas (4 records) and one record each of the Eastern Pygmy Possum and Tiger Quoll. These records indicate that this structure is more suitable to a wider range of species than the smaller, concrete culverts.

The faunal diversity of the different culvert types studied by Kinhill Pty Ltd (1996) is shown in Table 7.9.

Table 7.9 Number of species (including introduced species) recorded in each culvert type during the survey (from Kinhill 1996)

	Culvert type and size			
	Small pipe <0.5 m dia.	**Large pipe >0.5 m dia.**	**Small box <1.2 x 1.2 m**	**Large box >1.2 x 1.2 m**
Number of species recorded in each culvert type	12	7	6	8

The highest species diversity in the Kinhill Pty Ltd (1996) study was recorded from small reinforced concrete pipes. This is most likely a reflection of higher trapping and surveying efforts able to be undertaken in a confined space. During this survey, the same methodology and trapping effort (i.e. number of traps at each location) was applied to both small pipes less than 0.5 m in diameter and large box culverts. It is proposed to undertake additional studies to test this assumption, and to present the results in the second volume of this series.

7.3 VEGETATION ASSOCIATED WITH CULVERTS

Many studies suggest that revegetating entrances to culverts makes these culverts more suitable for fauna movement. While this was confirmed by numerous bandicoots making noticeable tracks through dense stands of Cumbungi (*Typha orientalis*), it was also found that animals of varying sizes traversed expanses of bare ground, either in or on the approach to the Mooney Mooney tunnel (AMBS Consulting 1997).

Culverts located in areas adjacent to native bushland should accommodate a larger range of species. Table 7.10 lists the number of species recorded within the culverts and observed in surrounding

vegetation or identified on local fauna databases. Both Mooney Mooney and Palmers Road were surrounded by native vegetation, whilst Sparks Road was near rural development.

Table 7.10 Number of native species recorded in culverts or in surrounding vegetation (from AMBS Consulting 1997)

	Culvert location and description of surrounding vegetation		
Number of species	**Mooney Mooney Cleared approach surrounded by native vegetation**	**Sparks Road Cleared approach near woodland and cleared pasture**	**Palmers Road Regenerated vegetation on approach near forest**
Native species recorded in culvert	13	5	9
Native species in surrounding vegetation	32	20	23

Analysis of Kinhill Pty Ltd's (1996) data determined that of the 35 culverts examined, 16 had vegetated approaches or entrances, 15 had no vegetation on the approach and 4 were not suitably described to determine the extent of vegetation. Table 7.11 describes the number of species trapped in culverts with vegetated and non-vegetated entrances.

Table 7.11 Number of native species recorded in culverts with vegetated or non-vegetated entrances (from Kinhill Pty Ltd 1996)

Number of species	**Culverts with vegetated approach or entrance (16 sites)**	**Culverts with non-vegetated approach or entrance (15 sites)**
Native species recorded in culvert	9	5
Number of native species recorded in surrounding vegetation	24	24

Table 7.11 indicates that a higher representation of native species from the surrounding environment were trapped in culverts which had vegetated entrances. This is supported by research conducted by Ecologia Environmental Consultants (1995) who found a reduction in faunal activity outside culverts with non-vegetated entrances.

7.4 WET OR DRY PASSAGE THROUGH CULVERTS

Culverts examined by AMBS Consulting (1997) were chosen for their dry conditions and unobstructed entrances. Although culverts at Sparks Road and Palmers Road did contain shallow surface waters at times, these conditions were generally not sufficient to impede animal movement. Both culverts had silted floors which would provide a natural surface for fauna.

The data presented by Kinhill Pty Ltd (1996) in Table 7.12 shows that more native species are recorded in culverts with dry passage than wet passage. Although the data set is small, this is not surprising, as many species especially some small mammals and reptiles are unlikely to cross deep or fast flowing water.

Table 7.12 Number of native species recorded in wet and dry culverts (from Kinhill Pty Ltd 1996)

	Dry culverts (27 sites)	Wet culverts (6 sites)
Number of native species	12	3

7.5 WILDLIFE FENCING

Three sections of highway were examined by Kinhill Pty Ltd (1996):

- The Nambour Bypass which has no wildlife fencing.
- The Cooroy Bypass which has some wildlife fencing, mainly confined to one side of the road.
- The Sunshine Coast Motorway which has specifically designed wildlife fencing in most locations.

Table 7.13 provides results of road-kill surveys along these sections of road over a one month period.

Table 7.13 Number of fauna road-kills along three sections of the Bruce Highway over a one month period (from Kinhill Pty Ltd 1996)

Road-killed animals	Nambour Bypass No wildlife fencing	Cooroy Bypass Some wildlife fencing mainly on one side of the road	Sunshine Coast Motorway Wildlife fencing installed on both sides of road
Mammals	12	11	1
Amphibians	5	2	-
Birds	2	5	2
Reptiles	1	1	4
Total	**20**	**19**	**7**

The results show a significant reduction in road kills on the Sunshine Coast Motorway which has specifically-designed wildlife fencing. The wildlife fencing installed on both sides of the road is designed to prevent mammals entering the road and guide mammals through culverts. Also, the animals killed on the section of road with fencing on both sides were predominantly birds and reptiles and these fauna types are not excluded from the road by wildlife fencing.

It is important to note that fencing installed on one side of the road only does not reduce road kills. In some instances fencing on one side of the highway can increase the likelihood of road kills, as mammals can be prevented from exiting the road after they have successfully crossed the road once. This chance of increased deaths can be exacerbated in areas where the fence comes close to the road, such as at culverts, where the change in fence direction tends to funnel animals back onto the carriageway. This has been discussed previously in Chapter 6 (refer to Section 6.3).

Field data on road kills collected over a nine-month period by AMBS Consulting (1997) is described in Table 7.14. This indicates a reduction in total road kills where wildlife fencing is present. However, this data records large numbers of mammal kills and indicates a potential deficiency in the installed fencing as it appears that many mammals are not being guided through the fauna tunnel. High road kill totals at Sparks and Palmers Roads have been largely attributed to birds, which cannot be excluded from the pavement by wildlife fencing.

Table 7.14 Road-kill data for fenced and unfenced culverts over a nine month period (from AMBS Consulting 1997)

Road killed animals	Mooney Mooney Wildlife fencing installed	Sparks Road No wildlife fencing	Palmers Road No wildlife fencing
Mammal	33	29	38
Amphibian	-	-	-
Bird	3	20	13
Reptile	-	3	-
Total	**36**	**52**	**51**

7.6 SUMMARY OF FINDINGS

This review of available field data regarding the use of culverts by fauna has identified general trends. Importantly however, this review has also established the need to undertake additional field surveys in a targeted manner and with a sound experimental design, so that the trends noted in the two data sets recorded here may be tested.

General conclusions from the available field data are listed below. It is again stressed that the following findings are preliminary in nature and need to be confirmed. Present investigations being undertaken by the Queensland Department of Main Roads and other Australian road authorities are aimed at testing these generalities and will be presented in the second volume of this series.

General findings from information outlined in this chapter are:

- Small ground-dwelling mammals may utilise any size culvert.
- Medium-sized ground-dwelling mammals are more likely to utilise underpasses greater than 0.5 m in width.
- The most reliable data on large ground-dwelling mammals suggests that this fauna type prefers large box culverts (greater than 1.5 m in height) and bridge underpasses.
- Arboreal (tree-dwelling) mammals do not appear to utilise culverts and therefore additional measures (such as canopy bridges) require investigation to assess their effectiveness in accommodating movement of this fauna type across the road.
- The present field surveys did not target reptiles, birds or amphibians. Incidental recordings suggest these fauna groups may utilise culverts or pipes of any dimension. This requires testing.
- Introduced predators do not appear to have a preference for any culvert type or size.
- The most reliable data on faunal diversity suggest that a greater number of species utilise bridge underpasses, when compared with culverts or reinforced concrete pipes.
- Higher numbers of animals and species are recorded in culverts with vegetated approaches or entrances, or those contiguous with native vegetation.
- Notably more fauna species utilise culverts that provide dry passage.
- Where properly installed, wildlife fencing significantly reduces road mortalities if the fencing is installed on both sides of the road. In most cases, fencing on one side of the road only, appears to have no benefit over no fencing with regard to road kills, and may result in an increase in mortalities.

Surveys investigating fauna movement over roads are important, as fauna provisions should provide for a variety of species, not only generalist species which are able to readily adapt to new environments. The Queensland Department of Main Roads intends to use these studies to design suitable methodologies to monitor the effectiveness of fauna-specific culvert designs. Numerous projects regarding the safe movement of fauna over or under roads are currently being undertaken by road authorities, and the second volume of this series ‘Fauna Sensitive Road Design—Preferred Practices’ will compile the findings from these, so as to further enhance the design of structures included in road projects.