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WP7

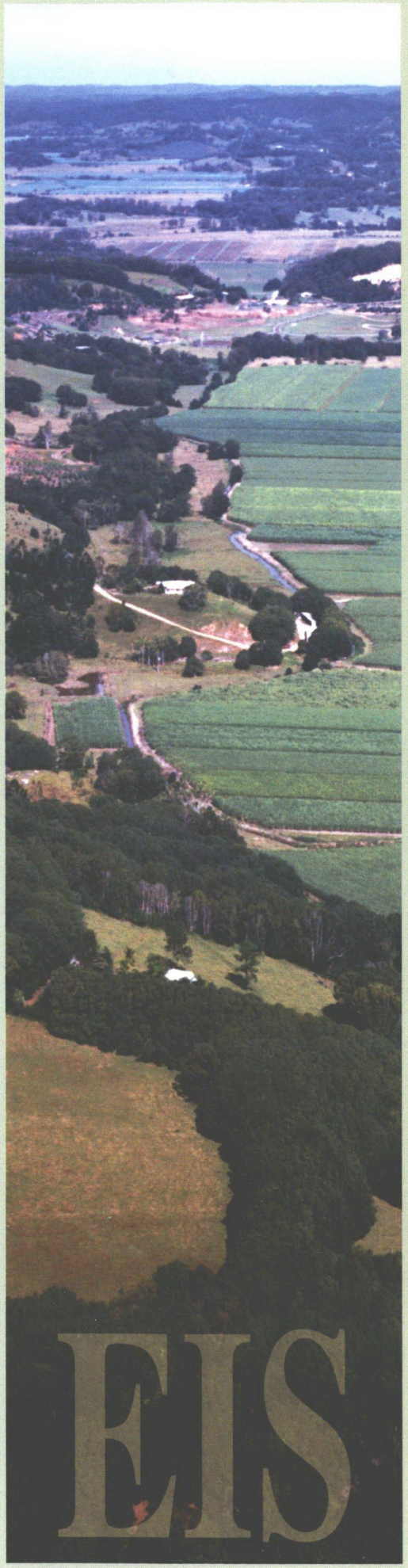
Pacific Highway Upgrade
Yelgun to Chinderah

Environmental Impact Statement

JULY 1998

WORKING PAPER No. 7

Flora and Fauna Assessment



RTA

COMMONWEALTH DEPARTMENT OF
TRANSPORT AND
REGIONAL DEVELOPMENT

SINCLAIR KNIGHT MERZ

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WP 7

Upgrade of the Pacific Highway
Yelgun to Chinderah

Environmental Impact Statement

Flora and Fauna Assessment
Working Paper No. 7

July 1998

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Note: This Working Paper contains two parts. The first part comprises the Flora and Fauna assessment which was prepared by Woodward Clyde and Landmark Ecological Services. The second part comprises a Fish Fauna Assessment which was prepared by The Ecology Lab.

REPORT

PROPOSED PACIFIC HIGHWAY UPGRADE YELGUN - CHINDERAH ENVIRONMENTAL IMPACT STATEMENT WORKING PAPER NO. 7

FLORA AND FAUNA

Prepared for
SINCLAIR KNIGHT MERZ

15 July 1998

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(Note: Chainage Inequality - Chainage Brunswick Heads to Yelgun Section 50.743529 km = 0 Yelgun to Chinderah Section)

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1.1 INTRODUCTION

1.1.1 Study Background

The Roads and Traffic Authority (RTA) is proposing to upgrade the Pacific Highway between Yelgun and Chinderah, on the far north coast of New South Wales. The upgrade would be undertaken as part of the Pacific Highway Upgrading Program.

The proposal is for the construction and operation of a new dual carriageway which is located, for the most part, east of the existing highway and travels generally in a north-south direction. The proposal would start just north of Yelgun and continue through to an interchange with the existing highway, at the northern end of Oak Avenue near Chinderah. The total length of the proposal is approximately 28.5 km.

The proposal has been planned in conjunction with the Proposed Pacific Highway Upgrade, Brunswick River to Yelgun. A separate Environmental Impact Statement (EIS) is being prepared for that project.

The proposed upgrade of this section of the highway is part of the Pacific Highway Upgrading Program, which is a joint New South Wales State/Commonwealth Government initiative. The Program has committed some $2.2 billion for upgrading the Pacific Highway between Hexham and the Queensland border over ten years commencing July 1996.

The proposal is within the Byron and Tweed local government areas (LGA) and is subject to the provisions of the Byron Local Environmental Plan (LEP), 1988, and the Tweed LEP, 1987. Under the provisions of those environmental planning instruments the proposal will be considered under Part 5 of the Environmental Planning and Assessment Act, 1979, as amended (EP&A Act).

This Working Paper is one of a series that documents the detailed investigations carried out to assess the environmental impact of the proposal. These Working Papers accompany the EIS which has been prepared by Sinclair Knight Merz, on behalf of the RTA.

The EIS and accompanying Working Papers are being placed on exhibition for a period of at least 4 weeks, during which time all interested parties are invited to make submissions on the proposal. Following the exhibition period, the RTA will review submissions and address the issues raised. All copies of the submissions and the RTA's consideration of them will be forwarded to the Department of Urban Affairs and Planning (DUAP). The proposal requires the approval of the Minister for Urban Affairs and Planning. If and when that approval is obtained the proposal and DUAP conditions will be considered by the Chief Executive of the RTA, for ultimate determination.

1.1.2 The Proposal

The upgrading of this section of the highway has been the subject of a number of strategic transport planning studies. This particular proposal arose directly from a land use and transport strategy study undertaken in 1996 by the DUAP and the RTA. That study identified the need for upgrading the highway between the Brunswick River and Yelgun, and identified an investigation corridor for the section between Yelgun and Chinderah.

The preferred route for the proposal, which is the subject of the EIS and was the subject of the detailed investigations described in this Working Paper, was selected following extensive investigation of the corridor defined by the DUAP/RTA study and analysis of several alignment options. The proposal is shown on **Figure 1.1**.

The preferred route commences just north of Yelgun and at this location it is confined between the Billinudgel Nature Reserve, the existing highway and the Main Northern Railway. The proposal crosses underneath the existing highway just north of Jones Road and from there it is located on the eastern side of the existing highway. From Jones Road the existing highway starts to swing away to the north-west, while the proposal travels generally in a north-south direction.

In the southern section the proposal has been located to minimise property impacts, particularly impacts on agriculture and on areas of high nature conservation value. Relocation of about 700m of the Pottsville-Mooball Road would be necessary to avoid sensitive vegetation in Burringbar Creek The proposal crosses underneath the Pottsville-Mooball Road at Sleepy Hollow and travels north to a grade separated diamond interchange at Cudgera Creek Road. The local road would be raised over a short stretch to pass over the proposal.

Between Cudgera Creek Road and Clothiers Creek Road the proposal has been located to minimise impacts on agricultural activity, particularly on existing and future cane land, and on rural residential properties.

The interchange at Clothiers Creek Road is a modified trumpet design, located to take advantage of better ground conditions in that vicinity. As for Cudgera Creek Road, the interchange would be grade separated and allow for connections with the local road network.

The proposal would pass under Eviron Road travelling between Tweed Council's Botanic Gardens and Cemetery. From Eviron Road it hugs the lower western slopes of the Duranbah Ridge to minimise impacts on cane farms.

There would be a tunnel of approximately 150 m under Cudgen Road, to avoid a major cut in this location and to preserve the scenic qualities of the area. The proposal then travels north to an interchange at Oak Avenue.

The proposal will be within a road corridor of variable width, typically varying from 50-100m (and wider in the larger cuttings). The corridor has been defined to allow for the road itself as well as landscaping and other environmental mitigation measures including noise mitigation measures, erosion and sedimentation control, and fauna crossings. **Figure 1.2** shows a typical cross-section for the proposal. The concept design also includes details of proposed measures to maintain local drainage networks and to maintain access for agricultural properties.

The description and assessment of the proposal is based on a concept design. For the purposes of this EIS, the design illustrates the general configuration of the proposal and includes the location of interchanges, areas requiring cut and fill, local road realignments and a preliminary road profile.

Detailed design of the proposal would be undertaken when and if the RTA makes a decision that the proposal is to proceed. The detailed design stage would use the concept designs and the information provided in this EIS including the recommended environmental safeguards and mitigation measures. It would also need to take into account issues raised during the exhibition period and the RTA's determination, including any conditions imposed as part of that determination. The more detailed engineering investigation of the proposal would then be undertaken so that construction could commence.

1.1.3 Environmental Impacts and Mitigation Measures

The purpose of the environmental assessment was to identify impacts associated with the proposal, and establish their significance. An important part of the process has been to identify the mitigation and environmental measures that need to be incorporated into the project to ensure that the environment can be adequately protected.

The potential environmental impacts of the proposal are described in each Working Paper, and are described cumulatively in the EIS document. Each Working Paper, and the EIS document also identifies any further additional environmental approvals and/or licences that would be required to enable the project to proceed.

The environmental mitigation and management measures, together with statutory requirements are collated in the form of an outline Environmental Management Plan (EMP) in the EIS document.

1.2 SCOPE OF FLORA/FAUNA STUDY

The flora and fauna assessment describes the floristic and vertebrate fauna assemblages of the study area and assesses the impacts of the proposal on these flora and fauna resources.

Information in this report is based on previous fauna and flora studies conducted for the original Pacific Motorway proposal as well as extensive fieldwork over a period of ten months. The floristic component of this assessment was conducted by Landmark Ecological Services Pty Ltd.

The Assessment has involved the following:

- Consulting the NSW National Parks and Wildlife Service (NPWS) Wildlife Atlas Database, records held by local interest groups and relevant information contained in local studies to determine the flora and fauna species which have previously been recorded in the area.
- Mapping and ground truthing vegetation communities.
- Searching for and recording any species listed on the Schedules of the Commonwealth Endangered Species Protection Act (1992), the Threatened Species Conservation (TSC) Act (1995), ROTAP (Rare or Threatened Australian Plants) species as defined by Briggs and Leigh (1995) and regionally significant species as defined by Sheringham and Westaway (1995).
- Compiling an inventory of plants identified from surveys.
- Compiling an inventory of fauna observed in the study area.

- Undertaking a detailed fauna sampling program to detect the full range of fauna utilising the study area. Species specific techniques were used where appropriate to detect threatened species.
- Assessing habitat within the study area to identify significant habitat areas to be affected by the proposal.
- Assessing the major wildlife corridors impacted by the proposal.

This report is being prepared in conjunction with a Species Impact Statement (SIS) pursuant to Section 111 of the TSC Act (1995) in which the impact on threatened species and their habitats is examined in detail.

2.1 GEOLOGY

The study area forms a narrow corridor running in a north-south direction intersecting low foothills and creek flats to the east of the Condong and Burringbar Ranges. Altitude ranges within the study area from less than 10 m above sea level (ASL) on creek flats to over 90 m ASL in the Sleepy Hollow area.

The geology of the study area according to the Forestry Commission of NSW (1984) is "essentially Palaeozoic and Mesozoic sediments overlain by Tertiary basaltic and rhyolitic flows. The old sedimentary land surface was initially covered by basaltic lava flows from the Mt. Warning shield volcano. In the next phase of volcanic activity rhyolitic lava covered the basalt. The final stage resulted in further outpourings of basaltic lava. The Tweed River system has eroded away most of the covering layers of lava exposing the underlying sedimentary rocks".

From the Tweed/Byron Shire boundary in the south-east to Round Mountain and Duranbah and west to Murwillumbah the soils are derived from Palaeozoic schist whilst Quaternary/Pleistocene muds, gravels, alluvium, sands and silts dominate the north-east of the Shire. There are two locations in coastal Tweed Shire with remnants of overlying basalt, one to the north-west of Cudgen Lake and the other at Terranora. The study area does not include these areas.

2.2 REGIONAL OVERVIEW

The region is a part of the Macleay-McPherson overlap, described by Burbidge (1960) as a distinct phytogeographical zone, containing tropical and temperate species. The main limits of the zone are recognised as the Mary-Burnett Rivers in the north and the Hunter River to the south.

The rich assemblage of plant species, resulting in a complex mosaic of vegetation communities, has led to its recognition as containing an outstanding biodiversity in comparison to the rest of Australia. Additional factors contributing to this richness in the area include wide physiographic and geomorphic variation and a mild climate promoting plant growth throughout the year (Nix, 1976, Adam, 1987, Gilmore *et al*, 1986, Milledge, 1991).

A fauna survey report conducted by the CSIRO (1996) and commissioned by State Forests of NSW describes the vertebrate fauna of the forest environments of the Murwillumbah area as one of the richest and most diverse areas in Australia.

Three of Australia's five historic land biotas mingle in north-eastern New South Wales - Tumbunan, Bassian and Torresian (Olsen, 1991). Only in the north-east wet tropics of Queensland is the biotic mixture more complex, where four of the five biotas abut (CSIRO, 1995).

The Tumbunan biota is described as the subtropical notophyll rainforest biota which retreated to refugial pockets on the east coast and montane New Guinea as Australia desiccated through the later Tertiary to the Quaternary periods. The two major refugial pockets in Australia today remain in the Herbert-Daintree area in north-east Queensland and across the New South Wales/Queensland border centred on the Mt. Warning Caldera (CSIRO, 1995).

The Bassian biota is described as the temperate biota of southern Australia which occurs in sclerophyllous vegetation dominated by Eucalypts but includes heath and mallee vegetation (CSIRO, 1995). Examples of the Bassian fauna include the Striped Marsh Frog *Limnodynastes peronii*, Bearded Dragon *Pogona barbata*, Lace Monitor *Varanus varius*, Crimson Rosella *Platycercus elegans*, Spotted-tailed Quoll *Dasyurus maculatus*, Bush Rat *Rattus fuscipes* and Greater Glider *Petauroides volans*.

The Torresian biota is described as the tropical biota of northern Australia that occurs in savannah and sclerophyllous vegetation dominated by open Eucalypt forests with a grassy understorey. In the region, the Torresian is the predominant non-rainforest biota at altitudes up to approximately 200 m. Torresian fauna species include: Rocket Frog *Litoria nasuta*, Forest Kingfisher *Todiramphus macleayii*, Blue-faced Honeyeater *Entomyzon cyanotis*, Common Planigale *Planigale maculata*, Northern Brown Bandicoot *Isoodon macrourus* and Little Red Flying Fox *Pteropus scapulatus*.

Additionally, the diversity of available habitats over a wide range of altitudes from near sea level to over 1,000 m ASL creates a wide variety of niches for flora and fauna.

Development of the region and historic land clearance practices have collectively resulted in general fragmentation and alienation of habitats within the area, particularly on low lying areas. These clearance activities have had the effect of enhancing the value of remaining remnants over and above their intrinsic value.

The relatively high biodiversity of the area is well recognised and rare, vulnerable, threatened and otherwise endangered species are concentrated in the area. Any substantial areas of relatively intact native vegetation in the area can be expected to support a complement of rare or threatened flora and fauna species.

The vegetation of the region can be broadly divided into five (5) major vegetation groupings: Rainforest, Wet Sclerophyll Forest, Dry Sclerophyll Forest, Swamp Sclerophyll Forest and Heath. Each of these is a response to the primary environmental influences of rainfall, temperature and lithology. These broad vegetation groups can be further divided into a variety of vegetation types, the floristic and structural characteristics of which vary with aspect, slope, soil type and other factors.

Webb (1959) devised a structural classification for Australian rainforests. According to this classification, most of the rainforests within the study region correspond with Complex and Simple Notophyll Vine forest, with the exception of areas of Araucarian Notophyll Vine forest (Floyd, 1989). These correspond respectively with subtropical, temperate and dry rainforest types.

The Eucalypt communities of the region found on higher nutrient basalt and rhyolite lithologies tend to have more mesic understoreys. The demarcation between rainforest and wet Eucalypt forest becomes difficult in the wetter ends of these communities, where Eucalypt and rainforest species are mixed together (CSIRO, 1995). Species such as Flooded Gum *Eucalyptus grandis* and Tallowwood *E. microcorys* can be emergent over rainforest whilst Brush Box *Lophostemon confertus* ranges between the wetter and drier forest communities (CSIRO, 1995).

The drier forest communities found in the region (notably the Scribbly Gum and Blackbutt communities) form very distinctive associations on the lower nutrient sedimentary lithologies. These associations may have a heathy understorey with sclerophyllous members of the Myrtaceae, Proteaceae and Rutaceae families.

Investigations for Route Selection

During 1993/94, a number of route options were investigated for a proposed motorway between Billinudgel and Chinderah. An EIS incorporating a Flora and Fauna Assessment was prepared by Mount King Ecological Services (MKES) (1994) on the basis of a preferred central route.

This proposed motorway was subsequently abandoned.

Following re-appraisal of the Pacific Highway upgrading strategy and extensive consultation with the community and government agencies, a preferred investigation area for the proposed Pacific Highway upgrade was identified and announced by the Minister for Roads in April 1997. This area was similar to that of the proposed motorway.

AGC Woodward-Clyde Pty Limited (Woodward-Clyde) was commissioned by Sinclair Knight Merz in June 1997 to undertake preliminary flora and fauna investigations within the identified corridor area. The purpose of this assessment was to provide information on areas with significant flora and fauna values by way of reviews of available information (including MKES, 1994) and a preliminary flora and fauna survey report.

Information from this report was taken into consideration in the selection of a preferred route which was subsequently announced by the Minister for Roads during December 1997.

The selection of the preferred route enabled detailed studies of the potential impacts of the proposal on flora and fauna issues. At this stage of the project, Woodward-Clyde subcontracted Landmark Ecological Services Pty Ltd to undertake the floristic component of the study. Further field investigations were also initiated. A preliminary report identifying expected impacts to threatened species, significant habitats and corridor values was produced in April 1998.

The findings of these studies gave rise to refinements to the preferred route and provided the basis for the development of mitigation strategies to reduce impacts on flora and fauna associations.

A copy of this report and a request for the requirements of a SIS pursuant to Section 111 of the TSC Act (1995) was forwarded to the NPWS.

4.1 INTRODUCTION

Landmark Ecological Services Pty Ltd were contracted by Woodward-Clyde to undertake the flora assessment for the proposed duplication and deviation of the Pacific Highway between Billinudgel (Yelgun) and Chinderah. Earlier assessments have been completed on a number of options.

Plant species are referred to by their common names in the text of this document, except where no such name is widely accepted. Methodology for the flora assessment is contained in **Appendix D** and lists of species by common and scientific names are provided in **Appendix A**.

4.2 RESULTS

4.2.1 Mapping

Six (6) communities, including twenty-two (22) associations were mapped and identified as follows:

1. Rainforest
   - 1.1 Warm subtropical rainforest (White Booyong *Heritiera trifoliolatum* alliance – Floyd, 1990)
   - 1.2 Hoop Pine +/- rainforest
   - 1.3 Rainforest with exotic species (e.g. Camphor Laurel, Lantana) sub-dominant
   - 1.4 Rainforest regrowth
2. Brush Box Forest
   - 2.1 Brush Box +/- Hoop Pine, Eucalypt and rainforest
   - 2.2 Brush Box +/- emergent Eucalypt
   - 2.3 Brush Box regrowth (with rainforest, Acacia and exotic species)
3. Wet Sclerophyll Forest
   - 3.1 Mixed Eucalypt
   - 3.2 Blackbutt
   - 3.3 Grey Ironbark – Pink Bloodwood
   - 3.4 Tallowwood
   - 3.5 Flooded Gum
   - 3.6 Wet sclerophyll regrowth
4. Dry or Moist Sclerophyll Forest
   - 4.1 Forest Red Gum
   - 4.2 Cypress Pine
   - 4.3 Brush Ironbark Wattle
   - 4.4 Black Wattle

4.5 Forest Oak/Swamp Oak

5. Mixed Regrowth Communities

5.1 Brush Box-Wet Sclerophyll-Rainforest–Wattle-Camphor regrowth

6. Camphor Laurel Dominated Forest

7. Swamp Sclerophyll Forest

7.1 Paperbark

7.2 Swamp Oak.

4.2.2 Description of the Associations

A summary of the vegetation sites is presented in **Appendix B**. The location of sites is depicted in **Figures 2 a-n**.

1.0 Rainforest

1.1 Warm subtropical rainforest (White Booyong *Heritiera trifoliolatum* alliance - Floyd, 1990) (sites 10, 12, 14 and 18)

Warm subtropical rainforest occurred in moist sheltered sites on fertile soils mainly on floodplain areas and in gullies. Remnants were usually confined to riparian areas with Blue Fig, Bangalow Palm, Giant Water Gum, Black Bean and Hairy Rosewood common in the canopy. The ground stratum was usually sparse with a few seedlings present and where the canopy was disturbed exotic species such as Lantana and Mistweed commonly dominated. Warm subtropical rainforest provides habitat for the threatened species Davidson's Plum, Rusty Rose Walnut, Crystal Creek Walnut, Green-leaved Rose Walnut, Red Boppel Nut, Slender Marsdenia, Spiny Gardenia, Red Lilly Pilly and Durobby.

1.2 Hoop Pine +/- rainforest (sites 15 and 16)

This association occurred where soils were drier, mainly on slopes and ridges. Hoop Pine dominated the canopy and was sometimes the dominant species in all strata.

Brush Box, Australian Teak and Cudgerie were typical in the canopy and the midstratum commonly included Red Kamala, Rose Myrtle and Red Ash. The ground stratum usually included species such as Gristle Fern, Morinda and Mat-rush. As the mid and understrata were often dominated by rainforest species this association provides habitat for the following threatened species Davidson's Plum, Rusty Rose Walnut, Crystal Creek Walnut, Green-leaved Rose Walnut, Red Boppel Nut, Slender Marsdenia, Spiny Gardenia and Red Lilly Pilly.

1.3 Rainforest with exotic species (e.g. Camphor Laurel, Lantana) sub-dominant

This association included fragmented areas of rainforest, and rainforest regrowth, which had been invaded by exotic species, particularly on the edges. Such areas tend to be regarded as being of low conservation significance but often provide habitat for threatened species. Davidson's Plum was recorded in this association in several areas.

1.4 Rainforest regrowth

Rainforest regrowth included pioneer and midstage species such as Umbrella Cheese Tree, Cheese Tree, Red Ash, Black Wattle, Brown Kurrajong, Bastard Crows Ash and Cudgerie. This association describes rainforest regrowth with a low proportion of exotic weeds.

2.0 Brush Box Forest

2.1 Brush Box +/- Hoop Pine and Eucalypt (sites 1, 2, 3, 23 and 24)

Brush Box occurred on well-drained medium to high fertility soils in sheltered fire-protected areas. On moist soils rainforest species were often present in the canopy and in these situations if the forest remains undisturbed, rainforest will eventually replace the Brush Box forest. Eucalypt species are often emergent in the canopy.

On drier lower fertility soils where Eucalypt species were common in the overstorey, Forest Oak, Tree Bitter Pea, Guioa, Bolwarra and Scentless Rosewood typically dominated the midstratum. Higher fertility sites supported dry rainforest species such as Hoop Pine, Marblewood, Rose Myrtle, Red-fruited Laurel, Silky Myrtle, Yellow Tulipwood, Black Walnut, Smooth Scrub Turpentine and Riberry. These higher fertility sites also provide habitat for rainforest-dependent threatened species.

Mistweed, Native Ginger and Gristle Fern *Blechnum cartilagineum* generally dominated the ground stratum.

2.2 Brush Box regrowth (with rainforest, Acacia and exotic species)

This association describes Brush Box regrowth to a height of no more than 6 m with Blackwood and Camphor Laurel common associates. This association was common along the roadside and on forest edges.

3.0 Wet Sclerophyll Forest

Wet sclerophyll forest usually describes tall forest (over 30 m in height); frequently with a scattered understorey of small trees, and with a mesomorphic shrub layer and ground herbs (Forestry Commission of NSW, 1989). Most forest recorded on the route reached a height of no more than 20 m. For the purposes of this report wet sclerophyll forest describes Eucalypt forest with a mesomorphic shrub layer and ferny ground stratum.

Blackbutt was dominant to occasional on ridgetops and upper slopes on metasediments and less common on the more sheltered lower slopes where moisture levels were higher and the vegetation was less fire-prone. Small-fruited Grey Gum was recorded on slopes and ridges on shallow soils often in association with Forest Red Gum. Grey Ironbark and Pink Bloodwood formed associations on the mid and lower slopes with Tallowwood grading in with increases in soil fertility. Red Mahogany was recorded on lower moister slopes. Flooded Gum was recorded on the footslopes and in gullies on moist higher fertility soils. White Mahogany was occasionally recorded with Grey Ironbark and Pink Bloodwood and in mixed Eucalypt forest. Flooded Gum was often present on lower sheltered slopes on moderately fertile soils.

3.1 Mixed Eucalypt (site 30)

This category is used to describe Eucalypt associations where no particular species dominated the canopy. Such associations generally included Blackbutt, Small-fruited Grey Gum, Tallowwood, Pink Bloodwood, Grey Ironbark, Red Mahogany and Broad-leaved White Mahogany.

3.2 Blackbutt (site 26)

Blackbutt was dominant to occasional on ridgetops and upper slopes on metasediments and less common on the more sheltered lower slopes where moisture levels were higher and the vegetation was less fire-prone. The midstratum included Camphor Laurel, Red Ash and Orange Boxwood *Denhamia celastroides*. The ground stratum was dominated by Gristle Fern.

3.3 Grey Ironbark – Pink Bloodwood (site 13)

Grey Ironbark and Pink Bloodwood formed associations on the mid and lower slopes. Other Eucalypt species encountered in this association were White Mahogany and Blackbutt. The understorey generally included species such as Tree Bitter Pea, Rose Myrtle, Prickly Alyxia, the rare Black Walnut and the regionally significant Marblewood. Gristle Fern, Mat-rush, and Settler's Flax were regularly recorded in the ground stratum. The rare Brush Cassia was recorded in Grey Ironbark-Pink Bloodwood forest on the Leybourne property (Mooball Range).

3.4 Tallowwood (sites 9, 11 and 25)

Tallowwood was recorded on the mid and lower slopes but usually on moister soils than Grey Ironbark-Pink Bloodwood. Hoop Pine and Brush Box were often present in this association. Scentless Rosewood was very common in the understorey and Gristle Fern was the most common ground stratum species.

3.5 Flooded Gum

Flooded Gum occurred on lower sheltered slopes on moderately fertile soils. Brush Box and Hoop Pine were often present in the canopy and the midstratum was usually dominated by rainforest species. The route will not impact upon any associations dominated by Flooded Gum.

3.6 Wet sclerophyll regrowth

This association describes early Eucalypt regrowth (<5 m in height).

4.0 Dry or Moist Sclerophyll Forest

Dry sclerophyll forest describes forest with a single tree layer and an understorey of sometimes dense sclerophyllous shrubs and a sparse or grassy understorey (Forestry Commission of NSW, 1989). Moist sclerophyll forest, for the purposes of this report, describes forest with sclerophyllous and rainforest elements present in the understorey.

4.1 Forest Red Gum (sites 4, 7 and 28)

Forest Red Gum was found on heavy soils with high moisture content. Pink Bloodwood was recorded at all sites and Grey Ironbark was a common associate. Two sites were in dry sclerophyll forest with an open midstratum and a ground stratum dominated by Kangaroo Grass and Barbed Wire Grass. A third site was wetter with Tallowwood and Broad-leaved White Mahogany present in the canopy and Rose Myrtle dominating the midstratum.

4.2 White Cypress Pine (site 29)

White Cypress Pine is usually found on old dunal sands. However, south-west of Jones Road on Marshalls Ridges this association was found growing on metasediments. Associated species at this site were Swamp Box and Cheese Tree. The ground stratum was sparsely covered with a Mat-rush, Harsh Ground Fern *Hypolepis muelleri* and *Goodenia hederacea.*

4.3 Brush Ironbark Wattle

Several hectares of Brush Ironbark Wattle were recorded to the north of Jones Road. Brush Ironbark Wattle dominated to the exclusion of most other species.

4.4 Blackwood

Blackwood was found throughout the survey area although it was not usually a canopy dominant except for one small area near Kellehers Dip on Eviron Road. Blackwood dominated in most areas with Camphor Laurel, Brush Box and Brown Kurrajong co-dominant to occasional in the canopy. Camphor Laurel and Creek Sandpaper Fig were recorded in the midstratum and Bracken, Mistweed and Common Ground Fern dominated the sparse ground cover.

4.5 Forest Oak/Swamp Oak

Forest Oak was recorded as a co-dominant in mixed Eucalypt forest on the ridges to the north of Stotts Creek. Swamp Oak was recorded on steep slopes at Stotts Creek as a co-dominant with Brush Box and Camphor Laurel. As Swamp Oak was growing on metasediments in a non-swamp situation the association has been included under moist sclerophyll communities (see also Swamp Sclerophyll below).

5.0 Mixed Regrowth Communities

5.1 Brush Box-Wet Sclerophyll-Rainforest–Wattle-Camphor regrowth

Mixed regrowth was recorded in many areas along the route, particularly roadsides and disturbed edges of mature forest. This community was dominated by immature trees usually to a height of <10 m.

6.0 Camphor Laurel Dominated Forest (sites 8 and 32)

The introduced Camphor Laurel favours high fertility sites which would formerly have supported subtropical rainforest but is also invading Eucalypt forest on soils with lower fertility. Camphor Laurel associations on the red soils to the north of the survey area (Kellehers Dip through Duranbah to Stotts Creek) comprised mainly Camphor Laurel with few other species in the canopy or lower strata (site 32).

However, Camphor Laurel associations towards the south of the study area tended to include rainforest species in the canopy and lower strata. Site 8 with 90% Camphor Laurel in the canopy was dominated in the lower strata by Yellow Carabeen with Camphor Laurel forming a small percentage of the understorey species. Camphor Laurel associations are floristically of low conservation significance although they provide habitat for threatened fauna (e.g. Rose-crowned Fruit Dove). This association also occasionally includes threatened flora species that may easily be overlooked.

7.0 Swamp Sclerophyll Forest

Paperbark (sites 6, 19, 20, 21 and 27)

Paperbark occurred in low-lying, regularly inundated areas. With rise in elevation this association often contained Swamp Mahogany and Red Mahogany. On waterlogged soils in protected sites Bangalow Palm, Umbrella Cheese Tree and Pink-flowered Doughwood often formed an association. Foambark, Scrub Turpentine, Blackwood and Blue Lilly Pilly were common midstratum species. The ground stratum was generally dominated by Harsh Ground Fern and Gristle Fern.

7.2 Swamp Oak

This association was recorded in the north of the study area on low-lying areas near Stotts Creek. Swamp Oak is usually found in saline areas close to the coast.

4.2.3 Conservation Status of Recorded Associations

An evaluation of the conservation status of the plant associations recorded from the study area is presented below. Conservation status is based on the area of vegetation known to be protected in reserves.

Table 4-1

Conservation Status Of The Vegetation Associations

1.1	Warm subtropical rainforest (Floyd's *Heritiera trifoliolatum* alliance) Sub-alliance 2 *Toona-Flindersia*	Inadequate, mostly cleared for agriculture (Floyd, 1990)
1.1	Warm subtropical rainforest (Floyd's *Heritiera trifoliolatum* alliance) Sub-alliance 3 *Cryptocarya obovata-Dendrocnide excelsa-Ficus* spp-*Araucaria*	Adequate (Floyd, 1990)
1.1	Warm subtropical rainforest (Floyd's *Heritiera trifoliolatum* alliance) *Sub-alliance 4 Elaeocarpus grandis*	Adequate (Floyd, 1990)
1.1	Warm subtropical rainforest (Floyd's *Heritiera trifoliolatum* alliance) Sub-alliance 5 *Castanospermum-Dysoxylum muelleri*	Adequate (Floyd, 1990)

Table 4-1 (cont'd)

Conservation Status Of The Vegetation Associations

1.1	Warm subtropical rainforest (Floyd's *Heritiera trifoliolatum* alliance) Sub-alliance 6 *Archontophoenix-Livistona*	Good (Floyd, 1990)
1.2	*Araucaria cunninghamii*	Adequately conserved (Floyd, 1990)
2.0	*Lophostemon confertus* includes *Eucalyptus grandis - Lophostemon confertus - E.microcorys*	Adequately conserved (Floyd, 1990); 45% remains of pre-1750 extent in the upper north-eastern New South Wales, 40% of conservation target met in protected areas (Interim Forest Assessment, 1996) A small area of Flooded Gum - Brush Box - Tallowwood was included in this association. Flooded Gum - Brush Box - Tallowwood is poorly conserved (Hager and Benson 1994)
3.1	Mixed Eucalypt includes *Eucalyptus propinqua*	No data is available on the conservation status of mixed eucalypt forest. A few small stands of Small-fruited Grey Gum were included in this association. Small-fruited Grey Gum is inadequately conserved over all its range (Hager and Benson 1994)
3.2	*Eucalyptus pilularis*	"Moist Blackbutt" is inadequately conserved (Hager and Benson, 1994); 55% remains of pre-1750 extent in upper north-eastern New South Wales, 33% of conservation target met in protected areas (Interim Forest Assessment, 1996)
3.3	*Eucalyptus siderophloia-Corymbia intermedia*	Grey Ironbark is poorly conserved. No data is available on the conservation status of Pink Bloodwood (Hager and Benson, 1994)
3.4	*Eucalyptus microcorys*	Tallowwood is poorly conserved (Hager and Benson, 1994); 50% remains of pre-1750 extent in upper north-eastern New South Wales, 100% of conservation target met in protected areas (Interim Forest Assessment, 1996)

Table 4-1 (con'd)

Conservation Status Of The Vegetation Associations

3.5	*Eucalyptus grandis*	Flooded Gum is inadequately conserved over all its range (Hager and Benson, 1994); 47% remains of pre-1750 extent in north-eastern New South Wales, 36% of conservation target met in protected areas (Interim Forest Assessment, 1996)
4.1	*Eucalyptus tereticornis*	Forest Red Gum is inadequately conserved over all of its range (Hager and Benson, 1994); 33% remains of pre-1750 extent in upper north-eastern New South Wales, 63% of target met in protected areas (Interim Forest Assessment, 1996)
4.2	*Callitris columellaris*	Inadequately conserved over all its range (Hager and Benson, 1994); unusual occurrence on metasediments (S. Griffiths *pers comm*); 13% remains of pre-1750 extent in upper north-eastern New South Wales (Interim Forest Assessment, 1996)
4.5	*Allocasuarina torulosa* *Casuarina glauca*	No data is available on the conservation status of this association The conservation status of *Casuarina glauca* on metasediments is unknown. An unusual occurrence on metasediments; likely to be a result of past disturbance (S. Griffiths *pers comm*).
7.1	*Melaleuca quinquenervia - Glochidion sumatranum - Melicope elleryana - Archontophoenix cunninghamiana*	Of local and regional significance (Broadbent and Stewart, 1976), limited in distribution to far north-eastern New South Wales (Harden, 1991, 1993)
7.1	*Melaleuca quinquenervia*	Adequately conserved (Hager and Benson, 1994); 36% remains of pre-1750 extent in north-eastern New South Wales, 100% of conservation target met in protected areas (Interim Forest Assessment, 1996)
7.2	*Casuarina glauca*	Adequately conserved (Hager and Benson 1994); 100% of conservation target met in protected areas (Interim Forest Assessment 1996)

4.2.4 Threatened, Rare and Regionally Significant Species Likely to Occur in the Study Area

Threatened flora species considered likely to occur in the study area and not recorded by previous surveys are listed below:

(i) Acalypha *Acalypha eremorum*

(ii) Rusty Plum *Amorphospermum whitei*

(iii) Small-leaved Myrtle *Austromyrtus fragrantissima*

(iv) Heart-leaved Bosistoa *Bosistoa selwynii*

(v) Three-leaved Bosistoa *Bosistoa transversa*

(vi) Corokia *Corokia whiteana*

(vii) Stinking Cryptocarya *Cryptocarya foetida*

(viii) *Cyperus aquatilis*

(ix) Smooth Davidson's Plum *Davidsonia* sp. A (Mullumbimby-Currumbin Creek)

(x) Gympie Stinger *Dendrocnide moroides*

(xi) Thorny Pea *Desmodium acanthocladum*

(xii) Red-fruited Ebony *Diospyros mabacea*

(xiii) Shiny-leaved Ebony *Diospyros major* var. *ebenus*

(xiv) Small-leaved Tamarind *Diploglottis campbellii*

(xv) Hairy Quandong *Elaeocarpus williamsianus*

(xvi) Crystal Creek Walnut *Endiandra floydii*

(xvii) Rusty Rose Walnut *Endiandra hayesii*

(xviii) Green-leaved Rose Walnut *Endiandra muelleri* subsp. *bracteata*

(xix) Ball Nut *Floydia praealta*

(xx) Fontainea *Fontainea australis*

(xxi) *Isoglossa eranthemoides*

(xxii) Slender Marsdenia *Marsdenia longiloba*

(xxiii) Southern Ochrosia *Ochrosia moorei*

(xxiv) Swamp Orchid *Phaius australis*

(xxv) Swamp Orchid *Phaius tankervilliae*

(xxvi) Brush Sauropus *Sauropus albiflorus* subsp. *microcladus*

(xxvii) Small-leaved Hazelwood *Symplocos baeuerlenii*

(xxviii) Arrow-head Vine *Tinospora tinosporoides*.

4.2.5 Threatened, Rare and Regionally Significant Species Recorded During Survey

Five (5) endangered species and six (6) vulnerable species (as scheduled under the TSC Act, 1995) and six (6) species otherwise listed by Briggs and Leigh (1996) were recorded during this survey (**Table 4-2**).

Table 4-2

Threatened And ROTAP Species Recorded During This Survey

Species	Threatened Species classification (NSW Threatened Species Conservation Act, 1995)	Commonwealth Endangered Species Protection Act, 1992	ROTAP classification (Briggs and Leigh, 1996)#
Davidson's Plum *Davidsonia pruriens* var. *jerseyana*	Schedule 1 - Endangered	Not listed	2ECi
Crystal Creek Walnut *Endiandra floydii*	Schedule 1 - Endangered	Schedule 2 - Vulnerable	2VC-
Green-leaved Rose Walnut *Endiandra muelleri* subsp. *bracteata*	Schedule 1 - Endangered	Not listed	Not listed
Slender Marsdenia *Marsdenia longiloba*	Schedule 1 - Endangered	Schedule 1 - Endangered	3RC
Spiny Gardenia *Randia moorei*	Schedule 1 - Endangered	Schedule 1 - Endangered	3ECi
Stinking Cryptocarya *Cryptocarya foetida*	Schedule 2 - Vulnerable	Schedule 2 - Vulnerable	3VCi
Rusty Rose Walnut *Endiandra hayesii*	Schedule 2 - Vulnerable	Schedule 2 - Vulnerable	3VC-
Red Boppel Nut *Hicksbeachia pinnatifolia*	Schedule 2 - Vulnerable	Schedule 2 - Vulnerable	3RC-
Macadamia Nut *Macadamia tetraphylla*	Schedule 2 - Vulnerable	Schedule 2 - Vulnerable	2VC-
Red Lilly Pilly *Syzygium hodgkinsoniae*	Schedule 2 - Vulnerable	Schedule 2 - Vulnerable	3VC-
Durobby *Syzygium moorei*	Schedule 2 - Vulnerable	Schedule 2 - Vulnerable	2VCi
Veiny Lace Flower *Archidendron muellerianum*	Not listed	Not listed	3RCa
Brush Cassia *Cassia brewsteri* var. *marksiana*	Not listed	Not listed	2RCi
Long-leaved Tuckeroo *Cupaniopsis newmannii*	Not listed	Not listed	2RC-

Table 4-2 (cont'd)

Threatened And ROTAP Species Recorded During This Survey

Species	Threatened Species classification (NSW Threatened Species Conservation Act, 1995)	Commonwealth Endangered Species Protection Act, 1992	ROTAP classification (Briggs and Leigh, 1996)#
Black Walnut *Endiandra globosa*	Not listed	Not listed	2RC-
Blunt-leaved Wisteria *Millettia australis*	Not listed	Not listed	3RC-
Smooth Scrub Turpentine *Rhodamnia maideniana*	Not listed	Not listed	2RC-

\# Key to Risk Code (Briggs and Leigh, 1996)

Distribution Category

2 geographical range < 100 km

3 geographical range > 100 km

Conservation Status

E Endangered - species in serious risk of disappearing from the wild state within one or two decades if present land use and other causal factors continue to operate.

V Vulnerable - species not presently endangered but at risk of disappearing from the wild state over a longer period (20-50 years) through continued depletion, or which largely occur on sites likely to experience changes to land use that would threaten the survival of the species in the wild.

R Rare - species considered rare in Australia, represented by a relatively large population in a very restricted area or by smaller populations spread over a wider range.

Conservation Reservation and Adequacy Code

C population reserved - known to be represented within a conservation reserve (national park or other proclaimed reserve).

a population considered adequately reserved with a population of 1000 plants or more known to occur within conservation reserves.

i population considered inadequately reserved with a total population of less than 1000 plants known to occur within a conservation reserve.

\- the species has been recorded from within a conservation reserve but the population size within the reserve is unknown.

Impacts and amelioration upon these species are discussed in detail within the SIS.

Thirty-three (33) species of regional significance (*sensu* Sheringham and Westaway, 1995) were recorded during this survey (**Table 4-3**).

Table 4-3

Species Of Regional Significance Recorded During This Survey

Species	Reason for Listing*
Rosary Pea *Abrus precatorius*	only known population in New South Wales
Marblewood *Acacia bakeri*	approaching southern limit - Federal area
Broad-leaved Lilly Pilly *Acmena hemilampra*	approaching southern limit - Iluka
White Ash *Alphitonia petriei*	approaching southern limit - Lennox Head
Incense Cedar *Anthocarapa nitidula*	approaching southern limit - Bundjalung National Park
White Lace Flower *Archidendron hendersonii*	approaching southern limit - Alstonville
Twin-leaved Coogera *Arytera distylis*	approaching southern limit - Mt. Coramba Flora Reserve
Large-leaved Banksia *Banksia robur*	disjunct occurrence, nearest record to Tweed Shire is Crowdy Bay National Park
White Cypress Pine *Callitris columellaris*	approaching southern limit - Angourie
Mango Bark *Canarium australasicum*	approaching southern limit - Buckombil, South of Wardell
Palm Lily *Cordyline rubra*	approaching southern limit - Lismore
Stinking Cryptocarya *Cryptocarya foetida*	approaching southern limit - Iluka
Red-fruited Laurel *Cryptocarya laevigata*	approaching southern limit - Lismore
Grey Ebony *Diospyros fasciculosa*	approaching southern limit - Iluka
Broad-leaved Native Cherry *Exocarpus latifolius*	approaching southern limit - Bundjalung National Park

* Reasons for listings from Sheringham and Westaway (1995) supplemented by details of locations of geographical limits from Harden (1990, 1991).

Table 4-3 (cont'd)

Species Of Regional Significance Recorded During This Survey

Species	Reason for Listing*
White Fig *Ficus virens*	approaching southern limit - Clarence Gorge
Bennett's Ash *Flindersia bennettiana*	approaching southern limit - Trenayr near Grafton
Australian Teak *Flindersia australis*	approaching southern limit - Cloud's Creek State Forest
Yellowwood *Flindersia xanthoxyla*	approaching southern limit - Lismore
Umbrella Cheese Tree *Glochidion sumatranum*	approaching southern limit - Yuraygir National Park
Hedraianthera *Hedraianthera poryphropetala*	approaching southern limit - Ballina
Rusty Helicia *Helicia ferruginea*	approaching southern limit - Dorrigo National Park
Pinkheart *Medicosma cunninghamii*	approaching southern limit - Richmond River
Pink-flowered Doughwood *Melicope elleryana*	approaching southern limit - Clarence River
Finger Lime *Microcitrus australasica* var *australasica*	approaching southern limit - Victoria Park Nature Reserve
Bastard Crows Ash *Pentaceras australe*	approaching southern limit - Richmond River
Thin-leaved Coondoo *Planchonella chartacea*	approaching southern limit - Byron Bay
Blush Coondoo *Planchonella laurifolia*	approaching southern limit - Brunswick Heads
Rose Marara *Pseudoweinmannia lachnocarpa*	approaching southern limit - Marara near Dalmorton
Red-fruited Kurrajong *Sterculia quadrifida*	approaching southern limit - north from Broken Head
Triumfetta *Triumfetta rhomboidea*	approaching southern limit - Byron Bay

* Reasons for listings from Sheringham and Westaway (1995) supplemented by details of locations of geographical limits from Harden (1990, 1991).

Table 4-3 (cont'd)

Species Of Regional Significance Recorded During This Survey

Species	Reason for Listing*
Smooth Wilkiea *Wilkiea austroqueenslandica*	approaching southern limit - Richmond River
Large-leaved Wilkiea *Wilkiea macrophylla*	approaching southern limit - Richmond River

4.2.6 Significant Flora Locations

Conservation significance was assessed on the basis of ecosystem integrity and maturity (tree size), conservation status of the vegetation associations, presence of threatened, rare and regionally significant species and landscape context. Some aspects of fauna habitat values were considered, but will be assessed more comprehensively in the fauna component of this study. A discussion of potential impacts of the proposal on significant flora locations is discussed. Amelioration and mitigation measures which are site-specific are described in **Section 7.3**.

High flora values were recognised in those areas shown on **Figure 3**. These areas are discussed in detail below.

1. Marshalls Ridges in the Jones Road-Wooyung Road area (Figures 3a/b):

Values and Impacts

This area is of high conservation value as it contains mature Eucalypt and rainforest trees and a number of rare rainforest species. At South Marshalls Ridges the proposed route passes through a small area of Brush Box with Blackbutt, Broad-leaved White Mahogany and Pink Bloodwood grading in on the western edge, fringing the Pacific Highway. Black Walnut is common in the understorey of this patch. Mature specimens of Blackbutt, Broad-leaved White Mahogany, Pink Bloodwood and Tallowwood will be removed during road construction. Fifteen (15) rare Black Walnuts will also be removed. The proposed route then passes through the edge of a banana plantation, across the edge of a sugarcane field and crosses the Pacific Highway.

To the south-west of the Jones Road intersection the corridor will pass through the side of a small forested hill. Blackbutt dominates the canopy on the upper slopes and ridge with Pink Bloodwood sub-dominant. White Cypress Pine and Brush Box dominate the mid stratum.

Flooded Gum, Tallowwood, Brush Box and Hoop Pine dominate the canopy on the lower slopes and Brush Box and rainforest species dominate the midstratum.

Flooded Gum – Brush Box – Tallowwood is poorly conserved (Hager and Benson, 1994).

* Reasons for listings from Sheringham and Westaway (1995) supplemented by details of locations of geographical limits from Harden (1990, 1991).

The proposed route will heavily impact upon this area. The patch contains a number of mature rainforest trees including Riberry, the rare Black Walnut, the rare Long-leaved Tuckeroo, the rare Veiny Lace Flower and the regionally significant Rose Marara. These trees are in the direct line of the road and will be removed during construction. Mature specimens of Flooded Gum, Brush Box and White Cypress Pine will also be removed.

The corridor then passes through a grassed area to the top of another small hill to the north and through the edge of an area containing Brush Box and "dry" rainforest. Hoop Pine and Pink Bloodwood are emergent. The proposed route will not directly impact upon this area. The rare Smooth Scrub Turpentine and Black Walnut were recorded in this patch but will not be impacted by the road which will pass 100 m to the east.

An area of White Cypress Pine forest running parallel to the road will not be impacted by the road construction. However, a small clump of trees in the paddock to the west of this area will be removed by the road construction.

White Cypress Pine is inadequately conserved over all its range (Hager and Benson, 1994). This species is found on coastal sands (Harden, 1990). Its presence on metasediments at Marshalls Ridges is unusual (S. Griffiths *pers comm*).

Davidson's Plum has been recorded in the Tallowwood – Flooded Gum – Brush Box forest to the north of this area but the population should not be adversely affected as the road does not impact upon this area.

Proposals to re-route the old Pacific Highway may involve removing some areas of mixed Eucalypt forest along the western edge of Pyke's banana plantation.

Where the proposed route passes over the boundary of the Cole and Pyke properties (to the north of Jones Road) several mature Small-fruited Grey Gums are likely to be removed during road construction. Small-fruited Grey Gum is inadequately conserved over all its range (Hager and Benson, 1994) and is uncommon in coastal Byron Shire. This species is a favoured food tree for Koala in the area.

Threatened Species Recorded (TSC Act, 1995)

Davidson's Plum

Davidsonia pruriens var. *jerseyana*

ROTAP Species Recorded (Briggs and Leigh, 1996)

Veiny Lace Flower

Archidendron muellerianum

Long-leaved Tuckeroo

Cupaniopsis newmannii

Black Walnut

Endiandra globosa

Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Rose Marara

Pseudoweinmannia lachnocarpa

Vegetation of Conservation Significance

Small-fruited Grey Gum is inadequately conserved over all its range (Hager and Benson, 1994) and is uncommon in coastal Byron Shire.

White Cypress Pine is inadequately conserved over all its range (Hager and Benson, 1994).

Flooded Gum – Brush Box – Tallowwood forest is poorly conserved (Hager and Benson, 1994).

2. Wooyung Road (Figure 3b):

Values and Impacts

The proposed route passes from the Cole property boundary north towards Wooyung Road. The vegetation south of the boundary is dominated by Brush Ironbark Wattle and Camphor Laurel. The road will directly impact upon a small area (est. 0.25 ha) of Brush Box forest with a rainforest understorey dominated by Yellow Carabeen. This vegetation fringes a small creek running parallel to the railway line.

A strip of vegetation between the railway line and the proposed route contains two endangered Davidson's Plums. Another stem and one seedling were recorded to the north of Wooyung Road, again in the strip of vegetation running to the east of the railway line.

Threatened Species Recorded (TSC Act, 1995)

Davidson's Plum

Davidsonia pruriens var *jerseyana*

ROTAP Species Recorded (Briggs and Leigh, 1996)

Long-leaved Tuckeroo

Cupaniopsis newmannii

Black Walnut

Endiandra globosa

Regionally Significant Species Recorded

White Lace Flower

Archidendron hendersonii

3. A spur of the Burringbar Range in the Hulls Road area (Figure 3c):

Values and Impacts

The area is of high conservation significance containing a population of the endangered Davidson's Plum, a reproducing population of Green-leaved Rose Walnut and a reproducing population of the vulnerable Durobby. The Durobby population is located between the existing road and the railway line and should not be impacted by the proposed route.

The Davidson's Plums were recorded in two locations. One population (7 stems) directly to the south of Hulls Road is located within the proposed route and will be directly impacted. The rare Veiny Lace Flower and the rare Smooth Scrub Turpentine are also present and will be directly impacted during road construction. Rosary Pea was recorded at this location in 1996. This was the first record for New South Wales. This climber which has a cosmopolitan distribution is common in south-east Queensland. It has spread markedly at Hulls Road since 1996 and is now very common through the Forest Red Gum area. The road is unlikely to impact negatively on the population and the disturbance may favour further colonisation.

The other Davidson's Plum location, approx. 250 m to the south comprised 15 stems plus one seedling and a juvenile (less than 1.5 m high). The proposed route will require the removal of 6 stems. One mature Green-leaved Rose Walnut was also recorded in this patch but should not be directly impacted although it is only 4 m outside the western batter.

To the north of Hulls Road a population of Red Boppel Nut and a population of Green-leaved Rose Walnut located within 50 m of the proposed route will not be directly impacted by the road construction provided adequate precautionary measures are taken. However, several individuals of the rare Veiny Lace Flower and one rare Long-leaved Tuckeroo will be removed during road construction. Several mature trees of the rare Black Walnut will also be removed.

The road corridor passes directly through an area of Forest Red Gum on the north of Hulls Road. Forest Red Gum, a favoured food tree for Koala in the area, is inadequately conserved over all its range (Hager and Benson, 1994). Several large mature Small-fruited Grey Gum and several large Blackbutt trees will also be removed during road construction.

To the north of this area the road passes through "Benwerrin" (Catterall property). The road will require the removal of a stand of eight mature Forest Red Gum and three mature Grey Ironbark , and one large Moreton Bay Fig. A large White Fig will also be removed.

Threatened Species Recorded (TSC Act, 1995)

Davidson's Plum

Davidsonia pruriens var *jerseyana*

Green-leaved Rose Walnut

Endiandra muelleri subsp. *bracteata*

Red Boppel Nut

Hicksbeachia pinnatifolia

Durobby

Syzygium moorei

ROTAP Species Recorded (Briggs and Leigh, 1996)

Veiny Lace Flower

Archidendron muellerianum

Long-leaved Tuckeroo

Cupaniopsis newmannii

Black Walnut

Indiandra globosa

Smooth Scrub Turpentine

Rhodamnia maideniana

Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

White Lace Flower

Archidendron hendersonii

White Fig

Ficus virens

Other Values Recorded

Moreton Bay Fig

Ficus macrophylla

4. Burringbar Creek east of Mooball (Figure 3c):

Values and Impacts

Burringbar Creek runs eastwards across the north of "Benwerrin" (Ken Catterall) and the eastern boundary of the neighbouring property (J. Harbison). Riparian remnants of rainforest fringe the creek.

The rainforest consists of Floyd's (1990) *Heritiera trifoliolata* alliance, or warm subtropical rainforest. The remaining vegetation suggests affinities with sub-alliance 3 *Cryptocarya obovata – Dendrocnide excelsa – Ficus* spp. *– Araucaria* and sub-alliance 4 Blue Fig *Elaeocarpus grandis* and sub-alliance 5 Black Bean *Castanospermum australe* and Red Bean *Dysoxylum mollissimum*. Situated on the creek bank, the species recorded represent a flood-tolerant subset of those that would formerly have occupied the surrounding alluvial plains.

Warm (lowland) subtropical rainforest has very high conservation significance. Very little of this rainforest subformation is conserved in Tweed Shire, most of these areas having been cleared for grazing and sugarcane.

Floyd (1990) lists the sub-alliances as having an overall conservation status of "adequate" on a scale that ranges from "excellent" to "not conserved". However, in the Tweed area most lowland subtropical rainforest has been cleared, and these sub-alliances are locally inadequately conserved, and poorly represented on both reserved and private land.

This section of Burringbar Creek contains three (3) threatened species (NSW TSC Act, 1995) – Rusty Rose Walnut, Red Boppel Nut and Red Lilly Pilly, three (3) Rare or ROTAP – species Long-leaved Tuckeroo, Black Walnut and Smooth Scrub Turpentine. It contains a number of large old growth rainforest trees including Giant Water Gum, Purple Cherry, Black Bean, Blue Fig, Pepperberry, Red Bean and White Booyong, White Fig and Small-leaved Fig. A number of these trees, e.g. the Giant Water Gum, were measured at over 100 cm dbh (diameter at breast height).

Threatened Species Recorded (TSC Act, 1995)

Rusty Rose Walnut

Endiandra hayesii

Red Lilly Pilly

Syzygium hodgkinsoniae

Red Boppel Nut

Hicksbeachia pinnatifolia

Durobby

Syzygium moorei

ROTAP Species Recorded (Briggs and Leigh, 1996)

Long-leaved Tuckeroo

Cupaniopsis newmannii

Black Walnut

Endiandra globosa

Smooth Scrub Turpentine

Rhodamnia maideniana

5. A spur of the Burringbar Range in the Warwick Park Road area (Figure 3d):

Values and Impacts

The road passes through cleared agricultural land and through a small area (0.5 ha) of Hoop Pine and rainforest along a creek. Eleven stems of Davidson's Plum were recorded in the cleared land and these will not be directly impacted by the road, the closest stem being 20 m from the proposed route. In the Hoop Pine rainforest remnant two Davidson's Plums stems were recorded. The road will avoid the Hoop Pine rainforest remnant.

Threatened Species Recorded (TSC Act, 1995)

Davidson's Plum

Davidsonia pruriens var. *jerseyana*

6. A spur of the Burringbar Range in the Sleepy Hollow area – Sheens Creek and southern and northern tributaries (Figure 3d):

Values and Impacts

South of the golf course the road may cut through a small area of Tallowwood – Brush Box forest lining a southern tributary of Sheens Creek. A single stem of Davidson's Plum is located on the edge of this remnant. The stem will be directly impacted by the road.

The proposed route crosses Sheens Creek and cuts through the disturbed edge of a patch of Brush Box – Hoop Pine – rainforest. The more intact vegetation contains a population of Davidson's Plum and the rare Black Walnut. The edge area although disturbed contains a clump of the vulnerable Red Boppel Nut and a single stem of Davidson's Plum. The proposed route passes within 20 m of the Red Boppel Nut population. The Davidson's Plum will not be directly impacted. To the south of the patch, three trees of the vulnerable Durobby have been left as paddock trees. Two of these trees are within 20 m of the proposed road. The other tree is in the direct route of the road. The road will avoid impacting this tree.

To the north the road will pass through a small rainforest fringed creek (Sheens Creek tributary north). The creek flows out from the forested area to the west. One Veiny Lace Flower was recorded in this gully and will be removed during road construction. Mature rainforest trees to be removed during the road construction include White Beech *Gmelina leichhardtiana*, Cudgerie *Flindersia schottiana*, Brown Bolly Gum *Litsea australis* and Guioa *Guioa semiglauca*.

Threatened Species Recorded (TSC Act, 1995)

Davidson's Plum

Davidsonia pruriens var *jerseyana*

Red Boppel Nut

Hicksbeachia pinnatifolia

Durobby

Syzygium moorei

ROTAP Species Recorded (Briggs and Leigh, 1996)

Black Walnut

Endiandra globosa

Veiny Lace Flower

Archidendron muellerianum

Locally and Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Broad-leaved Native Cherry

Exocarpus latifolius

7. Forested hillside to the north of Sleepy Hollow (Figure 3e):

Values and Impacts

The lower south-facing slope supports regrowth rainforest grading uphill into Brush Box with White Mahogany, Tallowwood and Pink Bloodwood. Blackbutt dominates the crest of the hill. The rare Black Walnut is a common mid and understorey species in this patch. Regionally significant species recorded here were Broad-leaved Native Cherry, Bastard Crows Ash, Thin-leaved Coondoo, Australian Teak and Bennett's Ash. The road construction will remove an estimated 10 large mature Black Walnut (<14m high) and approximately 20 smaller trees and saplings. Mature Brush Box, Eucalypt and rainforest trees will also be removed.

Threatened Species Recorded (TSC Act, 1995)

Slender Marsdenia

Marsdenia longiloba

ROTAP Species recorded (Briggs and Leigh, 1996)

Black Walnut

Endiandra globosa

Locally and Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Broad-leaved Native Cherry

Exocarpus latifolius

Bastard Crows Ash

Pentaceras australe

Thin-leaved Coondoo

Planchonella chartacea

Australian Teak

Flindersia australis

Bennett's Ash

Flindersia bennettiana

8. Edge of rainforest remnant north of Sleepy Hollow (Figure 3e):

Values and Impacts

The corridor cuts across the edge of a tongue of rainforest that extends down a gully from a larger area of forest to the west. The rainforest consists of Floyd's (1990) *Heritiera trifoliolata* alliance, or warm subtropical rainforest. The vegetation suggests affinities with sub-alliance 2 *Toona-Flindersia* spp.

The rainforest contains a number of significant species including a population of the endangered Crystal Creek Walnut (5 small trees) and several individuals of the vulnerable Stinking Cryptocarya. This rainforest alliance is inadequately conserved (Floyd, 1990). The population of Crystal Creek Walnut and the Stinking Cryptocarya trees will not be directly impacted as they are over 50 m from the proposed route.

The proposed route will directly impact upon an area of vegetation containing the rare Smooth Scrub Turpentine and a number of significant species (see below). A Green-leaved Rose Walnut should not be directly impacted but it is within 2 m of the western batter. A large mature Riberry on the southern edge of the remnant is likely to be removed.

On the edge of the area several mature paddock trees will be removed during road construction – Hairy Walnut, Cudgerie, Hoop Pine and Australian Teak.

Threatened Species Recorded (TSC Act, 1995)

Crystal Creek Walnut

Endiandra floydii

Green-leaved Rose Walnut

Endiandra muelleri subsp. *bracteata*

Stinking Cryptocarya

Cryptocarya foetida

ROTAP Species Recorded (Briggs and Leigh, 1996)

Long-leaved Tuckeroo

Cupaniopsis newmannii

Smooth Scrub Turpentine

Rhodamnia maideniana

Locally and Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Marblewood

Acacia bakeri

Red-fruited Laurel

Cryptocarya laevigata

Broad-leaved Native Cherry

Exocarpus latifolius

Australian Teak

Flindersia australis

Pinkheart

Medicosma cunninghamii

Thin-leaved Coondoo

Planchonella chartacea

Blush Coondoo

Planchonella laurifolia

9. Spur of the Burringbar Range north of Sleepy Hollow (Taggets/Leybourne Properties) (Figurs 3e/f):

Values and Impacts

The vegetation in this area is of high conservation significance. The proposed route passes through three distinct vegetation types. These are listed below.

1. Grey Ironbark *Eucalyptus siderophloia* – Pink Bloodwood *Corymbia intermedia*- Brush Box *Lophostemon confertus* wet sclerophyll forest with rainforest species in the understorey. The conservation status of Grey Ironbark-Pink Bloodwood-Brush Box forest is presently unknown (not listed by Hager and Benson, 1994).
2. Rainforest - the rainforest consists of Floyd's (1990) *Heritiera trifoliolata* alliance, or warm subtropical rainforest. The vegetation suggests affinities with sub-alliance 2 *Toona-Flindersia* spp.

3. Rainforest (suggesting affinities with sub-alliance 2) with Hoop Pine (occasional to dominant). Rainforest sub-alliance 2 is inadequately conserved (Floyd, 1990).

The vegetation on the south-facing slope of the first ridge is Grey Ironbark – Pink Bloodwood – Brush Box wet sclerophyll forest. The rare Brush Cassia was recorded in this patch and will be directly impacted during road construction.

The road then passes down a north-facing slope which has been cleared for a banana plantation, through a patch of rainforest on the lower south-facing slope of the second ridge and across an area of Grey Ironbark – Pink Bloodwood forest. Two Crystal Creek Walnut were recorded on the ecotone between the rainforest and the wet sclerophyll forest. The endangered Green-leaved Rose Walnut and the endangered Spiny Gardenia were recorded on the eastern edge of this area.

Threatened Species Recorded (TSC Act, 1995)

Davidson's Plum

Davidsonia pruriens var. *jerseyana*

Crystal Creek Walnut

Endiandra floydii

Green-leaved Rose Walnut

Endiandra muelleri subsp. *bracteata*

Spiny Gardenia

Randia moorei

ROTAP Species Recorded (Briggs and Leigh, 1996)

Brush Cassia

Cassia brewsteri var. *marksiana*

Black Walnut

Endiandra globosa

Locally and Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Marblewood

Acacia bakeri

White Lace Flower

Archidendron hendersonii

Palm Lily

Cordyline rubra

Bennett's Ash

Flindersia bennettiana

Bastard Crows Ash

Pentaceras australe

10. The fields near an area of lowland subtropical rainforest (Cudgera Creek southern tributary) (Figure 3f):

Values and Impacts

The proposed road route cuts across the fields about 50 m from two patches of remnant lowland warm subtropical rainforest. The road should not directly impact on the remnants. To the south-west of the remnants the road crosses a southern tributary of Cudgera Creek. This tributary connects with the southern remnant. The proposed route then passes to the north through cleared paddocks and onto the floodplain where it crosses Cudgera Creek. Patches of Camphor Laurel are scattered along the creek in this section.

Threatened Species Recorded (TSC Act, 1995)

Davidson's Plum

Davidsonia pruriens var *jerseyana*

Durobby

Syzygium moorei

ROTAP Species Recorded (Briggs and Leigh, 1996)

Brush Cassia

Cassia brewsteri var *marksiana*

11. The Series of Low Ridges in the Kanes Road Area (Figure 3g):

Values and Impacts

The proposed route crosses Cudgera Creek Road and heads north over the floodplain area, crossing a southern tributary of Christies Creek. The floodplain area is mainly cleared with Camphor Laurel along the fence-lines and creek edge. On the hills to the north of the tributary small pockets of remnant Hoop Pine, rainforest and Eucalypt are scattered over the area. The road passes in proximity to one stem of Davidson's Plum and several Durobby. The road then passes through a small area of regrowth rainforest. A Brush Cassia in this patch will be directly impacted.

Threatened Species Recorded (TSC Act, 1995)

Davidson's Plum

Davidsonia pruriens var. *jerseyana*

Durobby

Syzygium moorei

ROTAP Species Recorded (Briggs and Leigh, 1996)

Brush Cassia

Cassia brewsteri var *marksiana*

12. The tributary of Christies Creek in the Kanes Road area (Figure 3g):

Values and Impacts

This area has very high conservation significance. The corridor cuts through Christies Creek. The proposed route cuts through the edge of a fragmented section. Christies Creek links a patch of remnant warm (lowland) subtropical rainforest to the west of the proposed route with a patch of Floyd's sub-alliance 6 Bangalow *Archontophoenix cunninghamii*-Cabbage Palm *Livistona australis* in the east.

The patch to the west has affinities with Floyd's sub-alliance 3 *Cryptocarya obovata-Dendrocnide excelsa-Ficus* spp. The overall conservation status of this association is listed as 'adequate' (Floyd, 1990). However, this patch is of very high conservation significance, being in excellent condition with little weed infestation and containing a number of threatened, ROTAP and regionally significant species. Very little of this rainforest subformation is conserved in Tweed Shire (see area of conservation significance #4), most of these areas having been cleared for grazing and sugarcane.

Sub-alliance 6 Bangalow *Archontophoenix cunninghamii*-Cabbage Palm *Livistona australis* fringes Christies Creek has an overall conservation status of "Good" (Floyd, 1990). Again this association is of high conservation significance locally and regionally due to most of these areas having been cleared for grazing and sugarcane.

On the north-eastern edge of the proposed route a patch of rainforest includes 11 Spiny Gardenia, 5 Smooth Scrub Turpentine, 9 Long-leaved Tuckeroo, and 1 Black Walnut. This area will not be directly impacted by the proposed route.

Threatened Species Recorded (TSC Act, 1995)

Crystal Creek Walnut

Endiandra floydii

Green-leaved Rose Walnut

Endiandra muelleri subsp. *bracteata*

Spiny Gardenia

Randia moorei

Red Lilly Pilly

Syzygium hodgkinsoniae

Durobby

Syzygium moorei

ROTAP Species Recorded (Briggs and Leigh, 1996)

Veiny Lace Flower

Archidendron muellerianum

Long-leaved Tuckeroo

Cupaniopsis newmannii

Black Walnut

Endiandra globosa

Smooth Scrub Turpentine

Rhodamnia maideniana

Locally and Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Marblewood

Acacia bakeri

Red-fruited Laurel

Cryptocarya laevigata

Long-leaved Tuckeroo

Cupaniopsis newmannii

Grey Ebony

Diospyros fasciculosa

Umbrella Cheese Tree

Glochidion sumatranum

Rusty Helicia

Helicia ferruginea

Pink-flowered Doughwood

Melicope elleryana

Bastard Crows Ash

Pentaceras australe

Blush Coondoo

Planchonella laurifolia

Scrub Beefwood

Stenocarpus sinuatus

Red-fruited Kurrajong

Sterculia quadrifida

Smooth Wilkiea

Wilkiea austroqueenslandica

Other Values Recorded

Large mature Cabbage Palm

Livistona australis

After crossing Christies Creek the proposed route passes through a small patch (0.5 ha) of Paperbark forest with Brush Box common in the overstorey and Bangalow Palm common in the midstratum. Paperbark forest is of high conservation significance (see reference to *Melaleuca quinquenervia* in **Table 4-1**). The proposal will require the removal of most of this vegetation. The road then passes through a hill to the north. Several mature Tallowwood and Blackbutt are likely to be removed during road construction.

13. Christies Creek in the Wilman Road area and norther tributary of Christies Creek (Figure 3h):

Values and Impacts

There is little intact vegetation where the corridor cuts Christies Creek in this area. This area may provide a connection between Round Mountain, Wilman Road and the forested hills to the west at Reserve Creek. Blackbutt, Tallowwood, Swamp Mahogany and Small-fruited Grey Gum occur as scattered trees on the hills to the west of Christies Creek. To the east of Christies Creek the forest around Wilman Road is comprised of mixed Eucalypt species (including Blackbutt, Swamp Mahogany, Red Mahogany and Tallowwood) and Paperbark swamp forest.

The road cuts through an area of Paperbark forest with a small patch of Grey Gum, Brush Box and Tallowwood on the eastern adjacent hill slope. On the western edge of the Paperbark a population of Large-leaved Banksia *Banksia robur* will be directly impacted by the road.

Locally and Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Large-leaved Banksia

Banksia robur

14. Clothiers Creek Road (Figure 3i):

Values and Impacts

The corridor cuts across a drain which is fringed with Paperbark forest and through an area of mature Blackbutt forest with rainforest species present in the mid and understorey. To the north of the road an interchange section will necessitate removing several hectares of Blackbutt forest.

Locally and Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Blush Coondoo

Planchonella laurifolia

Other Values Recorded

Large *Ficus* sp.

15. Condong Range in the Eviron Road area (Figures 3j/k):

Values and Impacts

The corridor runs through an area of mature and regrowth Blackbutt forest and regrowth Blackwood to the east of a quarry south of Kellehers Dip. Several large scenescing Blackbutt trees should not be impacted by the road although they are within 20 m of the western batter. A Black Walnut in this area will be directly impacted. The road crosses Eviron Road and cuts through an area of remnant Paperbark– Bangalow Palm forest with Camphor Laurel on the edges. The proposed route then passes through the edge of a patch of sugarcane and north along the eastern edge of the cane fields. Most of the vegetation between this area and Stotts Creek was heavily dominated by Camphor Laurel with little native vegetation remaining. Notable exceptions were a patch of Weeping Lilly Pilly north-west of the Tweed Cemetery/Botanic Gardens, a small area of Brush Box forest to the west of the proposed route and several patches of remnant palms. The proposed road route impacts upon the southern-most patch near an area containing remnant Brush Box and rainforest trees (see below). The proposed route does not directly impact upon the other two patches.

The Weeping Lilly Pilly patch comprises seven senescing remnant trees, the largest with a diameter measured at 2 m and the six others with diameters estimated as over 1 m. The largest Weeping Lilly Pilly recorded previously was 75 cm at Uki in western Tweed Shire (Floyd, 1990). This area will not be impacted by the proposed route.

The Brush Box forest contained senescing trees including several Brush Box, one Hard Quandong and an Australian Teak with a diameter estimated as around 75 cm. Approximately 50 m to the north a Black Walnut was recorded in Camphor Laurel forest. This area is likely to be impacted by the proposed route.

ROTAP Species Recorded (Briggs and Leigh, 1996)

Black Walnut

Endiandra globosa

Long-leaved Tuckeroo

Cupaniopsis newmannii

Smooth Scrub Turpentine

Rhodamnia maideniana

Locally and Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Pink-flowered Doughwood

Melicope elleryana

Umbrella Cheese Tree

Glochidion sumatranum

16. Ridge in the Stotts Creek - Cudgen Road area (Figure3l):

Values and Impacts

The corridor cuts through an area of forest dominated by Camphor Laurel with Swamp Oak and Brush Box common in the canopy. Swamp Oak is usually found in swampy saline environments but at this site is growing on a steep hillslope on metasediments. The presence of Swamp Oak in this situation is unusual (S. Griffiths *pers comm*) and should be regarded as being of local significance. The understorey is dominated by Rose Myrtle. Six stems of the rare Veiny Lace Flower were recorded in the direct proposed route area and are likely to be removed during road construction. The rare Smooth Scrub Turpentine was recorded on the proposed route in a previous survey and is also likely to be removed. At the foot of the south-facing ridge the proposed route passes between a very large Small-leaved Fig and a group of remnant Bangalow Palms.

ROTAP Species Recorded (Briggs and Leigh, 1996)

Veiny Lace Flower

Archidendron muellerianum

Smooth Scrub Turpentine

Rhodamnia maideniana

Locally Significant Species (see above)

Swamp Oak

Casuarina glauca

17. The ridge to the north of the proposed Cudgen Road tunnel - McLeods Creek (Figure3m):

Values and Impacts

The corridor cuts through a ridge of mixed Eucalypt forest (Blackbutt-Tallowwood-Small-fruited Grey Gum- Brush Box). There is little remaining native vegetation in the Stotts Creek area most of the plateau having been cleared for agriculture and grazing. This area should be regarded as being of local significance. Much of the tree cover now comprises Camphor Laurel and Slash Pine plantation. This patch of forest is in proximity to Stotts Island (1.5 km to the north-west with cane fields disconnecting the areas). A patch of remnant Cabbage Palm with Blackbutt and Brush Box fringes the base of the ridge.

Locally and Regionally Significant Species Recorded (Sheringham and Westaway, 1995)

Thin-leaved Coondoo

Planchonella chartacea

18. The toe of a ridge in the Stotts Creek area - South Cudgen Ridge (Figure 3m):

Values and Impacts

This ridge comprises mixed Eucalypt forest (Blackbutt-Tallowwood- Small-fruited Grey Gum–Brush Box). Rainforest grades in on the toe of the ridge. The rare Long-leaved Tuckeroo and the rare Blunt-leaved Native Wisteria were recorded in this area. The area has high conservation value and is of local significance because there is little remaining native vegetation in the Stotts Creek area and because these ridges are in proximity to Stotts Island providing a tenuous connection between the reserve and the Stotts Creek plateau.

ROTAP Species Recorded (Briggs and Leigh, 1996)

Blunt-leaved Native Wisteria

Millettia australis

Long-leaved Tuckeroo

Cupaniopsis newmannii

Locally Significant (see above)

Regrowth rainforest

Blackbutt-Tallowwood- Small-fruited Grey Gum-Brush Box

5.1 INTRODUCTION

The methodology for this analysis was developed with a view to clarifying or identifying the occurrence of vertebrate fauna in the study area and the consequent potential impacts of the development on the environment of these species.

Nomenclature used in this section follows that of Strahan (1995) for the mammals, Christidis and Boles (1994) for the birds and Cogger (1994) for the reptiles and amphibians. Scientific names are provided in the first instance, thereafter common names are used.

MKES (1994) has provided lists of fauna recorded from within the Tweed Shire. This list was compiled as a result of literature review, discussions with residents of the area and an interrogation of records held by the Australian Museum and the NPWS (Atlas of NSW Wildlife). This survey lists:

29 Amphibians (1 introduced);

51 Reptiles;

219 Birds (4 introduced);

67 Mammals (29 bat species, 7 introduced species);

recorded from the area. This list of fauna is presented as **Appendix C**.

In order to clarify the fauna occurring in habitats of the study area a comprehensive fauna survey was initiated. This survey was designed to sample fauna present in habitats to be disturbed within the study area. This survey recorded:

17 Amphibians (1 introduced);

8 Reptiles;

128 Birds (2 introduced);

26 Mammals (4 introduced).

Species lists for this survey are presented in **Appendix E**.

5.2 RESULTS OF THE FIELD SURVEY PROGRAM

The survey was designed to sample habitats representative of those to be disturbed within the study area. Surveys also included those areas not directly affected by the proposal, but proximate to the study area and considered likely to support a diversity of species.

The fauna survey periods were from 1 to 5 August 1997 and 25 to 31 August 1997, with supplementary surveys occurring from 13 to 16 April and 21 to 25 April 1998. Harp trapping was conducted from 18 to 21 September, 1997. Information on the methodology of this survey is presented in **Appendix D**.

5.2.1 Amphibians

Twenty-nine (29) amphibian species are known to occur in the northern New South Wales region (MKES, 1994) representing 13.6% of the Australian frog fauna (**Appendix C**). Of these species:

The following seven (7) are listed on the TSC Act (1995):

Pouched Frog	*Assa darlingtoni*
Wallum Froglet	*Crinia tinnula*
Giant Barred Frog	*Mixophyes iteratus*
Loveridges Frog	*Philoria loveridgei*
Green and Golden Bell Frog	*Litoria aurea*
Green-thighed Frog	*Litoria brevipalmata*
Wallum Tree Frog	*Litoria olongburensis*

although only the Giant Barred Frog and the Green-thighed Frog are considered likely to occur within the study area due to the availability of habitat.

Four (4) of these species, the Pouched Frog, Wallum Tree Frog, Green-thighed Frog and Loveridges Frog are endemic to south-eastern Queensland and north eastern New South Wales (Gilmore and Parnaby, 1994).

Although not listed in **Appendix C**, the occurrence of the Red-eyed Tree Frog *Litoria chloris* is considered likely due to its preference for rainforest and wet sclerophyll habitat areas and regrowth associated with roads and clearings.

Seventeen (17) species of amphibians were recorded during current surveys. These were represented by five genera of the predominantly southern Myobatrachidae family, one genus of the Hylidae (Tree Frog) family and one species of the introduced Bufonidae family (**Appendix E**). The majority of these species are considered to be widespread habitat generalists which are unlikely to be affected by most forms of habitat modification. The Common Eastern Froglet *Crinia signifera*, Spotted Marsh Frog *Limnodynastes tasmaniensis*, and the Red-backed Toadlet *Pseudophryne coracea* are specifically noted to be widespread and common in northern New South Wales, particularly in areas with modified habitat (NSW NPWS, 1994). Their presence in the area is not unexpected given the largely disturbed nature of the area.

A tadpole identified as belonging to the *Mixophyes* genus is considered likely to be that of *Mixophyes fasciolatus* Great Barred Frog and not that of the threatened species *Mixophyes iteratus* (Paul Webber *pers comm*). Tyler's Tree Frog *Litoria tyleri*, while not listed in the TSC Act (1995) is listed as a species of concern in northern New South Wales (NSW NPWS, 1994). Its distribution is limited in coastal and near coastal areas from far south-eastern Queensland to southern New South Wales. No threatened species of amphibian were recorded during current surveys.

5.2.2 Reptiles

The number of reptile species likely to occur in the study region totals fifty-one (51) species (MKES, 1994) comprising 7.2% of the total Australian land reptile fauna. Of these, the Three-toed Snake-tooth Skink *Coeranoscincus reticulatus,* Challengers Skink *Saproscincus challengeri* and Murray's Skink *Eulampris murrayi* are endemic to the region (Gilmore and Parnaby, 1994). Three (3) species, Stephens' Banded Snake *Hoplocephalus stephensii,* Pale-headed Snake *H. bitorquatus* and Three-toed Snake-tooth Skink are currently listed in Schedule 2 of the TSC Act (1995) as Vulnerable.

Surveys by MKES (1994) noted the occurrence of twenty-three (23) reptile species in the study area including 2 species of turtle, 6 snake species and 15 species of lizard including skinks, dragons and monitors, all of which are contained in **Appendix C**. Most of the skinks were located within forest habitats and included several of the large species (e.g. Eastern Blue-tongued Lizard *Tiliqua scincoides,* Land Mullet *Egernia major)* as well as the smaller grass skinks (MKES, 1994). Several skinks associated with rocky outcrops were also located such as the Black Crevice Skink *Egernia saxatilis* and White's Rock Skink *Egernia saxatilis.* Species such as Challenger's Skink and the Three-toed Skink *Saiphos equalis* were found in moister forests with associated deep litter (MKES, 1994). The Blackish Blind Snake *Ramphotyphlops nigrescens* was located during litter searches in a rainforest patch north of Jones Road.

Eight (8) species of reptile were recorded during current surveys (**Appendix E**), none of which are currently listed in the TSC Act (1995). Three (3) species, including the Wall Skink *Cryptoblepharus virgatus,* Grass Skink *Lampropholis delicata,* and the Striped Skink *Ctenotus robustus* were observed in forest habitats similar to previous surveys by MKES (1994) as were the two (2) dragon species, the Bearded Dragon *Pogona barbata* and Eastern Water Dragon *Physignatus lesueurii.* Other species observed in current surveys included the Lace Monitor *Varanus varius* and the Green Tree Snake *Dendrelaphis punctulata.*

All of the species recorded in current surveys have been previously recorded in the study area by MKES (1994) and are considered to be common in the area.

It is recognised that the reptilian fauna of the study area is more diverse than indicated by the current survey results, and therefore the proposal is likely to affect a much greater range of species than those recorded. Potential impacts on threatened reptiles considered likely to occur are addressed in the SIS.

5.2.3 Birds

A total of two hundred and nineteen (219) bird species are likely to occur or are known to occur within the study area (**Appendix C**). Approximately 20% of these species are associated with the aquatic environment (MKES, 1994). There are seventeen (17) raptors known from the region including some which are associated with water (e.g. Osprey and White-bellied Sea-eagle) but most will utilise the timber habitat for perching and roosting and exploit the more open areas for feeding (Ibid.). These birds range widely and many could nest outside the study area while utilising habitats within the study area for hunting. The largest component of birds likely to occur within the study area are those associated with forest habitats. This large grouping includes those with a preference for the wetter habitats or rainforests such as the Fruit Doves, Figbird *Specotheres viridis*, Black-faced Monarch *Monarcha melanopsis* and Varied Triller *Lalage leucomela* as well as those with a preference towards the drier forests including the Whistlers *Pachycephala spp.*, Wrens *Malurus spp.* and Cuckoos *Cuculus spp.*

The current surveys recorded one hundred and twenty-eight (128) bird species overall for the proposed route. An additional twenty-six (26) species have been recorded from previous surveys near the study area, taking the total to one hundred and fifty-four (154) species recorded. The high bird diversity reflects the diversity of habitats traversed by the study area, the size of the study area, and the conduct of the field survey over two seasons (winter and spring). A previous field survey of habitats within and adjacent to the study area in summer-autumn (MKES, 1994) recorded a further eighteen (18) species. Field surveys of the proposed route have thus spanned all seasons.

The breakdown of habitat types where bird species were observed is as follows: thirty-five (35) in rainforest, sixty (60) in moist Eucalypt, forty-seven (47) in dry Eucalypt, nine (9) in swamp sclerophyll, sixty (60) in grassland/disturbed/open, and sixteen (16) from wetland habitats (**Appendix E**). These figures may partly reflect relative survey effort in the different habitat types and the relative area of each habitat. Moist Eucalypt was the most extensive forest habitat in the corridor, and was therefore sampled more than other habitats. The small patches of rainforest supported approximately half as many species, but most of these are rainforest specialists or also occur in the mesic understorey of moist Eucalypt habitats. Dry Eucalypt, with a xeric or grassy understorey, which was poorly represented in the corridor, was confined to exposed ridges, and during the survey period was not in flower. During the cool wet weather of the supplementary survey period, birds avoided the ridge tops in favour of sheltered mesic gullies. Swamp sclerophyll within the corridor was confined to one small, degraded patch dominated by Noisy Miners *Manorina melanocephala* which exclude other species. Forest dominated by exotic species (Camphor Laurel) was mostly inhabited by common, adaptable species but also supported small numbers of Rose-crowned Fruit Doves *Ptilinopus regina* which were foraging on the fruits. The species common to grasslands were either associated with contiguous open wetlands, or were common grassland or pasture specialists.

Of the species targeted by call playback in 1997 the results were negative for, Black-breasted Button Quail *Turnix melanogaster*, Owls (Grass, Sooty and Powerful) and Marbled Frogmouth *Podargus ocellatus*. The Bush Hen *Amaurornis olivacea* was detected; the Masked Owl *Tyto novaehollandiae* was recorded on a previous survey; and the White-eared Monarch *Monarcha leucotis* was observed. Supplementary surveys in April of 1998 detected possible but inconclusive auditory records of the Masked Owl and Grass Owl *Tyto capensis* from Wilman Road and Round Mountain Road respectively.

Bushland on the Condong Range at the northern end of the study area appears to be significant habitat, with thirty (30) species of birds recorded in a short time. All were previously recorded on bird surveys of other parts of the proposed route in 1997. In addition, fruiting trees and shrubs in the Condong Range area are likely to support threatened fruit dove species at least during their non-breeding movements. The Southern Boobook *Ninox novaeseelandiae* was added to the list of birds recorded specifically for the study area during surveys in 1997. The Rose-crowned Fruit Dove was observed flying down the valley separating the Leybourne property from Taggets Quarry.

The survey for Grass Owls on Clothiers Creek Road, Round Mountain Road and Wilman Road was inconclusive, with detections of a faint, distant call (the cricket like trill) that might have been a Grass Owl at Clothiers Creek Road and Round Mountain. A brief sighting on Clothiers Creek Road of a Tyto Owl foraging in flight low over tall wet grassland could not be confirmed as Grass Owl however, the extensive areas of habitat appears suitable, and it is assumed that the Grass Owl occurs there.

The Tweed volcano region is a minor centre for endemism for birds in Australia, with seven (7) taxa being centred in this area (Alberts Lyrebird *Menura alberti* and the Black-breasted Button Quail; and subspecies of the Double-eyed Fig Parrot *Psittaculirostris diophthalma*, Marbled Frogmouth, Eastern Bristlebird *Dasyornis brachypterus*, Yellow-throated Scrub Wren *Sericornis citreogularis* and Little Shrike-thrush *Colluricincla megarhyncha*.

Threatened Species

The following Threatened Species were recorded by field surveys. Their location is presented in **Figure 5**.

Osprey: Recorded over the proposal on previous surveys.

Square-tailed Kite: Identified from photographs of two birds over Jones Road, Yelgun; also several records (by M. Fitzgerald *pers comm*) for the Tweed Coast.

Bush Hen: A pair detected by call playback on Sheens Creek, Sleepy Hollow Golf Course, in man-made habitat of rank introduced grass and weeds on a heavily disturbed watercourse. Also previously observed in Billinudgel Nature Reserve. The proposal will potentially remove a small area of potential habitat at Sleepy Hollow and Christies Creek.

Rose-crowned Fruit Dove: Initial surveys observed this species on Jones Road, Yelgun and it was suspected to be present in other areas of Camphor Laurel and rainforest remnants. Also recorded from Taggets Hill.

Supplementary surveys detected this species in wet sclerophyll and adjoining disturbed forest at the quarry on Eviron Road, 17 April 1998 (heard; probably foraging in Camphor Laurel). The area contained Blackbutt with a mesic understorey of native and introduced fruiting shrubs, grading into regenerating wattle thickets and young Camphor Laurels on edge of pasture.

At least two birds were heard in wet sclerophyll off Jones Road west (north side), 19 April 1998. The site is described as Blackbutt/Brush Box forest with mesic understorey, near paperbark swamp sclerophyll with mesic understorey and Camphor Laurel around the edges. Two birds were seen in disturbed forest (19 April 1998), feeding on Camphor Laurel fruits, off Jones Road east. The area contained young Camphor Laurels in open area beside a wattle thicket, grading into Blackbutt/Brush Box with mesic understorey. Both birds flushed into adjoining Blackbutt forest where they sheltered.

Glossy Black Cockatoo: A flock observed at Billinudgel, flying across the existing highway westward from Ocean Shores. Also observed previously on the Burringbar Range and Tweed Coast.

Masked Owl: Initial surveys detected this species by call playback on Jones Road, Yelgun; also a road kill for the Pacific Highway at Yelgun (Debus and Rose, 1994). An owl fitting this species' description has been observed regularly on the Leybourne property adjoining Taggets Quarry, and was detected there by other members of the Woodward-Clyde fauna survey team.

Supplementary surveys detected a probable though inconclusive auditory record, by call playback, of a distant single screech in remnant wet sclerophyll/swamp sclerophyll/grassland mosaic off Wilman Road, 17 April 1998. The species was reported again for Taggets Hill area by local residents in recent weeks or months (B. and M. Leybourne).

White-eared Monarch: One bird in the rainforest patch adjoining Taggets Quarry, and three birds on the adjacent Leybourne property.

Grass Owl: Supplementary surveys detected possible though inconclusive auditory records, by call playback, of a distant trill in grasslands/cane fields on Round Mountain Road (16 April 1998). A distant screech at the same site on the next night was also detected, and a distant, brief sighting on Clothiers Creek Road of a Tyto Owl foraging in flight low over tall wet grassland (17 April). A Barn Owl was seen and heard at the last site for comparison. This species was also observed foraging amongst Eucalypts in the Christies Creek/Kanes Road area (D Milledge *pers comm*).

5.2.4 Mammals

Non Flying Mammals

A total of thirty-eight (38) non-flying mammals are known to occur in the region (MKES, 1994), seven of which are introduced species (**Appendix C**). Nine (9) non-flying mammal species known to occur in the region are listed as threatened on the TSC Act (1995). One (1) endemic species, the Parma Wallaby *Macropus parma* is known to the area (Gilmore and Parnaby, 1994).

A number of species occur to the west of the study area, but are rarely, if ever, recorded (CSIRO, 1995). These include the Squirrel Glider *Petaurus norfolcensis*, Common Wombat *Vombatus ursinus*, Rufous Bettong *Aepyprymnus rufescens*, Brush-tailed Rock Wallaby *Petrogale penicillata*, Eastern Grey Kangaroo *Macropus giganteus*, Common Wallaroo *Macropus robustus*, Whiptail Wallaby *Macropus parryi*, Black-striped Wallaby *Macropus dorsalis*, Eastern Chestnut Mouse *Pseudomys gracilicaudatus*, New Holland Mouse *Pseudomys novaehollandiae* and Hastings River Mouse *Pseudomys oralis*.

Seventeen (17) species of non-flying mammals were recorded during current surveys (**Appendix E**) including the four (4) introduced species, House Mouse *Mus musculus*, Black Rat *Rattus rattus*, Fox *Vulpes vulpes* and Brown Hare *Lepus capensis*. Five (5) arboreal mammals were recorded from a variety of sites but most commonly from sclerophyll forest habitats. One (1) macropod species, the Swamp Wallaby *Wallabia bicolor* was observed from Yelgun and Sleepy Hollow with hair tube evidence from additional sites at Taggets Hill and Kanes Road. The smaller ground dwelling mammals such as Brown Antechinus *Antechinus stuartii*, Fawn-footed Melomys *Melomys cervinipes* and the Bush Rat *Rattus fuscipes* are considered to be widespread within the forest habitats from which they were recorded.

The Koala *Phascolarctos cinereus* was the only species recorded during current surveys which is listed in the TSC Act (1995). The likely distribution of this species within the study area is discussed below.

Common species not recorded during current surveys, but considered likely to occur within the study area include: the Common Dunnart *Sminthopsis murina*, Water Rat *Hydromys chrysogaster*, Grassland Melomys *Melomys burtoni*, European Rabbit *Oryctolagus cuniculus*, Feral Dog *Canis familiaris* and Feral Cat *Felis cattus*. Non-flying mammals detected during current surveys are generally well represented in similar habitats throughout the region.

Distribution of the Koala in the Study Area

Reed *et al* (1990) note that the Koala is sparse in its distribution on the south coast of New South Wales, but there is a concentration of sightings on the North Coast, Northern Tablelands and Western Slopes.

A considered but speculative estimate of the total population for the Tweed Coast is between 200 and 300 individuals (Australian Koala Foundation (AKF), 1996). There are one hundred and sixty-eight (168) recorded sightings from the NSW Atlas of Wildlife for the Tweed Heads/Murwillumbah region. Twenty-one (21) additional records have been sourced from Milledge (1997) and the Tweed Koala Rescue Unit has supplied a further 800 records. Locations of these sightings are presented in **Figure** 7.

The Koala has been recorded from the Border Ranges National Park, Stotts Island Nature Reserve, Ukerabagh Nature Reserve, Mebbin, Wollumbin and Nullum State Forests. A map showing Koala sightings for the Tweed Coast between 1977-1988 is located in **Figure** 7.

Faulks (1991) identifies six (6) potential Koala habitat areas of particular value in Tweed Shire, these are:

1. Round Mountain - Cudgen Lake;
2. Condong Range;
3. Ukerabagh Nature Reserve;
4. Mt. Warning- Mt. Nullum- Burringbar Range;
5. Ridges and Creeks; and
6. State Forests.

The AKF completed a Koala habitat mapping program for Tweed Shire in 1996. The habitat mapping was achieved by the modelling of Koala tree preference and utilisation data accumulated from field plots. The majority of the study area is mapped as mainly cleared (some trees). The proposed route will, however, pass between significant areas of Koala habitat.

Primary Koala Habitat:

The AKF has defined Primary Koala Habitat as *"habitat with recognisable floristic alliances and/or association wherein tree species known to be both preferentially utilised by Koalas and demonstrating a faecal pellet strike rate which is independent of density are a dominant or co-dominant component of the overstorey vegetation."*.

Primary Koala Habitat is further described as:

(a) communities dominated by Swamp Mahogany *E. robusta* growing on Aeolian and Swamp spill landscapes associated with the Quaternary deposits of largely Pleistocene origin;

(b) communities dominated by Swamp Mahogany *E. robusta* and/or Forest Gum *E. tereticornis* growing on Transferral landscapes associated with Alluvial deposits;

(c) communities dominated by Forest Red Gum *E. tereticornis* and/or the naturally occurring hybrid *E. robusta x tereticornis* growing on Alluvial soil landscapes associated with Quaternary and Neranleigh-Fernvale Group geomorphologies; and

(d) communities dominated by Forest Red Gum *E. tereticornis* growing on erosional landscapes of predominantly yellow podzolics and lithosols associated with Neranleigh-Fernvale group geomorphologies.

Within the study area, Primary Koala Habitat occurs extensively to the north of Cudgen Lake, to the west of Hastings Point (Round Mountain), Billinudgel Nature Reserve, Burringbar Range, South west of Pottsville (Black Rocks) and Chinderah. No Primary Koala Habitat occurs within the study area.

Secondary Koala Habitat:

The AKF has defined Secondary (A) Habitat as *"recognisable floristic alliances and/or association wherein tree species known to be preferentially utilised by Koalas, on average, constitute less than 35% of the overstorey vegetation."*.

Secondary Koala Habitat (Class A) is further described as:

(a) Forest communities on Aeolian and/or Swamp and/or Transferral soil landscapes supporting specimens of Swamp Mahogany *E. robusta* and/or Forest Red Gum *E. tereticornis*, and/or the naturally occurring hybrid *E. robusta x tereticornis* as sub-dominant components of the overstorey;

(b) Forest communities on erosional soil landscapes associated with the Neranleigh-Fernvale group geomorphologies which are supporting specimens of Forest Red Gum *E. tereticornis*, Tallowwood *E. microcorys* and/or Grey Gum *E. propinqua* as sub-dominant components of the overstorey. Both *E. microcorys* and *E. propinqua* are species which will sometimes occur at sufficient densities in some areas to warrant classification as Primary Habitat.

Secondary Koala Habitat (Class A) occurs extensively to the east and west of the study area, particularly between Round Mountain and Cudgen Lake to the east, and extensively

throughout the Burringbar and Condong Ranges.

The AKF has defined Secondary (B) Habitat as *"recognisable floristic alliances and/or associations wherein tree species known to be preferentially utilised by Koalas are largely absent or otherwise occur at very low densities (10%).".*

Secondary Koala Habitat (Class B) is further described as forest communities, including agricultural and/or largely cleared areas supporting low densities of the abovementioned species.

Secondary Habitat (Class B) is also extensive in its distribution adjacent to the study area. The study area does in fact, pass through a number of Secondary Koala Habitat areas to the west of Round Mountain.

The AKF note that *"Field research suggests that approximately 80% of the Primary Habitat category and a similar proportion of Secondary (Class A) Habitats are no longer supporting stable populations, the contention supported by the frequently low activity levels recorded during fieldwork, the proportion of inactive sites which otherwise contain species known to be preferentially utilised by Koalas and extensive foot based traverses of other parts of the study area.".*

Koala Activity Within the Study Area

Koala activity was noted at a number of locations within the study area. These locations are listed from north to south below:

Cudgen Road;

Kellehers Dip (Eviron Road);

Round Mountain Road;

Wilman Road;

Kanes Road;

Taggets Hill;

Sleepy Hollow Golf Course;

Hulls Road;

Jones Road (north and north west of).

These locations are indicated on **Figure** 5.

Megachiropteran and Microchiropteran Bats

Twenty-nine (29) species of megachiropteran and microchiropteran bats are known from the study region (MKES, 1994). Thirteen (13) of these species are listed as Threatened on the TSC Act (1995). Four (4) species of bats are at, or approaching their northern distributional limits in the study area. These are: Chocolate Wattled Bat *Chalinolobus morio*, Eastern Forest Bat *Vespadelus pumilus*, Little Forest Bat *Vespadelus vulturnus* and Eastern Freetail Bat *Mormopterus norfolkensis*. Three (3) species are approaching their southern distributional limits: the Black Flying Fox *Pteropus alecto*, Queensland Tube-nosed Bat *Nyctimene robinsoni* and Northern Long-eared Bat *Nyctophilus bifax*.

Seven (7) species of microchiropteran bats were recorded during current surveys (**Appendix E**), of which the following species are listed as Vulnerable on the TSC Act (1995):

Little Bentwing-bat *Miniopterus australis*

Common Bentwing-bat *Miniopterus schreibersii*

Large-footed Myotis *Myotis adversus*

Northern Long-eared Bat *Nyctophilus bifax*.

The majority of species were recorded with Anabat II ultrasonic detection in forest habitats or cleared flyways adjacent to forest habitats, at Taggets Hill, Eviron Road, Yelgun and Cudgen Road. The Large-footed Myotis, the Little Bentwing-bat and the Northern Long-eared Bat were all detected through harp trapping. The Large-footed Myotis was caught at Sleepy Hollow as was the Little Bentwing-bat although the Little Bentwing-bat was also caught from Yelgun. The Northern Long-eared Bat was caught at Eviron Road, Cudgen Road and Kanes Road.

Two (2) species of megachiropteran bats were recorded during the current field surveys. The Grey-headed Flying Fox *Pteropus poliocephalus* was observed at Yelgun, Kanes Road and Cudgen Road. The Black Flying Fox was observed feeding on Camphor Laurel fruits at Burringbar Creek. This species is recorded as Vulnerable in Schedule 2 of the TSC Act (1995).

The possibility of further species occurring within the study area is addressed in **Section 5.3**.

5.3 THREATENED FAUNA KNOWN OR CONSIDERED LIKELY TO OCCUR WITHIN THE STUDY AREA

A number of sources were utilised to determine the spectrum of threatened fauna previously recorded from and considered likely to occur within a 5 km radius of the study area. These sources included databases held by NPWS and community groups associated with wildlife rescue. Additionally, a number of flora and fauna studies have been conducted in proximal or analogous habitat to that which is represented in the study area. Threatened species recorded as part of these surveys have also been acknowledged. These investigations indicate a total of sixty-two (62) threatened fauna species have been recorded from the broad vicinity of the study area.

Thirteen (13) species of threatened fauna were identified from the study area as a result of field survey. Eleven (11) were identified from the current survey (**Appendix E**) and two (2), Osprey and Square-tailed Kite, from previous studies.

In order to determine the likely occurrence of threatened fauna species previously recorded for the study area a rapid habitat assessment of the proposed route was undertaken. In conjunction with the list of threatened fauna recorded as a result of field survey this method is expected to provide a comprehensive list of threatened fauna likely to be affected by the proposal.

The rapid habitat assessment involved recording macro and micro-habitat components occurring within the study area and comparing these to species known habitat requirements.

Those species recorded or considered likely to occur in habitats specifically affected by the proposal are presented below.

Table 5-1

Predicted And Recorded Occurrence Of Threatened Species Within The Study Area

Threatened Fauna Previously Recorded or Predicted to Occur Within the Vicinity of the Study Area		Recorded in Current Field Survey	Considered Likely to Occur in Habitats Within the Study Area
Common Name	**Scientific Name**		
Amphibians			
Hylidae			
Green/Golden Bell Frog	*Litoria aurea*		
Green-thighed Frog	*Litoria brevipalmata*		X
Wallum Tree Frog	*Litoria olongburensis*		
Myobatrachidae			
Pouched Frog	*Assa darlingtoni*		
Wallum Froglet	*Crinia tinnula*		
Fleays Barred Frog	*Mixophyes fleayi*		
Giant Barred Frog	*Mixophyes iteratus*		X
Loveridges Frog	*Philoria loveridgei*		
Reptiles			
Elapidae			
White-crowned Snake	*Cacophis harriettae*		
Pale-headed Snake	*Hoplocephalus bitorquatus*		X
Stephens' Banded Snake	*Hoplocephalus stephensii*		X

Table 5-1 (cont'd)

Predicted And Recorded Occurrence Of Threatened Species Within The Study Area

Threatened Fauna Previously Recorded or Predicted to Occur Within the Vicinity of the Study Area		Recorded in Current Field Survey	Considered Likely to Occur in Habitats Within the Study Area
Common Name	**Scientific Name**		
Scinidae			
Three-toed Snake-tooth Skink	*Coeranoscincus reticulatus*		X
Birds			
Ciconiiformes			
Australasian Bittern	*Botaurus poiciloptilus*		
Black Bittern	*Ixobrychus flavicollis*		X
Black-necked Stork	*Ephippiorhynchus asiaticus*		X
Falconiformes			
Red Goshawk	*Erythrotriorchis radiatus*		X
Square-tailed Kite	*Lophoictinia isura*		X
Osprey	*Pandion halieatus*		X
Gruiformes			
Bush Hen	*Amaurornis olivaceus*	X	
Brolga	*Grus rubicunda*		X
Black-breasted Button Quail	*Turnix melanogaster*		X
Charadriiformes			
Bush Stone-curlew	*Burhinus grallarius*		
Comb-crested Jacana	*Irediparra gallinacea*		X
Columbiformes			
Wompoo Fruit Dove	*Ptilinopus magnificus*		X
Rose-crowned Fruit Dove	*Ptilinopus regina*	X	
Superb Fruit Dove	*Ptilinopus superbus*		X

Table 5-1 (cont'd)

Predicted And Recorded Occurrence Of Threatened Species Within The Study Area

Threatened Fauna Previously Recorded or Predicted to Occur Within the Vicinity of the Study Area		Recorded in Current Field Survey	Considered Likely to Occur in Habitats Within the Study Area
Common Name	**Scientific Name**		
Psittaciformes			
Glossy Black Cockatoo	*Calyptorhynchus lathami*	X	
Red-tailed Black Cockatoo	*Calyptorhynchus banksii*		
Double-eyed Fig Parrot	*Cyclopsitta diopthalma*		X
Strigiformes			
Powerful Owl	*Ninox strenua*		X
Eastern Grass Owl	*Tyto capensis*	*unconfirmed record*	X
Masked Owl	*Tyto novaehollandiae*	X	
Sooty Owl	*Tyto tenebricosa*		X
Caprimulgiformes			
Marbled Frogmouth	*Podargus ocellatus*		
Coraciiformes			
Collared Kingfisher	*Todiramphus chloris*		
Passeriformes			
Rufous Scrub Bird	*Atrichornis rufescens*		
Yellow-eyed Cuckoo Shrike	*Coracina lineata*		X
Mangrove Honeyeater	*Lichenostomus fasciogularis*		
Alberts Lyrebird	*Menura alberti*		
White-eared Monarch	*Monarcha leucotis*	X	
Mammals			
Dasyuridae			
Spotted-tailed Quoll	*Dasyurus maculatus*		
Brush-tailed Phascogale	*Phascogale tapoatafa*		
Common Planigale	*Planigale maculata*		X

Table 5-1 (cont'd)

Predicted And Recorded Occurrence Of Threatened Species Within The Study Area

Threatened Fauna Previously Recorded or Predicted to Occur Within the Vicinity of the Study Area		Recorded in Current Field Survey	Considered Likely to Occur in Habitats Within the Study Area
Common Name	**Scientific Name**		
Emballonuridae			
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*		X
Macropodidae			
Parma Wallaby	*Macropus parma*		
Muridae			
Eastern Chestnut Mouse	*Pseudomys gracilicaudatus*		
Molossidae			
Beccari's Freetail Bat	*Mormopterus beccari*		X
Eastern Little Mastiff Bat	*Mormopterus norfolkensis*		X
Petauridae			
Yellow-bellied Glider	*Petaurus australis*		
Squirrel Glider	*Petaurus norfolcensis*		
Phascolarctidae			
Koala	*Phascolarctos cinereus*	X	
Pteropodidae			
Queensland Tube-nosed Bat	*Nyctimene robinsoni*		X
Black Flying Fox	*Pteropus alecto*	X	
Queensland Blossom Bat	*Syconycteris australis*		X
Potoriodae			
Rufous Bettong	*Aepyprymnus rufescens*		X
Long-nosed Potoroo	*Potorous tridactylus*		X

Table 5-1 (cont'd)

Predicted And Recorded Occurrence Of Threatened Species Within The Study Area

Threatened Fauna Previously Recorded or Predicted to Occur Within the Vicinity of the Study Area		Recorded in Current Field Survey	Considered Likely to Occur in Habitats Within the Study Area
Common Name	**Scientific Name**		
Vespertilionidae			
Large Pied Bat	*Chalinolobus dwyeri*		X
Hoary Bat	*Chalinolobus nigrogriseus*		X
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*		
Golden-tipped Bat	*Kerivoula papuensis*		X
Little Bentwing-bat	*Miniopterus australis*	X	
Common Bentwing-bat	*Miniopterus schreibersii*	X	
Large-footed Myotis	*Myotis adversus*	X	
Northern Long-eared Bat	*Nyctophilus bifax*	X	
Greater Broad-nosed Bat	*Scoteanax rueppellii*		X
Eastern Cave Bat	*Vespadelus troughtoni*		X

Sixty-six (66) Threatened (Schedule 1 and 2, TSC Act, 1995) fauna species have been identified as known or likely to occur in the general area. Forty-four (44) of these species are considered likely to occur in habitats within the study area. The impacts on these species is discussed in detail in the SIS.

5.4 HABITAT TYPES

The classification of habitat types is based primarily on floristic criteria and secondarily on structural attributes (Gilmore *et al*, 1986). Classification of vegetation for vertebrate resources differs from floristic classification however, in that it recognises many plant species as being substitutes or analogues, in accordance with a particular species' needs (Ibid).

Also considered in habitat assessment are habitat features including the number of large stags, the size and abundance of trunk and branch hollows, the presence of rock outcrops or fallen logs and the presence and diversity of fruiting trees and shrubs. The density of understorey, depth of leaf litter, and the presence of exotic plant species were also taken into consideration.

Based on this criteria, six (6) broad habitat types have been recorded from within the study area as follows:

5.4.1 Rainforests

This habitat type includes vegetation associations:

1.1 Warm subtropical rainforest;

1.2 Hoop Pine +/- rainforest;

1.3 Rainforest with exotic species;

1.4 Rainforest regrowth;

2.1 Brush Box +/- Hoop Pine and rainforest;

as described by Landmark (1998) (**Figures 2 a-n**).

Most of this habitat type is represented within the study area as highly fragmented remnants of a habitat type that was once widespread on the lowland areas of Tweed region. It contains habitat components suitable for a wide variety of fauna.

Fruiting species found in the overstorey and mid-storey of this habitat type (e.g. Figs, Laurels and Lilly Pillys) offers a food source for frugivorous birds including the threatened species Rose-crowned, Wompoo and Superb Fruit Doves and the Yellow-eyed Cuckoo Shrike. Megachiropteran bat species would also utilise this habitat type for a forage resource.

This habitat is also likely to provide important overwintering habitat for a number of nectivorous and frugivorous bird species, e.g. White-eared Monarch (listed as Vulnerable under the TSC Act, 1995), Fantail Cuckoo *Cuculus flabelliformis*, Sacred Kingfisher *Todiramphus sanctus*, Noisy Pitta *Pitta versicolor*, Black-faced Cuckoo Shrike *Coracina novaehollandiae* and Golden Whistler *Pachycephala pectoralis*, Rufous Whistler *Pachycephala rufiventris*, Rose Robin *Petroica rosea*, Grey Fantail *Rhipidura fuliginosa*, White-throated Gerygone *Gerygone olivacea*, Silvereye *Zosterops lateralis*, Olive-backed Oriole *Oriolus sagittatus*, Spangled Drongo *Dicrurus bracteatus* and Pied Currawong *Strepera graculina* (Nix, 1976).

Structural diversity within this habitat provides opportunities for roost sites for microchiropteran bats as well as nesting and foraging opportunities for insectivorous birds.

This habitat type contained low numbers of trees with hollows suitable for nesting sites for Large Forest Owls, Cockatoos or large arboreal fauna. The dense layer of leaf litter and occasional large fallen log offers habitat for a range of reptiles and amphibians endemic to this habitat, e.g. the Barred Frogs, Stephens' Banded Snake and Three-toed Snake-tooth Skink.

5.4.2 Wet Sclerophyll Forests

This habitat type includes the vegetation associations:

2.2 Brush Box regrowth (with rainforest Acacia and exotic species);

3.1 Mixed Eucalypt +/- Brush Box;

3.2 Blackbutt;

3.3 Grey Ironbark - Pink Bloodwood;

3.4 Pink Bloodwood;

3.5 Tallowwood;

3.6 Flooded Gum;

3.7 Wet Sclerophyll regrowth;

5.1 Brush Box - Wet Sclerophyll - Rainforest - Wattle - Camphor Laurel regrowth;

as described by Landmark (1998) (**Figures 2 a-n**).

This habitat type invariably occurred in close proximity to remnant rainforest patches and with an understorey component of rainforest species. The incidence of large hollow bearing trees was low, possibly due to past logging operations in this habitat type. This factor limits the value of this habitat for the large forest owls and arboreal, hollow dependent mammals. Smaller hollows were recorded from this habitat type and these would provide potential nest sites for smaller hollow dependent bird species, e.g. Parrots, Lorikeets and Kingfishers, and roost sites for microchiropteran bats.

This habitat type contains an understorey dominated by mainly mesophytic species offering fruits (e.g. Lilly Pillys, Laurels and Lantana) attractive to frugivorous birds. The flowering characteristics of tree species in this habitat type (particularly Eucalypts), may be providing a seasonal food source for latitudinal migratory fauna, possibly including species such as the Black Flying Fox and Queensland Blossom Bat, which have been recorded from the general area and are listed as Threatened on the TSC Act (1995). The continuity of nectar availability will also support a stable population of Honeyeaters and similar sized birds which are a favoured sources of prey for some raptors.

A range of insectivorous, altitudinal, migratory birds will also depend upon this habitat to provide a winter forage source. Groundcover of this habitat type contains fallen logs and leaf litter providing shelter for ground dwelling mammals and reptiles.

Koala forage trees occurred throughout this habitat type in varying densities.

5.4.3 Dry Sclerophyll Forests

This habitat type contains vegetation associations:

4.1 Forest Red Gum +/- Small-fruited Grey Gum;

4.2 Cypress Pine;

4.3 Brush Ironbark Wattle;

4.4 Black Wattle;

4.5 Casuarina Sp.;

as recorded by Landmark (1998) (**Figures 2 a-n**).

This habitat type occurred on the drier, more elevated areas of the study site and was observed to have a lower canopy height than the previous two habitats, a xeric shrub understorey and/or high levels of grass cover in the ground layers including areas of bare soil and low litter cover. Lantana is also usually present in the understorey. Large hollows were either absent or occurred at extremely low densities reflecting these areas' historical disturbance through clearing and thinning for agriculture and logging to provide fencing or building materials. The reduction in this habitat component can be expected to decrease the likelihood of the occurrence of large forest owls and larger hollow dependent arboreal mammals. Smaller hollows are spread throughout this habitat type and are expected to provide nest hollows for Lorikeets and Parrots and roost sites for microchiropteran bats and smaller arboreal mammals. The shedding bark trees present are also likely to provide microchiropteran bat roost sites.

This habitat type also includes regrowth Acacia forests likely to offer forage opportunities for Sugar Gliders and shelter for smaller insectivorous birds.

The flowering characteristics of tree species present within this habitat may be providing a forage resource for latitudinal and altitudinal migratory fauna during the overwintering period. Forest Red Gum was recorded in this habitat type. This species is known to flower in winter and is implicated as an important forage resource for Lorikeets in their winter breeding period.

This habitat type is also recognised as containing an abundance of Koala forage trees.

5.4.4 Swamp Sclerophyll Forests

This habitat type contains the vegetation associations:

7.1 Paperbark;

7.2 Swamp She-oak;

as described by Landmark (1998) (**Figures 2 a-n**).

One small area of this habitat type occurred in the study area. Habitat components were limited owing to the area's small size, current grazing regime and previous burning. The most important habitat component specific to this site is the occurrence of Broad-leaved Paperbark which flowers on the north coast in late autumn and winter, Boland *et al* (1992), and provides a nectar resource for nectivorous species which regularly overwinter in this area. Such species include the Scarlet Honeyeater *Myzomela sanguinolenta*, Eastern Spinebill *Acanthorhynchus tenuirostris*, Noisy Friarbird *Philemon corniculatus* and Little Friarbird *Anthochaera chrysoptera*. This feature may also provide an important forage resource for some of the megachiropteran bats. Although disturbed, the area is still likely to encounter seasonal flooding offering breeding opportunities for common amphibian species.

5.4.5 Grasslands

This man-made habitat type dominated the study area. It includes introduced grassland swards and cultivated sugarcane and associated drains. Habitat components present were limited, however, a range of suitably adapted species have been recorded from and is likely to occur here. The drains within this area are likely to offer forage resources for some of the mobile freshwater wader species such as Herons, Egrets, Ibis and Spoonbills. Species of insectivorous birds will utilise these habitats offered by up to 100% grass cover. Species such as the Brown Quail *Coturnix ypsilophora*, Superb Fairy Wren *Malurus cyaneus*, Richard's Pipit *Anthus novaeseelandiae*, Red-browed Firetail *Emblema temporalis* and Tawny Grassbird *Megalurus timoriensis* were recorded and are considered to be widespread throughout these habitats. Macropods such as the Swamp Wallaby also commonly utilise grassland areas adjacent to forested areas. Small native and introduced mammals from the *Melomys and Rattus* genera are also likely to occur and provide prey for diurnal raptors and the Eastern Grass Owl which is listed as Vulnerable under the TSC Act (1995).

5.4.6 Disturbed Forests Dominated by Exotic Species

This habitat type contains the vegetation types associations mapped as 6.0 Camphor Laurel dominated forest as described by Landmark (1998) (**Figures 2 a-n**).

Large areas of this habitat type occurred in the north of the study area. Camphor Laurel dominated this habitat often occurring as exclusive stands. Although dominated by introduced plant species these habitat types are well documented as providing essential habitat for a range of threatened fauna species (Milledge, 1998). Fruiting species provide a forage resource for a range of frugivorous birds including the Rose-crowned, Superb and Wompoo Fruit Doves. Such habitats are also likely to provide shelter for a range of species likely to forage in surrounding grasslands. This habitat type also provides refuge to altitudinal and latitudinal migratory birds during movement phases.

5.5 ASSESSMENT OF FAUNA HABITATS

Previous studies within the general area not associated with the study area have attempted to ascribe conservation values to habitat types. Gilmore *et al* (1986) states that.

By applying a set of criteria, a habitat conservation value can be assigned to a particular habitat type. These criteria are as follows:

1. The presence of endangered and/or significant vertebrates;
2. Presence of habitat containing plants providing a seasonally important food supply for migratory vertebrates;
3. Presence of habitat with a rich faunal assemblage;
4. Habitat not subject to recent disturbance and possessing a wide range of age classes and associated structural complexity; and
5. Overall regional status of habitat types in terms of area.

Based on information available on the fauna assemblages within analogous habitat types to that represented within the study area (Smith *et al*, 1993; Tanton, 1996; CSIRO, 1996; Milledge, 1991) and field survey work completed as part of this study, habitat types recorded from the study area were assessed according to the criteria used by Gilmore *et al* (1986).

As a consequence of this analysis the following ranking was applied to the habitats as they occur in the study area. Habitat types are presented in order of decreasing significance.

1. Rainforests;
2. Wet sclerophyll forests;
3. Dry sclerophyll forests;
4. Swamp sclerophyll forests;
5. Disturbed forests dominated by exotic species;
6. Grasslands.

Information from the flora survey was examined to determine the distribution of habitat within the study area and to determine areas containing significant habitat or forming a composite area of significant habitats. The distribution of habitat types throughout the area of the proposal is presented in the table below.

Table 5-2

Location Of Significant Habitats

Area and Centreline Metreage South to North	Rainforest	Wet Sclerophyll	Dry Sclerophyll	Swamp Sclerophyll	Disturbed Forest (introduced sp.)	Grasslands
Marshalls Ridges 1,000m - 2,200m	*	*	*			*
Hulls Road 4,500m - 5,200m	*	*	*			
Burringbar Creek 5,900m - 6,200m	*					
Pottsville - Mooball Road Crossing 7,600m - 7,800m		*				
Sleepy Hollow 1 9,400m - 9,600m	*	*				
Sleepy Hollow 2 10,400m - 11,200m	*	*	*			*
Kanes Road 14,400m - 14,500m			*			
Tributary to Christies Creek 14,600m - 14,700m	*					
Wilman Road 15,900m - 16,050m					*	
Round Mountain Road 16,700m - 16,800m				*		
Eviron Road 1 20,800m - 21,100m			*			
Eviron Road 2 21,600m - 21,650m		*				
Duranbah Road 23,900m - 24,050m					*	
Cudgen Road 24,800m - 25,000m					*	
West of Cudgen Road 25,500m - 25,600m		*	*			
North or Cudgen Road 26,200m - 26,400m					*	

Areas to be impacted by the proposal containing a mosaic of habitats of the greatest significance are the Marshalls Ridges, Hull Road and Sleepy Hollow areas. These areas are likely to support the highest diversity of vertebrate fauna species and are shown in **Figure 6**. An assessment of the potential impacts of the proposal on these habitats is provided in **Section 6.2.1**.

5.6 CORRIDOR VALUES

Corridors consist of areas between vegetation communities which allow fauna, from all phyla to move with confidence and safety. The corridor can be either a well vegetated area which provides a continuous link with larger habitat areas or small pockets of vegetation closely spaced which mobile species are able to utilise for their local and/or migratory movements.

Development of the region and historic land clearance practices have collectively resulted in general fragmentation and alienation of habitats in the area, particularly on low lying areas. These clearance activities have had the effect of enhancing the value of remaining corridors linking relatively intact habitats over and above their intrinsic value. Examination of Landsat Satellite Imagery and 1:25 000 scale aerial photography indicates that the proposed route will intersect two, separate areas of east-west contiguous vegetation in the Marshalls Ridges and Taggets Hill area. These areas are likely to facilitate wildlife movement and hence maintain gene flow between local coastal and hinterland fauna populations in that they provide links between remnant lowland heaths and Melaleuca forest on the coastal plain with the dry sclerophyll, wet sclerophyll and rainforest habitats associated with the Mt. Warning caldera. The maintenance of these links are considered important for species of birds, megachiropteran and microchiropteran bats utilising the significant winter forage resources offered by lowland habitats, returning to the hinterland forests in the summer.

Fauna records contained in other reports and an examination of fauna road death data and the results of the field studies indicate a concentration of fauna species (common and threatened) within these areas.

A recent Commission of Inquiry regarding a proposal to rezone land east of the Marshalls Ridges area but within the identified corridor area has formally recognised the occurrence of a wildlife corridor in the area (NSW Department of Environment & Planning, 1997). As a result of this inquiry, Byron Shire Council has resolved to examine the options for the amendments to their LEP to ensure protection and management of wildlife corridors. These measures are still in the formulative stages (S. Walker, Byron Shire Council, *pers comm*).

Remnant vegetation associated with the road reserves of Eviron Road and Cudgen Road are likely to function as corridors on a local scale. Although heavily disturbed and consisting of primarily introduced plant species (Camphor Laurel), the Cudgen Road corridor links an area of remnant lowland sub-tropical rainforest (Stotts Island Nature Reserve) with swamp sclerophyll forests north of Cudgen Lake via a network of vegetated and semi-vegetated ridges. The Eviron Road corridor also links swamp sclerophyll forests to the north of Cudgen Lake with the remnant forests largely on freehold lands and ultimately Mooball State Forest via a continuous ridgeline forming the summit of Condong Range.

Koalas are distributed throughout the area. A review of the Koala Habitat Atlas for the Tweed Shire (AKF, 1996) indicates that preferred habitat for this species is mainly concentrated on two areas and it is expected that these areas contain core populations of breeding Koalas. The first, to the east of the proposed route, is mainly confined to within 4 km of the coast between Old Bogangar Road and Pottsville wetlands. The second area is concentrated on the vegetated Mooball Range to the west of the proposal. The proposal does not impact directly on these areas but does have the potential to form a barrier to movement for the Koalas which disperse between these two areas.

Information obtained from a review of Koala records shows possible movement corridors for this species in the Kanes Road and Round Mountain Road area. Gordon (1989) indicates a maximum tree spacing of approximately 20 m will allow an area of land to be used as a corridor by Koalas. Remnant vegetation and isolated trees in the Kanes Road area fulfil this criteria and it is likely that this area, although not forming areas of core habitat, is important for dispersal of Koalas.

Areas considered to be functioning as corridors of connective importance for vertebrate fauna are shown in **Figure 6**.

6.1 GENERAL FLORA ASSEMBLAGES

Reduction in area of a community or association directly reduces the number of plants present. As a result, threshold densities necessary for demographic processes to operate may be reached, and the effectiveness and operation of other biotic and abiotic interactions may be reduced. Whenever plant numbers and the area they occupy is reduced, there is an increased probability that chance events unrelated to the proposal will further reduce numbers below critical levels. The impact of removal of any vegetation may thus be substantial, though invariably not precisely predictable. Where the vegetation or individual species have high conservation value, the impacts are the more significant.

Indirect impacts on vegetation and species arise from edge and fragmentation effects. When new edges are created, light and wind penetrate into formerly sheltered vegetation. Weed invasion is facilitated and biomass may be reduced by physical damage. The result is an increase in the ratio of edge to core vegetation so that early successional vegetation replaces species of later successional stages. The distribution or movements of other elements of the system, such as insect pollinators, may also be affected.

Fragmentation results in the division of one large patch into two smaller patches of vegetation, or may isolate one community from a formerly contiguous patch of another. Pollination and seed dispersal may be disrupted so that gene flow between sections of a population is disrupted. Fragmentation effects are also modified by the nature of the matrix between the fragments. Bisection of forest patches by clearing for agriculture will have a different effect from bisection by roadworks.

The impact of reduction in area and fragmentation of vegetation may be serious, but must also be viewed in the context of the existing condition of the vegetation to be affected by the proposal. Much of the vegetation and its component species has high conservation significance, and some is in excellent condition. However, other areas are already severely degraded by the effects of past clearing and fragmentation, and other human-induced modification. Some of the indirect effects described will take place over long time frames, during which the impacts of this proposal may become less significant in relation to other land use changes in the region. The cumulative and long term effects of past clearing and fragmentation will also continue to cause degradation.

In general, accurate prediction of the indirect impacts of vegetation removal and fragmentation are difficult, since the ecology of impacted species is usually poorly understood, and some effects will become apparent only over long time periods. In addition, it is not possible to separate the indirect impacts of this proposal from the effects of other past and present modification to the environment.

Hence a precautionary approach is required, and ameliorative and compensatory measures significantly beyond the more readily predictable direct impacts are recommended.

6.2 GENERAL FAUNA ASSEMBLAGES

The potential impacts of the proposal on general fauna assemblages can be summarised as follows:

(a) Loss of fauna habitat;

(b) Fragmentation of fauna habitat and interruption of corridors;

(c) Increased incidence of road strike;

(d) Alterations to hydrological regimes;

(e) Increased noise and therefore disturbance to fauna;

(f) Edge effects and the potential to introduce exotic species or promote their dispersal;

(g) Introduction of dust and pollution into proximate habitat areas.

(h) Increased incidence of human-induced fires.

The most significant effects of the proposal are considered likely to be the loss of fauna habitat, fragmentation of fauna habitat (interruption of movement corridors) and an increase in the incidence of road strike.

6.2.1 Habitat Loss

Habitat types represented within the study area have been described in **Section 5.4** and are analogous to the vegetation mapping presented in **Figures 2 a-n**. To quantify the amount of habitat to be directly disturbed as a result of the proposal, a plan of the proposed road was superimposed over the vegetation mapping at a scale of 1:10 000. Where the proposed route intersected vegetation types this was recorded. Remnants equal to or greater than 0.04 ha were included in this assessment. The results are presented in the table below.

Table 6-1

Habitat Types To Be Removed By Proposal (ha)

	Rainforests	Wet Sclerophyll Forests	Dry Sclerophyll Forests	Swamp Sclerophyll Forests	Disturbed Forest Dominated by Exotic Species
Area to be removed	6.56	9.18	5.56	2.6	5.6

Key:

Rainforests
This habitat type includes vegetation associations:
1.1 Warm subtropical rainforest
1.2 Hoop Pine +/- rainforest
1.3 Rainforest with exotic species
1.4 Rainforest regrowth
2.1 Brush Box +/- Hoop Pine and rainforest

Dry Sclerophyll Forests
This habitat type includes vegetation associations:
4.1 Forest Red Gum +/- Small-fruited Grey Gum
4.2 Cypress Pine
4.3 Brush Ironbark Wattle
4.4 Black Wattle
4.5 Casuarina Sp.

Disturbed Forest Dominated by Exotic Species
This habitat type includes vegetation associations:
6.0 Camphor Laurel dominated forest

Wet Sclerophyll Forest
This habitat type includes the vegetation associations:
2.2 Brush Box regrowth (with rainforest acacia and exotic species)
3.1 Mixed Eucalypt +/- Brush Box
3.2 Blackbutt
3.3 Grey Ironbark - Pink Bloodwood
3.4 Pink Bloodwood
3.5 Tallowwood
3.6 Flooded Gum
3.7 Wet Sclerophyll regrowth
5.1 Brush Box - Wet Sclerophyll - Rainforest - Wattle - Camphor Laurel regrowth

Swamp Sclerophyll
This habitat type includes the vegetation associations:
7.1 Paperbark
7.2 Swamp She-oak

A large proportion of habitat types to be removed are located in the Marshalls Ridges and Taggets Hill area (**Table 6-2**). These areas contain the greatest range of significant habitats and thus the potentially highest diversity of fauna species.

There are fragmented areas distributed along the length of the proposed route representing habitats for fauna guilds. The impact on the loss of these habitats for the expected and recorded fauna assemblage is discussed below.

Amphibians

The presence of moisture is perhaps the most important characteristic of amphibian habitat, given that the life cycle of the members of this group usually involves an aquatic larval state (Cogger, 1992). Amphibians are not however, restricted to such environments during all stages of their life cycle and may persist well away from water when not breeding (Cogger, 1992; Robinson, 1993).

Within the study area swamp sclerophyll forests could be considered core breeding habitat for amphibian species. These habitats are heavily impacted by anthropogenic influences and occur as scattered remnants or are often composed of single lines of trees regenerating along cane drains.

Other areas of core habitat are likely to be associated with permanent and ephemeral creeks within rainforest and wet sclerophyll habitats.

The amphibian species recorded as a result of the field survey are considered common and adaptable species which display a capacity to tolerate a degree of disturbance. One notable exception being the Great Barred Frog recorded from a watercourse in the Taggets Hill area.

It is expected that the proposal will displace a relatively small number of individuals of species during construction, however, given appropriate revegetation and construction techniques described in the mitigation section, amphibian species are expected to successfully recolonise areas adjacent to the roadway during its operational phase.

Reptiles

Few reptiles were recorded during current surveys. This is considered to be due partly to the timing of the survey, and partly as a result of the absence of particularly suitable habitat for these species in the study area. MKES (1994) considered fifty-seven (57) species of reptiles were potential occurrences within the study area.

The proposal will generally result in the loss of moderately to highly disturbed habitats, with the exception of areas of wet sclerophyll forest and rainforest found in the vicinity of Taggets Hill. Species which are likely to be affected include, but are not restricted to, the Lace Monitor *Varanus varius*, Copper-tailed Skink *Ctenotus taeniolatus*, Striped Skink *Ctenotus robustus*, Grass Skink *Lampropholis delicata*, Garden Skink *Lampropholis delicata*, Blue-tongued Lizard *Tiliqua scincoides*, Eastern Brown Tree Snake *Boiga irregularis*, Green Tree Snake, Eastern Small-eyed Snake *Cryptophis nigrescens* and Red-bellied Black Snake *Pseudoechis prophyriacus*.

It is expected that the proposal may displace a relatively small number of reptile species during the construction phase, however, given appropriate revegetation techniques incorporating necessary habitat components certain reptile species are expected to recolonise areas adjacent to the roadway.

Avifauna

Most species of avifauna recorded in the study area will incur some form of habitat loss. Habitat loss for the highest diversity of species, e.g. nocturnal, non-passerine and passerine species, is likely to be greatest in the Taggets Hill and Marshalls Ridges areas, which have been identified as containing the greatest diversity of habitats within the study area. However, relative to existing habitats within the area and given the appropriate mitigation measures as described in **Section** 7, this loss is not expected to be significant.

Non-Flying Mammals

Habitat loss for the highest diversity of mammal species is likely to be greatest within the Marshalls Ridges and Taggets Hill areas which have been identified as containing the greatest diversity of habitats and habitat components.

The proposal will displace a number of relatively common species of non-flying mammals. Such species include the Sugar Glider *Petaurus breviceps*, Common Brushtail Possum *Trichosurus vulpecula*, Common Ringtail Possum *Pseudocheirus peregrinus*, Bush Rat *Rattus fuscipes*, Fawn-footed Melomys *Melomys cervinipes*, Brown Antechinus *Antechinus stuartii*, Northern Brown Bandicoot *Isoodon macrourus* and Long-nosed Bandicoot *Paremeles nasuta*.

Megachiropteran and Microchiropteran Bats

All habitats recorded in the study area are considered forage habitat for megachiropteran and microchiropteran bats. No roost sites (camps) were recorded for common megachiropteran species and limited numbers of roost sites for tree-hollow dependant microchiropteran species were recorded. Thus it is considered the proposal will result in a small loss of forage habitat for megachiropteran and microchiropteran bats and some loss of roost habitat for microchiropteran bats.

6.2.2 Interruption to Movement Corridors

General

The entire landscape within the study area functions as a movement corridor for fauna, many species of which will not restrict localised movements to heavily vegetated areas. Areas likely to function as important corridors have been identified in the Marshalls Ridges and Taggets Hill area. These two major corridors also provide a mosaic of significant habitat types. The proposed route will also pass between two significant areas of Koala habitat (AKF, 1996), west of Round Mountain.

Expected impacts on general fauna assemblages outside the identified corridor areas is discussed below.

Reptiles

Reptiles are not known to make large scale migrations, with the exception of the Water Python *Liasis fuscus*, which is known to make seasonal movements of up to 12 km in search of its preferred prey source, the Dusky Rat *Rattus colletti*.

Reptiles may move freely throughout the study area, particularly where dense ground cover occurs. Movement corridors are not known to be critical to the survival of reptile species.

Amphibians

Amphibians do not rely on movement corridors but do require access to breeding sites during the appropriate seasons. Thus isolation of breeding sites such as streams, dams and temporary ponds may adversely affect local populations of relatively common species which were observed to occur in the study area. Amphibians are most likely to make movements across low lying areas and thus the mitigation measures suggested in **Section** 7 should be incorporated into the road design at such locations.

Birds

The proposed route is in close proximity to the Pottsville wetlands and Cudgen Nature Reserve, with possible consequences for waterbirds on flight paths approaching these areas. There may be regular movement by wetland birds foraging in valleys traversed by the study area and commuting to roosts/nests in paperbark swamps away from the proposed route.

There is likely to be seasonal movement between littoral and subtropical rainforest (e.g. Date *et al*, 1991). Commuting birds may be at risk from vehicle strike. Sedentary species in small habitat patches traversed by the proposed route may be at risk of habitat fragmentation, and hence displacement by aggressive 'edge' species, as well as vehicle strike.

Mitigation strategies for the reduction of bird mortalities are described in **Section 7.2** of this report.

Mammals

Species adapted to open habitats (e.g. Koala, *Melomys* sp.) are currently expected to be moving freely throughout these areas. The construction of the roadway through these habitats has the potential to fragment populations of these species.

Mobile mammal species such as megachiropteran and microchiropteran bats are unlikely to be affected to the same extent as terrestrial vertebrates given that they can move freely between vegetated areas.

Of all the mammals known or likely to occur within the study area, the Koala presents the greatest concern in that movement of this species is likely to be adversely affected by the proposal. Local populations of the Koala are likely to become further isolated as a result of the proposal, and given that the species will utilise scattered paddock trees, Koala movements may be restricted throughout the entire length of the study area.

The mosaic of habitats associated with the contiguously vegetated areas of Marshalls Ridges and Taggets Hill are likely to have importance as a corridor for a wide variety of mammal species. Impacts on these areas is discussed separately, below.

Identified Major Corridors

The potential impacts likely to arise from the construction of the proposal within the identified corridor areas of Marshalls Ridges and Taggets Hill are outlined below.

1) **Removal of Habitat**

There will be a physical loss of habitat as a result of road construction within identified corridor areas. Habitat loss at each of the areas is presented below.

Table 6-2

Habitat Areas To Be Removed At Marshalls Ridges And Taggets Hill

Location	Habitat Areas to be Removed (ha)					
	R	WSF	DSF	SSF	GRASS	DF/E
Marshalls Ridges	1.08	0.92	1.56	0	0	0.88
Taggets Hill	3.84	2.04	0	0	0	0

Key: R = Rainforests
WSF = Wet Sclerophyll Forests
DSF = Dry Sclerophyll Forests
SSF = Swamp Sclerophyll Forests
GRASS = Grasslands
DF/E = Disturbed Forests dominated by exotic species

2) **Disruption to Fauna Movement**

The construction of a dual carriageway with an expected high volume traffic flow and associated engineering features such as road cuttings and traffic separation devices (concrete barriers) has the capacity to form an insurmountable barrier to terrestrial fauna. The proposal has the potential to isolate habitats, resulting in a decrease in population viability of fauna dependant on those habitats.

Amelioration strategies designed to mitigate impacts of the proposal on corridor values of identified areas are discussed in **Section 7**.

3) **Wildlife Road Mortality Zones**

The relatively intact habitats recorded within the corridor areas and the likelihood that these areas facilitate wildlife movement, as well as the relatively high species diversity recorded from these areas as a result of field survey, indicates that there is potential for large scale wildlife mortality to occur where the proposal intersects these areas.

6.2.3 Road Strike

The road proposal will have varying levels of impact on the major fauna groups. For example birds are typically very mobile and can readily cross a road with little chance of injury from a moving vehicle. There will be an inevitable increase in mortality given that birds will be attracted to the road surface or edge by the presence of food, and will be struck occasionally whilst flying low. This increase is likely to be minor, and there will be a shifting of impact from the current Pacific Highway to the proposal. Mitigation strategies to reduce bird fatalities are discussed in **Section 7**.

Reptiles and amphibians are dependent on moving along the ground and are obviously more vulnerable to being killed by moving vehicles. Ehmann and Cogger (1985) estimated that over four million frogs and over one million reptiles are killed on Australian roads each year.

Of the non-flying mammals there are several groups with distinctly different requirements for crossing roads. Species such as the Koala move along the ground whilst crossing between trees and often cross roads. Other arboreal mammal species such as the Sugar Gilder are less likely to cross along the ground and are thus unlikely to cross the proposed road carriageway where distances between trees exceed gliding capability.

Terrestrial mammals are generally more vulnerable to predation whilst crossing roads. This group is most likely to be adversely affected by the proposal, however, this group may receive the greatest benefit from the mitigation measures prescribed in **Section** 7.

6.2.4 Alterations to Hydrological Regimes

Alterations to hydrological regimes as a result of the proposed development is expected to cause the greatest impact upon amphibians, given that all or some of their life cycle is reliant on the presence of moisture.

During construction of the roadway there is expected to be a degree of disturbance within streams and watercourses traversing the construction zone which could result in localised sedimentation of these areas. The major effect of sedimentation is blanketing the bottom of aquatic microhabitat such as pools and stream beds resulting in a reduction in diversity of aquatic microhabitat. This factor has been implicated in the decline of a number of north-eastern Australian frog species (Tyler and Davies, 1985).

6.2.5 Increased Noise and Disturbance to Fauna

Small local roads currently intersect the study area. The construction of the roadway will substantially increase vehicle associated noise in the local area. This is expected to have the greatest impact in the relatively intact habitats of Taggets Hill where roads do not currently exist.

6.2.6 Edge Effects and Potential to Introduce Exotic Species or Promote Their Dispersal

Much of the vegetation within the study area occurs as isolated remnants in which edge effects are inherent and further fragmentation is not expected to expedite the insurgence of exotic fauna species. Within the less disturbed habitats such as that which occurs in the Taggets Hill area, there may be some change in fauna assemblages due to edge effects where bird species such as the aggressive Noisy Miner *Manorina melanocephala* is likely to dominate at the expense of smaller insectivores (Dow, 1978). The incursion of the roadway into this habitat may also increase the predation of amphibians, birds and small mammals by raptors which have been documented using forest edge areas as hunting sites (Yahner and Scott, 1988). It has also been recorded that the rate of nest predation of some of the smaller insectivorous birds at forest edges was 24 times the rate of nest predation in natural habitats (Wilcove, 1985).

7.1 GENERAL MITIGATION STRATEGIES

The following general mitigation strategies have been developed in order to minimise the impacts of the proposal on flora and fauna habitats and populations recorded within the study area.

7.1.1 Avoidance of Significant Areas

The process adopted in the selection of the final route has involved substantial public consultation and field investigation. A range of factors have been taken into consideration regarding the selection of the final route including the presence of significant flora and fauna attributes. Where possible, the proposed route has been diverted to avoid significant flora and fauna habitats identified in various stages of the planning phase of this development.

A summary of these areas is presented in the table below:

Table 7-1

Route Diversions To Conserve Flora And Fauna Habitat

Area	Road Distance (Centreline Metreage)	Avoidance Tactic	Reason
Burringbar Creek	6,000 m	Proposed highway moved to the west - Realignment of Pottsville-Mooball Road	Recorded Threatened Plants and Habitat for Threatened Fauna
Ridge North of Cudgen Tunnel	25,500 m	Proposed highway moved west	Avoid further fragmentation of remnant vegetation and Koala Habitat
Low Hills north-east of Stotts Hill	26,500 m	Proposed highway moved west	Presence of Rare or Threatened Australian Plants and Koala Habitat

Due to engineering constraints and competing land use values it has been necessary to impact upon some areas considered significant as wildlife corridors and which contain habitat for threatened flora and fauna. The amelioration strategies presented below are designed to mitigate impacts upon habitat, wildlife corridors and fauna and flora species.

7.1.2 Flora Strategies

It is suggested that a strategy for avoidance of, amelioration of, and compensation for, the impacts of this proposal should include some or all of the following measures:

Maintain connectivity (overpasses, etc.)

Maintaining fauna movement corridors (**Section 7.1.6**) has implications for the plants which are pollinated and dispersed by birds and mammals. Corridors can be created and enhanced by planting, and should be wide enough to maintain the functions of the core ecosystem, i.e. not consisting entirely of edge type vegetation. Patches of vegetation in the appropriate landscape context can also have value in facilitating movement of fauna species, generally birds, which can "island hop" between larger areas of habitat. Narrow strips of roadside vegetation are seen to have some limited ecological value, and also provide additional reservoirs of genetic material and seed sources when rare species can be incorporated. There will be some educational and aesthetic value to the driving public.

Minimise edge effects

Newly created edges should be protected by planting of quick-growing local native screen plants, particularly on the most exposed aspects. Suitable plantings should be carried out to fill in irregular edges. Weed sources adjacent to newly disturbed edges should be removed. Strategies which increase patch size and coalesce isolated trees and small vegetation patches should be considered when compensatory planting is planned.

Increase reservation status of impacted vegetation and species

Transfer significant areas of native vegetation to the control of NPWS or other management agency will ensure that conservation measures will be ongoing. Where vegetation that is unlikely to otherwise be cleared or modified is so protected, the measure will not result in a net increase in vegetation cover, so must also be accompanied by complementary compensation measures.

Improve quality of other examples of impacted vegetation and species

Rehabilitation of degraded examples of the same vegetation types.

Increase area of impacted vegetation type by compensatory restoration plantings

Planting should also serve to improve connectivity and edge integrity. Where mature vegetation is to be replaced with new plantings, there will be a time lag of more than 100 years before the full values of the impacted vegetation will be restored (though some values will be restored more quickly). Planting for compensation must therefore be accompanied by additional compensation measures.

Increase numbers of impacted species by planting and translocation

Species of conservation significance should be incorporated into compensatory plantings, rehabilitated vegetation in suitable habitat, and to roadside landscaping. The greatest ecological value will accrue where the planting restores the abiotic and biotic interactions which are typical for the species. Where mature plants are to be replaced with new plantings, there will be a time lag of more than 100 years before the full values of the impacted species will be restored (though some values will be restored more quickly). Planting for compensation must therefore be accompanied by additional compensation measures. Some plants of particular significance and suitable size should be transplanted. Consideration should be given to transplanting seedlings/small stems where the likelihood of successful transplantion will be greater. Planting and reintroduction involving threatened species must be carried out in accordance with Recovery Plans for those species. See also Section 7 of the SIS for individual species.

Increase numbers of impacted species by rehabilitating/reserving/planting habitat

Rehabilitating/reserving/planting habitat can be considered a compensatory measure complementary to direct actions involving planting and transplanting.

Public education re dumping of rubbish and weeds

Newly created roadsides permit human access to areas formerly distant from regular human visitation. Parking should not be encouraged in areas of particular significance. Public education and signage to discourage dumping of rubbish, especially garden waste including environmental weeds, should be supported. Regular inspection and removal of environmental weeds by trained personnel should be undertaken.

Contribution to Recovery Process through assistance to NPWS

Where shortcomings are perceived in proposed compensatory measures (such as in the time lag inherent in the replacement of mature vegetation by new plantings), more general assistance to the recovery process of impacted threatened species through funding to NPWS should be considered.

7.1.3 Fauna Underpasses

It is recommended that a range of fauna underpass heights and widths be employed along the proposed route with a concentration of these in areas identified as important habitats and corridors, i.e. Taggets Hill and Marshalls Ridges. A site plan for these areas is discussed in **Section 7.3**.

Within these areas fauna underpasses should be additional to that which is required for drainage purposes.

Underpasses designed particularly for fauna usage are only expected to be used in conjunction with exclusion fencing which directs animals into the underpass. It is anticipated that some species will display reluctance to entering a darkened tunnel of the length required to traverse the roadway. To alleviate this, it is important to ensure fauna underpasses are of a size which allows the skyline or adjoining habitat to be seen from either end and where possible, incorporate skylight.

The approach to fauna underpasses should also be landscaped with appropriate native species to attract and provide cover for fauna. In particular, horizontal logs, held in place about 2m above the ground by vertical logs located about 5m apart, should be installed the length of

fauna underpasses to provide protection for arboreal fauna such as Koalas and gliders from predators such as dogs and foxes whilst the native fauna are traversing the structures.

An example of a fauna access underpass is presented as **Figure 8**.

In addition to underpasses designed specifically to facilitate wildlife movement, it is proposed to modify general structures such as bridges and local road underpasses to cater for current or future wildlife movement requirements. The incorporation of these modifications during construction of the Highway is expected to facilitate local wildlife movements and alleviate costly solutions during the operational phase of the project should an area subsequently become important as a movement corridor. Examples of modifications to local road underpasses and bridge crossings are presented in **Figures 10 and 11**.

7.1.4 Fauna Overpasses

Constructed overpasses have not been trialed for Australian roads and their effectiveness consequently, for Australian fauna is not known. In theory they may provide links to habitat for a wider variety of species than that which has been recorded utilising underpasses.

There appears to be a general absence of arboreal marsupials documented using underpasses (AMBS, 1997). Given appropriate revegetation techniques, overpasses are expected to provide linkages for these species. Constructed overpasses recommended for use in this project would involve a cut and cover tunnel configuration (**Figure 9**).

These structures would need to be placed in positions along the road within those areas identified as important for wildlife movement (Marshalls Ridges and Taggets Hill). The positions within these areas need to be carefully designed and take into account factors such as engineering constraints, and location to take advantage of existing habitats likely to be the focus of fauna movements. Subsequent plantings of recognised forage trees for target species may be also planned to ultimately focus wildlife movement across the overpass area. On the overpass area itself, subsoil and topsoil will need to be replaced to the extent necessary to ultimately support a vegetation type similar to that of the surrounding area.

Implementation of wildlife exclusion fencing directing fauna into the overpass and running the length of the overpass is considered necessary to exclude fauna from the road carriageway.

It may also be necessary to incorporate large logs and rocks and perhaps leaf litter to increase habitat components for a wider variety of faunal species. In particular, horizontal logs, held in place about 2m above the ground by vertical logs located about 5m apart, should be installed the length of fauna overpasses to provide protection for arboreal fauna such as Koalas and gliders from predators such as dogs and foxes whilst the native fauna are traversing the structures.

7.1.5 Implementation of Wildlife Exclusion Fencing in Identified Areas

Wildlife exclusion fencing is recommended in identified areas such as Taggets Hill and Marshalls Ridges. Exclusion fencing will prevent fauna from entering the road carriageway and also funnel them into underpasses and overpasses proposed for these and other areas. It is recommended that the exclusion fencing to be utilised adjacent to the proposed carriageway should be of the "floppy top" design which has proven to be successful on other RTA projects. A plan of this type of fencing is provided as **Figure 12**.

7.1.6 Revegetation of Existing Wildlife Corridors

The Taggets Hill and Marshalls Ridges areas have been identified as the prime wildlife corridors to be impacted by the proposal. Within these areas there has been a system of overpasses, underpasses and exclusion fencing designed to ensure the connective importance of these areas is not significantly compromised.

Vegetation cover or the lack thereof appears critical in determining the success or failure of fauna underpasses (AMBS, 1997) and overpasses. Vegetative cover should lead to these crossing points, and embellishment plantings of suitable species should be undertaken as soon as possible following development approval.

There are also previously cleared lands adjacent to the proposed roadway within the identified corridor areas. There may be some scope for purchase and revegetation of these lands and incorporation into road reserves. Such revegetation can be used to focus future wildlife movements on structures designed to facilitate movement over or under the roadway. The revegetation of distinct areas within the Marshalls Ridges and Taggets Hill areas is discussed in more detail in (**Section 7.3**).

A body of expertise in the planting and rehabilitation of local rainforest and wet sclerophyll forest communities has accumulated, particularly over the last decade. The principles and techniques are embodied in two recent publications (Kooyman, 1996; Big Scrub Landcare Group, 1998a). Further detail about the identification and control of environmental weeds is given by the Big Scrub Landcare Group (1998b). Comprehensive horticultural advice at the level of the individual species is also available (Nicholson and Nicholson, 1985, 1988, 1991, 1994).

Much material from these sources will be also be relevant to wet sclerophyll communities.

7.1.7 Providing Areas of Compensatory Habitat

The acquisition and dedication of land outside the study area but proximate to areas to be affected by the proposal is recommended. The area of habitat to be considered should be of sufficient size to at least offset the amount of habitat that will be lost as a result of the proposal, and should be located such that it will contribute to the conservation needs along the proposed route. Areas selected for such works should be adjacent to existing areas offering value as habitat, wherever possible. Consideration of areas for potential compensatory habitat is still in the planning stages.

7.1.8 Long Term Monitoring

It is proposed that long term monitoring be undertaken of the effectiveness of prescribed mitigation measures. Assessments should be made at least seasonally in conditions likely to facilitate detection and consider reptiles, amphibians arboreal and terrestrial mammals. The long term effects of the proposal on local Koala populations should be the subject of further research. Such research should involve the use of Radio Tracking Studies to determine preferred dispersal pathways.

It will also be necessary to monitor wildlife mortality rates in the dispersed and fragmented habitats not proposed to be fenced to exclude wildlife.

Road crews present an ideal means of assessment in this regard. Basic training in identification skills and an efficient reporting system will be required to undertake this activity.

If conflict zones are identified, exclusion fencing of a type discussed in **Section 7.1.5** should be implemented directing fauna to structures such as bridges and local road underpasses that have been designed to accommodate fauna movements. The design for these structures has been discussed in **Section 7.1** and presented in **Figures 10 and 11**.

7.1.9 Employment of Rehabilitation Officer

The feasibility of the employment of a rehabilitation officer should be investigated. This position would be expected to provide advice and implement rehabilitation strategies including revegetation and follow-up weed control. Other roles may include the possible co-ordination of labour market projects and liaison with Statutory Authorities and community groups in the rehabilitation phase of the project, which could be up to three (3) years. This position may also have a primary role in the initiation and implementation of long term monitoring projects.

7.2 SPECIES SPECIFIC MITIGATION MEASURES

7.2.1 Amphibians

The proposal is not expected to impact on threatened (TSC Act, 1995) or regionally significant amphibian species.

General culverts and bridges associated with drainage works and water courses are likely to act as movement pathways for common species. Within these structures, steps or large drop-offs should be avoided as these could potentially limit amphibian movements. Disturbance to waterways, creek crossings and drainage depressions expected to form core breeding areas for amphibian species should be kept to a minimum and appropriate sediment and erosion control techniques should be emplaced during the construction period.

Where these topographic features will be disturbed as a result of construction, appropriate revegetation should be undertaken. Species to be used in revegetation should include appropriate water plants such as *Baumea Spp.*, *Cyperus Spp.*, *Eleocharis Spp.*, *Phragmites Spp.*, and *Typha Spp.*native to the area, which will increase habitat diversity for a range of amphibian species. Appropriate revegetation of constructed sediment basins will also improve habitat value for amphibians.

Within underpasses designed specifically as fauna crossings and likely to be utilised by amphibians, consideration should be given to the placement of a layer of mulch and/or pebbles and small rocks at least 15 cm deep to facilitate amphibian movement and provide some degree of protection against predation.

7.2.2 Reptiles

General impacts on reptile species have been discussed in **Section 6**. Areas with the greatest diversity of habitats, (e.g. Marshalls Ridges and Taggets Hill), are expected to contain the highest number of reptile species.

A range of general mitigation strategies incorporating underpasses and overpasses are recommended for these areas and are discussed in more detail in the following subsection.

Outside these areas, reptile species are also likely to utilise general culverts and bridges associated with drainage works and water courses to facilitate movement.

To limit disturbance to reptile habitat, it is recommended that clearing for road construction including access and haul roads be limited to the smallest possible area necessary. These areas should be revegetated following completion of the construction phase. Replacement of essential habitat components such as rocks, logs and leaf litter will need to be incorporated into the revegetation program.

7.2.3 Avifauna

Amelioration measures devised to reduce impacts on avifauna have been devised according to the following principles:

- habitat regeneration on alternative sites to compensate for habitat lost;
- re-establishment of "stepping stones" of such habitat along movement corridors and between remnant patches in the area (Date *et al*, 1991);
- overlap in rainforest species required by the Fruit Doves and White-eared Monarch;
- discouraging species from foraging on road verges and flying across the proposed motorway at vehicle height;
- good visibility at road verges for motorists and wildlife;
- road mortality of birds such as owls is most likely on exposed, elevated sections of highway built on fill embankments (Taylor and Mooney, 1991).

Road mortality on elevated sections of the highway can be reduced by maintaining good visibility for birds at ground level on the roadside verge. Visibility at ground level could be maintained by keeping wide verges closely slashed, and by using cable and flat posts rather than solid steel guard rails.

It is recommended to establish a dense screen of trees and shrubs set back from the road verge along the highway to force birds to fly over the road at greater than vehicle height (Taylor and Mooney, 1991). Species to be planted in the screen should not be rainforest species used by the Fruit Doves or the White-eared Monarch as listed in **Table 7-2**. Suitable species would include Eucalypts (non Koala forage trees) and sclerophyllous shrubs such as Wattles. Species selection should be confined to regionally indigenous species sourced from local seed and appropriate to the topographic position and soil type. An appropriately qualified horticulturalist may need to be consulted.

Specific mitigation measures recommended to reduce impacts on threatened Avifauna include:

Fruit Doves

In addition to the provision of compensatory habitat, areas should be revegetated on those parts of properties acquired for the proposal but not occupied by the proposed works. Habitat patches, by natural regeneration or planting from local seed sources, should consist of the locally indigenous forage plants for Fruit Doves. These include fruiting rainforest species such as those listed in **Table 7-2**. Effort should be made to enhance corridor links and establish "stepping stones" between patches (Date *et al*, 1991). Plant species used should be appropriate to the topographic position and soil type at each site, and selected in consultation with botanical expertise. Such compensatory habitat should be located well away from highway verges, so that vehicle strike is minimised.

Table 7-2

Suitable Fruit Dove Forage Trees For Planting In Revegetation Areas And In Compensatory Habitat

Scientific Name	Common Name
Acmena ingens	Red Apple
Acronychia oblongifolia	Common Acronychia
Archontophoenix cunninghamiana	Bangalow Palm
Diospyros pentamera	Myrtle Ebony
Diploglottis australis	Native Tamarind
Ehretia acuminata	Koda
Elaeocarpus grandis	Blue Fig
Endiandra muelleri	Green-leaved Rose Walnut
Endiandra Spp.	
Ficus macrophylla	Moreton Bay Fig
Ficus obliqua	Small-leaved Fig
Ficus rubiginosa	Rusty Fig
Ficus superba	Deciduous Fig
Ficus watkinsiana	Strangling Fig
Livistona australis	Cabbage-tree Palm
Melia azedarach	White Cedar
Pennantia cunninghamii	Brown Beech
Piper novaehollandiae	Pepper Vine
Polyscias elegans	Silver Basswood
Polyscias murrayi	Pencil Cedar
Smilax australis	Austral Sarsaparilla
Syzygium corynanthum	Sour Cherry

Masked Owl

During the construction phase, large hollow trees and surrounding protective habitat should be avoided by the proposed route, as far as practicable. Vehicle strike is likely to be minimised by discouraging owls from foraging on road verges. This can be achieved by maintaining wide verges closely slashed, in order to reduce cover for prey animals, and using guardrails of a type unlikely to be used as hunting perches (i.e. cable rather than solid steel barriers, with posts flat rather than solid in cross-section). Tree and shrub screens on elevated sections of highway, as discussed above, should also be employed.

Grass Owl

Amelioration can be achieved mainly through minimising the potential for vehicle strike, as discussed for the Masked Owl.

White-eared Monarch

Patches of compensatory habitat should be established on those parts of properties acquired for the proposal but not occupied by the proposed works. Habitat patches, by natural regeneration or planting from local seed sources, should consist of locally indigenous rainforest species, including pioneer or edge species as the White-eared Monarch will use secondary growth. Effort should be made to enhance corridor links and establish "stepping stones" between patches. Plant species used should be appropriate to the topographic position and soil type at each site, and selected in consultation with botanical expertise. Such compensatory habitat should be located well away from highway verges, so that vehicle strike is not encouraged.

7.2.4 Mammals

Areas with the greatest diversity of habitats, (e.g. Marshalls Ridges and Taggets Hill) are expected to contain the highest complement of mammal species. Within these areas a range of general mitigation strategies, (e.g. overpasses and underpasses) are recommended. In conjunction with wildlife exclusion fencing these features are expected to restore to a significant degree maintain the connective integrity of these areas.

In order to limit disturbance to mammal habitat it is recommended that clearing for road construction including access and haul roads should be confined to the smallest possible area.

Specific mitigation strategies designed to reduce impacts of the proposal on certain mammal guilds is discussed below.

Arboreal Mammals

With the exception of the Koala, for which mitigation is discussed separately, populations of arboreal mammals are confined to well timbered habitats of Marshalls Ridges and Taggets Hill (a range of general mitigation strategies have been proposed for these areas including underpasses and overpasses.). AMBS (1997) notes the general reluctance of arboreal fauna to use underpasses, however, with appropriate landscaping, particularly at the underpass entrance, these structures may become practical in facilitating arboreal mammal movement. In addition to underpasses, an overpass structure in the form of a cut and cover tunnel is recommended for these areas. It is recommended the overpass be revegetated with a mix of suitable species to allow quick vegetative cover (e.g. Wattles) to establish an unbroken link of vegetation across the overpass, as well as long lived species, e.g. Eucalypts, to ensure long term connectivity and eventual development of essential arboreal mammal components (e.g. hollows). The use of horizontal logs supported above the ground as specified previously in Section 9.1.3 and 9.1.4 should help to provide protection for arboreal fauna.

Koalas

The occurrence of Koalas has been previously discussed in **Section 5.2.4**. Primary Koala Habitat (AKF, 1996) is considered to occur within the Taggets Hill and Marshalls Ridges area. Within these areas it is recommended that wildlife exclusion fencing of a type shown in **Figure 12** be erected. Fencing should incorporate the length of the proposed road within the vegetated areas as shown on **Figures 13 and 14** and up to 50 m into cleared areas.

Additionally, fragmented vegetation located around the Kanes Road/Christies Creek area is considered likely to be functioning as a dispersal corridor linking areas of Primary Koala Habitat to the east of the proposal with Secondary Koala Habitat centred on Mooball Range (AKF, 1996) to the west of the proposal. Mitigation recommendations to ensure the connective integrity of this area is maintained is shown in **Figure 15**.

Exclusion fencing should be designed to direct animals to a system of overpasses and underpasses not more than 250 m apart. Recognised Koala forage trees of a type shown in **Table 7-3** should be planted leading up to underpasses and form a large component of the plantings on overpasses.

Table 7-3

Recognised Koala Forage Trees In Tweed Shire (AKF, 1996)

Scientific Name	Common Name
Eucalyptus microcorys	Tallowwood
E. robusta	Swamp Mahogany
E. tereticornis	Forest Red Gum
E. tereticornis x E. robusta	Hybrid
E. propinqua	Grey Gum

Recognised Koala forage trees should also be established on those parts of properties acquired for the proposal but not occupied by the proposed works. Such areas should be located well away from the roadway itself and should link with plantings around and over overpasses.

Recognised Koala forage trees should not be used in general landscape plantings as these may encourage Koalas within the vicinity of the roadway.

Outside Marshalls Ridges and Taggets Hill areas the remainder of the proposed route is considered to affect Secondary Koala Habitat (Class B) (AKF, 1996). It is recommended that throughout this area general structures such as local road underpasses, bridges and culverts be constructed according to **Figures 8, 10 and 11**. This would facilitate the implementation of mitigation works (i.e. exclusion fencing linking built structures) identified as a result of a post construction-operational monitoring period as previously described in **Section 7.1.8**.

Terrestrial Mammals

The greatest diversity of terrestrial mammals is expected to be focussed on the vegetated areas of Taggets Hill and Marshalls Ridges. A range of general mitigation strategies have been recommended for these areas and are discussed in detail in the following subsection.

Megachiropteran Bats

The proposal is expected to have a very minor impact on forage habitat of these species. Mitigation strategies previously discussed for Fruit Doves will also effectively reduce impacts for this guild.

Microchiropteran Bats

Although trees with hollows were not numerous within the study area efforts should be directed towards retaining these where they occur. The stand of Bangalow Palms (considered as potential roost sites for Northern Long-eared Bat in the vicinity of Christies Creek should be protected from unnecessary impacts during the construction phase.

7.3 SITE SPECIFIC MITIGATION

7.3.1 Significant Flora Locations

The table below recommends mitigation, amelioration and compensatory measures for the significant flora locations discussed in **Section 4.2.6** and depicted in **Figures 3 a-n**.

A total of six (6) measures are recommended, the details of which are presented after the table.

Table 7-4

Mitigation, Amelioration And Compensatory Measures

Significant Flora Site Locations	1	2	3	4	5	6
1. Marshalls Ridges in the Jones Road-Wooyung Road area	X	X	X	X	X	X
2. Wooyung Road	X	X	X	X		X
3. A spur of the Burringbar Range in the Hulls Road area	X	X	X	X	X	X
4. Burringbar Creek east of Mooball	X	X	X	X	X	X

Table 7-4 (cont'd)

Mitigation, Amelioration And Compensatory Measures

Significant Flora Site Locations	1	2	3	4	5	6
5. A spur of the Burringbar Range in the Warwick Park Road area	X	X		X	X	X
6. A spur of the Burringbar Range in the Sleepy Hollow area – Sheens Creek and southern and northern tributaries	X	X	X	X	X	X
7. Forested hillside to the north of Sleepy Hollow	X	X	X	X	X	X
8. Edge of a strip of rainforest remnant north of Sleepy Hollow (Sheens Creek northern tributary 2 - Murphys)	X	X		X	X	X
9. A spur of the Burringbar Range north of Sleepy Hollow; (north spur, Burringbar Range (Taggets/Leybourne Properties))	X	X	X	X	X	X
10. Remnant lowland subtropical rainforest (Cudgera Creek southern tributary)	X	X		X	X	X
11. Remnant regrowth rainforest in the Kanes Road area	X	X	X	X	X	X
12. Remnant lowland rainforest on a tributary of Christies Creek in the Kanes Road area	X	X		X	X	X
13. Christies Creek in the Wilman Road area	X	X		X	X	X
14. Clothiers Creek Road	X	X		X	X	X
15. Condong Range in the Eviron Road area	X	X	X	X	X	X
16. A ridge in the Stotts Creek-Cudgen Road area	X	X	X	X	X	X
17. A ridge to the north of the Cudgen Road tunnel	X	X	X	X	X	X
18. A toe of a ridge in the Stotts Creek-Cudgen Road area	X	X		X	X	X

Key

1. Mitigation for impacts on Threatened, ROTAP and significant species
2. Replanting newly created edges
3. Environmental Weed Removal
4. Mitigation for Fragmentation effects
5. Habitat expansion
6. Monitoring.

1. Mitigation for impacts on Threatened, ROTAP and significant species:

Site specific mitigation measures for Threatened, ROTAP and otherwise significant species are discussed in detail in the SIS.

Strategies discussed include:

- transplanting;
- propagation from seed or cuttings;

- identifying locations and protection during construction.

2. Replanting newly created edges:

Cleared areas near the road should be replanted with appropriate local species including those species to be removed during road construction (see species list for appropriate associations). Fast growing (local native) shelter or screen trees should be used to protect the more exposed edges. Planting should include Threatened, ROTAP and significant species recorded at the site (see **Section 4.2.6**).

3. Environmental Weed Removal:

The opportunity to remove exotic vegetation that will act as seed sources to newly disturbed areas should be taken in the course of site rehabilitation. This includes Camphor Laurel.

4. Mitigation for Fragmentation effects:

Some measures to maintain connectivity are proposed in relation to fauna movement in this area, though the effectiveness of these measures is unpredictable from current knowledge. At best only a small section of the existing connectivity can be replaced by the proposed mitigation measures (overpasses/cut and cover tunnels, etc). As the road bisects numerous vegetation patches and populations of rare species, compensation beyond the replacement of vegetation directly impacted is proposed, e.g. additional compensatory habitat.

5. Habitat Expansion :

Investigations should be initiated to acquire land in the vicinity of sites identified as significant. The acquisition of such land shall compensate for the loss of habitat and populations of Threatened, ROTAP and significant plant species.

6. Monitoring:

It is essential that regular maintenance and monitoring be carried out to ensure successful establishment of the planted areas. The threatened species populations occurring on site should be monitored on a long term basis (10+ years) to assess and identify both short and medium term impacts of the proposed route. Such impacts might include changes in drainage patterns, weed invasion and/or wind exposure.

7.3.2 Fauna

Marshalls Ridges

The range of mitigation strategies recommended for the Marshalls Ridges area is presented in the table below and depicted in **Figure 13**. Chainage distance is calculated for the current project (Yelgun to Chinderah Pacific Highway Upgrade) and as a continuation of the Brunswick to Yelgun Pacific Highway upgrade project.

Table 7-5

Mitigation Strategies For Marshalls Ridges

Structure	Distance Along Roadway (Chainage)	Dimensions	Purpose
Fauna Arch	1,150m - current project 51,893.53m - continuous	22m x 7m	Designed exclusively for the facilitation of fauna movement
Culvert with low flow pipe	1,375m - current project 52,118.529m - continuous	2.1 x 3m	Facilitate the movement of small terrestrial fauna including reptiles and amphibians
Cut and Cover Tunnel	1,550m - current project 52,293.529m - continuous	45m	Provide an access for movement of fauna, particularly arboreal species
Pipe Culvert	1920m - current project 52,663.529m - continuous	2.1m	To facilitate movement of small terrestrial fauna, including reptiles and amphibians
Exclusion Fencing	750m - 2,500m - current project 51,493.529m - 53,243.529m - continuous	Figure 12	Designed to direct fauna to underpass and overpass structures
Fauna Underpass	2,250m - current project 52,993.529m - continuous	2.1m x 3m	Designed exclusively to facilitate fauna movement
Realignment of old Pacific Highway and construction of 65m span bridge over new highway	N/A	N/A	To be incorporated as a fauna crossing to enable crossing of new highway see Fig. 13
Signage on old Pacific Highway	Perimeter of identified wildlife corridor	N/A	Identifying wildlife corridor area. Should include an appropriate speed limit

In addition to these structures, two 12x4m fauna arches will be established on the old Pacific Highway in the Marshalls Ridges area (**Figure13**).

Consideration should also be given to the acquisition of land in the southern section of the corridor area, known as Lot 1 DP122613 and Lot 1 DP434565, part of which is shown as hatched, and identified to be revegetated within **Figure 13**. The total area to be revegetated on these lands is 12.8 hectares. It is considered that given appropriate revegetation with the recognised forage trees previously discussed, this area may become a focus for fauna movement which will be facilitated by the large fauna arch. In any event, the revegetation of this area is expected to improve the overall integrity of the corridor.

This area also contains existing habitats which may be considered suitable as compensatory habitat (see table below).

Table 7-6

Existing Habitat On Lot 1 DP122613 And Lot 1 DP434565

Rainforest	Wet Sclerophyll	Dry Sclerophyll
3.4 ha	6.28 ha	1.32 ha

Future management of the area will need to be considered but it is recommended that revegetation be undertaken by an appropriate contractor during the construction phase of the project. Revegetation success should be monitored against set criteria and when these are met and it can be proven that a self regenerating ecosystem is established investigations should be made into the feasibility of including the area within Billinudgel Nature Reserve.

Taggets Hill

The range of mitigation strategies recommended for the Taggets Hill area is presented in the table below and depicted in **Figure 14**. Chainage is calculated for the current project (Yelgun - Chinderah Pacific Highway Upgrade) and continuously incorporating the Brunswick - Yelgun Pacific Highway Upgrade.

Table 7-7

Mitigation Strategies For Taggets Hill

Structure	Distance Along Roadway (Chainage)	Dimensions	Purpose
Overpass	10,650m - current project 61,393.529m - continuous	Width = 40m Vegetated Area = 30m	Designed exclusively for the facilitation of fauna movement
Fauna Underpass	11,000m - current project 61,743.529m - continuous	2.1 x 3m	Designed exclusively for the facilitation of fauna movement
Fauna Exclusion Fencing	10,600m - 11,500m - current project 61,343.529m - 62,243.529m - continuous	Figure 12	Designed to direct fauna to overpass and underpass structures

In addition to these structures revegetation works are recommended for those hatched areas shown on **Figure 14**. Investigations should also be undertaken into the further acquisition of land within the area depicted in **Figure 14** and future management options to ensure the connective importance of the Taggets Hill area in general is not degraded.

Kanes Road–Christies Creek

The range of mitigation strategies recommended for the Kanes Road–Christies Creek area is presented in the table below and depicted in **Figure 15**. Chainage is calculated for the current project (Yelgun - Chinderah Pacific Highway Upgrade) and continuously incorporating the Brunswick - Yelgun Pacific Highway Upgrade.

Table 7-8

Mitigation Strategies For Kanes Road–Christies Creek

Structure	Distance Along Roadway (Chainage)	Dimensions	Purpose
Culvert	14,000m - current project 64,743.529m - continuous	2.4 x 1.2m	Drainage but will facilitate fauna movement
Pipe Culvert	14,400m - current project 65,143.529m - continuous	1.5m	Drainage but will facilitate fauna movement
Bridge Span	14,770m - current project 65,513.529m - continuous	20m 2m clearance	Underpass to facilitate fauna movement (Koalas) Figure 10
Fauna Exclusion Fencing	13,950m - 14,820m - current project 64,693.529m - 65,563.529m - continuous	Figure 12	Designed to direct fauna to underpass structures

Revegetation works are recommended for those hatched areas shown on **Figure 15**. Revegetation should include a high proportion of Koala forage trees, particularly leading up to the bridge structure.

The study area, located in north-eastern New South Wales contains a rich assemblage of plant and animal species. The complex mosaic of vegetation communities in the area has led to its recognition as containing an outstanding biodiversity in comparison to the rest of Australia. Additional factors contributing to this richness in the area include wide physiographic and geomorphic variation and a mild climate promoting plant growth throughout the year (Nix, 1976; Adam, 1987; Gilmore *et al*, 1986; Milledge, 1991). The fauna survey report conducted by the CSIRO (1996) and commissioned by State Forests NSW describes the vertebrate fauna of the forest environments of the Murwillumbah area as one of the richest and most diverse areas in Australia.

The current surveys investigated the flora and fauna of the study area with a view to establishing the assemblage of biota throughout the area to be affected by the proposed development including determining the presence of any threatened, rare or regionally significant species as specified in the Schedules of the Commonwealth Endangered Species Protection Act (1992), TSC Act (1995), Briggs and Leigh (1996) and/or Sheringham and Westaway (1995). Also examined as part of the current surveys was the identification of key habitat areas, significant flora locations and investigations of areas operating as corridors for dispersal of fauna. Surveys were conducted from August to September (1997) with supplementary surveys undertaken in March to April of 1998.

The vegetation surveys, conducted by Landmark Ecological Services Pty Ltd, involved mapping of vegetation communities and the sampling of thirty-two (32) survey sites throughout the study area. Six (6) communities, including twenty-two (22) associations were mapped with eleven (11) threatened plant species identified (TSC Act, 1995). A further six (6) species listed as ROTAP species (Briggs and Leigh, 1996) were identified along with thirty-three (33) species of regional significance.

Fauna survey methods employed, targeting the specified threatened species, included active searches, opportunistic sightings, Elliott trapping, Hair Tube Sampling, Spotlighting, bird and frog call recording, call playback, Harp Trapping, ultrasonic bat detection (Anabat) and mammal cages. The fauna surveys identified the presence of seventeen (17) species of amphibians, eight (8) species of reptiles, one hundred and twenty-eight (128) bird species and twenty-six (26) mammals within the study area. A total of thirteen (13) threatened species were detected during surveys. The White-eared Monarch, Masked Owl, Glossy Black Cockatoo, Bush Hen, Rose-crowned Fruit Dove, Koala, Northern Long-eared Bat, Large-footed Myotis, Black Flying Fox, Little Bentwing-bat and the Common Bentwing-bat were all detected within the study area during the current survey period. The Osprey and the Square-tailed Kite were observed from a previous survey of the study area.

Six (6) main habitat types were identified within the study area. These were Rainforest, Wet Sclerophyll, Dry Sclerophyll, Swamp Sclerophyll, Grasslands and Disturbed Forests dominated by exotic species. Significant habitat areas were identified in various locations along the route but were mostly found in the Marshalls Ridges and Taggets Hill areas.

Impacts of the proposal on the flora of the study area will include a reduction in the area of those communities or associations directly affected by the development, thereby reducing plant numbers. Whenever plant numbers and the area they occupy is reduced, there is an increased probability that chance events unrelated to the proposal will further reduce numbers below critical levels. The impact of removal of any vegetation may thus be substantial, though invariably not precisely predictable. Where the vegetation or individual species have high conservation value, the impacts are the more significant. The main impacts of the proposal on fauna species on the area are anticipated to be habitat loss, increased incidence of road strike and interruption of movement corridors.

A number of mitigation strategies have been recommended to ameliorate the impacts of the proposed development on the flora and fauna of the area to be affected. While avoidance of significant areas has been employed where possible, the use of fauna underpasses and overpasses, the implementation of exclusion fencing, the revegetation of existing wildlife corridors and the provision of compensatory habitat should ensure that the connective integrity of existing populations is not lost and that impacts on local species are minimised.

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Figures

SOURCE: TWEED HEADS (9641) and MURWILLUMBAH (9541) 1:100000 Topographic Maps

0 1 2 3 4 5Km

SCALE - 1 : 125 000

Woodward-Clyde

CLIENT
SINCLAIR KNIGHT MERZ

PROJECT
PROPOSED PACIFIC HIGHWAY UPGRADE, YELGUN TO CHINDERAH ENVIRONMENTAL IMPACT STATEMENT - FLORA / FAUNA WORKING PAPER

PREPARED: LL DATE: MAR 98

CHECKED: N/A REVISION: A

APPROVED: CAD FILE No: -G-001

DRAWING No: A3201193-0004-G-001

TITLE
LOCALITY PLAN

FIGURE 1

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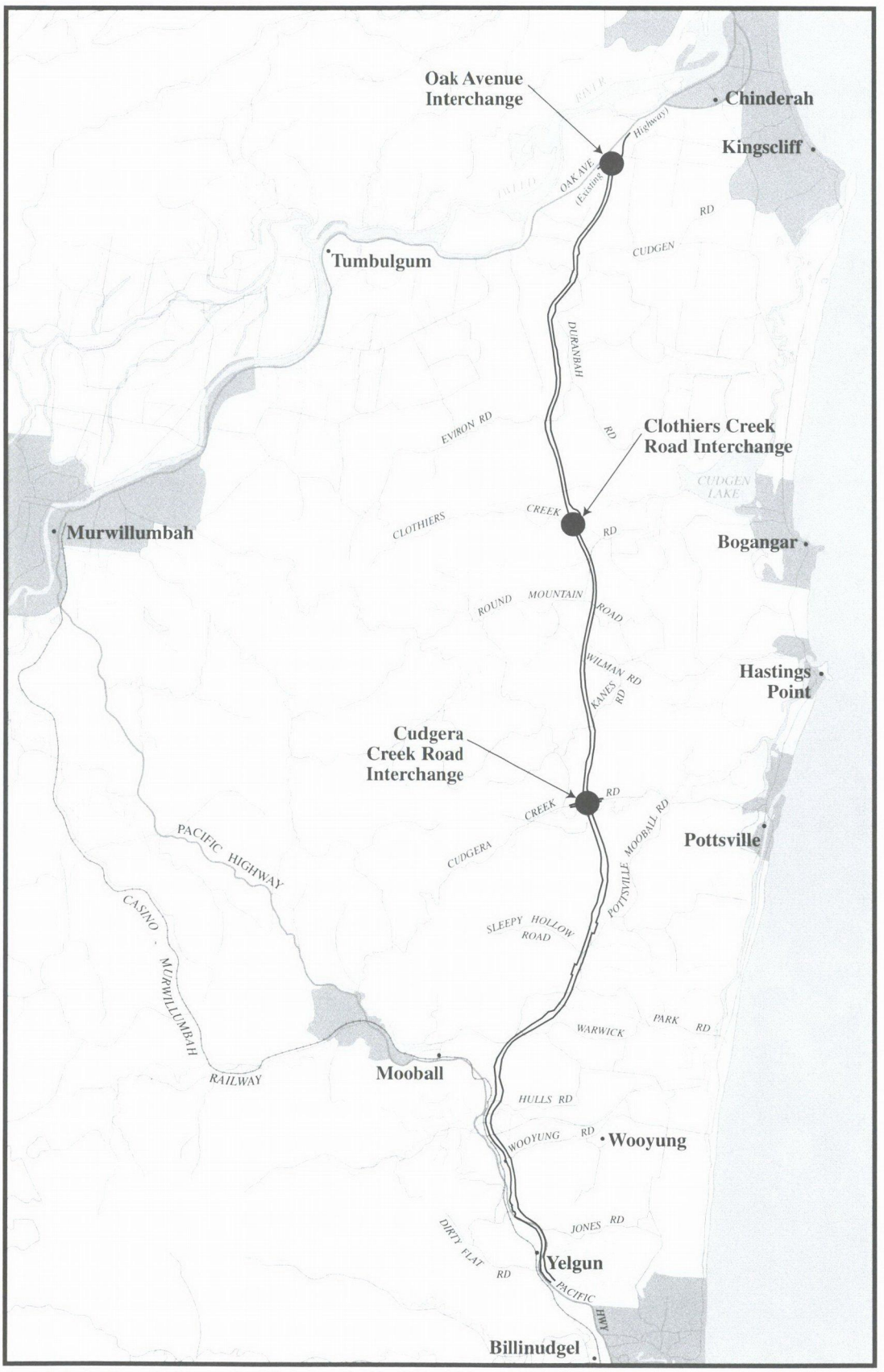

Legend

Proposed Road Corridor

Interchanges

Figure 1.1
PREFERRED ROUTE ALIGNMENT

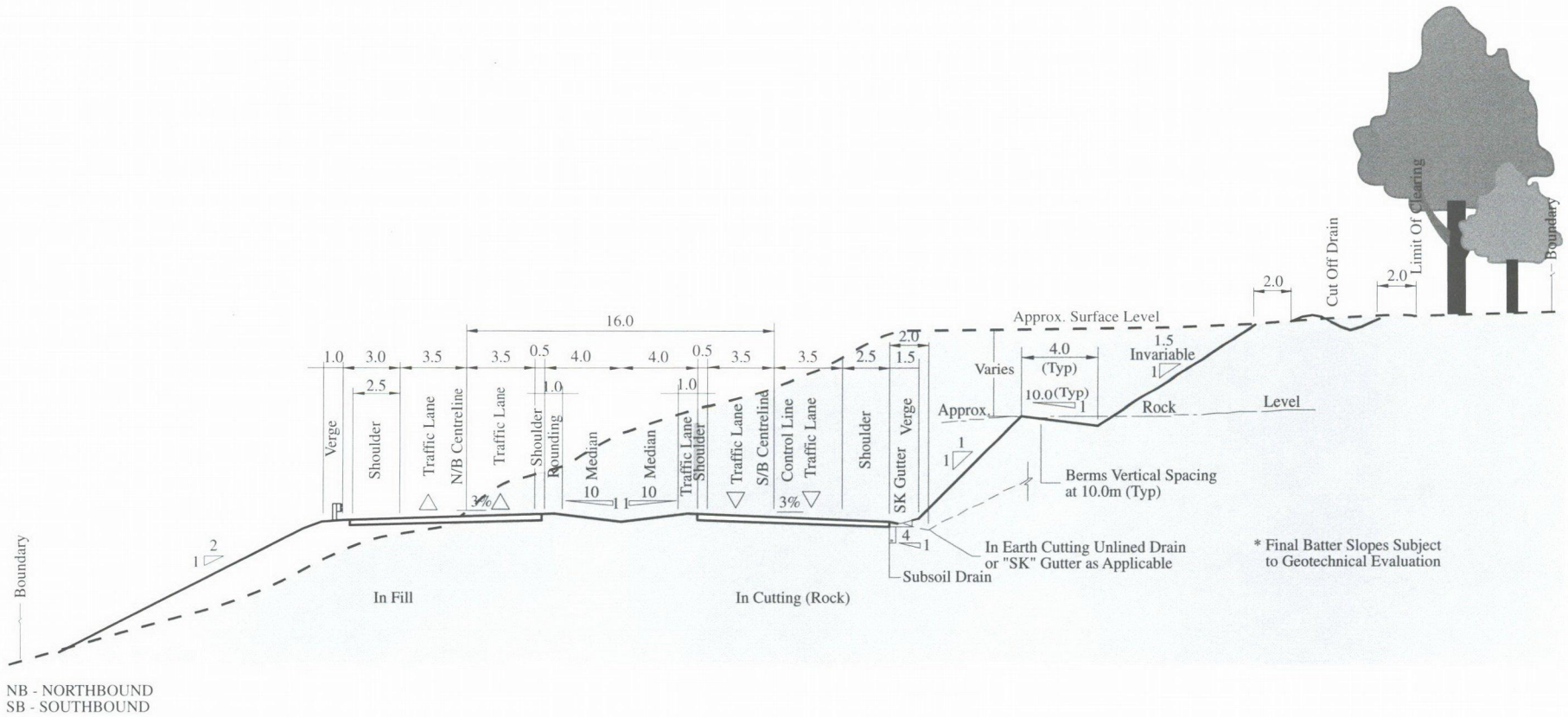

Figure 1.2
TYPICAL CROSS SECTION

SOURCE: TWEED HEADS (9641) and MURWILLUMBAH (9541) 1:100000 Topographic Maps

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES - SHEET KEY

FIGURE 2 KEY

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DESCRIPTION OF THE ASSOCIATIONS

1.0 Rainforest
- 1.1 Warm subtropical rainforest (Floyd's *Heritiera trifoliolatum* alliance)
- 1.2 Hoop Pine +/- rainforest

2.0 Brush Box Forest
- 2.1 Brush Box +/- Hoop Pine and rainforest
- 2.2 Brush Box +/- emergent Eucalypt
- 2.3 Brush Box regrowth (with rainforest, acacia and exotic species)

3.0 Wet Sclerophyll forest
- 3.1 Mixed Eucalypt
- 3.2 Blackbutt
- 3.3 Grey Ironbark – Pink Bloodwood
- 3.4 Tallowwood
- 3.5 Flooded Gum
- 3.6 Wet Sclerophyll regrowth

4.0 Dry Sclerophyll forest
- 4.1 Forest Red Gum +/- Small-fruited Grey Gum
- 4.2 Cypress Pine
- 4.3 Brush Ironbark Wattle
- 4.4 Black Wattle

5.0 Mixed regrowth communities
- 5.1 Brush Box-Wet Sclerophyll-Rainforest–Wattle-Camphor Laurel regrowth

6.0 Camphor Laurel dominated forest

7.0 Swamp Sclerophyll forest
- 7.1 Paperbark;
- 7.2 Swamp She-oak.

Key For Threatened Plants (TSC Act, 1995)

Dp = *Davidsonia pruriens*
EF = *Endiandra floydii*
Emb = *Endiandra muelleri subsp. bracteata*
Ml = *Marsdenia longiloba*
R. moorei = *Randia moorei*
Cf = *Cryptocarya foetida*
Eh = *Endiandra hayesii*
Hb = *Hicksbeachia pinnatifolia*
Mt = *Macadamia tetraphylla*
Sh = *Syzygium hodgkinsoniae*
Sm = *Syzygium moorei*

Rare or Threatened Australian Plants (Briggs & Leigh, 1995)

Eg = *Endiandra globosa*
Rm = *Rhodamnia maideniana*
Cn = *Cupaniopsis newmanii*
Am = *Archidendron muellerianum*
Cb = *Cassia brewsteri var. marksiana*
Ma = *Millettia australis*

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DRAWING No: A3201193-0004-G-042

TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES

FIGURE 2 LEGEND

FLORA DATA SOURCE:
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SOURCE: DMR AERIAL PHOTOGRAPHY
(NSW 3152) @1:6000 08-10-1997
S.K.M Supplied digital centre line data
(Design.dxf 25-02-1998)

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DRAWING No: A3201193-0004-G-011

TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
0km to 2km

FIGURE 2a

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
2km to 4.5km

FIGURE 2b

FLORA DATA SOURCE:
Landmark Ecological Services P/L

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
4.5km to 7km

FIGURE 2c

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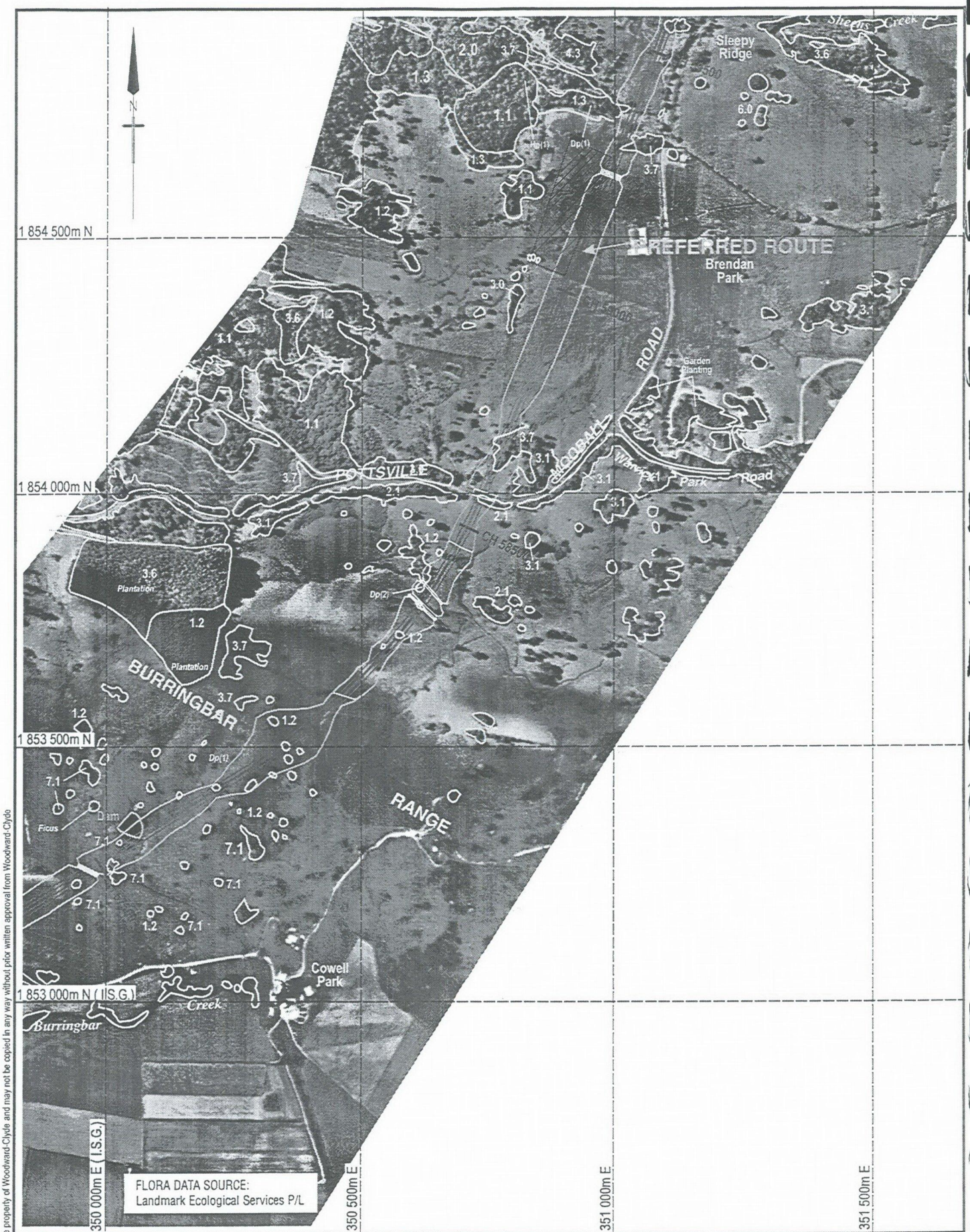

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
7km to 9km

FIGURE 2d

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
9km to 11km

FIGURE 2e

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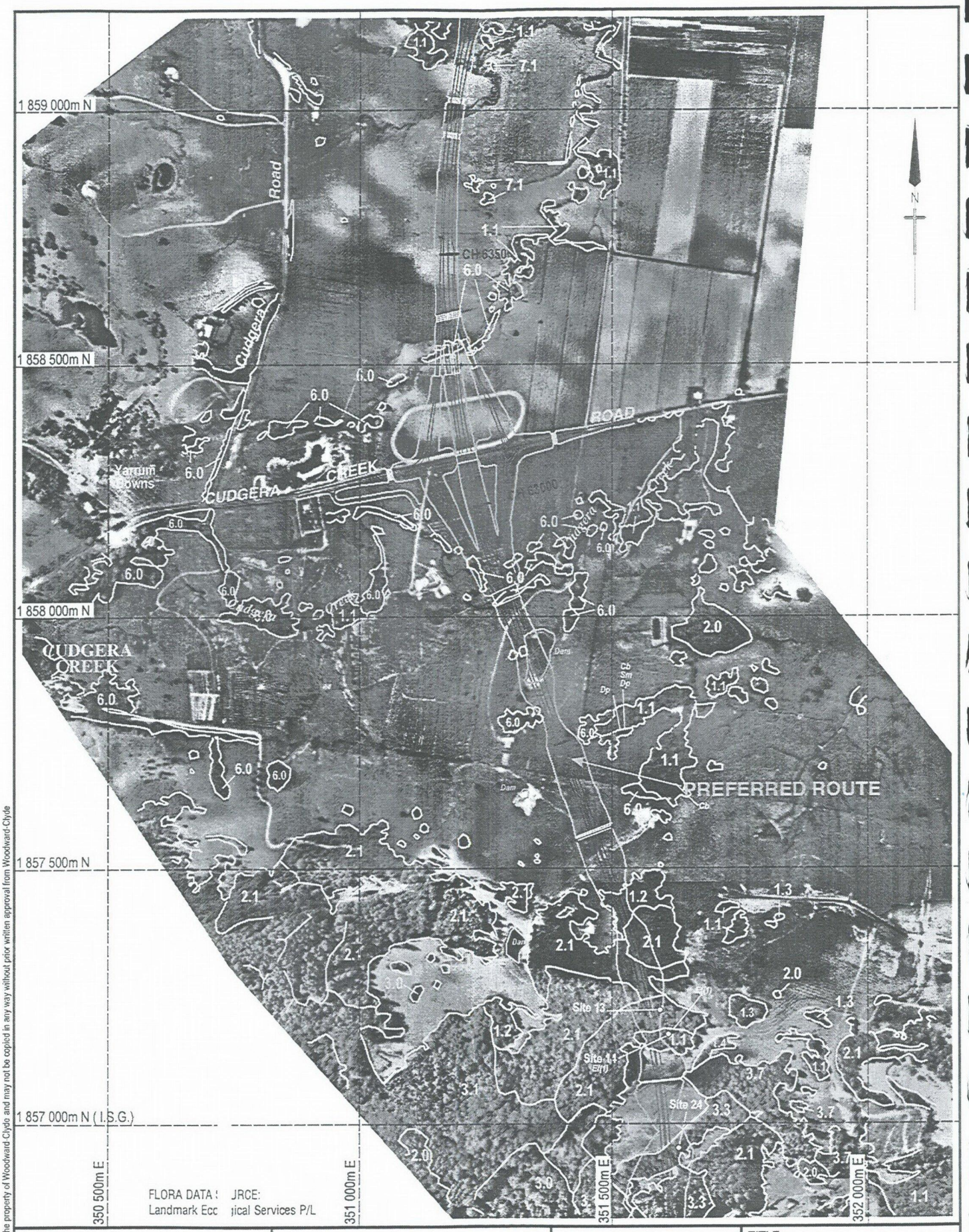

FLORA DATA SOURCE: Landmark Ecological Services P/L

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
S.K.M. Supplied digital data (Design.dxf) 25-02-1998

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SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
11km to 13km

FIGURE 2f

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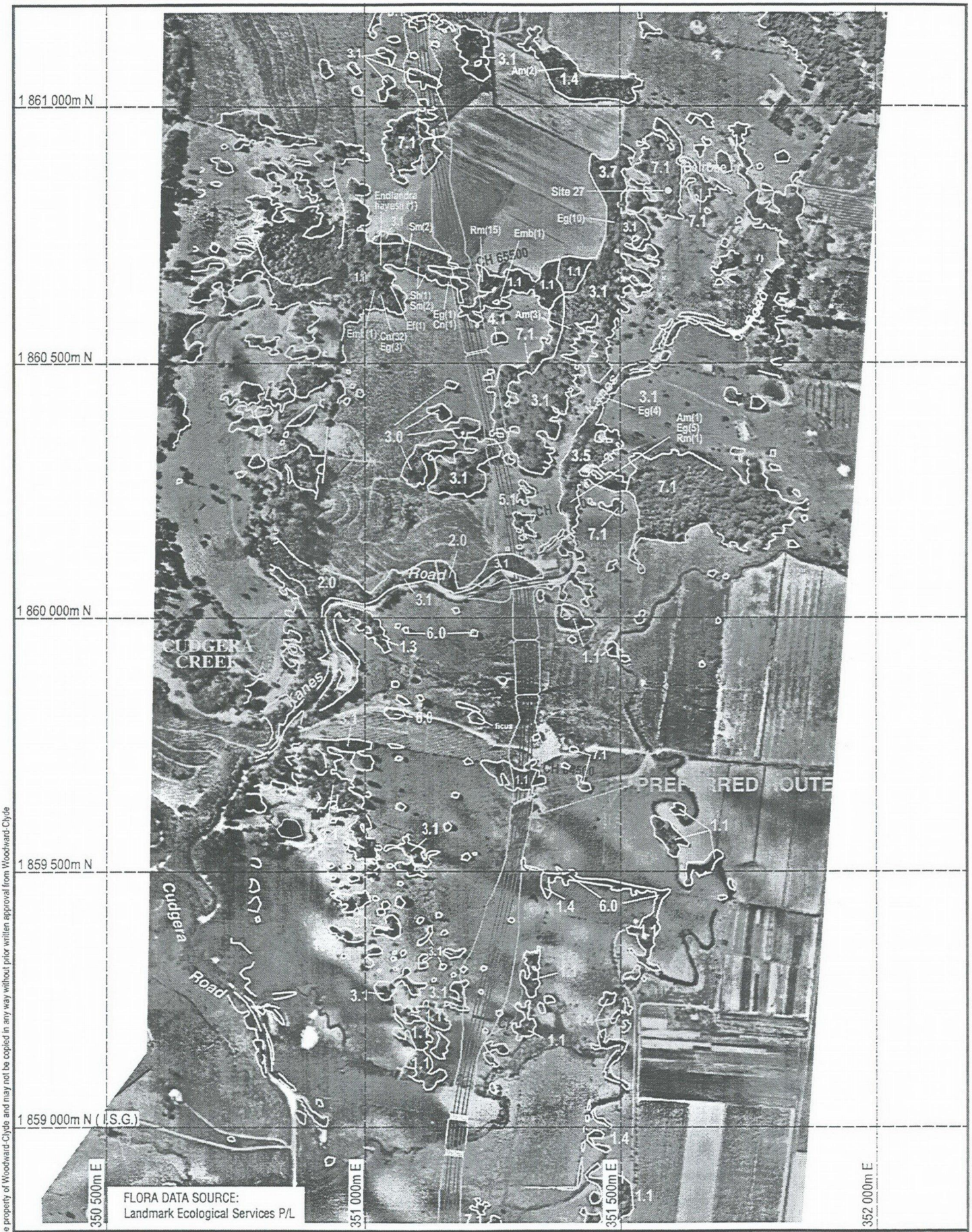

DMR AERIAL PHOTOGRAPHY
(NSW 3152) @1:6000 08-10-1997
S.K.M. Supplied digital data
(Design.dxf) 25-02-1998

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SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
13km to 15km

FIGURE 2g

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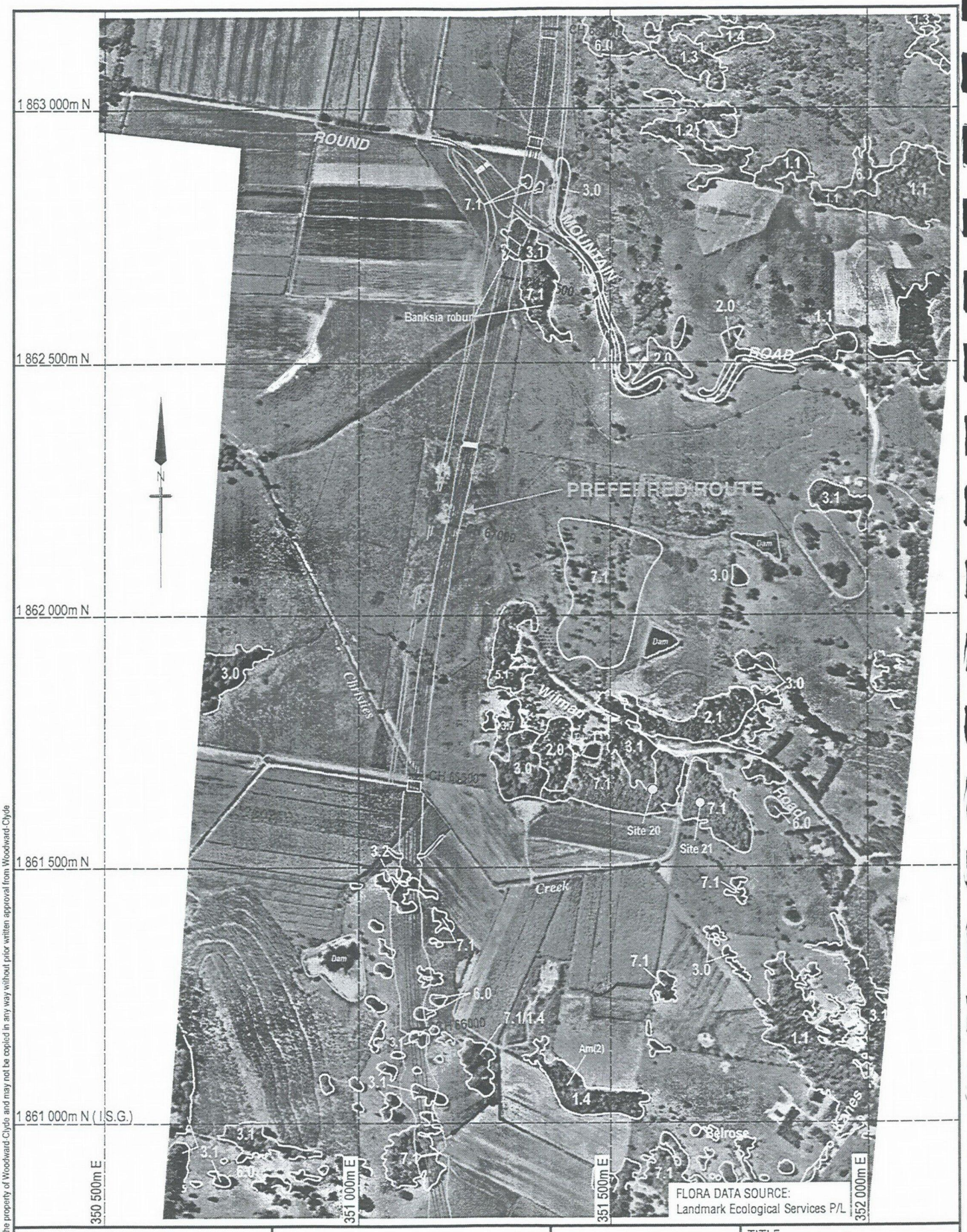

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
S.K.M Supplied digital centre line data (Design.dxf 25-02-1998)

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
15km to 17km

FIGURE 2h

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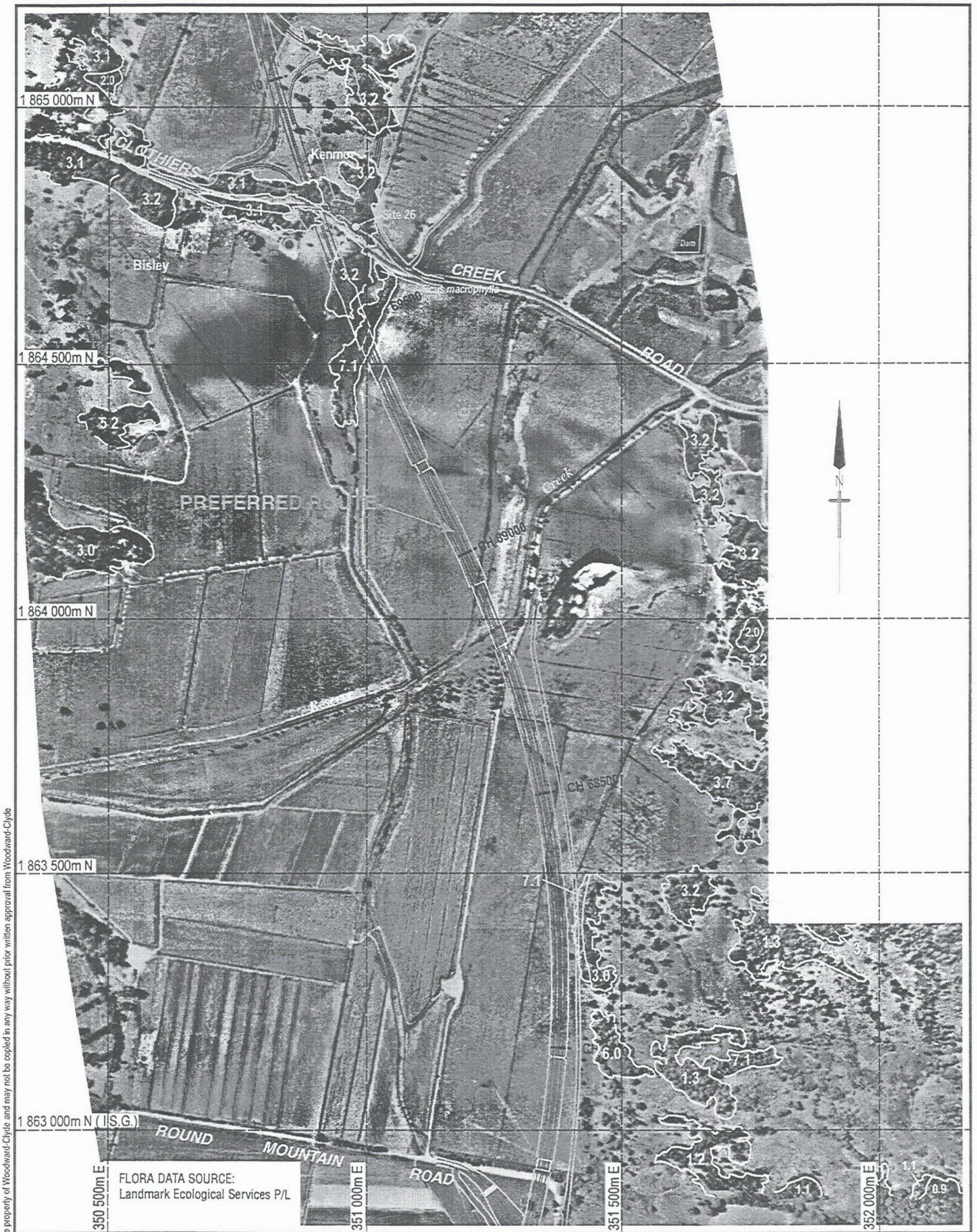

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
S.K.M Supplied digital centre line data (Design.dxf 25-02-1998)

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
17km to 19km

FIGURE 2i

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FLORA DATA SOURCE:
Landmark Ecological Services P/L

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
19km to 21km

FIGURE 2j

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FLORA D/ SOURCE:
Landmark cological Services P/L

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
21km to 23km

FIGURE 2k

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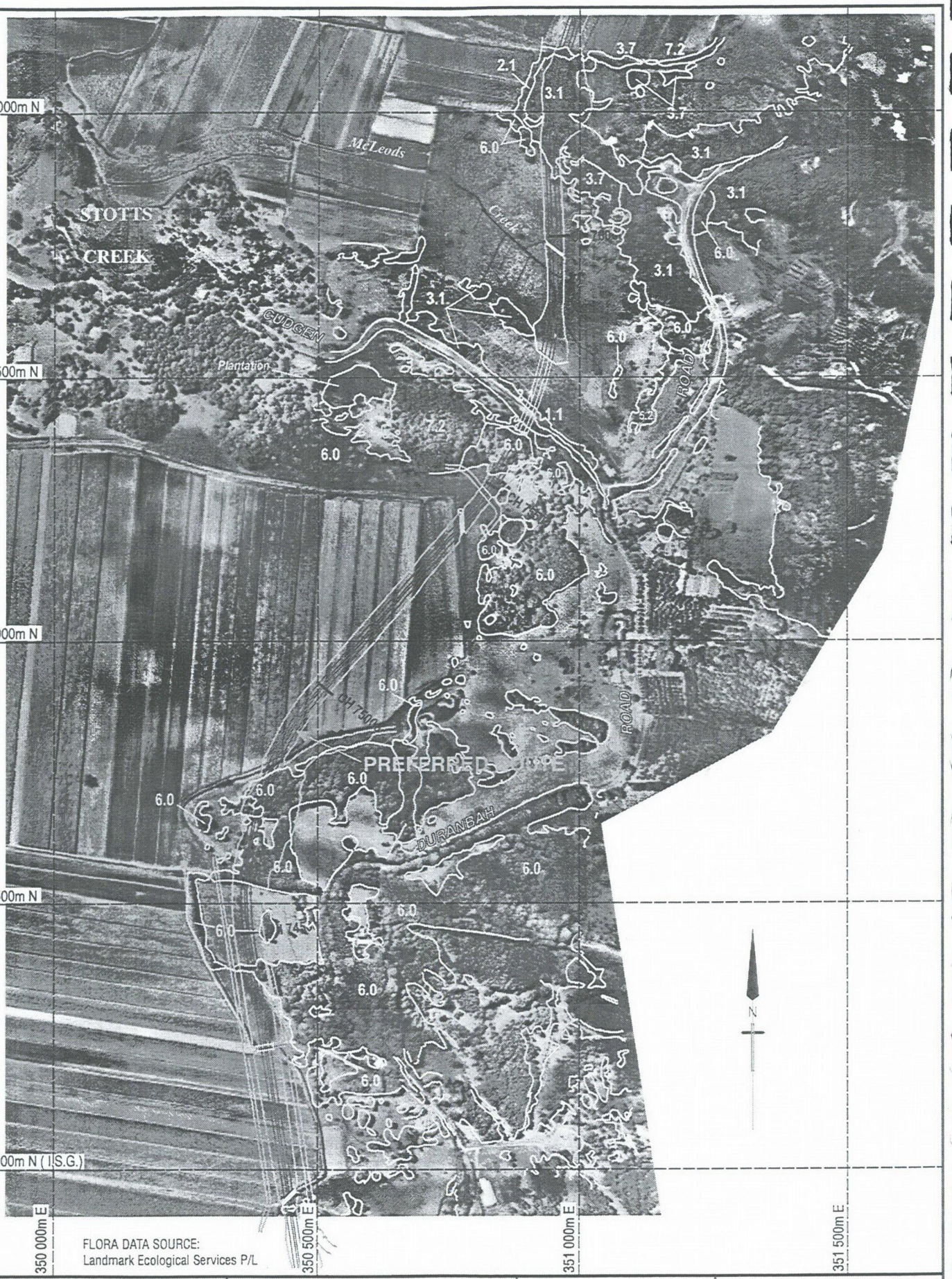

FLORA DATA SOURCE:
Landmark Ecological Services P/L

SOURCE: DMR AERIAL PHOTOGRAPHY
(NSW 3152) @1:6000 08-10-1997
S.K.M Supplied digital centre line data
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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
23km to 25km

FIGURE 21

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES 25km to 27km

FIGURE **2m**

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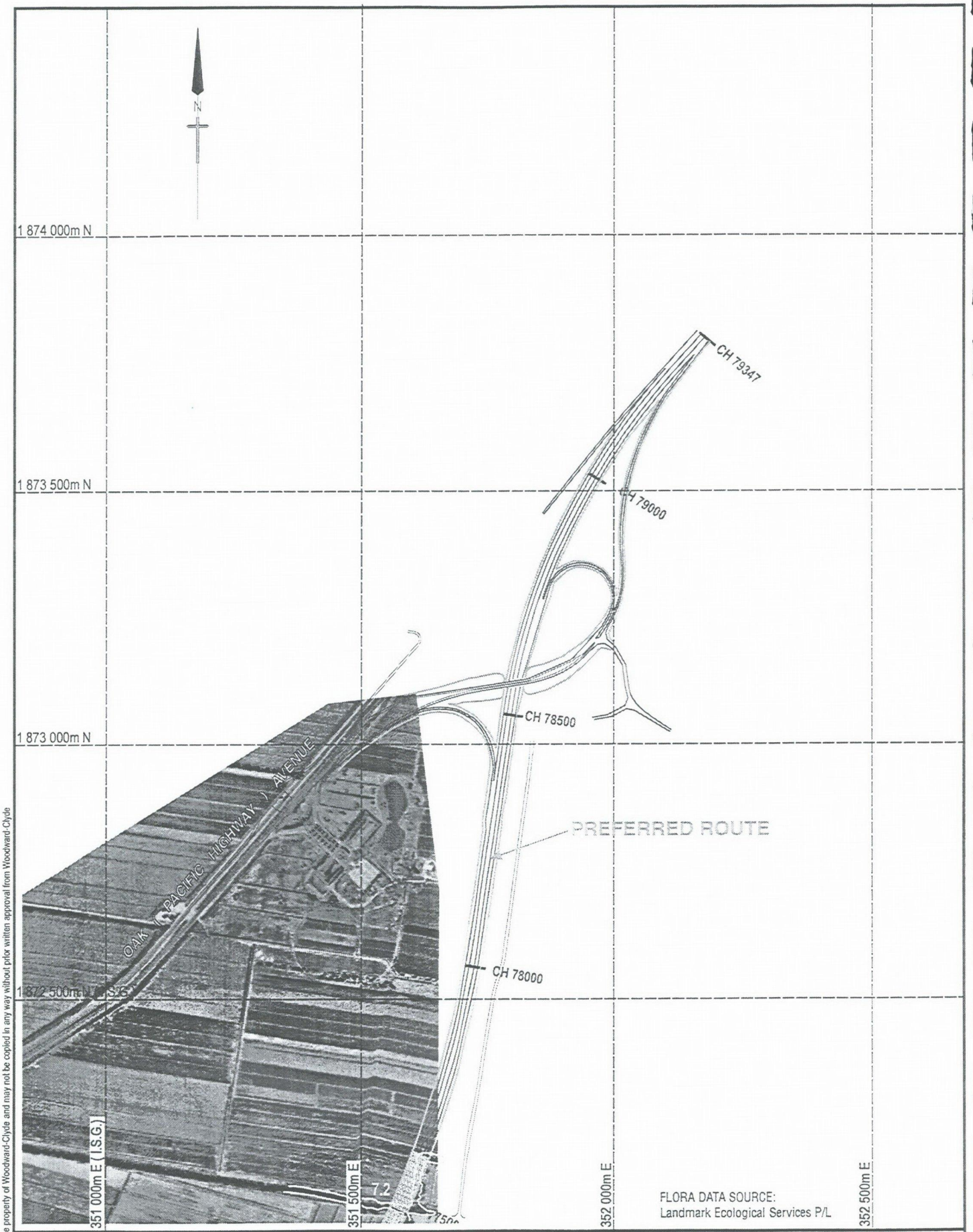

FLORA DATA SOURCE:
Landmark Ecological Services P/L

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
VEGETATION COMMUNITIES AND SAMPLING SITES
27km to 28.5km

FIGURE 2n

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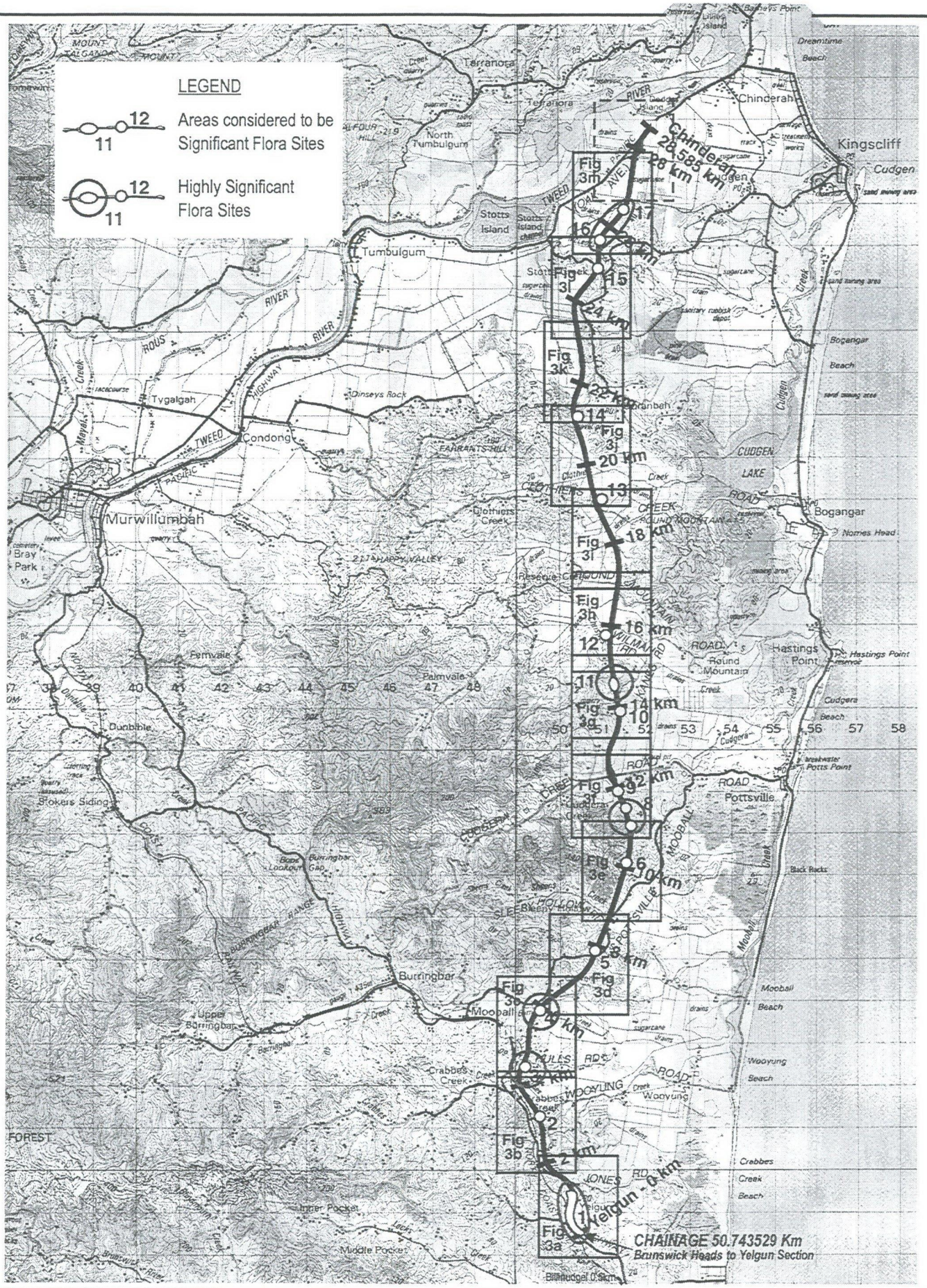

SOURCE: TWEED HEADS (9641) and MURWILLUMBAH (9541) 1:100000 Topographic Maps

0 1 2 3 4 5Km

SCALE - 1 : 125 000

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TITLE
LOCATION OF SIGNIFICANT FLORA SITES - SHEET KEY

FIGURE 3 KEY

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES
0km to 2km

FIGURE 3a

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 2km to 4.5km

FIGURE 3b

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TITLE
SIGNIFICANT FLORA SITES
4.5km to 7km

FIGURE 3c

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 7km to 9km

FIGURE 3d

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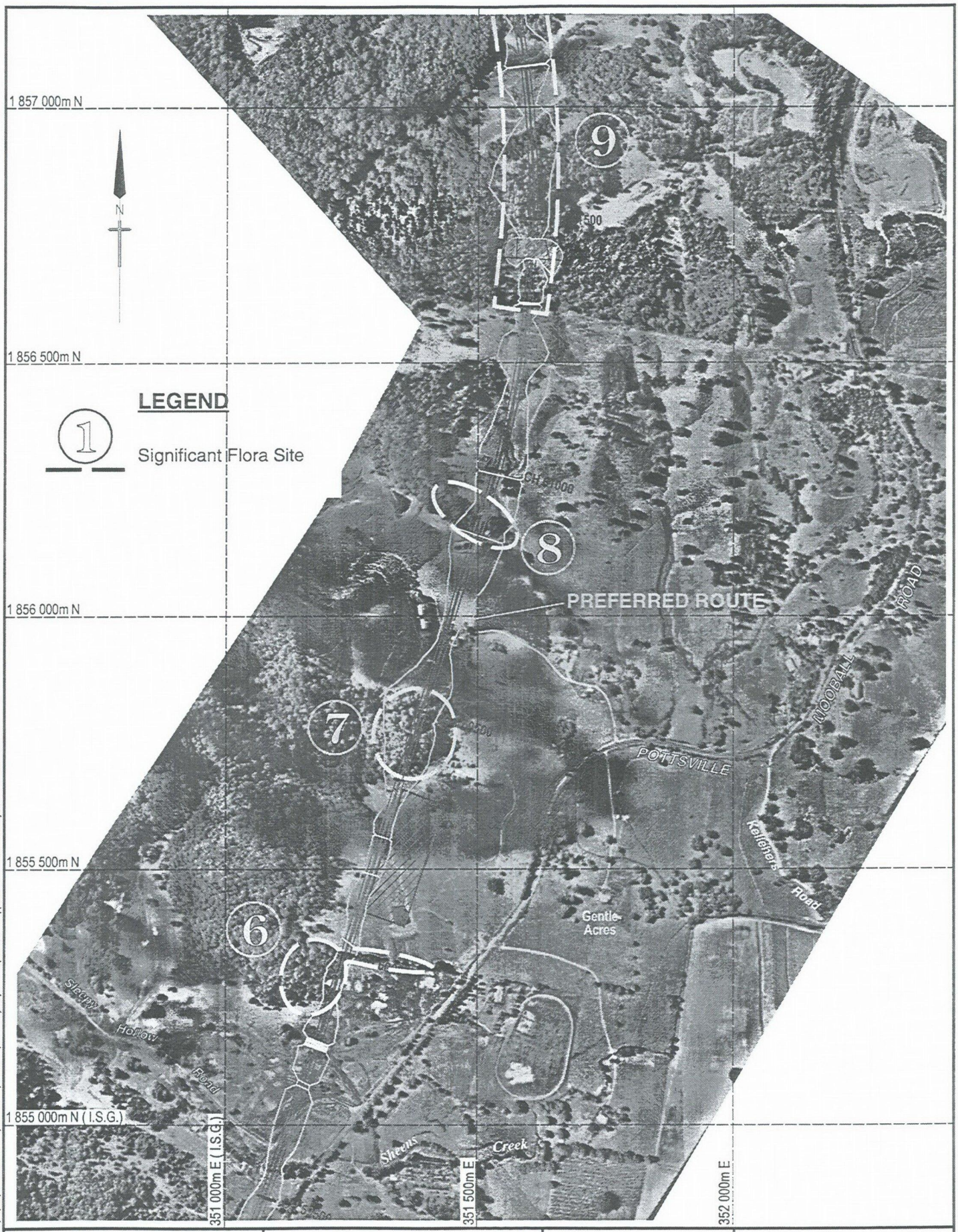

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
S.K.M. Supplied digital data (Design.dxf) 25-02-1998

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 9km to 11km

FIGURE 3e

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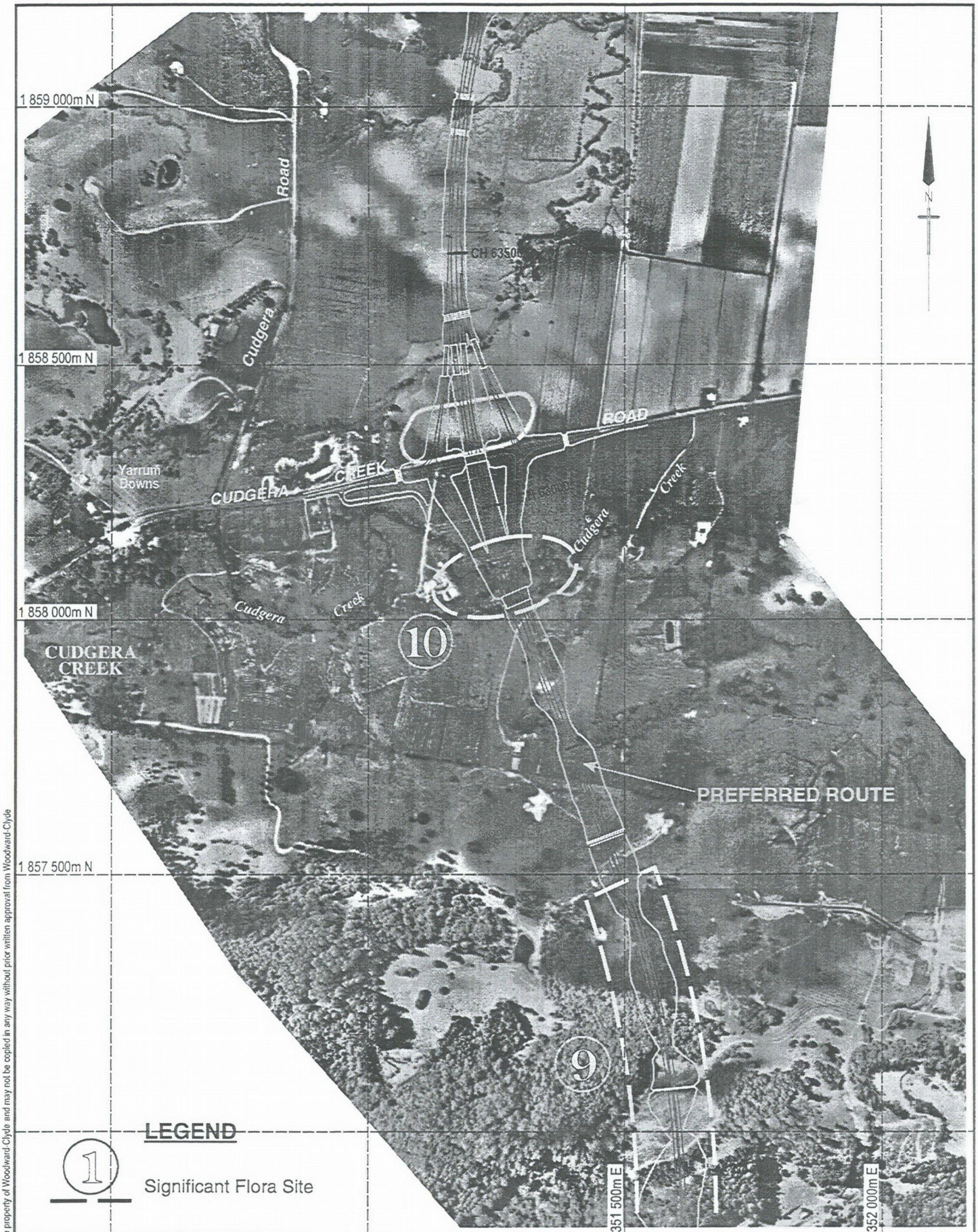

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
S.K.M. Supplied digital data (Design.dxf) 25-02-1998

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 11km to 13km

FIGURE 3f

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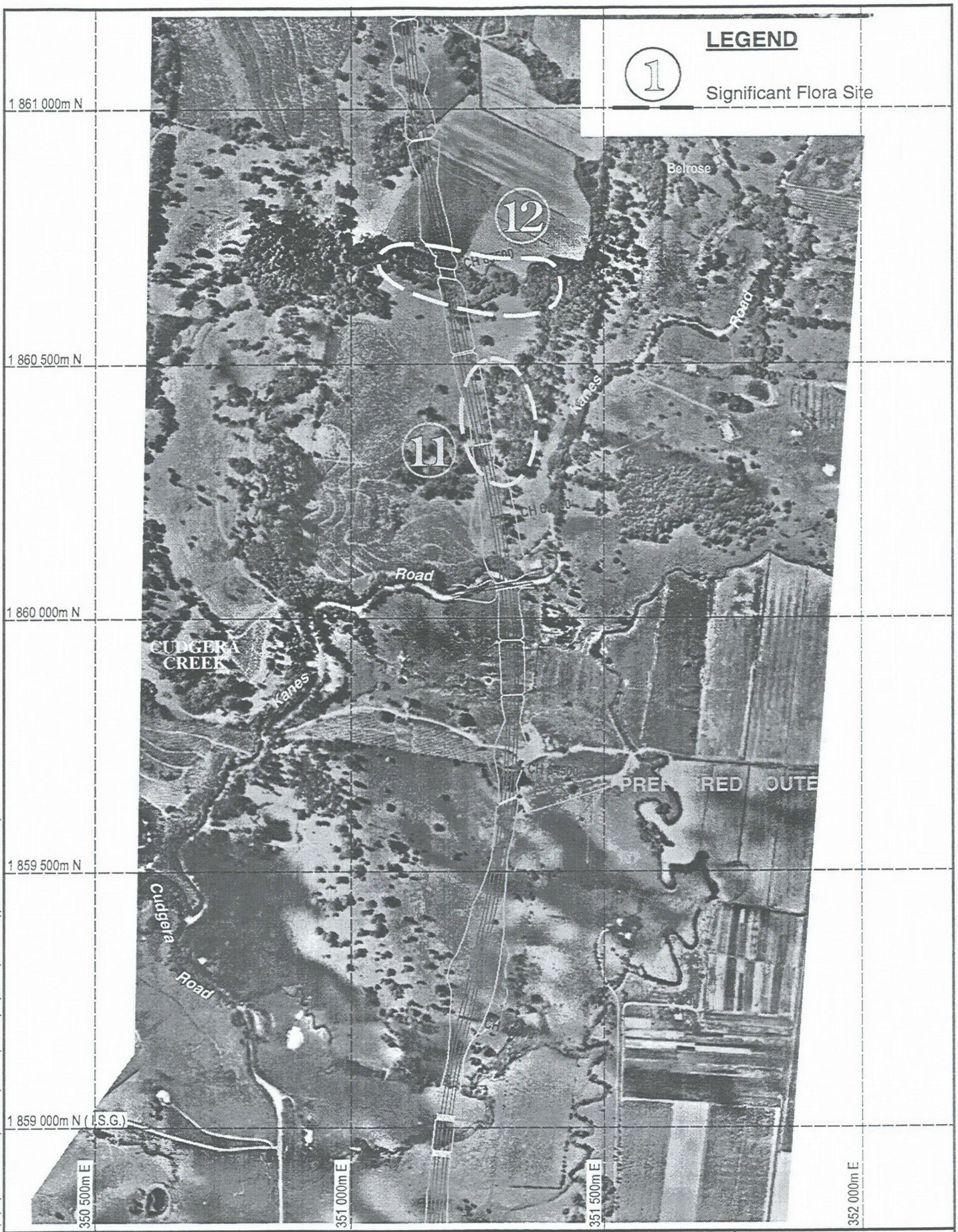

DMR AERIAL PHOTOGRAPHY
(NSW 3152) @1:6000 08-10-1997
S.K.M. Supplied digital data
(Design.dxf) 25-02-1998

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 13km to 15km

FIGURE 3g

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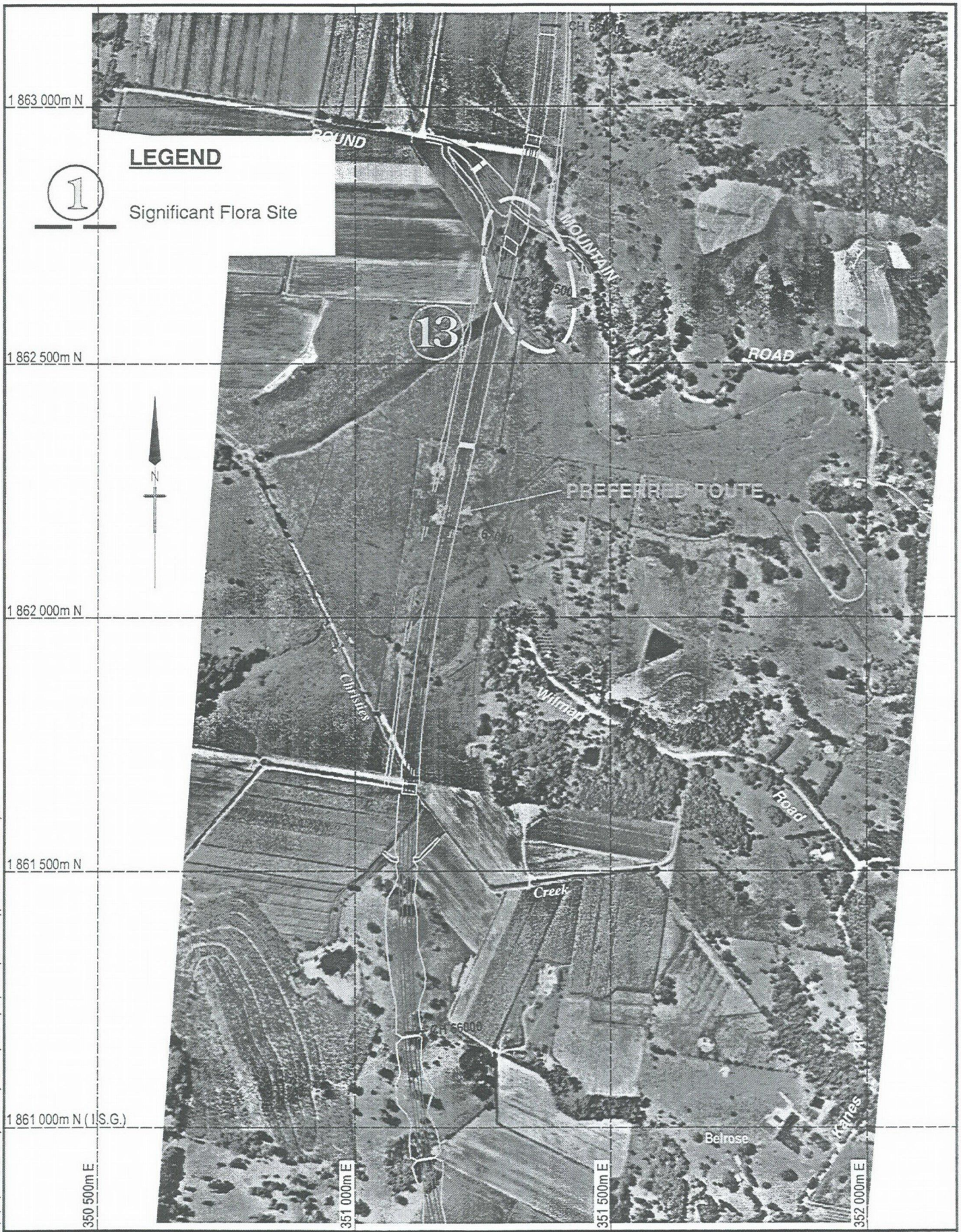

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
S.K.M Supplied digital centre line data (Design.dxf 25-02-1998)

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 15km to 17km

FIGURE 3h

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 17km to 19km

FIGURE 3i

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 19km to 21km

FIGURE 3j

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 21km to 23km

FIGURE 3k

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 23km to 25km

FIGURE 31

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0 100 200 300 400m

SCALE - 1 : 10 000

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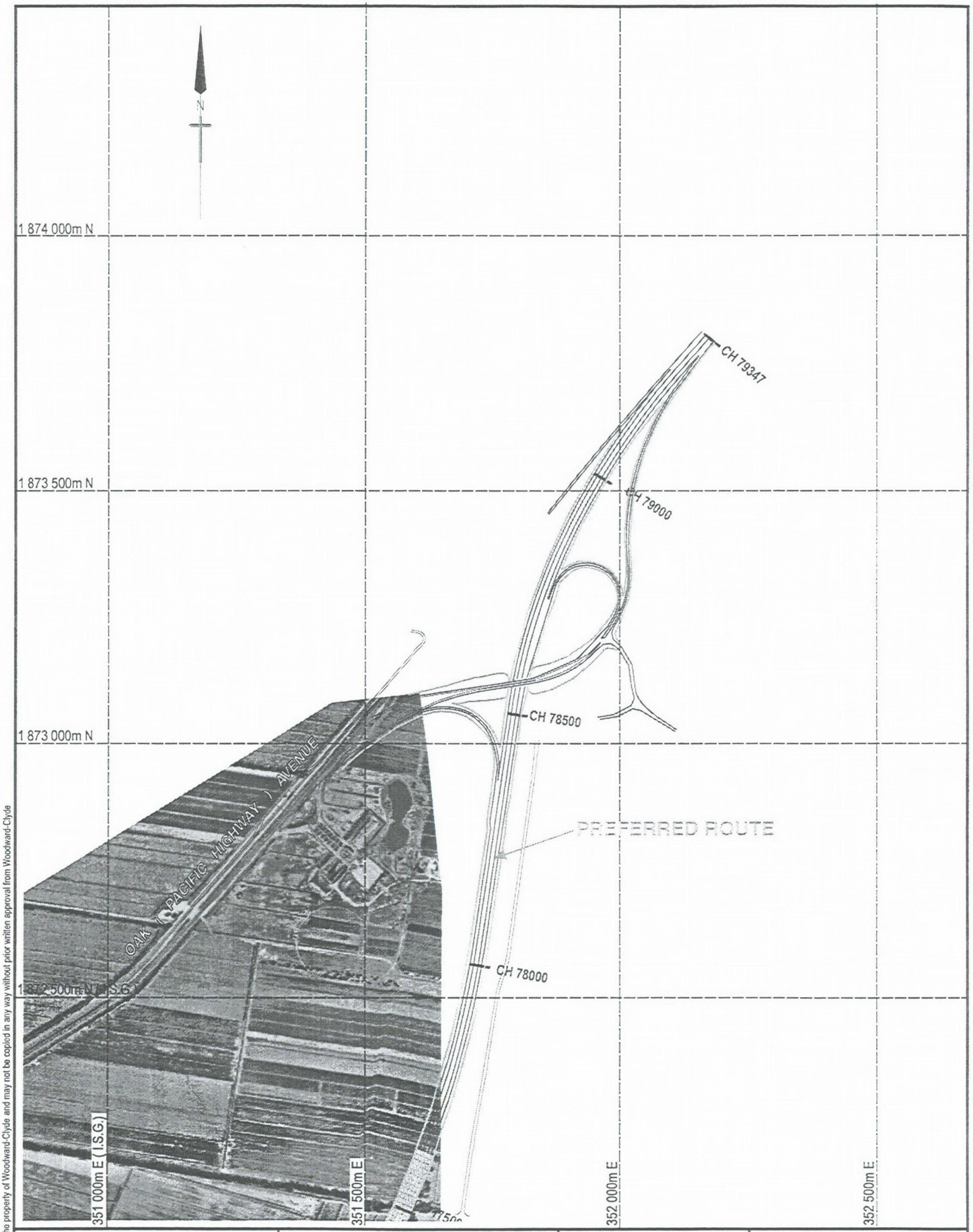
DRAWING No: A3201193-0004-G-023

TITLE
SIGNIFICANT FLORA SITES 25km to 27km

FIGURE 3m



SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997 S.K.M. Supplied digital data (Design.dxf) 25-02-1998

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
SIGNIFICANT FLORA SITES 27km to 28.5km

FIGURE 3n

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SOURCE: TWEED HEADS (9641) and MURWILLUMBAH (9541) 1:100000 Topographic Maps

0 1 2 3 4 5Km

SCALE - 1 : 125 000

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TITLE
FAUNA SURVEY SITES - SHEET KEY

FIGURE 4 KEY

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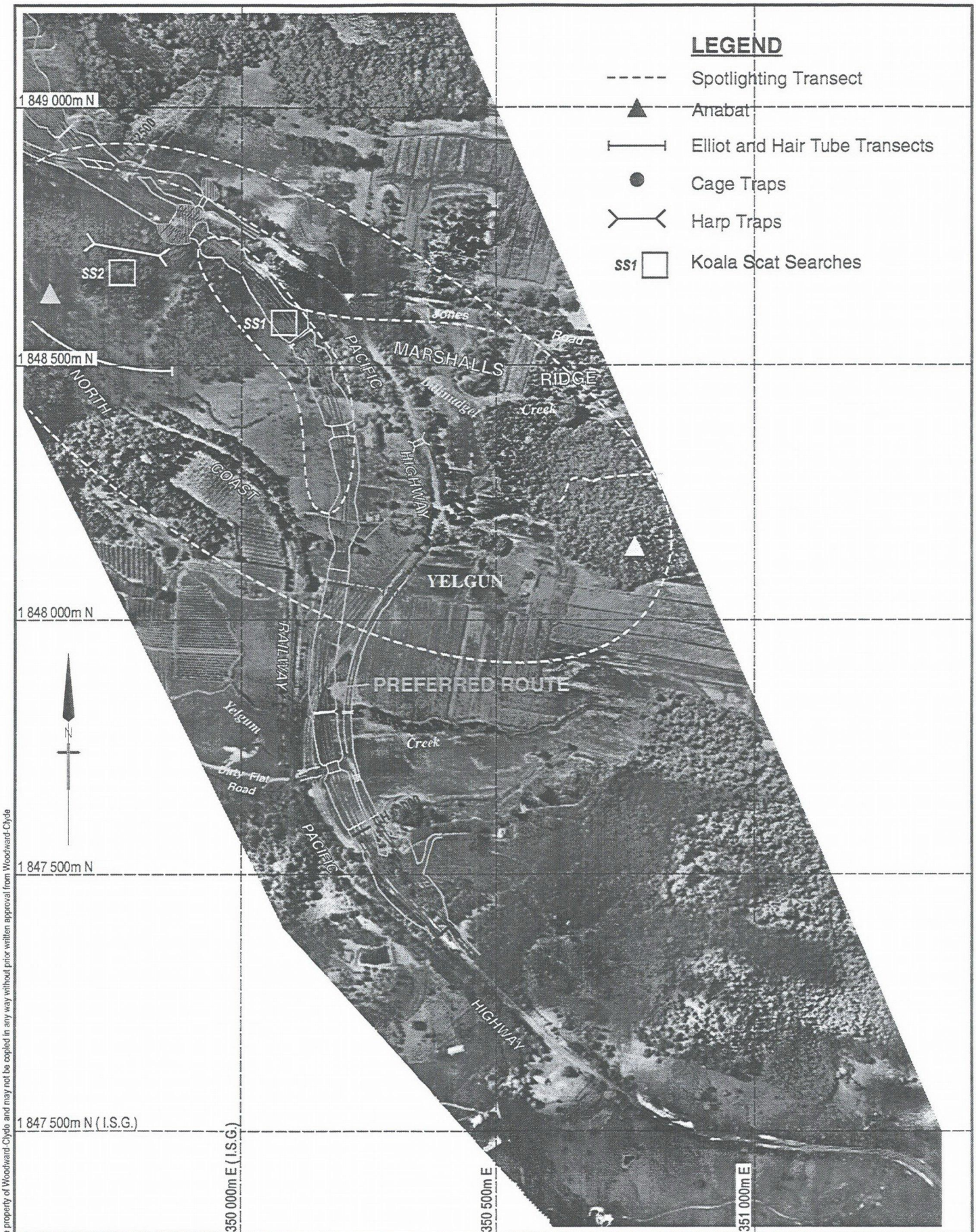

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
S.K.M Supplied digital centre line data (Design.dxf 25-02-1998)

0 100 200 300 400m

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TITLE
FAUNA SURVEY SITES
0km to 2km

FIGURE 4a

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES
2km to 4.5km

FIGURE 4b

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SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
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DRAWING No: A3201193-0004-G-013

TITLE
FAUNA SURVEY SITES 4.5km to 7km

FIGURE 4c

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES 7km to 9km

FIGURE 4d

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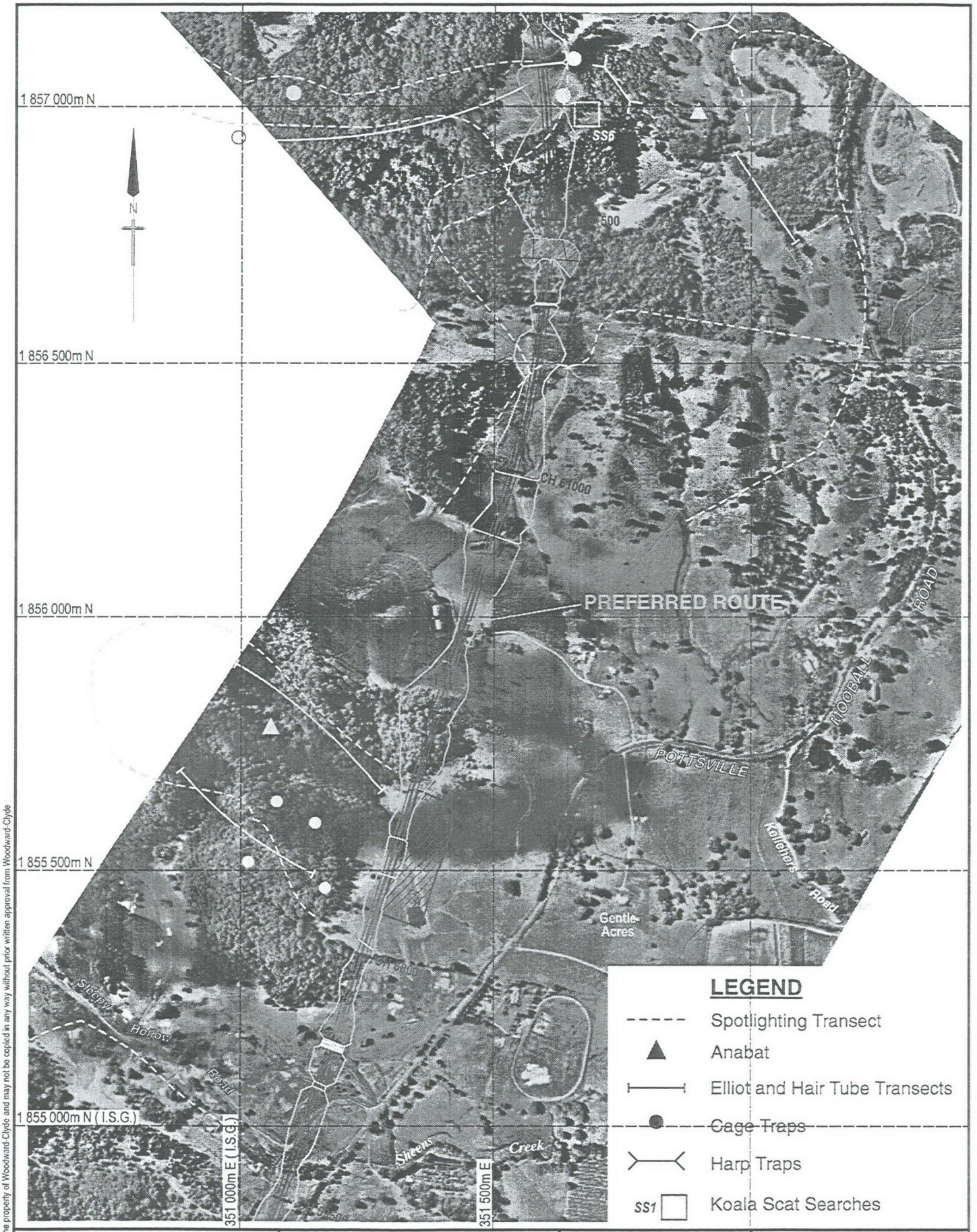

LEGEND

- Spotlighting Transect
- Anabat
- Elliot and Hair Tube Transects
- Cage Traps
- Harp Traps
- SS1 Koala Scat Searches

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES 9km to 11km

FIGURE 4e

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES
11km to 13km

FIGURE 4f

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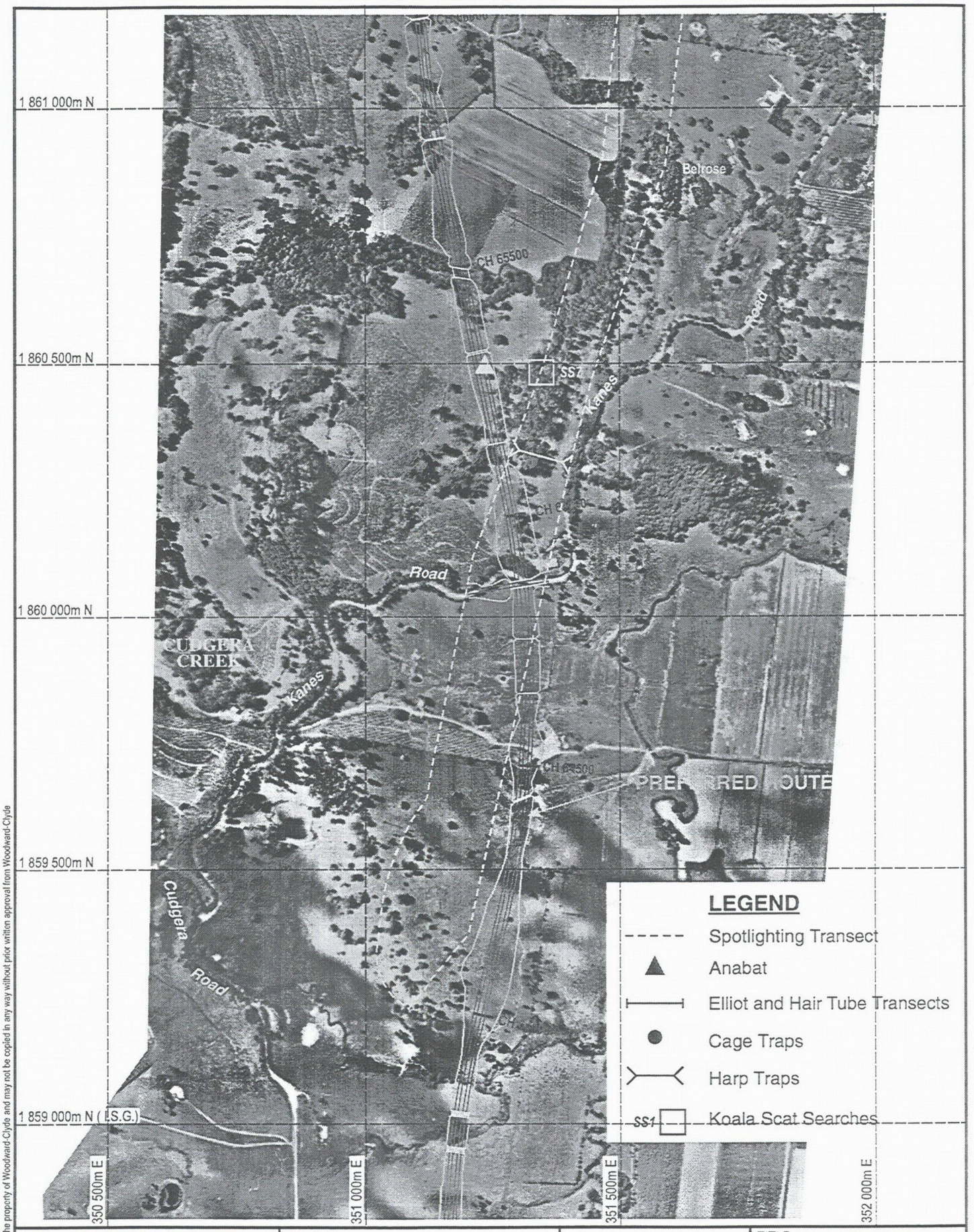

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0 100 200 300 400m

SCALE - 1 : 10 000

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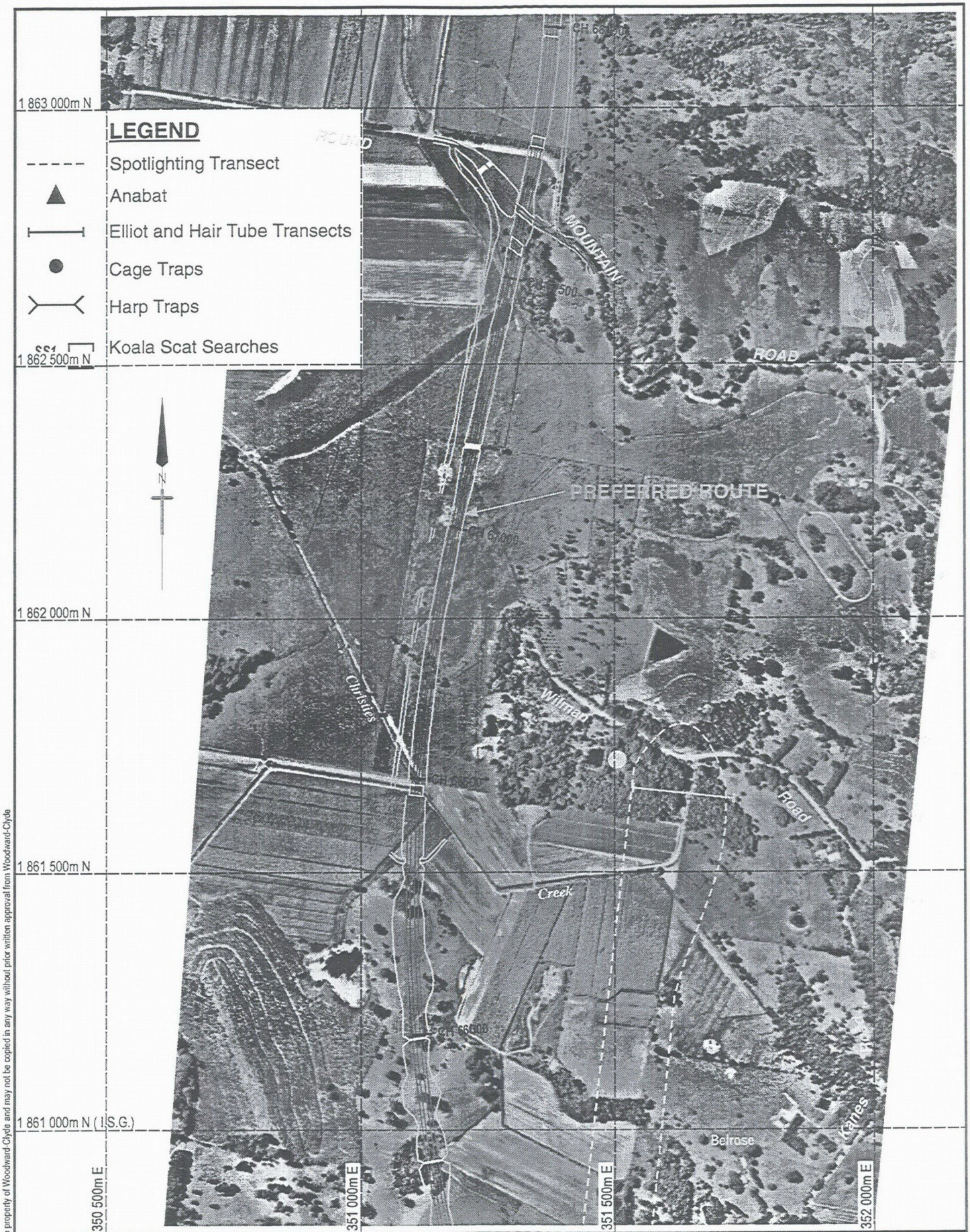
DRAWING No: A3201193-0004-G-017

TITLE
FAUNA SURVEY SITES
13km to 15km

FIGURE 4g



SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
S.K.M Supplied digital centre line data (Design.dxf 25-02-1998)

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES
15km to 17km

FIGURE 4h

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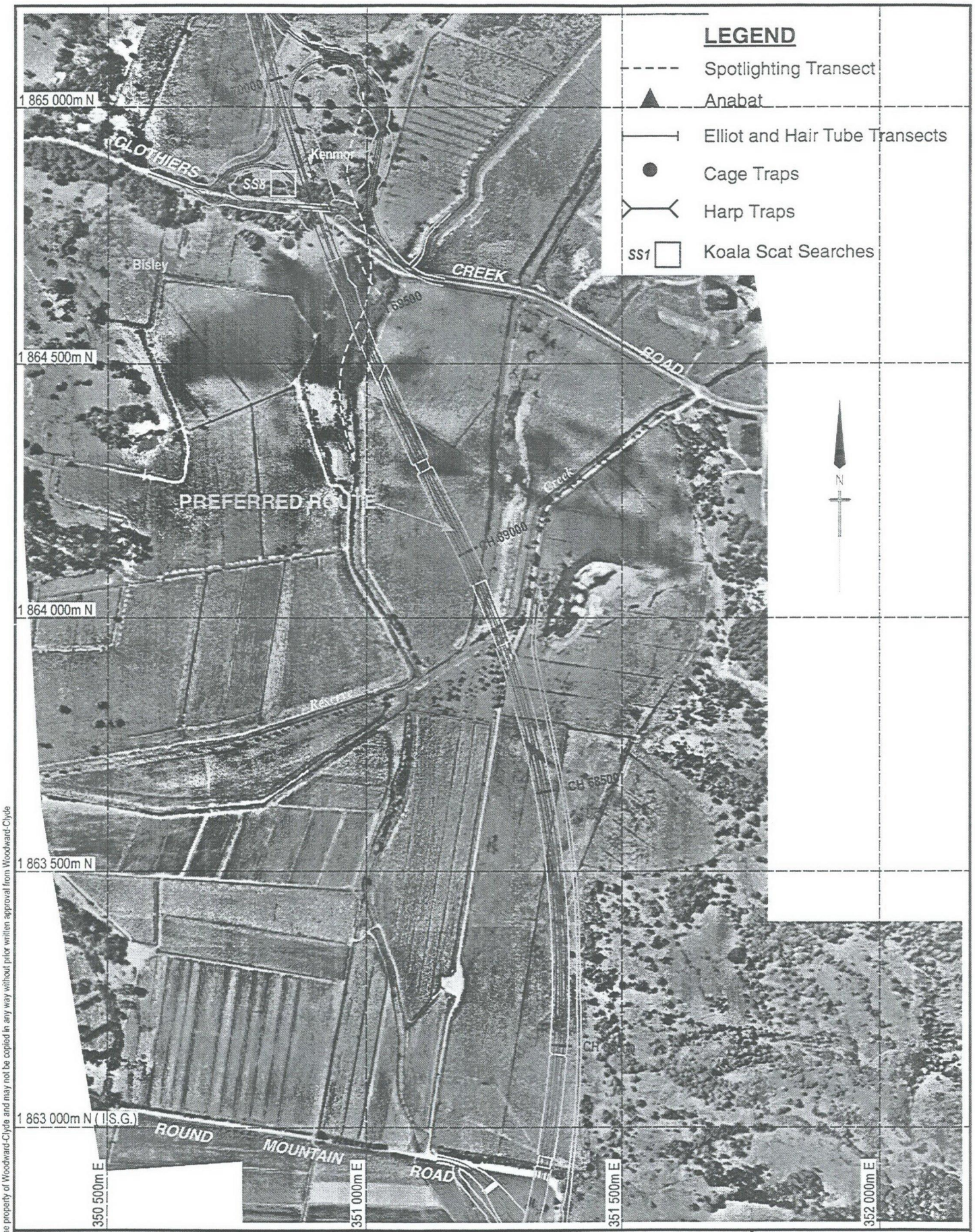

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997 S.K.M Supplied digital centre line data (Design.dxf 25-02-1998)

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES 17km to 19km

FIGURE 4i

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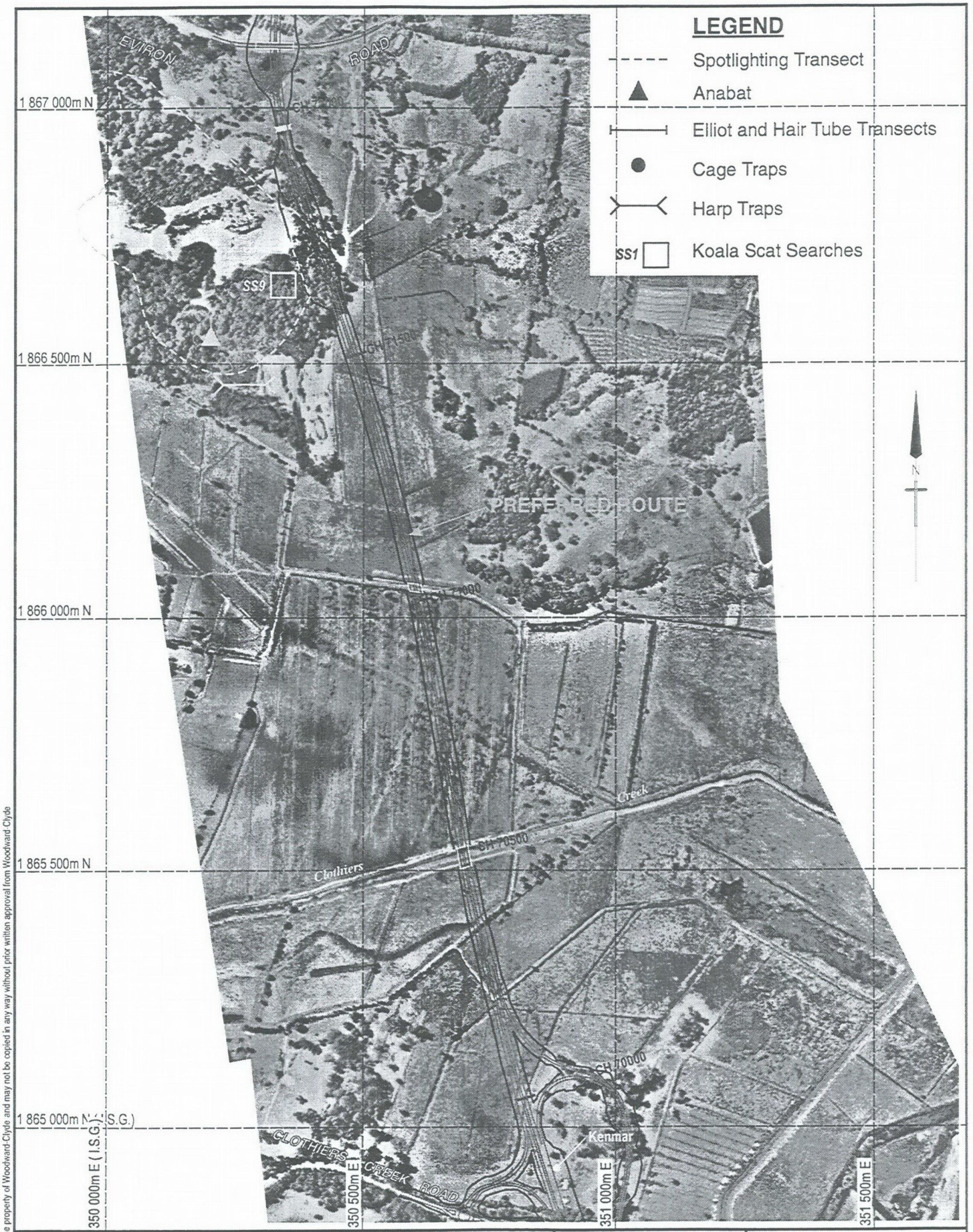

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
S.K.M Supplied digital centre line data (Design.dxf 25-02-1998)

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES
19km to 21km

FIGURE 4j

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES
21km to 23km

FIGURE 4k

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997
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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA
SURVEY SITES
23km to 25km

FIGURE 41

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0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES
25km to 27km

FIGURE 4m

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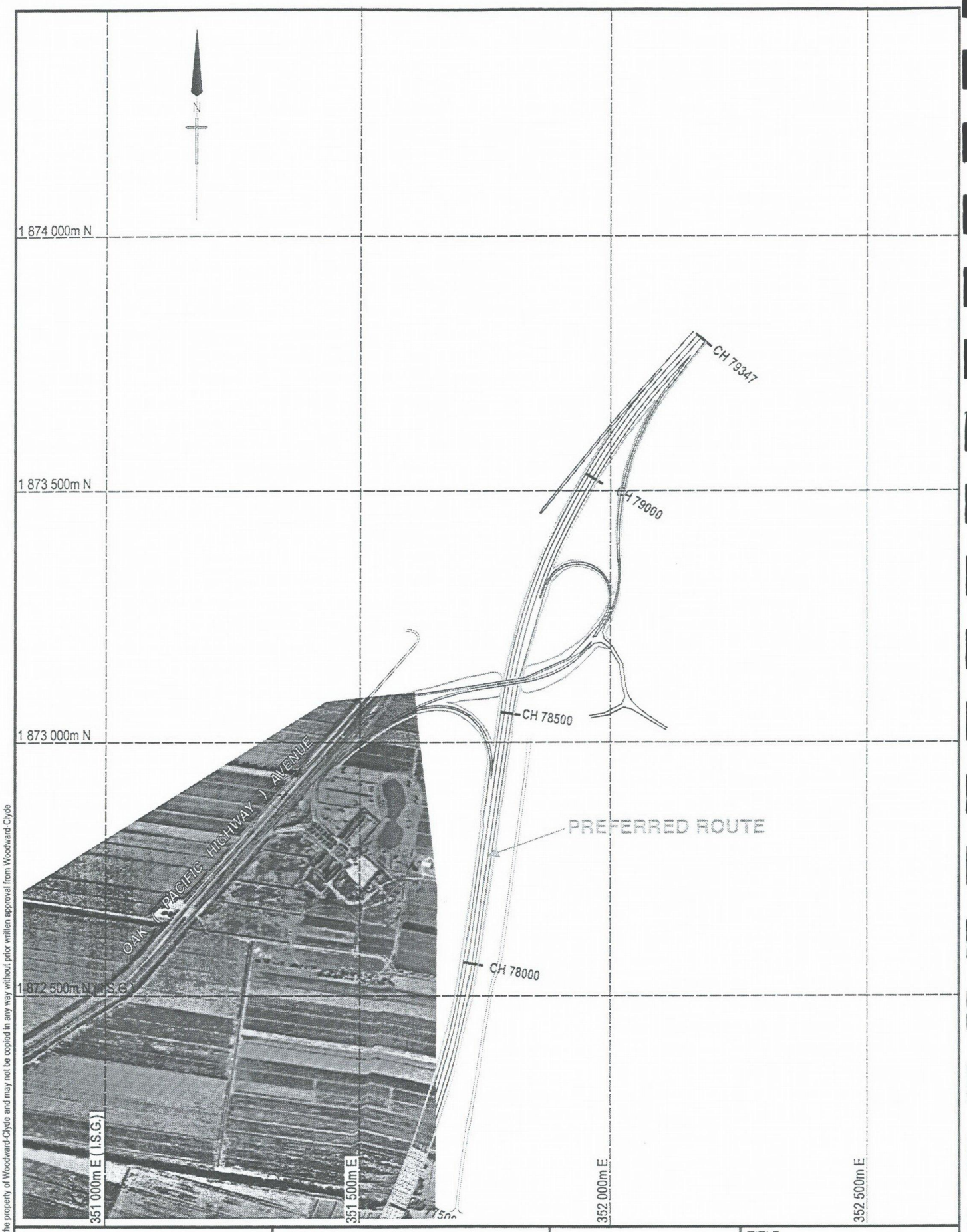

SOURCE: DMR AERIAL PHOTOGRAPHY (NSW 3152) @1:6000 08-10-1997 S.K.M. Supplied digital data (Design.dxf) 25-02-1998

0 100 200 300 400m

SCALE - 1 : 10 000

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TITLE
FAUNA SURVEY SITES 27km to 28.5km

FIGURE 4n

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SOURCE: TWEED HEADS (9641) and MURWILLUMBAH (9541) 1:100000 Topographic Maps

0 1 2 3 4 5Km

SCALE - 1 : 125 000

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TITLE
LOCATION OF THREATENED FAUNA SPECIES RECORDED DURING FIELD SURVEYS

FIGURE 5

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SOURCE: TWEED HEADS (9641) and MURWILLUMBAH (9541) 1:100000 Topographic Maps

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TITLE
LOCATION OF SIGNIFICANT HABITAT AND WILDLIFE CORRIDORS

FIGURE 6

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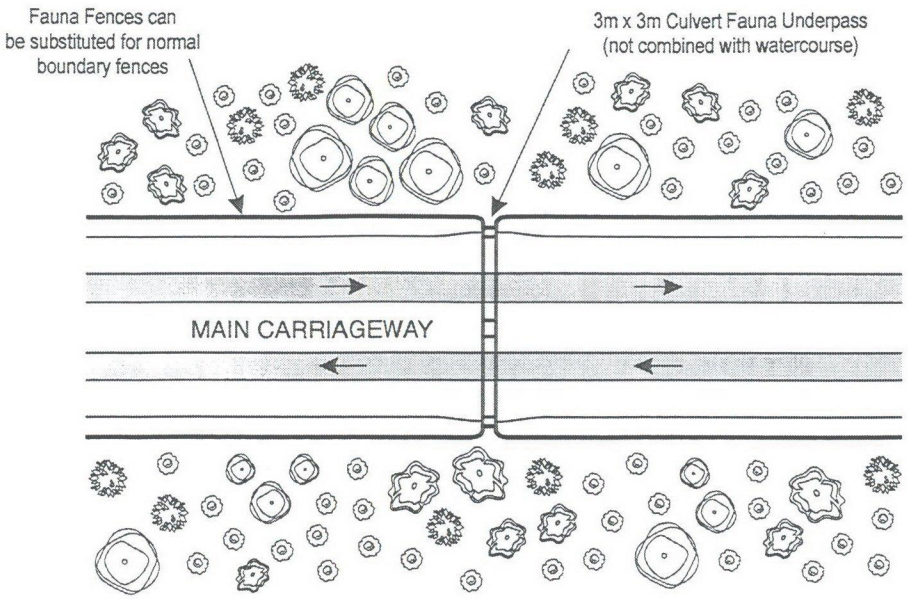
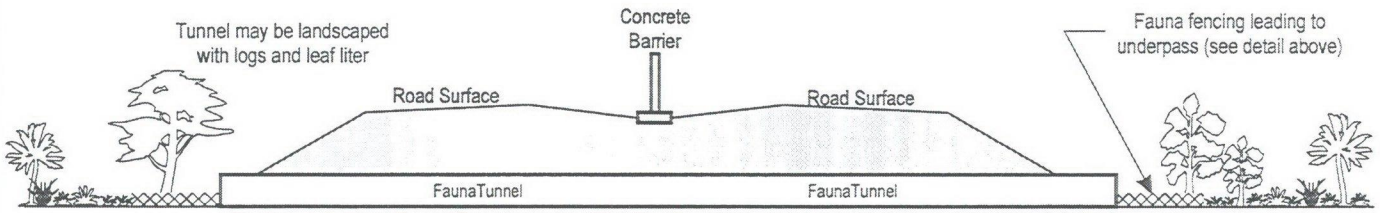
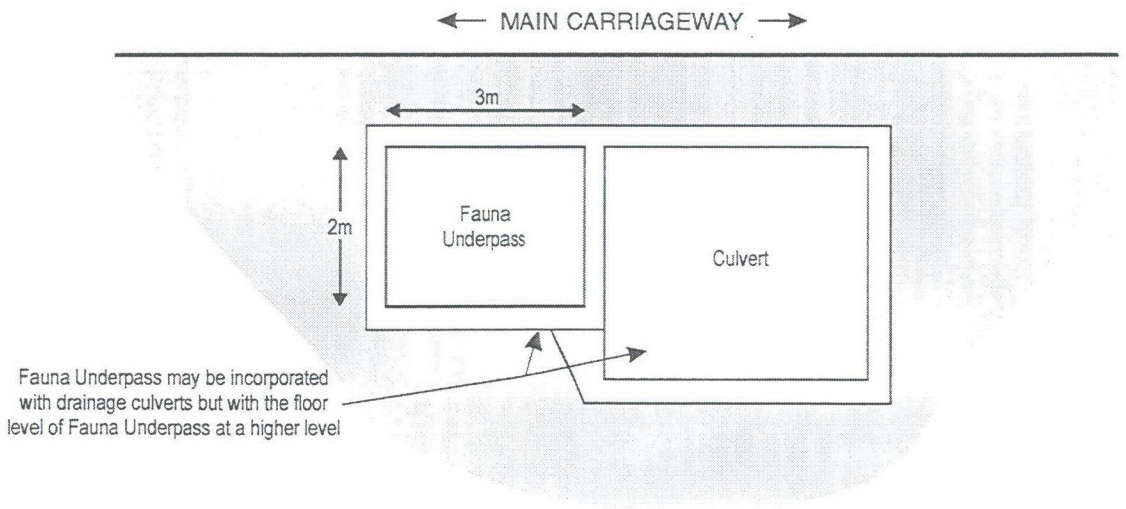
540 000m E
545 000m E
550 000m E
555 000m E
6870 000m N
6865 000m N
6860 000m N
6855 000m N
6850 000m N
Tumbulgum
North Tumbulgum
Stotts Island
Stotts Island channel
Stotts Creek
Kingscliff
Cudgen
Cudgera Creek
Tygalgah
Condong
Murwillumbah
Fernvale
Palmvale
Dunbible
Stokers Siding
Burringbar
Upper Burringbar
Mooball
Durranbah
Bogangar
Hastings Point
Round Mountain
Pottsville
Black Rocks
Cudgera Beach
Mooball Beach
Wooyung Beach
Crabbes Creek
Yelgun
Inner Pocket
Bray Park
Dinseys Rock
Clothiers Creek
Wooyung
Norries Head
Potts Point
TWEED HIGHWAY
PACIFIC HIGHWAY
OAK AVE
CUDGEN LAKE ROAD
MOUNTAIN VIEW RD
KANES RD
MOOBALL RD
POTTSVILLE RD
SLEEPY HOLLOW RD
HULLS RD
WOOYUNG ROAD
JONES RD
CLOTHIERS CREEK ROAD
COAST HIGHWAY
BURRINGBAR RANGE
CUDGERA CREEK ROAD
POTTSVILLE ROAD
McLeods Creek
Sleepy Hollow
Christies
Blindworm
Lacks
Sheens Creek
Mooball Creek
Cudgen Creek
Rous River
Oxley River
Mayal Creek
Piggabeen Creek
Dunbible Creek
Crabbes Creek
Wooyung Creek
Cudgera Creek
Black Rocks Creek
Hastings Point reservoir
sand mining
sand mining area
sanitary rubbish depot
racecourse
quarry
quarry (disused)
cemetery
radio mast
radio
falls
rainforest
FORREST
FARRANTS HILL
CHAPPY VALLEY
BOB'S LOOKOUT
Bobs Lookout
Burringbar Gap
Reserve Ground
Round Mountain
Cudgera Creek
Crabbes Creek
Wooyung Creek
Mooball Creek
Sleepy Hollow
Trotting track
Travel pit
Travel on
Golf Course
Caravan Park
Cemetery
Drains
Pine
Mining area
Works
Treatment
Wage
Island
Channel
Gauge
Tank
Pipeline
Creek
Beach
Point
Reserve
Mountain
Hill
Park
Valley
Range
Coast
Highway
Road
Drive
Avenue
Pacific
Tweed
Oak
Cudgen
Lake
Mooball
Pottsville
Hulls
Wooyung
Jones
Kanes
Mountain View
Clothiers
Creek
Sleepy Hollow
Christies
Blindworm
Lacks
Sheens



PLAN



ROAD CROSS SECTION AT FAUNA UNDERPASS



SECTION THROUGH FAUNA UNDERPASS

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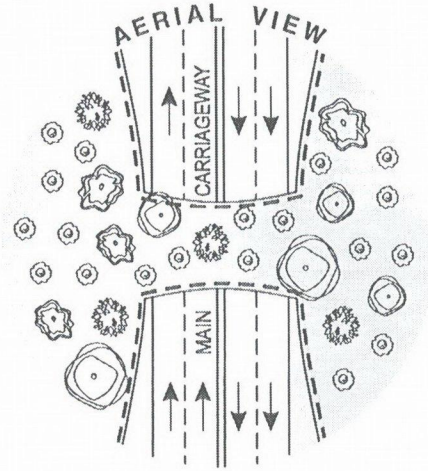
A Small Local Road may be incorporated over the Cut and Cover Tunnel

Fauna Fences
(See Figure 12 for details)



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TITLE FAUNA OVERPASS

FIGURE 9

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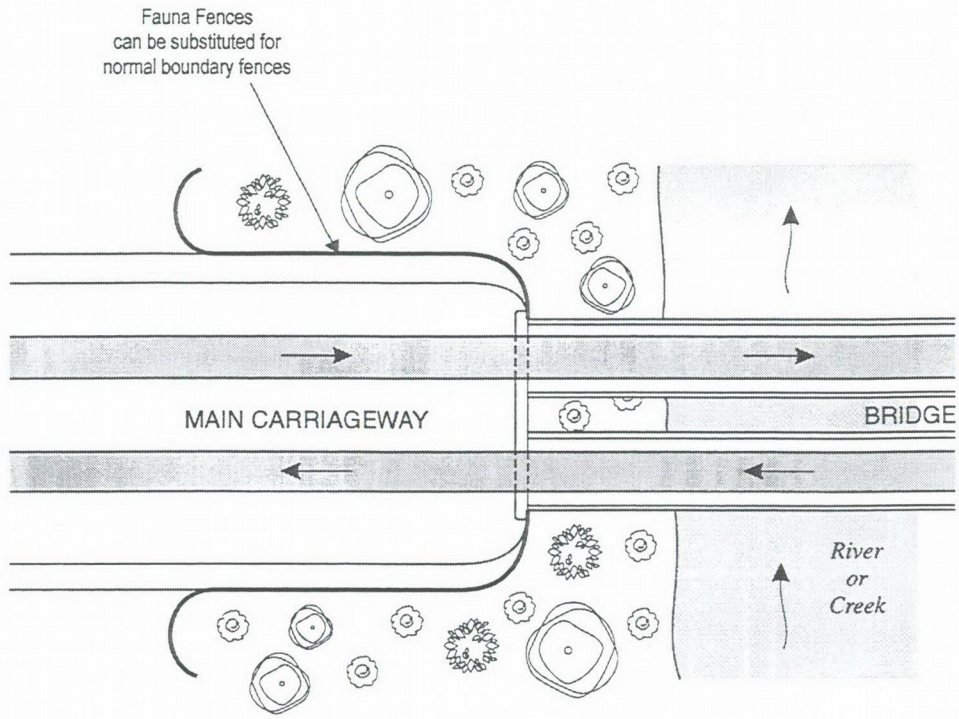
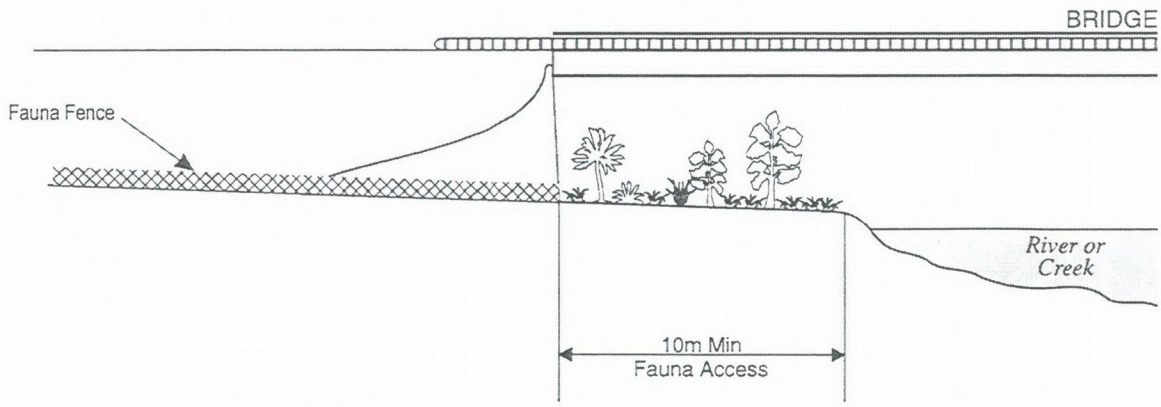


PLAN



ELEVATION

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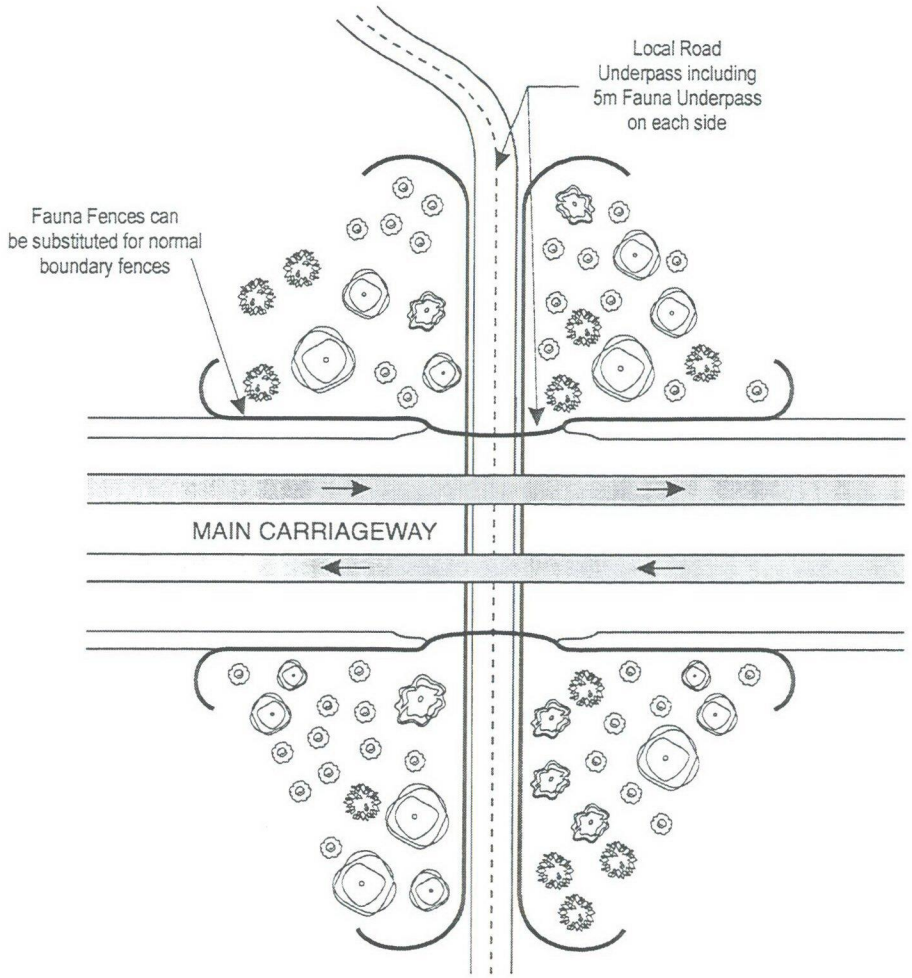
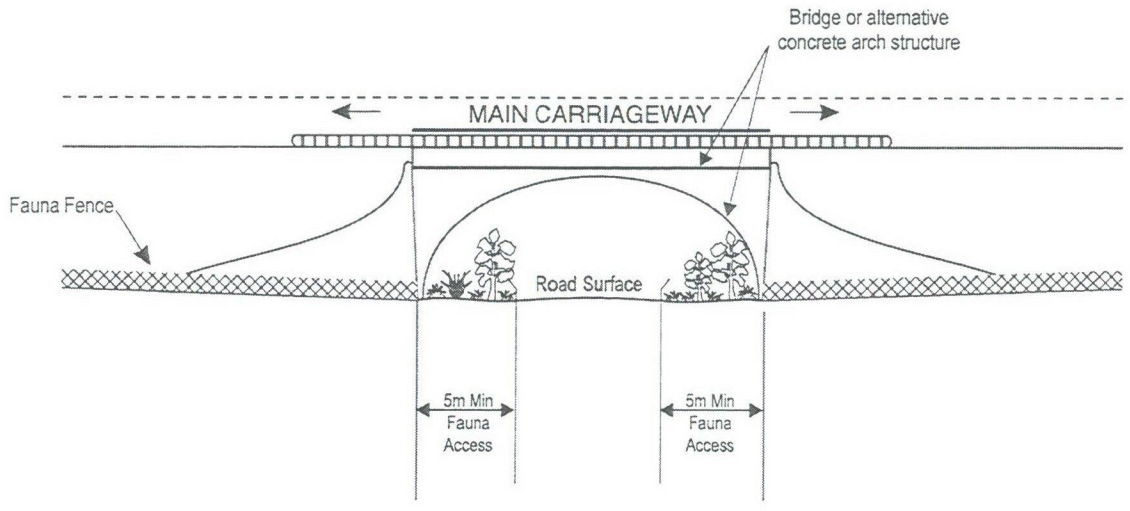


PLAN



ELEVATION

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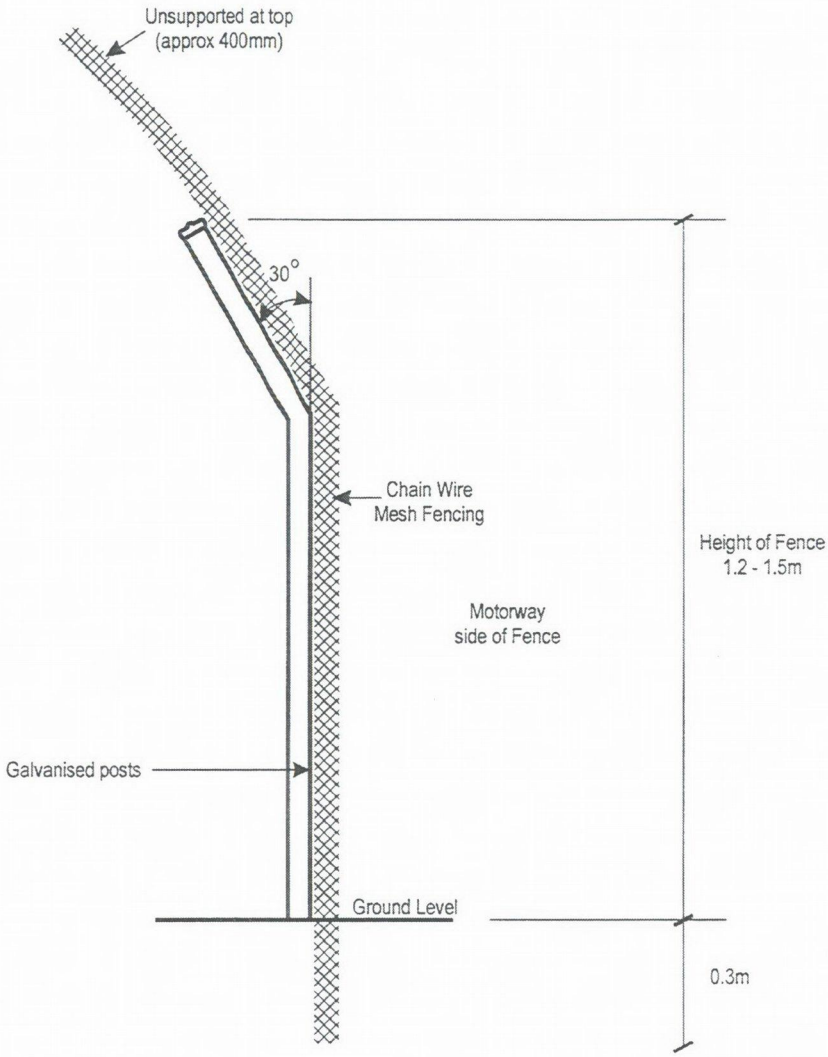

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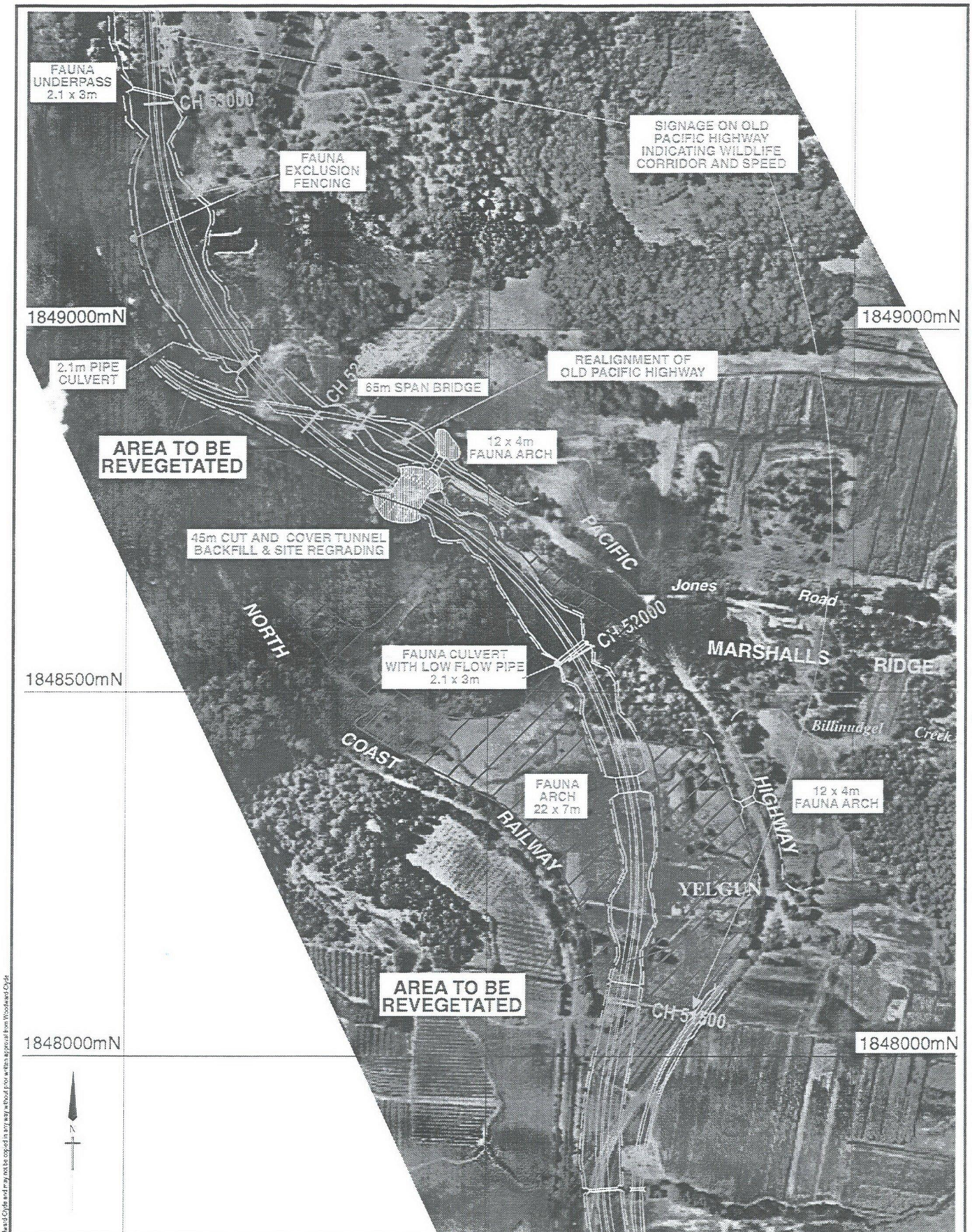

SOURCE: CLIENT SUPPLIED AERIAL PHOTO

0 50 100 150 200m

SCALE

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TITLE
MITIGATION PLAN - MARSHALLS RIDGES

FIGURE 13

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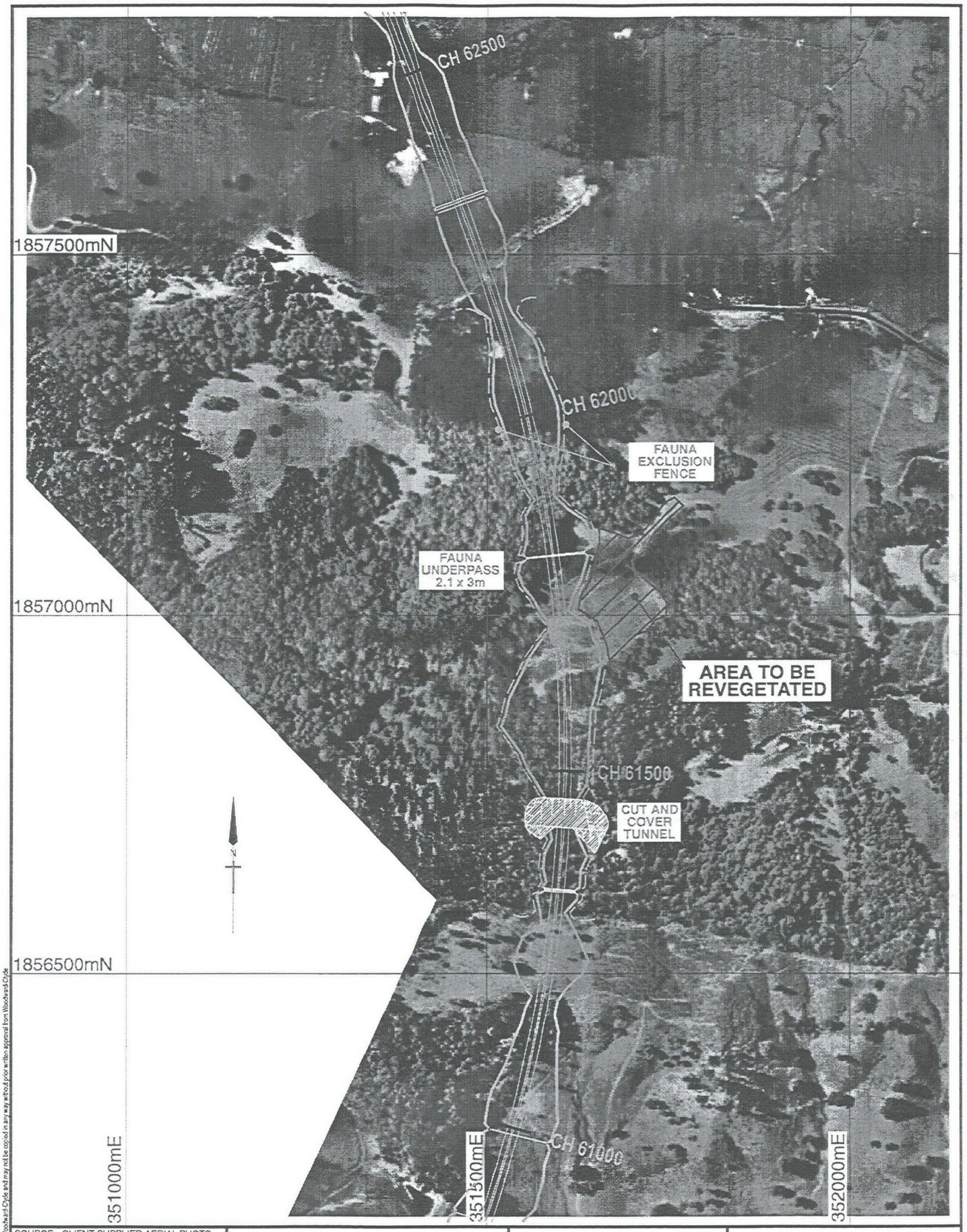

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0 50 100 150 200m

SCALE

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DRAWING No: A3201193-0004-G-009

TITLE
MITIGATION PLAN - TAGGETS HILL

FIGURE 14

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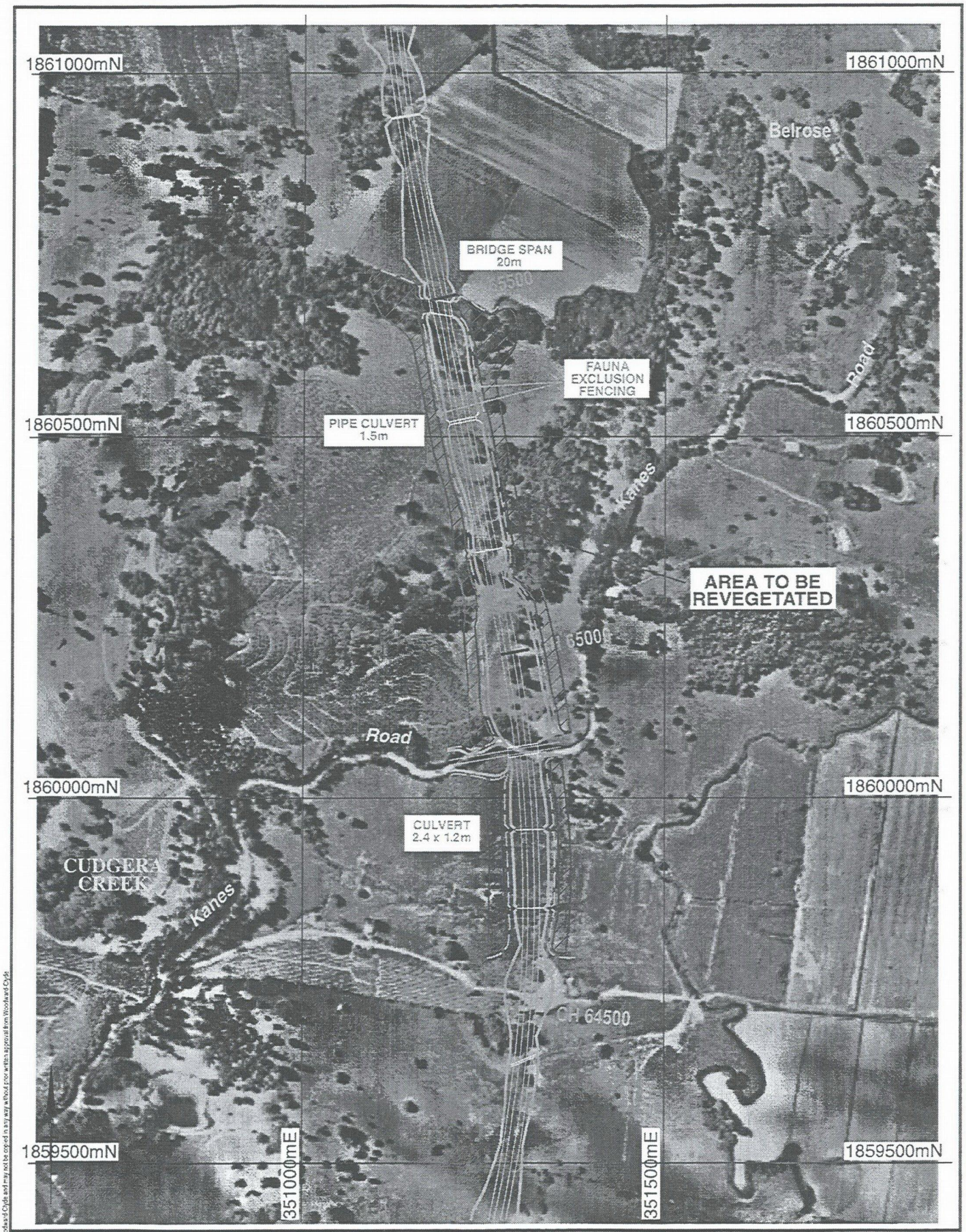

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SCALE

Woodward-Clyde

CLIENT
SINCLAIR KNIGHT MERZ

PROJECT
PROPOSED PACIFIC HIGHWAY UPGRADE, YELGUN TO CHINDERAH ENVIRONMENTAL IMPACT STATEMENT - FLORA / FAUNA WORKING PAPER

PREPARED: LL DATE: MAY 98

CHECKED: NA REVISION: B

APPROVED: CAD FILE No: -G-025

DRAWING No: A3201193-0004-G-025

TITLE
MITIGATION PLAN - KANES ROAD/CHRISTIES CREEK AREA

FIGURE 15

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Appendix A
Plant Species List

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
rs	*Abrus precatorius*	Rosary Pea	a cycad	*Lepidozamia peroffskyana*
	Acacia aulacocarpa	Brush Ironbark Wattle	Actephila	*Actephila lindleyi*
R	*Acacia bakeri*	Marblewood	Ardisia	*Ardisia crenulata*
	Acacia melanoxylon	Blackwood	Austral Sarsparilla	*Smilax australis*
rs	*Acmena hemilampra*	Broad-leaved Lilly Pilly	Australian Teak	*Flindersia australis*
	Acmena smithii	Lilly Pilly	Banana Bush	*Tabernaemontana pandacaqui*
	Acmena smithii rheotypic race	Narrow-leaved Lilly Pilly	Bangalow Palm	*Archontophoenix cunninghamiana*
	Acronychia oblongifolia	Common Acronychia	Barbed Wire Grass	*Cymbopogon refractus*
	Acronychia wilcoxiana	Silver Aspen	Bastard Crows Ash	*Pentaceras australe*
	Actephila lindleyi	Actephila	Bat's Wing Coral Tree	*Erythrina vespertilio*
	Adiantum formosum	Giant Maidenhair	Bat's Wing Fern	*Histiopteris incisa*
	Adiantum hispidulum	Rough Maidenhair	Beetroot	*Elattostachys nervosa*
I	*Ageratina adenophora*	Crofton Weed	Bennett's Ash	*Flindersia bennettiana*
i	*Ageratina riparia*	Mistweed	Binung	*Christella dentata*
i	*Ageratum houstonianum*	Blue Mistweed	Bird's Nest Fern	*Asplenium australasicum*
	Alchornea ilicifolia	Native Holly	Bitou Bush	*Chrysanthemoides monilifera* subsp. *rotundata*
	Allocasuarina torulosa	Forest Oak	Black Apple	*Planchonella australis*
	Alocasia brisbanensis	Cunjevoi	Black Plum	*Diospyros australis*
	Alphitonia excelsa	Red Ash	Black Walnut	*Endiandra globosa*
rs	*Alphitonia petriei*	Pink Ash	Blackbutt	*Eucalyptus pilularis*
	Alpinia caerulea	Native Ginger	Blackwood	*Acacia melanoxylon*
	Alyxia ruscifolia	Prickly Alyxia	Blady Grass	*Imperata cylindrica*
i	*Andropogon virginicus*	Whisky Grass	Bleeding Heart	*Omalanthus populifolius*
rs	*Anthocarapa nitidula*	Incense Cedar	Blood Vine	*Austrosteenisia blackii*
	Aphananthe philippinensis	Rough-leaved Elm	Blue Fig	*Elaeocarpus grandis*
	Araucaria cunninghamii	Hoop Pine	Blue Flax Lily	*Dianella caerulea*
	Archidendron grandiflorum	Pink Lace Flower	Blue Flax Lily	*Dianella caerulea* var. *producta*
rs	*Archidendron hendersonii*	White Lace Flower	Blue Lilly Pilly	*Syzygium oleosum*
R	*Archidendron muellerianum*	Veiny Lace Flower	Blue Mistweed	*Ageratum houstonianum*
	Archirhodomyrtus	Rose Myrtle	Blue Wandering Dew	*Commelina cyanea*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	heckleri			
	Archontophoenix cunninghamiana	Bangalow Palm	Blueberry Ash	*Elaeocarpus reticulatus*
i	*Ardisia crenata*	Ardisia	Blunt-leaved Guinea Flower	*Hibbertia obtusifolia*
rs	*Arytera distylis*	Twin-leaved Coogera	Blunt-leaved Native Wisteria	*Millettia australis*
	Arytera divaricata	Rose Tamarind	Blunt-leaved Steelwood	*Toechima dasyrrache*
	Asplenium attenuatum	Simple Spleenwort	Blush Coondoo	*Planchonella laurifolia*
	Asplenium australasicum	Bird's Nest Fern	Blush Walnut	*Beilschmiedia obtusifolia*
	Asplenium flaccidum	Weeping Spleenwort	Bolwarra	*Eupomatia laurina*
	Astrotricha latifolia	Star-hair	Bordered Panic Grass	*Entolasia marginata*
	Austromyrtus (aff.) *hillii*	Scaly Myrtle	Bordered Shield Fern	*Lastreopsis marginans*
	Austromyrtus bidwillii	Python Tree	Bottlebrush Grass Tree	*Xanthorrhoea macronema*
	Austromyrtus dulcis	Midgenberry	Bracken Fern	*Pteridium esculentum*
	Austrosteenisia blackii	Blood Vine	Bristly Shield Fern	*Lastreopsis hispida*
i	*Baccharis halimifolia*	Groundsel	Broad Sword Sedge	*Lepidosperma laterale*
rs	*Banksia robur*	Large-leaved Banksia	Broad-leaved Cumbungi	*Typha orientalis*
	Baumea rubiginosa	Soft Twig-rush	Broad-leaved Lilly Pilly	*Acmena hemilampra*
	Beilschmiedia elliptica	Grey Walnut	Broad-leaved Native Cherry	*Exocarpus latifolius*
	Beilschmiedia obtusifolia	Blush Walnut	Broad-leaved Palm Lily	*Cordyline petiolaris*
	Bidens pilosa	Farmer's Friend	Broad-leaved Paspalum	*Paspalum wettsteinii*
	Blechnum camfieldii	Eared Swamp Water Fern	Broad-leaved White Mahogany	*Eucalyptus carnea*
	Blechnum cartilagineum	Gristle Fern	Brown Bolly Gum	*Litsea australis*
	Blechnum indicum	Swamp Water Fern	Brown Kurrajong	*Commersonia bartramia*
	Breynia oblongifolia	Coffee Bush	Brush Box	*Lophostemon confertus*
	Bridelia exaltata	Brush Ironbark	Brush Caper Berry	*Capparis arborea*
	Caesalpinia subtropica	Corky Prickle-vine	Brush Cassia	*Cassia brewsteri* var *marksiana*
	Calamus muelleri	Wait-a-While	Brush Ironbark	*Bridelia exaltata*
	Caldcluvia paniculosa	Rose-leaf Marara	Brush Ironbark Wattle	*Acacia aulacocarpa*
	Callicoma serratifolia	Callicoma	Brush Kurrajong	*Commersonia fraseri*
	Callistemon salignus	Willow Bottlebrush	Buff Hazelwood	*Symplocos thwaitesii*
rs	*Callitris columellaris*	White Cypress Pine	Burny Vine	*Malaisia scandens*
	Calochlaena dubia	Common Ground Fern	Cabbage Palm	*Livistona australis*
	Calystegia marginata	Calystegia	Callicoma	*Callicoma serratifolia*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	Canarium australasicum	Mango Bark	Calystegia	*Calystegia marginata*
	Canthium coprosmoides	Coast Canthium	Camphor Laurel	*Cinnamomum camphora*
	Capparis arborea	Brush Caper Berry	Cape Water Lily	*Nymphaea capensis*
	Carex appressa	Tall Sedge	Carronia	*Carronia multisepala*
	Carronia multisepala	Carronia	Celerywood	*Polyscias elegans*
R	*Cassia brewsteri* var *marksiana*	Brush Cassia	Celtis	*Celtis sp.*
	Casuarina glauca	Swamp Oak	Cheese Tree	*Glochidion ferdinandi*
	Celtis paniculata	Native Celtis	Cleistanthus	*Cleistanthus cunninghamii*
	Celtis sp.	Celtis	Climbing Asparagus	*Protasparagus plumosus*
	Cheilanthes sieberi	Rock Fern	Climbing Guinea Flower	*Hibbertia scandens*
	Christella dentata	Binung	Climbing Maidenhair Fern	*Lygodium microphyllum*
i	*Chrysanthemoides monilifera* subsp. *rotundata*	Bitou Bush	Climbing Nightshade	*Solanum seaforthianum*
i	*Cinnamomum camphora*	Camphor Laurel	Clubrush	*Schoenoplectus mucronatus*
	Cinnamomum oliveri	Oliver's Sassafras	Coast Canthium	*Canthium coprosmoides*
	Cinnamomum virens	Red-barked Sassafras	Cockspur Thorn	*Maclura cochinchinensis*
	Cissus antarctica	Water Vine	Coffee Bush	*Breynia oblongifolia*
	Cissus hypoglauca	Five-leaf Water Vine	Common Acronychia	*Acronychia oblongifolia*
	Citriobatus pauciflorus	Orange Thorn	Common Ground Fern	*Calochlaena dubia*
	Citrus limonia	Lemon Tree	Common Hovea	*Hovea linearis*
	Cleistanthus cunninghamii	Cleistanthus	Common Morning Glory	*Ipomoea purpurea*
	Clerodendrum tomentosum	Hairy Clerodendrum	Common Passionfruit	*Passiflora edulis*
	Commelina cyanea	Blue Wandering Dew	Common Reed	*Phragmites australis*
	Commersonia bartramia	Brown Kurrajong	Common Rush	*Juncus usitatus*
	Commersonia fraseri	Brush Kurrajong	Common Silkpod	*Parsonsia straminea*
i	*Conyza bonariensis*	Fleabane	Coral Tree (introduced)	*Erythrina X sykesii*
	Cordyline petiolaris	Broad-leaved Palm Lily	Cork Passionflower	*Passiflora suberosa*
	Cordyline rubra	Palm Lily	Corky Milk-vine	*Marsdenia suberosa*
	Cordyline stricta	Narrow-leaved Palm Lily	Corky Prickle-vine	*Caesalpinia subtropica*
	Corymbia intermedia	Pink Bloodwood	Creek Sandpaper Fig	*Ficus coronata*
	Croton verreauxii	Native Cascarilla	Creeping Beard Grass	*Oplismenus imbecillis*
V	*Cryptocarya foetida*	Stinking Cryptocarya	Creeping Shield Fern	*Lastreopsis microsora*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	Cryptocarya glaucescens	Jackwood	Crofton Weed	*Ageratina adenophora*
rs	*Cryptocarya laevigata*	Red-fruited Laurel	Crystal Creek Walnut	*Endiandra floydii*
	Cryptocarya microneura	Murrogun	Cudgerie	*Flindersia schottiana*
	Cryptocarya obovata	Pepperberry	Cunjevoi	*Alocasia brisbanensis*
	Cryptocarya rigida	Forest Maple	Davidson's Plum	*Davidsonia pruriens var. jerseyana*
	Cryptocarya triplinervis	Three-veined Cryptocarya	Desmodium	*Desmodium* sp.
	Cupaniopsis anacardioides	Tuckeroo	Durobby	*Syzygium moorei*
R	*Cupaniopsis newmannii*	Long-leaved Tuckeroo	Eared Swamp Water Fern	*Blechnum camfieldii*
	Cyathea australis	Rough Tree Fern	Elkhorn	*Platycerium bifurcatum*
	Cyathea cooperi	Straw Tree Fern	Embelia	*Embelia australiana*
	Cyathea leichhardtiana	Prickly Tree Fern	False Sarsparilla	*Hardenbergia violacea*
	Cyclosorus interruptus	Shield-fern	Farmer's Friend	*Bidens pilosa*
	Cymbopogon refractus	Barbed Wire Grass	Featherwood	*Polyosma cunninghamii*
	Cyperus lucidus	Leafy Flat Sedge	Finger Lime	*Microcitrus australasica*
E	*Davidsonia pruriens var. jerseyana*	Davidson's Plum	Fireweed	*Senecio madagascariensis*
	Daviesia arborea	Tree Bitter Pea	Firewheel Tree	*Stenocarpus sinuatus*
	Decaspermum humile	Silky Myrtle	Fishbone Fern	*Nephrolepis cordifolia*
	Denhamia celastroides	Orange Boxwood	Five-leaf Water Vine	*Cissus hypoglauca*
	Derris involuta	Native Derris	Fleabane	*Conyza bonariensis*
	Desmodium sp.	Desmodium	Flintwood	*Scolopia braunii*
i	*Desmodium uncinatum*	Silver-leaved Desmodium	Flooded Gum	*Eucalyptus grandis*
	Dianella caerulea	Blue Flax Lily	Foambark	*Jagera pseudorhus*
	Dianella caerulea var. *producta*	Blue Flax Lily	Forest Maple	*Cryptocarya rigida*
	Dioscorea transversa	Native Yam	Forest Oak	*Allocasuarina torulosa*
	Diospyros australis	Black Plum	Forest Red Gum	*Eucalyptus tereticornis*
	Diospyros fasciculosa	Grey Ebony	Fragrant Fern	*Microsorum scandens*
	Diospyros pentamera	Myrtle Ebony	Geebung	*Persoonia adenantha*
	Diploglottis australis	Native Tamarind	Giant Maidenhair	*Adiantum formosum*
	Doodia aspera	Prickly Rasp Fern	Giant Pepper Vine	*Piper novae-hollandiae*
	Doodia caudata	Small Rasp Fern	Giant Sedge	*Lepironia articulata*
	Doodia media	Small Rasp Fern	Giant Water Gum	*Syzygium francisii*
i	*Drymaria cordata* subsp. *diandra*	Tropical Chickweed	Goodenia	*Goodenia hederacea*
	Drypetes australasica	Yellow Tulipwood	Grass Beak-rush	*Rhynchospora corymbosa*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	Duboisia myoporoides	Soft Corkwood	Green Bolly Gum	*Neolitsea australiensis*
	Dysoxylum mollissimum	Red Bean	Green-leaved Rose Walnut	*Endiandra muelleri* subsp. *bracteata*
	Dyxoxylum rufum	Hairy Rosewood	Green-leaved Rose Walnut	*Endiandra muelleri* subsp. *muelleri*
	Elaeocarpus grandis	Blue Fig	Grey Ebony	*Diospyros fasciculosa*
	Elaeocarpus obovatus	Hard Quandong	Grey Ironbark	*Eucalyptus siderophloia*
	Elaeocarpus reticulatus	Blueberry Ash	Grey Walnut	*Beilschmiedia elliptica*
	Elattostachys nervosa	Beetroot	Gristle Fern	*Blechnum cartilagineum*
	Embelia australiana	Embelia	Groundsel	*Baccharis halimifolia*
	Endiandra discolor	Rose Walnut, Domatia Tree	Guioa	*Guioa semiglauca*
E	*Endiandra floydii*	Crystal Creek Walnut	Hairy Clerodendrum	*Clerodendrum tomentosum*
R	*Endiandra globosa*	Black Walnut	Hairy Pittosporum	*Pittosporum revolutum*
V	*Endiandra hayesii*	Rusty Rose Walnut	Hairy Psychotria	*Psychotria loniceroides*
E	*Endiandra muelleri* subsp. *bracteata*	Green-leaved Rose Walnut	Hairy Rosewood	*Dyxoxylum rufum*
	Endiandra muelleri subsp. *muelleri*	Green-leaved Rose Walnut	Hairy Supplejack	*Ripogonum elseyanum*
	Endiandra pubens	Hairy Walnut	Hairy Walnut	*Endiandra pubens*
	Endiandra sieberi	Hard Corkwood	Hard Corkwood	*Endiandra sieberi*
	Entolasia marginata	Bordered Panic Grass	Hard Quandong	*Elaoecarpus obovatus*
	Entolasia stricta	Wiry Panic Grass	Harsh Ground Fern	*Hypolepis muelleri*
	Erythrina vespertilio	Bat's Wing Coral Tree	Hedraianthera	*Hedraianthera poryphropetala*
I	*Erythrina X sykesii*	Coral Tree	Hodgkinsonia	*Hodgkinsonia ovatiflora*
	Eucalyptus acmenoides	White Mahogany	Hoop Pine	*Araucaria cunninghamii*
	Eucalyptus carnea	Broad-leaved White Mahogany	Horseshoe Felt Fern	*Pyrrosia confluens*
	Eucalyptus grandis	Flooded Gum	Hovea	*Hovea lanceolata*
	Eucalyptus microcorys	Tallowwood	Incense Cedar	*Anthocarapa nitidula*
	Eucalyptus pilularis	Blackbutt	Jackwood	*Cryptocarya glaucescens*
	Eucalyptus propinqua	Small-fruited Grey Gum	Kangaroo Grass	*Themeda australis*
	Eucalyptus resinifera	Red Mahogany	Knotweed	*Persicaria dichotoma*
	Eucalyptus robusta	Swamp Mahogany	Kreysigia	*Tripladenia cunninghamii*
	Eucalyptus siderophloia	Grey Ironbark	Lacy Wedge Fern	*Lindsaea microphylla*
	Eucalyptus tereticornis	Forest Red Gum	Lantana	*Lantana camara*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	Eupomatia laurina	Bolwarra	Large Mock Olive	*Notelaea longifolia*
	Euroschinus falcata	Ribbonwood	Large Spiny-headed Mat-rush	*Lomandra hystrix*
	Eustrephus latifolius	Wombat Berry	Large-leaved Banksia	*Banksia robur*
rs	*Exocarpus latifolius*	Broad-leaved Native Cherry	Large-leaved Privet	*Ligustrum lucidum*
	Ficus coronata	Creek Sandpaper Fig	Large-leaved Wilkiea	*Wilkiea macrophylla*
	Ficus fraseri	Sandpaper Fig	Leafy Flat Sedge	*Cyperus lucidus*
	Ficus macrophylla subsp *macrophylla*	Moreton Bay Fig	Lemon Tree	*Citrus limonia*
	Ficus obliqua	Small-leaved Fig	Lilly Pilly	*Acmena smithii*
rs	*Ficus virens*	White Fig	Lily	*Lilium sp.*
	Ficus watkinsiana	Strangling Fig	Long-leaved Tuckeroo	*Cupaniopsis newmannii*
	Flagellaria indica	Whip Vine	Macaranga	*Macaranga tanarius*
rs	*Flindersia australis*	Australian Teak	Maiden's Blush	*Sloanea australis*
rs	*Flindersia bennettiana*	Bennett's Ash	Mango Bark	*Canarium australasicum*
	Flindersia schottiana	Cudgerie	Mango Tree	*Mangifera indica*
	Flindersia xanthoxyla	Yellowwood	Many-flowered Mat-rush	*Lomandra multiflora*
	Gahnia aspera	Short Saw Sedge	Marblewood	*Acacia bakeri*
	Gahnia clarkei	Tall Saw Sedge	Melastoma	*Melastoma affine*
	Gahnia sieberiana	Red-fruit Saw Sedge	Micky Mouse Plant	*Ochna serrulata*
	Geissois benthamiana	Red Carabeen	Midgenberry	*Austromyrtus dulcis*
	Geitonoplesium cymosum	Scrambling Lily	Mistweed	*Ageratina riparia*
	Gleichenia dicarpa	Pouched Coral Fern	Molasses Grass	*Melinis minutiflora*
	Glochidion ferdinandi	Cheese Tree	Molucca Bramble	*Rubus hillii*
rs	*Glochidion sumatranum*	Umbrella Cheese Tree	Monotoca	*Monotoca scoparia*
	Glycine clandestina	Twining Glycine	Moreton Bay Fig	*Ficus macrophylla* subsp *macrophylla*
	Gomphocarpus fructicosus	Swan Plant	Morinda	*Morinda jasminoides*
	Goodenia hederacea	Goodenia	Murrogun	*Cryptocarya microneura*
	Grevillea robusta	Silky Oak	Muttonwood	*Rapanea variabilis*
	Guioa semiglauca	Guioa	Myrtle Ebony	*Diospyros pentamera*
	Gymnostachys anceps	Settler's Flax	Narrow-leaved Lilly Pilly	*Acmena smithii* rheotypic race
	Hardenbergia violacea	False Sarsparilla	Narrow-leaved Palm Lily	*Cordyline stricta*
	Harpullia pendula	Tulipwood	Native Cascarilla	*Croton verreauxii*
rs	*Hedraianthera porphropetala*	Hedraianthera	Native Celtis	*Celtis paniculata*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
rs	*Helicia ferruginea*	Rusty Helicia	Native Cottonwood	*Hibiscus tiliaceus*
	Heritiera trifoliolata	White Booyong	Native Derris	*Derris involuta*
	Hibbertia obtusifolia	Blunt-leaved Guinea Flower	Native Gardenia	*Randia benthamiana*
	Hibbertia scandens	Climbing Guinea Flower	Native Ginger	*Alpinia caerulea*
	Hibiscus heterophyllous	Native Rosella	Native Guava	*Rhodomyrtus psidioides*
	Hibiscus splendens	Pink Hibiscus	Native Holly	*Alchornea ilicifolia*
	Hibiscus tiliaceus	Native Cottonwood	Native Raspberry	*Rubus parvifolius*
V	*Hicksbeachia pinnatifolia*	Red Boppel Nut	Native Rosella	*Hibiscus heterophyllous*
	Histiopteris incisa	Bat's Wing Fern	Native Tamarind	*Diploglottis australis*
	Hodgkinsonia ovatiflora	Hodgkinsonia	Native Violet	*Viola hederacea*
	Hovea acutifolia	Pointed Leaf Hovea	Native Wisteria	*Millettia megasperma*
	Hovea lanceolata	Hovea	Native Yam	*Dioscorea transversa*
	Hovea linearis	Common Hovea	Oliver's Sassafras	*Cinnamomum oliveri*
	Hypolepis muelleri	Harsh Ground Fern	Oplismenus	*Oplismenus* sp.
	Imperata cylindrica	Blady Grass	Oplismenus	*Oplismenus undulatifolius* var. *mollis*
	Ipomoea purpurea	Common Morning Glory	Orange Boxwood	*Denhamia celastroides*
	Jagera pseudorhus	Foambark	Orange Thorn	*Citriobatus pauciflorus*
	Juncus usitatus	Common Rush	Paddy's Lucerne	*Sida rhombifolia*
	Kennedia rubicunda	Red Kennedy Pea	Palm Lily	*Cordyline rubra*
	Lantana camara	Lantana	Paperbark	*Melaleuca quinquenervia*
	Lastreopsis acuminata	Shiny Shield Fern	Pastel Flower	*Pseuderanthemum variabile*
	Lastreopsis decomposita	Trim Shield Fern	Pepperberry	*Cryptocarya obovata*
	Lastreopsis hispida	Bristly Shield Fern	Pink Ash	*Alphitonia petriei*
	Lastreopsis marginans	Bordered Shield Fern	Pink Bloodwood	*Corymbia intermedia*
	Lastreopsis microsora	Creeping Shield Fern	Pink Hibiscus	*Hibiscus splendens*
	Leersia hexandra	Swamp Ricegrass	Pink Lace Flower	*Archidendron grandiflorum*
	Lepidosperma laterale	Broad Sword Sedge	Pink-flowered Doughwood	*Melicope elleryana*
	Lepidozamia peroffskyana	a cycad	Pinkheart	*Medicosma cunninghamii*
	Lepironia articulata	Giant Sedge	Plum Myrtle	*Pilidiostigma glabrum*
I	*Ligustrum lucidum*	Large-leaved Privet	Plum Pine	*Podocarpus elatus*
i	*Ligustrum sinense*	Small-leaved Privet	Pointed Leaf Hovea	*Hovea acutifolia*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	Lilium sp.	Lily	Poison Peach	*Trema aspera*
	Lindsaea microphylla	Lacy Wedge Fern	Pothos	*Pothos longipes*
	Linospadix monostachya	Walking Stick Palm	Pouched Coral Fern	*Gleichenia dicarpa*
	Litsea australis	Brown Bolly Gum	Prickly Alyxia	*Alyxia ruscifolia*
	Livistona australis	Cabbage Palm	Prickly Rasp Fern	*Doodia aspera*
	Lomandra confertifolia subsp. *pallida*	Slender Mat-rush	Prickly Snake Vine	*Stephanea aculeata*
	Lomandra hystrix	Large Spiny-headed Mat-rush	Prickly Tree Fern	*Cyathea leichhardtiana*
	Lomandra longifolia	Spiny-headed Mat-rush	Purple Cherry	*Syzygium crebinerve*
	Lomandra multiflora	Many-flowered Mat-rush	Python Tree	*Austromyrtus bidwillii*
	Lophostemon confertus	Brush Box	Red Ash	*Alphitonia excelsa*
	Lophostemon suaveolens	Swamp Turpentine	Red Bean	*Dysoxylum mollissimum*
	Lygodium microphyllum	Climbing Maidenhair Fern	Red Boppel Nut	*Hicksbeachia pinnatifolia*
V *	*Macadamia tetraphylla*	Rough-shelled Bush Nut	Red Carabeen	*Geissois benthamiana*
	Macaranga tanarius	Macaranga	Red Cedar	*Toona ciliata*
	Maclura cochinchinensis	Cockspur Thorn	Red Kamala	*Mallotus philippensis*
	Malaisia scandens	Burny Vine	Red Kennedy Pea	*Kennedia rubicunda*
	Mallotus discolor	White Kamala	Red Lilly Pilly	*Syzygium hodgkinsoniae*
	Mallotus philippensis	Red Kamala	Red Mahogany	*Eucalyptus resinifera*
	Mangifera indica	Mango Tree	Red-barked Sassafras	*Cinnamomum virens*
E **	*Marsdenia longiloba*	Slender Marsdenia	Red-fruit Saw Sedge	*Gahnia sieberiana*
	Marsdenia suberosa	Corky Milk-vine	Red-fruited Kurrajong	*Sterculia quadrifida*
rs	*Medicosma cunninghamii*	Pinkheart	Red-fruited Laurel	*Cryptocarya laevigata*
	Melaleuca quinquenervia	Paperbark	Red-fruited Rice-flower	*Wikstroemia indica*
	Melastoma affine	Melastoma	Ribbonwood	*Euroschinus falcata*
rs	*Melicope elleryana*	Pink-flowered Doughwood	Riberry	*Syzygium luehmannii*
	Melicope erythrococca	Tingletongue	River Clubrush	*Schoenoplectus validus*
i	*Melinis minutiflora*	Molasses Grass	Rock Felt Fern	*Pyrrosia rupestris*
	Microcitrus australasica	Finger Lime	Rock Fern	*Cheilanthes sieberi*
	Microsorum scandens	Fragrant Fern	Rosary Pea	*Abrus precatorius*
R	*Millettia australis*	Blunt-leaved Native Wisteria	Rose Marara	*Pseudoweinmannia lachnocarpa*
	Millettia megasperma	Native Wisteria	Rose Myrtle	*Archirhodomyrtus beckleri*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	Mischocarpus pyriformis	Yellow Pear-fruit	Rose Tamarind	*Arytera divaricata*
	Monotoca scoparia	Monotoca	Rose Walnut, Domatia Tree	*Endiandra discolor*
	Morinda jasminoides	Morinda	Rose-leaf Bramble	*Rubus rosifolius*
	Neolitsea australiensis	Green Bolly Gum	Rose-leaf Marara	*Caldcluvia paniculosa*
	Neolitsea dealbata	White Bolly Gum	Rough Maidenhair	*Adiantum hispidulum*
	Nephrolepis cordifolia	Fishbone Fern	Rough Tree Fern	*Cyathea australis*
	Notelaea longifolia	Large Mock Olive	Rough-leaved Elm	*Aphananthe philippinensis*
	Nymphaea capensis	Cape Water Lily	Rough-shelled Bush Nut	*Macadamia tetraphylla*
i	*Ochna serrulata*	Micky Mouse Plant	Rusty Helicia	*Helicia ferruginea*
	Omalanthus populifolius	Bleeding Heart	Rusty Rose Walnut	*Endiandra hayesii*
	Oplismenus imbecillis	Creeping Beard Grass	Sandfly Zieria	*Zieria smithii*
	Oplismenus sp.	Oplismenus	Sandpaper Fig	*Ficus fraseri*
	Oplismenus undulatifolius var. *mollis*	Oplismenus	Satinwood	*Phebalium squameum* subsp. *squameum*
	Pandorea pandorana	Wonga Vine	Scaly Myrtle	*Austromyrtus hillii*
	Pararchidendron pruinosum	Snow Wood	Scaly Phebalium	*Phebalium squamulosum*
	Parsonsia straminea	Common Silkpod	Scentless Rosewood	*Synoum glandulosum*
i	*Paspalum wettsteinii*	Broad-leaved Paspalum	Scrambling Lily	*Geitonoplesium cymosum*
i	*Passiflora edulis*	Common Passionfruit	Scrub Turpentine	*Rhodamnia rubescens*
i	*Passiflora suberosa*	Cork Passionflower	Settler's Flax	*Gymnostachys anceps*
i	*Passiflora subpeltata*	White Passionflower	Shield-fern	*Cyclosorus interruptus*
	Pennisetum alopecuroides	Swamp Foxtail	Shiny Shield Fern	*Lastreopsis acuminata*
rs	*Pentaceras australe*	Bastard Crows Ash	Short Saw Sedge	*Gahnia aspera*
	Peperomia leptostachya	Slender Pepper Plant	Silky Bramble	*Rubus moorei*
	Persicaria dichotoma	Knotweed	Silky Myrtle	*Decaspermum humile*
	Persicaria strigosa	Spotted Knotweed	Silky Oak	*Grevillea robusta*
	Persoonia adenantha	Geebung	Silver Aspen	*Acronychia wilcoxiana*
	Phebalium squameum subsp. *squameum*	Satinwood	Silver-leaved Desmodium	*Desmodium uncinatum*
	Phebalium squamulosum	Scaly Phebalium	Simple Spleenwort	*Asplenium attenuatum*
	Phragmites australis	Common Reed	Slash Pine	*Pinus elliottii*
	Pilidiostigma glabrum	Plum Myrtle	Slender Marsdenia	*Marsdenia longiloba*
i	*Pinus elliottii*	Slash Pine	Slender Mat-rush	*Lomandra confertifolia* subsp. *pallida*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	Piper novae-hollandiae	Giant Pepper Vine	Slender Pepper Plant	*Peperomia leptostachya*
	Pittosporum revolutum	Hairy Pittosporum	Small Rasp Fern	*Doodia caudata*
	Pittosporum undulatum	Sweet Pittosporum	Small Rasp Fern	*Doodia media*
	Planchonella australis	Black Apple	Small-fruited Grey Gum	*Eucalyptus propinqua*
rs	*Planchonella chartacea*	Thin-leaved Coondoo	Small-leaved Fig	*Ficus obliqua*
rs	*Planchonella laurifolia*	Blush Coondoo	Small-leaved Privet	*Ligustrum sinense*
	Platycerium bifurcatum	Elkhorn	Smooth Scrub Turpentine	*Rhodamnia maideniana*
	Platycerium superbum	Staghorn	Smooth Senna	*Senna floribunda*
	Podocarpus elatus	Plum Pine	Smooth Wilkiea	*Wilkiea austroqueenslandica*
	Polyosma cunninghamii	Featherwood	Snake Vine	*Stephanea japonica*
	Polyscias elegans	Celerywood	Snow Wood	*Pararchidendron pruinosum*
	Pothos longipes	Pothos	Soft Corkwood	*Duboisia myoporoides*
	Pratia purpurascens	Whiteroot	Soft Twig-rush	*Baumea rubiginosa*
i	*Protasparagus plumosus*	Climbing Asparagus	Spice Bush	*Triunia youngiae*
	Pseuderanthemum variabile	Pastel Flower	Spiny Gardenia	*Randia moorei*
	Pseudoweinmannia lachnocarpa	Rose Marara	Spiny-headed Mat-rush	*Lomandra longifolia*
	Psychotria loniceroides	Hairy Psychotria	Spotted Knotweed	*Persicaria strigosa*
	Pteridium esculentum	Bracken Fern	Spreading Shield Fern	*Sticherus lobatus*
	Pyrrosia confluens	Horseshoe Felt Fern	Staghorn	*Platycerium superbum*
	Pyrrosia rupestris	Rock Felt Fern	Star-hair	*Astrotricha latifolia*
	Randia benthamiana	Native Gardenia	Steelwood	*Sarcopteryx stipata*
	Randia chartacea	Thin-leaved Gardenia	Stinking Cryptocarya	*Cryptocarya foetida*
E	*Randia moorei*	Spiny Gardenia	Stinkwood	*Zieria arborescens*
	Rapanea variabilis	Muttonwood	Strangling Fig	*Ficus watkinsiana*
R	*Rhodamnia maideniana*	Smooth Scrub Turpentine	Straw Tree Fern	*Cyathea cooperi*
	Rhodamnia rubescens	Scrub Turpentine	Swamp Foxtail	*Pennisetum alopecuroides*
	Rhodomyrtus psidioides	Native Guava	Swamp Mahogany	*Eucalyptus robusta*
	Rhynchospora corymbosa	Grass Beak-rush	Swamp Oak	*Casuarina glauca*
	Rhysotoechia bifoliolata	Twin-leaved Tuckeroo	Swamp Ricegrass	*Leersia hexandra*
	Ripogonum elseyanum	Hairy Supplejack	Swamp Turpentine	*Lophostemon suaveolens*
	Rubus hillii	Molucca Bramble	Swamp Water Fern	*Blechnum indicum*
	Rubus moorei	Silky Bramble	Swan Plant	*Gomphocarpus fructicosus*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	Rubus parvifolius	Native Raspberry	Sweet Pittosporum	*Pittosporum undulatum*
	Rubus rosifolius	Rose-leaf Bramble	Sweet Sarsparilla	*Smilax glyciphylla*
	Sambucus australasica	Yellow Elderberry	Tall Saw Sedge	*Gahnia clarkei*
	Sarcopteryx stipata	Steelwood	Tall Sedge	*Carex appressa*
i	*Schefflera actinophylla*	Umbrella Tree	Tallowwood	*Eucalyptus microcorys*
	Schoenoplectus mucronatus	Clubrush	Thin-leaved Coondoo	*Planchonella chartacea*
	Schoenoplectus validus	River Clubrush	Thin-leaved Gardenia	*Randia chartacea*
	Scolopia braunii	Flintwood	Three-veined Cryptocarya	*Cryptocarya triplinervis*
i	*Senecio madagascariensis*	Fireweed	Tingletongue	*Melicope erythrococca*
	Senna floribunda	Smooth Senna	Tree Bitter Pea	*Daviesia arborea*
	Senna pendula var *glabrata*	Winter Senna	Tree Heath	*Trochocarpa laurina*
i	*Sida rhombifolia*	Paddy's Lucerne	Trim Shield Fern	*Lastreopsis decomposita*
	Sloanea australis	Maiden's Blush	Triumfetta	*Triumfetta rhomboidea*
	Sloanea woollsii	Yellow Carabeen	Tropical Chickweed	*Drymaria cordata* subsp. *diandra*
	Smilax australis	Austral Sarsparilla	Tuckeroo	*Cupaniopsis anacardioides*
	Smilax glyciphylla	Sweet Sarsparilla	Tulipwood	*Harpullia pendula*
	Solanum mauritianum	Wild Tobacco	Turpentine	*Syncarpia glomulifera*
	Solanum seaforthianum	Climbing Nightshade	Twining Glycine	*Glycine clandestina*
	Stenocarpus sinuatus	Firewheel Tree	Twin-leaved Coogera	*Arytera distylis*
	Stephanea aculeata	Prickly Snake Vine	Twin-leaved Tuckeroo	*Rhysotoechia bifoliolata*
	Stephanea japonica	Snake Vine	Umbrella Cheese Tree	*Glochidion sumatranum*
rs	*Sterculia quadrifida*	Red-fruited Kurrajong	Umbrella Fern	*Sticherus flabellatus*
	Sticherus flabellatus	Umbrella Fern	Umbrella Tree	*Schefflera actinophylla*
	Sticherus lobatus	Spreading Shield Fern	Veiny Lace Flower	*Archidendron muellerianum*
	Streblus brunonianus	Whalebone Tree	Veiny Wilkiea	*Wilkiea huegeliana*
	Symplocos stawellii	White Hazelwood	Wait-a-While	*Calamus muelleri*
	Symplocos thwaitesii	Buff Hazelwood	Walking Stick Palm	*Linospadix monostachya*
	Syncarpia glomulifera	Turpentine	Wandering Dew	*Tradescantia albiflora*
	Synoum glandulosum	Scentless Rosewood	Water Gum, Kanuka	*Tristaniopsis laurina*
	Syzygium crebinerve	Purple Cherry	Water Vine	*Cissus antarctica*
	Syzygium francisii	Giant Water Gum	Weeping Lilly Pilly	*Waterhousea floribunda*
V	*Syzygium hodgkinsoniae*	Red Lilly Pilly	Weeping Spleenwort	*Asplenium flaccidum*

	Listed in alphabetical order by scientific name		Listed in alphabetical order by common name	
	Syzygium luehmannii	Riberry	Whalebone Tree	*Streblus brunonianus*
V	*Syzygium moorei*	Durobby	Whip Vine	*Flagellaria indica*
	Syzygium oleosum	Blue Lilly Pilly	Whisky Grass	*Andropogon virginicus*
	Tabernaemontana pandacaqui	Banana Bush	White Bolly Gum	*Neolitsea dealbata*
	Themeda australis	Kangaroo Grass	White Booyong	*Heritiera trifoliolata*
	Toechima dasyrrache	Blunt-leaved Steelwood	White Cypress Pine	*Callitris columellaris*
	Toona ciliata	Red Cedar	White Fig	*Ficus virens*
i	*Tradescantia albiflora*	Wandering Dew	White Hazelwood	*Symplocos stawellii*
	Trema aspera	Poison Peach	White Kamala	*Mallotus discolor*
	Tripladenia cunninghamii	Kreysigia	White Lace Flower	*Archidendron hendersonii*
	Tristaniopsis laurina	Water Gum, Kanuka	White Mahogany	*Eucalyptus acmenoides*
rs	*Triumfetta rhomboidea*	Triumfetta	White Passionflower	*Passiflora subpeltata*
	Triunia youngiae	Spice Bush	Whiteroot	*Pratia purpurascens*
	Trochocarpa laurina	Tree Heath	Wild Tobacco	*Solanum mauritianum*
	Typha orientalis	Broad-leaved Cumbungi	Willow Bottlebrush	*Callistemon salignus*
	Viola hederacea	Native Violet	Winter Senna	*Senna pendula*
	Waterhousea floribunda	Weeping Lilly Pilly	Wiry Panic Grass	*Entolasia stricta*
	Wikstroemia indica	Red-fruited Rice-flower	Wombat Berry	*Eustrephus latifolius*
rs	*Wilkiea austroqueenslandica*	Smooth Wilkiea	Wonga Vine	*Pandorea pandorana*
	Wilkiea huegeliana	Veiny Wilkiea	Yellow Carabeen	*Sloanea woollsii*
rs	*Wilkiea macrophylla*	Large-leaved Wilkiea	Yellow Elderberry	*Sambucus australasica*
	Xanthorrhoea macronema	Bottlebrush Grass Tree	Yellow Pear-fruit	*Mischocarpus pyriformis*
	Zieria arborescens	Stinkwood	Yellow Tulipwood	*Drypetes australasica*
	Zieria smithii	Sandfly Zieria	Yellowwood	*Flindersia xanthoxyla*

References used for Common Names

Harden, 1990, 1991, 1992.
Sainty and Jacobs, 1981.
Floyd unpubl., undated.
Williams *et al*, 1984.
Floyd, 1989.

Key:

E	Endangered (NSW Threatened Species Conservation Act, 1995)
V	Vulnerable (NSW Threatened Species Conservation Act, 1995)
R	Rare (Briggs and Leigh, 1996)
rs	Regionally Significant (Sheringham and Westaway, 1995)
I	Introduced species -
*	recorded in previous Woodward Clyde survey
**	recorded by Nil Desperandum, 1994

Appendix B
Summary of Vegetation Sites

Appendix B
Summary of Vegetation Sites

Site	Locality	Easting	Northing	Geology	Veg Assn.	Canopy Dom.
1	SW Dirty Flat Road, Yelgun	550300	6848500	Metamorphic	2.1	Brush Box
2	SW Jones Road, Yelgun	550200	6849650	Metamorphic	2.1	Brush Box, Blackbutt
3	NW Jones Road, Yelgun	550000	6849600	Metamorphic	2.1	Hoop Pine/Brush Box/Rainforest
4	Cole's property, Marshalls Ridges	549600	6850300	Metamorphic	4.1	Forest Red Gum
5	SW corner Jones Road, Pacific Highway	550300	6849650	Metamorphic	3.4	Pink Bloodwood
6	Yelgun, east of Site 1	550500	6848500	Alluvial	7.1	Paperbark/Red Mahogany
7	NW of Wooyung Road junction	549150	6851450	Metamorphic	4.1	Forest Red Gum
8	South of Wooyung Road	549400	6850700	Metamorphic	6	Camphor Laurel
9	South of Wooung Road	549380	6850880	Metamorphic	3.5	Tallowwood, Brush Box
10	Benwerrin, Mooball Creek	549650	6854000	Alluvial	1.1	Rainforest - no dominants
11	Hulls Road, Tallow site	549000	6852500	Metamorphic	3.5	Tallowwood
12	Rainforest tongue, Murphy's, Mooball Range	551400	6857300	Metamorphic	1.1	Rainforest - no dominants
13	Taggets Hill upper south facing slope	551500	6858250	Metamorphic	3.3	Grey Ironbark, Pink Bloodwood
14	Taggets Hill lower south facing slope	551500	6858200	Metamorphic	1.1	Rainforest - no dominants
15	Taggets Hill lower north facing slope	551500	6858500	Metamorphic	1.2	Hoop Pine/rainforest
16	South Cudgera Creek Road, Boorman property	551965	6859039	Metamorphic	1.2	Hoop Pine/rainforest
17	Pacific Highway, north Jones Road	550100	6858500	Metamorphic	3.1	Mixed Eucalypt
18	Riparian rainforest to south of Pottsville-Mooball Road, Harbison property	549650	6854000	Alluvial	1.1	Rainforest - no dominants
19	East of Stockyard Route Road, Yelgun	550500	6848400	Alluvial	7.1	Paperbark
20	West of Wilman Road, west Hastings Point	551550	6862700	Alluvial	7.1	Blackbutt, Red Mahogany
21	East of Wilman Road, west Hastings Point	551650	6862600	Alluvial	7.1	Paperbark
22	Sleepy Hollow, hill north Sheens Creek	551100	6856400	Metamorphic	1.2	Brush Box
23	1.5km south Cudgera Creek Road, Nil Desp 1	551500	6857850	Metamorphic	2.1	Brush Box
24	1.5km south Cudgera Creek Road, Nil Desp 2	551500	6858000	Metamorphic	2.1	Brush Box
25	North of Jones Road, west of highway	549700	6849700	Metamorphic	3.5	Tallowwood, Brush Box

Site	Locality	Easting	Northing	Geology	Veg Assn.	Canopy Dom.
26	Clothiers Creek Road	550850	6865900	Metamorphic	3.2	Blackbutt
27	West of Kanes Road, McConnell property	551600	6862900	Alluvial	7.1	Paperbark, Swamp Mahogany
28	Crabbes Creek, south of Wooyung Road	549350	6850950	Metamorphic	4.1	Red Gum
29	West of Jones Road turnoff	550050	6849600	Metamorphic	4.2	Cypress Pine
30	Stotts Creek, Critchelow property	550950	6872200	Metamorphic	3.1	Mixed Eucalypt
31	Stotts Creek, northern most ridge	551300	6872800	Metamorphic	1.1	Rainforest, Blackbutt emergent
32	Opposite Duranbah School	551600	6862900	Basic Volcanic	6	Camphor Laurel
33	South of Murphy's, Mooball Range			Metamorphic	1.1	Rainforest

Key

Nil Desp 1, 2 - Sites surveyed by Nil Desperandum (Nil Desperandum 1994)

Appendix C
Fauna Species Known or Recorded From the Vicinity of the Study Area

Scientific Name	Common Name
Myobatrachidae	
Adelotis brevis	Tusked Frog
Assa darlingtoni	**Pouched Frog**
Crinia signifera	Common Eastern Froglet
Crinia parinsignifera	Eastern Sign-bearing Froglet
Crinia tinnula	Wallum Froglet
Lechriodus fletcheri	Fletcher's Frog
Limnodynastes dumerilii	Eastern Banjo Frog
Limnodynastes ornatus	Ornate Burrowing Frog
Limnodynastes peroni	Striped Marsh Frog
Limnodynastes salmini	Salmon-striped Frog
Limnodynastes tasmaniensis	Spotted Marsh Frog
Limnodynastes terrraeginae	Northern Banjo Frog
Mixophyes fasciolatus	Great Barred Frog
Mixophyes iteratus	**Giant Barred Frog**
Philoria loveridgei	**Loveridges Frog**
Pseudophryne coriacea	Red-backed Toadlet
Uperoleia laevigata	Smooth Toadlet
Hylidae	
Litoria brevipalmata	**Green-thighed Frog**
Litoria caerulea	Green Tree Frog
Litoria dentata	Bleating Tree Frog
Litoria fallax	Eastern Dwarf Tree Frog
Litoria freycineti	Freycinet's Frog
Litoria gracilenta	Dainty Green Tree Frog
Litoria latopalmata	Broad Palmed Frog
Litoria lesueurii	Lesueur's Frog
Litoria nasuta	Rocket Frog
Litoria olongburensis	**Wallum Tree Frog**
Litoria tyleri	Tyler's Tree Frog

Appendix C
Fauna Species Known or Recorded From the Vicinity of the Study Area

Scientific Name	Common Name
Bufonidae	
Bufo marinus	Cane Toad
Chelidae	
Chelodina longicollis	Eastern Long-necked Turtle
Elseya latisternum	Saw-shelled Turtle
Pygopodidae	
Lialis burtonis	Burton's Snake-lizard
Pygopus lepidopodus	Southern Scaly-foot
Agamidae	
Pogona barbata	Eastern Bearded Dragon
Amphibolurus muricatus	Jacky Lizard
Amphibolorus nobbi	Nobbi
Hypsilurus spinipes	Southern Forest Dragon
Physignathus lesueurii	Eastern Water Dragon
Varanidae	
Varanus varius	Lace Monitor
Varanus gouldii	Sand Monitor
Scincidae	
Anomalopus verreauxii	Three-clawed Worm Skink
Carlia burnetti	
Carlia tetradactyla	Southern Rainbow Skink
Carlia vivax	Tussock Rainbow Skink
Coeranoscincus reticulatus	**Three-toed Snake-tooth Skink**
Cryptoblepharus virgatus	Wall Skink
Ctenotus taeniolatus	Copper-tailed Skink
Ctenotus robustus	Striped Skink
Egernia cunninghami	Spiny-tailed Skink
Egernia major	Land Mullet
Egernia saxatilis	Black-crevice Skink
Egernia striolata	Tree-crevice Skink

Scientific Name	Common Name
Egernia whitii	White's Rock Skink
Saproscincus challengeri	Challenger's Skink
Lampropholis delicata	Grass Skink
Lampropholis guichenoti	Garden Skink
Saiphos equalis	Three-toed Skink
Eulamprus quoyii	Eastern Water Skink
Eulamprus murrayi	Murray's Skink
Eulamprus tenuis	Barred-sided Skink
Hemisphaeriodon gerrardi	Pink-tongued Skink
Tiliqua scincoides	Eastern Blue-tongued Lizard
Typhlopidae	
Ramphotyphlops nigrescens	Blackish Blind Snake
Ramphotyphlops weidii	Brown-snouted Blind Snake
Boidae	
Morelia spilota	Diamond/Carpet Python
Colubridae	
Boiga irregularis	Eastern Brown Tree Snake
Dendrelaphis punctulata	Common Tree Snake
Tropidonophis mairii	Keelback Snake
Elapidae	
Acanthophis antarcticus	Southern Death Adder
Cacophis squamulosus	Golden Crowned Snake
Cryptophis nigrescens	Small-eyed Snake
Demansia psammophis	Yellow-faced Whipsnake
Furina diadema	Red-napped Snake
Hemiaspis signata	Marsh Snake
Hoplocephalus bitorquatus	**Pale-headed Snake**
Hoplocephalus stephensii	**Stephens Banded Snake**
Pseudechis guttatus	Blue-bellied Black Snake
Pseudechis porphyriacus	Red-bellied Black Snake

Scientific Name	Common Name
Pseudonaja textilis	Eastern Brown Snake
Tropidechis carinatus	Rough-scaled Snake
Vermicella annulata	Bandy-bandy
Megapodiidae : Mound-builders	
Alectura lathami	Australian Brush-turkey
Phasianidae : Quail, Partridges and Pheasants	
Coturnix ypsilophora	Brown Quail
Coturnix pectoralis	Stubble Quail
Turnicidae : Button Quails	
Turnix melanogaster	**Black-breasted Button Quail**
Turnix varia	Painted Button Quail
Turnix pyrrhothorax	Red-chested Button Quail
Pelecanoidae : Pelican	
Pelecanus conspicillatus	Australian Pelican
Anhingidae : Darters	
Anhinga melanogaster	Darter
Phalacrocoracidae : Cormorants	
Phalacrocorax carbo	Great Cormorant
Phalacrocorax varius	Pied Cormorant
Phalacrocorax melanoleucos	Little Pied Cormorant
Phalacrocorax sulcirostris	Little Black Cormorant
Podicipedidae : Grebes	
Tachybaptus novaehollandiae	Australasian (Little) Grebe
Anatidae : Ducks	
Anas superciliosa	Pacific Black Duck
Aythya australis	Hardhead
Cygnus atratus	Black Swan
Anas gibberifrons	Grey Teal
Chenonetta jubata	Australian Wood Duck
Dendrocygna eytoni	Grass Whistling Duck

Scientific Name	Common Name
Rallidae : Rails, Crakes, Water-hens and Coots	
Gallinula tenebrosa	Dusky Moorhen
Amaurornis olivacea	**Bush Hen**
Porphyrio porphyrio	Purple Swamphen
Rallus pectoralis	Lewin's Rail
Gallirallus philippensis	Buff-banded Rail
Fulica atra	Eurasian Coot
Ardeidae : Herons and Egrets	
Ardea pacifica	Pacific Heron
Ardea novaehollandiae	White-faced Heron
Nycticorax caledonicus	Rufous (Nankeen) Night Heron
Dupetor flavicollis	Black Bittern
Ardea ibis	Cattle Egret
Ardea alba	Great Egret
Ardea garzetta	Little Egret
Ardea intermedia	Intermediate (Plumed) Egret
Butorides striatus	Mangrove Heron
Egretta sacra	Reef Heron
Threskiornithidae : Ibises and Spoonbills	
Threskiornis molucca	Australian White Ibis
Threskiornis spinicollis	Straw-necked Ibis
Platalea regia	Royal Spoonbill
Platalea flavipes	Yellow-billed Spoonbill
Ciconiidae : Storks	
Ephippiorhynchus asiaticus	**Black-necked Stork**
Gruidae : Cranes	
Grus rubicundus	**Brolga**
Scolopacidae : Turnstones, Curlews, Snipe and Sandpipers	
Numenius madagascariensis	Eastern Curlew

Scientific Name	Common Name
Gallinago hardwickii	Latham's Snipe
Jacanidae	
Irediparra gallinacea	**Comb-crested Jacana**
Charadriidae : Plovers and Dotterels	
Vanellus miles	Masked Plover
Charadrius melanops	Black-fronted Plover
Charadrius ruficapillus	Red-capped Plover
Laridae : Gulls and Terns	
Larus novaehollandiae	Silver Gull
Sterna bergii	Crested Tern
Pandionidae	
Pandion haliaetus	**Osprey**
Accipitridae : Kites, Hawks, Eagles and Harriers	
Elanus axillaris	Black-shouldered Kite
Haliastur sphenurus	Whistling Kite
Haliastur indus	Brahminy Kite
Accipiter cirrhocephalus	Collared Sparrowhawk
Accipiter novaehollandiae	Grey Goshawk
Accipiter fasciatus	Brown Goshawk
Erythrotriorchis radiatus	**Red Goshawk**
Hieraaetus morphnoides	Little Eagle
Haliaeetus leucogaster	White-bellied Sea-eagle
Lophoictinia isura	**Square-tailed Kite**
Aquila audax	Wedge-tailed Eagle
Aviceda subcristata	Pacific Baza
Circus spilonotus	Eastern Marsh Harrier
Falconidae : Falcons and Kestrels	
Falco peregrinus	Peregrine Falcon
Falco berigora	Brown Falcon
Falco cenchroides	Australian Kestrel

Scientific Name	Common Name
Falco longipennis	Australian Hobby
Columbidae : Pigeons and Doves	
Ptilinopus regina	**Rose-crowned Fruit Dove**
Ptilinopus magnificus	**Wompoo Fruit Dove**
Ptilinopus superbus	**Superb Fruit Dove**
Lopholaimus antarcticus	Topknot Pigeon
Columba leucomela	White-headed Pigeon
Columba livia	Feral Pigeon (Int.)
Streptopelia chinensis	Spotted Turtle Dove (Int.)
Geopelia striata	Peaceful Dove
Geopelia humeralis	Bar-shouldered Dove
Geophaps lophotes	Crested Pigeon
Chalcophaps indica	Emerald Dove
Phaps chalcoptera	Common Bronzewing
Phaps elegans	Brush Bronzewing
Leucosarcia melanoleuca	Wonga Pigeon
Macropygia amboinensis	Brown Cuckoo Dove
Cacatuidae : Cockatoos	
Calyptorhynchus lathami	**Glossy Black Cockatoo**
Calyptorhynchus banksii	**Red-tailed Black Cockatoo**
Calyptorhynchus funereus	Yellow-tailed Black Cockatoo
Cacatua galerita	Sulphur-crested Cockatoo
Cacatua roseicapilla	Galah
Loriinae : Lorikeets and Allies	
Trichoglossus haematodus	Rainbow Lorikeet
Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet
Glossopsitta pusilla	Little Lorikeet
Polytelitidae : Long-tailed Parrots	
Alisterus scapularis	Australian King Parrot
Platycercidae : Broad-tailed Parrots	

Scientific Name	Common Name
Platycercus elegans	Crimson Rosella
Platycercus eximius	Eastern Rosella
Platycercus adscitus	Pale-headed Rosella
Cuculidae : Cuckoos and Coucals	
Cuculus pallidus	Pallid Cuckoo
Cuculus variolosus	Brush Cuckoo
Cuculus flabelliformis	Fan-tailed Cuckoo
Chrysococcyx basalis	Horsfield Bronze Cuckoo
Chrysococcyx lucidus	Shining Bronze Cuckoo
Chrysococcyx minutillus	Little Bronze Cuckoo
Eudynamys scolopacea	Koel
Scythrops novaehollandiae	Channel-billed Cuckoo
Centropus phasianinus	Pheasant Coucal
Strigidae : Owls	
Ninox strenua	**Powerful Owl**
Ninox novaeseelandiae	Southern Boobook
Ninox connivens	Barking Owl
Tytonidae : Barn Owls	
Tyto tenebricosa	**Sooty Owl**
Tyto alba	Barn Owl
Tyto capensis	**Eastern Grass Owl**
Tyto novaehollandiae	**Masked Owl**
Podargidae : Frogmouths	
Podargus strigoides	Tawny Frogmouth
Podargus ocellatus	**Marbled Frogmouth**
Aegothelidae : Owlet-Nightjars	
Aegotheles cristatus	Owlet-Nightjar
Caprimulgidae : Nightjars	
Eurostopodus mysticalis	White-throated Nightjar
Apodidae : Swifts	

Scientific Name	Common Name
Hirundapus caudacutus	White-throated Needletail
Apus pacificus	Fork-tailed Swift
Alcedinidae : Kingfishers and Kookaburras	
Alcedo azurea	Azure Kingfisher
Dacelo novaeguineae	Laughing Kookaburra
Todiramphus sanctus	Sacred Kingfisher
Todiramphus macleayii	Forest Kingfisher
Todiramphus pyrrhopygia	Red-backed Kingfisher
Todiramphus chloris	Mangrove Kingfisher
Meropidae : Bee-eaters	
Merops ornatus	Rainbow Bee-eater
Coraciidae : Dollarbird	
Eurystomus orientalis	Dollarbird
Pittadae : Pittas	
Pitta versicolor	Noisy Pitta
Menuridae : Lyrebirds	
Menura novaehollandiae	Superb Lyrebird
Menura alberti	**Alberts Lyrebird**
Atrichornithidae : Scrub-birds	
Atrichornis rufescens	**Rufous Scrub-bird**
Neosittidae : Sittellas	
Daphoenositta chrysoptera	Varied Sittella
Climacteridae : Treecreepers	
Cormobates leucophaea	White-throated Treecreeper
Cormobates erythrops	Red-browed Treecreeper
Maluridae : Australian Warblers (Wrens)	
Malurus cyaneus	Superb Fairy-wren
Malurus lamberti	Variegated Fairy-wren
Malurus melanocephalus	Red-backed Fairy-wren
Stipiturus malachurus	Southern Emuwren

Scientific Name	Common Name
Pardalotidae : Pardalotes,Scrubwrens, Gerygones and Thornbills	
Pardalotus punctatus	Spotted Pardalote
Pardalotus striatus	Striated Pardalote
Pardalotus striatus melanocephalus	Black-headed Pardalote
Sericornis magnirostris	Large-billed Scrub Wren
Sericornis citreogularis	Yellow-throated Scrub Wren
Sericornis frontalis	White-browed Scrub Wren
Acanthiza pusilla	Brown Thornbill
Acanthiza lineata	Striated Thornbill
Acanthiza nana	Yellow Thornbill
Acanthiza chrysorrhoa	Yellow-rumped Thornbill
Acanthiza reguloides	Buff-rumped Thornbill
Gerygone olivacea	White-throated Gerygone
Gerygone mouki	Brown Gerygone
Gerygone levigaster	Mangrove Gerygone
Meliphagidae : Honeyeaters	
Anthochaera lunulata	Little Wattlebird
Philemon corniculatus	Noisy Friarbird
Philemon citreogularis	Little Friarbird
Manorina melanophrys	Bell Miner
Manorina melanocephala	Noisy Miner
Entomyzon cyanotis	Blue-faced Honeyeater
Meliphaga lewini	Lewin's Honeyeater
Lichenostomus melanops	Yellow-tufted Honeyeater
Lichenostomus chrysops	Yellow-faced Honeyeater
Lichmera indistincta	Brown Honeyeater
Lichenostomus leucotis	White-eared Honeyeater
Lichenostomus fasciogularis	**Mangrove Honeyeater**
Melithreptus lunatus	White-naped Honeyeater
Melithreptus albogularis	White-throated Honeyeater

Scientific Name	Common Name
Phylidonyris nigra	White-cheeked Honeyeater
Plectorhyncha lanceolata	Striped Honeyeater
Acanthorhynchus tenuirostris	Eastern Spinebill
Myzomela sanguinolenta	Scarlet Honeyeater
Orthonychidae : Logrunners, Chowchillas	
Orthonyx temminckii	Logrunner
Cinclosomatidae : Whipbirds, Quail-thrushes	
Psophodes olivaceus	Eastern Whipbird
Petroicidae : Robins	
Petroica rosea	Rose Robin
Petroica multicolor	Scarlet Robin
Eopsaltria australis	Eastern Yellow Robin
Tregellasia capito	Pale-yellow Robin
Pachycephalidae : Crested Shrike-tit, Shrike-thrushes, Whistlers	
Zoothera lunulata	White's Thrush
Falcunculus frontatus	Crested Shrike-tit
Pachycephala rufiventris	Rufous Whistler
Pachycephala pectoralis	Golden Whistler
Colluricincla harmonica	Grey Shrike-thrush
Colluricincla megarhyncha	Little Shrike-thrush
Dicruridae : Monarchs, Flycatchers, Fantails	
Myiagra cyanoleuca	Satin Flycatcher
Myiagra rubecula	Leaden Flycatcher
Monarcha melanopsis	Black-faced Monarch
Monarcha trivirgatus	Spectacled Monarch
Monarcha leucotis	**White-eared Monarch**
Rhipidura rufifrons	Rufous Fantail
Rhipidura fuliginosa	Grey Fantail

Scientific Name	Common Name
Rhipidura leucophrys	Willie-Wagtail
Dicrurus bracteatus	Spangled Drongo
Grallina cyanoleuca	Australian Magpie-lark
Oriolidae : Orioles and Figbirds	
Oriolus sagittatus	Olive-backed Oriole
Sphecotheres viridis	Figbird
Paradisaeidae : Bowerbirds, Catbirds and Riflebirds	
Ptilonorhynchus violaceus	Satin Bowerbird
Sericulus chrysocephalus	Regent Bowerbird
Ailuroedus crassirostris	Green Catbird
Ptiloris paradiseus	Paradise Rifle-bird
Campephagidae : Cuckoo-shrikes and Trillers	
Coracina novaehollandiae	Black-faced Cuckoo-shrike
Coracina papuensis	White-bellied Cuckoo-shrike
Coracina lineata	**Yellow-eyed Cuckoo-shrike**
Coracina tenuirostris	Cicada-bird
Lalage leucomela	Varied Triller
Artamidae : Woodswallows, Butcherbirds, Currawongs	
Artamus leucorhynchus	White-breasted Woodswallow
Cracticus torquatus	Grey Butcherbird
Cracticus nigrogularis	Pied Butcherbird
Gymnorhina tibicen	Australian Magpie
Strepera graculina	Pied Currawong
Corvidae : Ravens, Crows	
Corvus orru	Torresian Crow
Hirundinidae : Swallows and Martins	
Hirundo neoxena	Welcome Swallow
Hirundo nigricans	Tree Martin

Scientific Name	Common Name
Hirundo ariel	Fairy Martin
Motacillidae : Pipits and Wagtails	
Anthus novaeseelandiae	Richard's Pipit
Sylviidae : Old World Warblers	
Acrocephalus stentoreus	Clamorous Reed Warbler
Megalurus gramineus	Little Grassbird
Megalurus timoriensis	Tawny Grassbird
Cisticola exilis	Golden-headed Cisticola
Ploceidae : Australian Grass Finches and Allies	
Neochmia temporalis	Red-browed Firetail
Taeniopygia bichenovii	Double-barred Finch
Lonchura castaneothorax	Chestnut-breasted Mannikin
Passer domesticus	House Sparrow (introduced)
Dicaeidae : Flowerpeckers	
Dicaeum hirundinaceum	Mistletoebird
Zosteropidae : (Silvereyes) White-eyes	
Zosterops lateralis	Silvereye
Sturnidae : Starlings and Mynas	
Sturnus vulgaris	Common Starling (introduced)
Ornithorhynchidae	
Ornithorhynchus anatinus	Platypus
Tachyglossidae	
Tachyglossus aculeatus	Short-beaked Echidna
Dasyuridae	
Dasyurus maculatus	**Spotted-tailed Quoll**
Phascogale tapoatafa	**Brush-tailed Phascogale**
Antechinus stuartii	Brown Antechinus
Antechinus swainsonii	Dusky Antechinus
Sminthopsis murina	Common Dunnart
Planigale maculata	**Common Planigale**

Scientific Name	Common Name
Peramelidae	
Isoodon macrourus	Northern Brown Bandicoot
Perameles nasuta	Long-nosed Bandicoot
Phascolarctidae	
Phascolarctos cinereus	**Koala**
Petauridae	
Petaurus australis	**Yellow-bellied Glider**
Petaurus breviceps	Sugar Glider
Petaurus norfolcensis	**Squirrel Glider**
Pseudocheiridae	
Petauroides volans	Greater Glider
Pseudocheirus peregrinus	Common Ring-tailed Possum
Phalangeridae	
Trichosurus caninus	Mountain Brushtail Possum
Trichosurus vulpecula	Common Brushtail Possum
Burramyidae	
Cercartetus nanus	Eastern Pygmy Possum
Acrobatidae	
Acrobates pygmaeus	Feathertail Glider
Potoroidae	
Potorous tridactylus	**Long-nosed Potoroo**
Macropodidae	
Macropus parma	**Parma Wallaby**
Macropus rufogriseus	Red-necked Wallaby
Thylogale thetis	Red-necked Pademelon
Wallabia bicolor	Swamp Wallaby
Pteropodidae	
Pteropus alecto	**Black Flying Fox**
Pteropus poliocephalus	Grey-headed Flying Fox
Pteropus scapulatus	Little Red Flying Fox

Scientific Name	Common Name
Nyctimene robinsoni	Queensland Tube-nosed Bat
Syconycteris australis	Queensland Blossom Bat
Emballonburidae	
Saccolaimus flaviventris	**Yellow-bellied Sheathtail Bat**
Rhinolophidae	
Rhinolophus megaphyllus	Eastern Horseshoe Bat
Mollosidae	
Mormopterus loriae	Little Free-tail Bat
Mormopterus beccarii	Beccari's Free-tail Bat
Mormopterus norfolkensis	Eastern Free-tail Bat
Tadarida australis	White-striped Mastiff Bat
Vespertilionidae	
Chalinolobus dwyeri	**Large Pied Bat**
Chalinolobus morio	Chocolate Wattled Bat
Chalinolobus gouldii	Gould's Wattled Bat
Chalinolobus nigrogriseus	**Hoary Bat**
Falsistrellus tasmaniensis	**Eastern False Pipistrelle**
Kerivoula papuensis	**Golden-tipped Bat**
Vespadelus pumilus	Eastern Forest Bat
Vespadelus vulturnus	Small Forest Bat
Miniopterus australis	**Little Bentwing-bat**
Miniopterus schreibersii	**Common Bentwing-bat**
Myotis adversus	**Large-footed Myotis**
Nyctophilus bifax	**Northern Long-eared Bat**
Nyctophilus geoffroyi	Lesser Long-eared Bat
Nyctophilus gouldi	Gould's Long-eared Bat
Scoteanax rueppellii	**Greater Broad-nosed Bat**
Scotorepens orion	Eastern Broad-nosed Bat
Vespadelus pumilus	Eastern Forest Bat
Vespadelus troughtoni	Eastern Cave Bat

Scientific Name	Common Name
Muridae	
Hydromys chrysogaster	Water Rat
Melomys cervinipes	Fawn-footed Melomys
Melomys burtoni	Grassland Melomys
Pseudomys gracilicaudatus	**Eastern Chestnut Mouse**
Rattus fuscipes	Southern Bush Rat
Rattus lutreolus	Swamp Rat
Rattus rattus	Black Rat
Mus musculus	House Mouse
Leporidae	
Oryctolagus cuniculus	Rabbit
Lepus capensis	Brown Hare
Canidae	
Canis familiaris dingo	Dingo/Feral Dog
Vulpes vulpes	Fox
Felidae	
Felis catus	Feral Cat

Bold denotes Threatened Species (TSC Act, 1995)

Appendix D
Survey Methodology

1.1 VEGETATION SURVEY METHODOLOGY

1.1.1 Mapping

Initial mapping of vegetation communities was undertaken at 1:6000 scale using air photo interpretation (api) from 1997 colour air photos (supplied by Sinclair Knight Merz). Vegetation units at the community and association levels, and their boundaries, were established and groundtruthed. Areas outside the corridor were mapped with less detail and groundtruthing to provide context.

1.1.2 Site Surveys

Vegetation sites (circular30 m radius) were placed at typical locations within each association. Thirty-two (32) sites were surveyed (**Figures 2a-n**), including at least one site within each of the most common associations. Associations occupying large areas, or encompassing substantial variation, were sampled more than once. Further sites will be surveyed during the next stage of the investigation.

Plant species lists were compiled by site and association. Additional biophysical data for each site to that presented herein, is held by Landmark Ecological Services Pty Ltd and Woodward-Clyde.

1.1.3 Threatened, Rare and Regionally Significant Plant Species

Possible and reported occurrences of threatened, rare or regionally significant (i.e. listed on the Schedules of the Commonwealth Endangered Species Protection Act (1992), TSC Act (1995), by Briggs and Leigh (1996) and/or by Sheringham and Westaway (1995)) were determined from:

- a literature review of previous flora assessments undertaken in the study area carried out during a previous survey (Woodward-Clyde – draft document 1997).
- NSW NPWS database.
- the authors' knowledge of the corridor area and its plant associations, together with of the habitat of local threatened, rare and regionally significant species.

A search for threatened, rare and significant plants was carried out, focusing on those areas within the corridor most likely to be impacted, ie. the projected road route. The area understood to encompass the route at the time of the survey was walked by a two-person team, examining all native vegetation and other suitable habitat (but excluding, for instance, agricultural land). Much of the vegetation close to but outside the route was also inspected, and species recorded in the literature and previous surveys were reconfirmed.

1.1.4 Conservation Assessment, Impacts and Mitigation

The conservation status of the identified vegetation associations was determined from the literature.

A list of threatened species considered likely to be impacted by the proposed highway upgrade was compiled. The species list was then examined for likelihood of significant impacts in relation to Section 5A of the Environmental Planning & Assessment Act (1979).

Vegetation patches considered to have high flora conservation value were identified and avoidance or mitigation measures discussed.

1.2 FAUNA SURVEY METHODOLOGY

The survey was designed to sample habitats representative of those to be disturbed within the study area. Surveys also included those areas not directly affected by the proposal, but proximate to the study area and considered likely to support threatened species.

The fauna survey periods were from 1 to 5 August 1997 and 25 to 31 August 1997, with supplementary surveys occurring from 13 to 16 April and 21 to 25 April 1998. Harp trapping was conducted from 18 to 21 September, 1997. Fauna sampling sites are shown in **Figures 4 a-n**. The limitations of this survey are discussed at the end of this section.

1.2.1 Amphibians

Approximately 30 hours of nocturnal observation was undertaken during the August 1997 survey periods. An additional 9.5 hours of nocturnal observation was undertaken during the April 1998 survey period. Active (diurnal and nocturnal) searching for amphibians was carried out during these survey periods. A survey of swamp sclerophyll habitats was undertaken during light rainfall on 29 September to target the Wallum Froglet *Crinia tinnula* and Wallum Tree Frog *Litoria olongburensis*. Active diurnal searches were undertaken for a total of 2 hours at Yelgun and Kanes Road.

Amphibians were recorded with a combination of habitat searches, wetland searches and a collation of opportunistic sightings or calls recorded during time spent in the field. Creeks, gullies and farm dams were examined for tadpoles as well as adult amphibia. Fresh water turtle searches were undertaken at Sleepy Hollow, Taggets Hill, Kanes Road and Cudgen Road. Searches were carried out (at night) in areas where frogs were calling. Habitat searches usually involved two operators between the hours of 6pm and 11pm on any day during the survey periods.

Road Based Night Survey

Driving between sites at night was utilised as a survey method and whilst spotlighting for mammals attention was given to both tracks and moist areas for any herpetofauna activity.

During a period of heavy rainfall over the nights of 15, 16 and 23 April 1998, roads within the study area were driven to detect species crossing the road. Spot surveys to identify the vocalisation of species were also undertaken when areas of high amphibian activity were encountered.

1.2.2 Reptiles

Herpetological survey work was carried out at a number of sites containing high quality habitat. 'High quality' refers to those areas with least environmental disturbance. These areas included sites at Taggets Hill, Sleepy Hollow, and west of the Pacific Highway between Jones Road and Wooyung Road.

Approximately 5 hours active diurnal searching was undertaken in the initial survey period (1 to 5 August 1997), and 10 hours of active searching was undertaken during the second fauna survey period (25 to 31 August). Five (5) hours of active searching was undertaken on 25 and 26 August 1997.

The Koala scat survey technique employed to determine the significance of Koala habitat involved disturbing leaf litter to a distance of 1 m around the base of trees in search of Koala scats. This survey was conducted from 24 to 26 April 1998. Any reptiles encountered during this survey were recorded.

Survey methodology broadly followed guidelines outlined for threatened species survey by York *et al* (1991) and Ferrier *et al* (1994). These consisted of road and track side searches, rolling logs, rocks and dumped rubbish, raking through leaf litter on the forest floor and quiet observation.

It had been anticipated that pitfalls and associated drift fences would be utilised as a passive sampling technique, however, many of the significant vegetated areas remaining within the study area are restricted to rocky ridges and steep slopes, rendering this technique impractical during the current survey.

Windy and cold conditions were avoided where possible during herpetological survey work.

1.2.3 Avifauna

The following methodology has been adapted from Debus (1997 and 1998).

(i) Diurnal Birds

Observation

Birds were surveyed over the period 31 July to 2 August 1997, and 12 to 13 and 15 to 16 September 1997. Diurnal birds were surveyed visually and aurally during habitat searches in bushland patches within the study area, concentrating on the most extensive and intact natural habitats, as determined by aerial photograph interpretation. Habitats were broadly categorised as follows:

i. rainforest;

ii. wet sclerophyll forest;

iii. dry sclerophyll forest;

iv. open and disturbed areas including grassland; and

v. wetland.

These habitats are considered broadly analogous to those habitats identified in **Section 5.4** of this report.

In July two whole days and an early morning were spent working slowly through each habitat patch from Billinudgel north to Taggets Quarry near Sleepy Hollow, and revisiting each patch on the return leg. The final night was spent in the field, in order to include the dawn chorus at Taggets Quarry. In September, habitat searches were conducted from 1130 h on the 12th to 0800 h on the 13th mainly at Sleepy Hollow and Taggets Quarry, with overnight camping to include the dawn chorus, and including an inspection of moist forest at Yelgun. Habitat patches were inspected where the study area crossed Cudgen, Eviron and Clothiers Creek Roads on the morning of the 15th, before the remaining time (1300 h on the 15th to 0800 h on the 16th) was spent at Sleepy Hollow and Taggets Quarry, again with overnight camping to include the dawn chorus. A further half hour was then spent revisiting habitat patches south to Yelgun. In some cases habitat patches adjoining the study area were included in searches, as surrogate sites for similar habitat within the study area.

Call Playback

Playback of recorded calls of Black-breasted Button Quail, Bush Hen and White-eared Monarch were carried out in these species' preferred habitats.

(ii) Nocturnal Birds

Nocturnal birds were surveyed by a standard procedure (Debus, 1995) of listening, playback of recorded calls, listening for replies and spotlighting (stationary at playback points and half hour walking or slow driving) at four sites, with two sites surveyed two or three times to give seven attempts:

(1) Jones Road, Yelgun on 31 July 1997;

(2) Quarry off Pacific Highway, Yelgun on 31 July 1997;

(3) Taggets Quarry near Sleepy Hollow on 31 July, 15 and 16 August 1997;

(4) Sleepy Hollow Golf Course on 15 and 16 August 1997.

Calls broadcast were Marbled Frogmouth, Grass Owl, Masked Owl, Sooty Owl and Powerful Owl as appropriate for the habitat at each site.

A supplementary survey was undertaken on the 12 October 1997 in order to:

(i) assess bushland on the Condong Range within the study area;

(ii) survey habitat on Clothiers Creek Road for the presence of the Grass Owl;

(iii) revisit habitat near Taggets Quarry.

Bushland on or near the Byrne property (Cudgen Road) was inspected in early afternoon then surveyed for birds in the last hour of daylight; the Taggets Hill area and adjoining Leybourne property were inspected for half an hour in mid afternoon; and the grassland on Clothiers Creek Road was surveyed for Grass Owls for 2 hours after dusk. A standard procedure of listening, playback of calls, stationary spotlighting and listening for replies was conducted at each of four points along 1 km of road, with spotlight driving between each point, and incorporating a one hour listening phase from sunset with periodic 360° spotlighting scans during each listening phase.

To provide additional records, results from surveys conducted in or near the study area in previous years were also utilised.

1.2.4 Non-flying Mammals

Mammals were surveyed utilising a variety of complementary standardised techniques including, spotlighting, scat collection, hair sampling, small mammal trapping, electronic detection and predator scat analysis. These sampling methods were utilised from 1 to 5 August 1997, 25 to 31 August and 18 to 29 September 1997. Elliott and Hair Tube transects were set adjacent to Sleepy Hollow Golf Course, Taggets Hill, Kanes Road, Wooyung Road, and west of the Pacific Highway between Jones Road and Wooyung Road.

Survey sites are shown on **Figures 4 a-n**.

(i) Elliott Trapping

Elliott trapping was undertaken from 1 to 5 August 1997. The second survey effort was undertaken from 25 to 31 August inclusive.

Small mammals in the following genera were targeted by Elliott Trapping: *Rattus, Sminthopis, Pseudomys, Antechinus* and *Phascogale* (Ferrier *et al*, 1994).

Initially one hundred (100) type A Elliott traps were baited with a mixture of peanut butter, honey, rolled oats and pistachio essence and set for a period of four (4) nights at four separate sites. A total of four hundred (400) trap nights were achieved during this component of the study.

A further twenty-five (25) Elliott traps were set at one site for a period of five (5) nights. A total of one hundred and twenty-five (125) trap nights were achieved during this component of the survey. In all, a total of five hundred and twenty-five (525) Elliott trap nights were achieved.

Sites were selected in areas supporting native vegetation with lowest disturbance levels (i.e. minimal clearing to largest size) both within the study area and in proximate habitat.

Traps were placed in a systematic manner in the habitat in which the target species were considered most likely to occur. Line transects were utilised and spacings of 10 - 20m were utilised depending on the nature of the habitat being sampled. Twenty-five (25) stations per transect were used.

(ii) Hair Tubes

Hair tubes were utilised to determine the occurrence of the following species: Brush-tailed Phascogale, Long-nosed Potoroo, and Spotted-tailed Quoll.

Fifty (50) hair tubes were baited with a mixture of peanut butter, honey, rolled oats and pistachio essence and spaced at a ratio of one (1) hair tube to two (2) Elliott traps. The hair tubes were left in place for nine (9) nights (1 to 10 August).

A further twenty-five (25) hair tubes were set at two sites over six (6) nights in the Sleepy Hollow area to sample for the Long-nosed Potoroo (25 to 31 August). Site selection was based on the presence of dense understorey vegetation in rainforest and wet sclerophyll forest. A dense understorey was viewed as a prerequisite for the occurrence of this species.

Thirty (30) hair tubes were baited with a meat bait and set for a period of eight (8) nights at three locations to sample for the Spotted-tailed Quoll (18 to 25 September).

A total of eight hundred and forty (840) sample nights were achieved during this component of the study.

(iii) Cage Trapping

Selection of cage-trapping sites was based on the occurrence of suitable habitat for the Long-nosed Potoroo and Spotted-tailed Quoll.

Long-nosed Potoroo

Initially, five (5) cage traps were placed at three sites for a period of four (4) nights (1 to 5 August 1997). A further sampling period was undertaken with five (5) cages employed at two separate sites for a period of six (6) nights (25 to 31 August). Cages were baited with both the peanut butter and rolled oats mixture (and pistachio essence), and a combination of fruit. A total of fifty-five (55) cage trap nights were achieved during this component of the study. Cages were set in habitat adjacent to Sleepy Hollow Golf Course, and at Taggets Hill.

Spotted-tailed Quoll

Four (4) cage traps were employed at four separate sites over a total of seven (7) nights (18 to 24 September). Cages were baited with meat bait (dog food). A total of twenty-eight (28) cage trap nights were achieved during this component of the study.

(iv) Spotlighting

Spotlighting was undertaken on the 1st (2 hours), 2nd (2 hours), 3rd (3 hours) and 5th (3 hours) of August 1997. The second survey effort was undertaken on the 25th (7 hours), 26th (5 hours), 27th (3 hours), 29th (3 hours), 30th (1.5 hours) of August 1997. Surveys were undertaken by two operators on the 3rd, 5th, 25th, 26th and 27th of August, giving a total of 50.5 person hours.

Spotlighting transects were walked in all significant vegetated areas occurring within the study area and proximate habitat areas. Road based spotlighting was undertaken from a vehicle between walked survey sites. Vehicle based spotlighting targeted the Koala. Hand held 50W and 100W spotlights were utilised. Spotlighting usually involved two operators between the hours of 6pm and 11pm on any day during the survey period.

During walking surveys, observers walked at approximately 1 km/h allowing intensive listening (for calls and movement) as an adjunct to visual detection. Spotlighting also focused on areas of likely Koala habitat, or areas where scats and scratches had been noted during vegetation surveys.

(v) Scat Analysis

Scats located during incidental survey work were collected. Scat searches were also undertaken during vegetation surveys. All predator scats and owl pellets were collected where possible. Samples were sent to Barbara Triggs for analysis.

(vi) Koala Habitat Assessment

Koala activity was assessed at all vegetation survey locations to determine the significance of the study area as habitat for this species. The AKF spot assessment technique was utilised at all sample sites. A brief summary of the field procedures involved is included below.

A tree with one of the following characteristics was selected where possible:

(1) a tree of any species beneath which scats have been observed;

(2) a tree in which a Koala has been sighted;

(3) any other tree considered likely to be utilised (i.e. preferentially utilised species).

A minimum of 20 trees surrounding the centre tree were searched for Koala faecal pellets and scratches. The scat searches involved the following level of assessment for each tree:

(a) a distance of 1 m around the base of each tree with a dbh of 40 cm or less;

(b) a distance of 1.2 m around the base of larger trees;

(c) undertake a more thorough inspection, including disturbance to leaf litter.

1.2.5 Microchiropteran Bats

Sample sites for microchiropteran bats were selected on the basis of areas offering habitat components likely to be utilised by these species. Such areas included vegetation offering roosting resources in small and large hollows and shedding bark trees for forest bats of areas containing rock overhangs or crevices for the cave dwelling species.

(i) Electronic Detection

Ultrasonic bat detection using an Anabat II bat detector was undertaken at seven (7) locations within the study area on 2, 3, 25, 27 and 28 August 1997. These sites were at Jones Road, west of the Pacific Highway between Jones Road and Wooyung Road, Wooyung Road, Sleepy Hollow Golf Course, Taggets Hill, Eviron Road and Kanes Road. Calls were recorded for a period of 45 minutes per site and sent to Greg Richards for analysis. Surveys were conducted on fine, calm nights during the first 2 hours following dusk. Ultrasonic bat survey was undertaken by one operator whilst walking through suitable habitat.

(ii) Harp Traps

Harp traps were utilised on 18, 19, 20 and 21 September 1997. Harp traps, are described as the most effective method yet devised for catching Forest bats although their application is limited to densely forested areas (Ferrier *et al*, 1994). Four (4) Harp traps were set at eight locations for a period of two (2) nights per Harp trap. These locations were Eviron Road., Cudgen Road, Kanes Road, Taggets Hill (2 sites), adjacent to Sleepy Hollow Golf Course and west of the Pacific Highway between Jones Road and Wooyung Road (2). Traps were placed in potential flyways and checked in the early morning.

1.2.6 Incidental Observations - March 1998

In addition to the field survey programme of late 1997, the area was visited again in March and April of 1998 in the course of defining and clarifying the present route. All species recorded during these visits were noted.

1.2.7 Supplementary Survey Methodology

Additional field work undertaken as a result of the identification of species likely to be significantly impacted on by the proposal.

Koalas

Supplementary survey work to determine the extent of the Koala population and habitat to be impacted by the proposal was undertaken in three phases. Each of these three phases is discussed in more detail below.

Information Review

The information review was partly conducted during the preparation and compilation of the preliminary flora and fauna assessment for the proposed Yelgun - Chinderah Pacific Highway Upgrade. This had involved an interrogation of Koala records held on the Wildlife Atlas Database maintained by the NSW NPWS and information held on a private database maintained by David Milledge of Landmark Ecological Services Pty Ltd. For the purpose of this report, this information was supplemented with a database containing some 537 records of reported Koala sightings maintained by Rhonda James (Tweed Koala Rescue Unit) with recordings dating to 1977.

Information obtained from these sources was then amalgamated and plotted to provide a total of approximately 800 records of Koala sightings. This information provides an understanding of areas where the incidence of Koala observation is high.

Public Consultation

Public consultation was undertaken throughout the duration of the study. The primary component of this phase was a resident survey which seeks information regarding Koala sightings within the study area. The survey was mailed to residents within the study area only.

The methodology employed for further public consultation was as follows:

- Discussions with Rhonda James of the Tweed Koala Rescue Unit indicating areas within the study area where Koala sightings were common.
- Discussions with Stan and Val Scanlon of Conservation of North Ocean Shores (CONOS) indicating areas along the existing Pacific Highway within the southern half of the route where previous Koala mortalities had been recorded.

Field Investigation

Field investigation has involved 29.5 hours of spotlighting in August 1997 in all significantly vegetated areas occurring in the study area. Methodologies adopted during this survey included random scat search analysis and noting trees encountered with evidence of Koala usage (scratch marks). Information from this survey has subsequently been incorporated into this report.

A supplementary field survey targeting Koalas was conducted in April 1998. For this survey areas of potential Koala habitat were identified from vegetation mapping initially conducted as a component of the preliminary flora and fauna survey. The definition for potential Koala habitat utilised for the purpose of this assessment is as follows "Those areas of vegetation within the study area where Eucalypts constitute at least 15% of the total number of trees in the vegetation type". This definition is based on the fact that Koalas have been recorded foraging on all Eucalypt species identified from the study area to a varying degree. Included in these communities are the recognised Koala forage trees *Eucalyptus tereticornis*, *E. microcorys*, *E. propinqua*, *E. robusta* and *E. resinifera*.

Areas within the study area fulfilling the definition of Koala habitat were then targeted for further spotlighting. A total of 11.25 hours of spotlighting was conducted in these areas.

The spot assessment technique as per Phillips and Callaghan (1995) was also employed in each of the areas identified as potential habitat to determine the significance of habitat utilisation by Koalas.

Birds

The following methodology has been adapted from Debus (1998).

A supplementary bird survey was conducted in the route corridor from 14 to 19 April 1997 inclusive. The purpose was to obtain additional records of bird species by habitat, to conduct specific searches for five (5) threatened species (Wompoo and Rose-crowned Fruit Doves, Masked and Grass Owls, White-eared Monarch), and to assess the value of habitat patches for these species.

Habitats were categorised into six (6) broad vegetation types, according to previous habitat stratification (Woodward-Clyde and Landmark 1998): Rainforest, Wet Sclerophyll, Dry Sclerophyll, Swamp Sclerophyll, Disturbed Forest dominated by exotic trees, and Grassland (non-forested areas). Five days and five nights were spent in the field within the corridor, visiting patches of each habitat identified as potentially significant in terms of size, corridor attributes, flora and possible presence of threatened birds:

These sites comprised:

- Condong Range near intersection of Cudgen and Duranbah Roads (disturbed forest and nearby wet sclerophyll);
- Eviron Road at Tweed Botanical Gardens (disturbed on north side, wet sclerophyll and disturbed at quarry on south side);
- Round Mountain Road (swamp sclerophyll, grassland);
- Wilman Road (wet sclerophyll, disturbed, grassland);
- Kanes Road (degraded wet sclerophyll, rainforest);
- Taggets Hill (rainforest, wet sclerophyll);
- Burringbar Range spur just north of Sleepy Hollow (rainforest, wet sclerophyll);
- Pottsville Road near Warwick Park Road (wet sclerophyll fragments, disturbed);
- Burringbar Creek (rainforest);
- Hulls Road (dry sclerophyll, wet sclerophyll, disturbed);
- Pacific Highway verge and Marshalls Ridges 1 km either side of Jones Road, Yelgun (wet sclerophyll, dry sclerophyll, swamp sclerophyll, disturbed; within or contiguous with the route corridor).

Each patch was visited two or more times, on different days and at different times, for variable periods of up to 2 hours depending on patch size and quality. The patches were surveyed for diurnal birds visually and aurally by means of walking transects and habitat search. Specific searches for the target diurnal threatened species were conducted in accordance with standard methodology, i.e. searching of fruiting trees in suitable habitat for Fruit Doves, searching suitable habitat in early mornings for the White-eared Monarch. In addition, simulated call playback was conducted successfully for the Rose-crowned Fruit Dove, and call playback was attempted for the White-eared Monarch. The dawn chorus was sampled at Wilman Road (one morning), Taggets Hill (three mornings) and Jones Road (one morning). The threatened owls were surveyed by listening, call playback and stationary spotlighting as per recommended methodology twice per site, on different nights for each site. Survey was undertaken for the Masked Owl at Wilman Road; Grass Owl at Clothiers Creek Road, Round Mountain Road and Wilman Road. The Masked Owl was already surveyed previously several times, on different nights, at Taggets Hill and Jones Road (Woodward-Clyde and Landmark, 1998).

All results are presented in **Appendix E**

1.3 LIMITATION OF FAUNA SURVEYS

1.3.1 Amphibians and Reptiles

Many amphibians are nocturnal and reside in inaccessible refuges whilst not active or are particularly cryptic when not active. Most species are active only under favourable temperature and humidity conditions, and most often at night. Recording rates of amphibians (particularly away from water bodies) are therefore expected to be higher immediately following rain.

A reasonable diversity of amphibian species were recorded during the survey period, although a number of additional species are also expected to occur. It is recognised that amphibian surveys were undertaken outside the optimum survey period for most species in this group.

The accepted optimum survey period for most reptile and amphibian species is from mid September to the end of January. The timing of the survey for this report is recognised as a significant limitation.

1.3.2 Birds

The high bird diversity reflects the diversity of habitats traversed within the study area, the size of the study area, and the conduct of the field survey over two seasons (winter and spring). A previous field survey within habitats adjacent to, and analogous to, those within the study area has been undertaken in summer-autumn (Mount King Ecological Surveys (MKES), 1994). Field surveys of the route have thus spanned all seasons. Targeted survey was undertaken for all significant species known to occur within the study area or within adjacent habitat. Appropriate techniques were utilised in the survey, and sampling effort is considered adequate to provide information on likely presence or absence of species. Survey effort in each habitat type was not systematic. The varied survey effort in each habitat type makes it difficult to interpret data to provide an indication of species richness in each habitat type.

1.3.3 Non-flying Mammals

One limitation of the fauna survey is common to all sampling programs, i.e. spotlighting survey results are always strongly biased by vegetation structure, due to the greater visibility in open forests relative to dense forests (Smith *et al*, 1992). The following limitations of the survey methodology for non-flying mammals have also been identified:

- tree based Elliott traps were not utilised

Threatened species sampled by this method include the Brush-tailed Phascogale *Phascogale tapoatafa* and Squirrel Glider *Petaurus norfolcensis*. Neither of these species were considered likely to occur within the study area.

- no pitfalls were utilised

This is probably the best sampling method for the Common Planigale *Planigale maculata*.

1.3.4 Microchiropteran Bats

Harp traps and ultrasonic bat detection were utilised during this survey. These methods are considered appropriate. Richards (*pers comm*) suggests that a 30 minute recording session utilising ultrasonic detection equipment is adequate to record species diversity at a site. Recording was undertaken for a minimum of 30 minutes at each site during this survey.

Appendix E
Species Recorded From Within Study Area

1.1 AMPHIBIANS

Amphibians Recorded From Habitats Within The Study Area

Family Name Scientific Name	Common Name	Methodology
Myobatrachidae		
Crinia signifera	Common Eastern Froglet	C
Crinia parinsignifera	Eastern Sign-bearing Froglet	C
Adelotus brevis	Tusked Frog	C
Pseudophryne bibroni	Bibrons Toadlet	C
Pseudophryne coracea	Red-backed Toadlet	C
*Mixophyes sp.**	Barred Frog	O
Limnodynastes salmini	Salmon-striped Frog	C
Limnodynastes peroni	Striped Marsh Frog	O
Limnodynastes tasmaniensis	Spotted Marsh Frog	C
Hylidae		
Litoria tyleri	Tyler's Tree Frog	C
Litoria fallax	Eastern Dwarf Tree Frog	O, C
Litoria nasuta	Rocket Frog	O
Litoria peroni	Laughing Tree Frog	C
Litoria verrauxii	Whistling Tree Frog	C
Litoria gracilenta	Dainty Green Tree Frog	C
Litoria caerulea	Green Tree Frog	O
Bufonidae		
Bufo marinus❖	Cane Toad	O

* Tadpole identified by Paul Webber who indicates that the species is likely to be *Mixophyes fasciolatus*.

Key

O Direct Observation
C Identification by Call
❖ Introduced

1.2 REPTILES

Reptiles Recorded From Habitats Within The Study Area

Family Name Scientific Name	Common Name	Methodology
Scincidae		
Cryptoblepharus virgatus	Wall Skink	O
Lampropholis delicata	Grass Skink	O
Ctenotus robustus	Striped Skink	O
Agamidae		
Pogona barbata	Bearded Dragon	O
Physignatus lesueurii	Eastern Water Dragon	O
Boidae		
Morelia spilota	Diamond Python	Anec.
Varanidae		
Varanus varius	Lace Monitor	O
Colubridae		
Dendrelaphis punctulata	Green Tree Snake	O

Key

O Direct Observation
Anec. Anecdotal record

1.3 BIRDS

Birds Recorded From Habitats Within The Study Area

R = rainforest, M = moist eucalypt; D = dry eucalypt;S=swamp sclerophyll
G = grassland/disturbed/open; W = wetland.

Species	R	M	D	S	G	W
MEGAPODIIDAE						
Australian Brush-turkey *Alectura lathami*	X	X				
Brown Quail *Coturnix ypsilophora*					X	
ANATIDAE						
Wandering Whistling-Duck *Dendrocygna arcuata*					X	X
Australian Wood Duck *Chenonetta jubata*					X	X
Pacific Black Duck *Anas superciliosa*					X	X
Hardhead *Aythya australis*					X	
PHALACROCORACIDAE						
Little Pied Cormorant *Phalacrocorax melanoleucos*					X	X
Little Black Cormorant *Phalacrocorax sulcirostris*						X
Great Cormorant *Phalacrocorax carbo*					X	X
ARDEIDAE						
White-faced Heron *Ardea novaehollandiae*					X	
White-necked Heron *Ardea pacifica*					X	X
Great Egret *Ardea alba*					X	X
Intermediate Egret *Ardea intermedia*						X
Cattle Egret *Ardea ibis*					X	
PLATALEIDAE						
Australian White Ibis *Threskiornis molucca*					X	X
Straw-necked Ibis *Threskiornis spinicollis*					X	
Royal Spoonbill *Platalea regia*						X
ACCIPITRIDAE						
Black-shouldered Kite *Elanus axillaris*					X	
Pacific Baza *Aviceda subcristata*		X	X			
Whistling Kite *Haliastur sphenurus*				X	X	
Brahminy Kite *Haliastur indus*				X		

Birds Recorded From Habitats Within The Study Area (cont'd)

R = rainforest, M = moist eucalypt; D = dry eucalypt;S=swamp sclerophyll
G = grassland/disturbed/open; W = wetland.

Species	R	M	D	S	G	W
White-bellied Sea-Eagle *Haliaeetus leucogaster*			X		X	
Swamp Harrier *Circus approximans*					X	
Brown Goshawk *Accipiter fasciatus*		X	X			
Grey Goshawk *Accipiter novaehollandiae*		X	X			
Wedge-tailed Eagle *Aquila audax*		X	X			
Little Eagle *Hieraaetus morphnoides*			X			
FALCONIDAE						
Peregrine Falcon *Falco perigrinus*		X				
Australian Hobby *Falco longipennis*					X	
RALLIDAE						
Buff-banded Rail *Gallirallus philippensis*					X	
Lewin's Rail *Rallus pectoralis*						X
Bush Hen *Amaurornis olivaceus**						X
Purple Swamphen *Porphyrio porphyrio*					X	X
Dusky Moorhen *Gallinula tenebrosa*					X	X
CHARADRIIDAE						
Masked Plover *Vanellus miles*					X	
COLUMBIDAE						
White-headed Pigeon *Columba leucomela*	X				X	
Spotted Turtle-Dove *Streptopelia chinensis*❖					X	
Brown Cuckoo-Dove *Macropygia amboinensis*	X					
Emerald Dove *Chalcophaps indica*		X				
Crested Pigeon *Ocyphaps lophotes*					X	
Bar-shouldered Dove *Geopelia humeralis*		X	X		X	
Wonga Pigeon *Leucosarcia melanoleuca*	X					
Rose-crowned Fruit-Dove *Ptilinopus regina**	X	X			X	
Topknot Pigeon *Lopholaimus antarcticus*		X				
CACATUIDAE						
Glossy Black Cockatoo *Calyptorhynchus lathami**		X				

Birds Recorded From Habitats Within The Study Area (cont'd)

R = rainforest, M = moist eucalypt; D = dry eucalypt;S=swamp sclerophyll
G = grassland/disturbed/open; W = wetland.

Species	R	M	D	S	G	W
Galah *Cacatua roseicapilla*					X	
Little Corella *Cacatua sanguinea*					X	
Sulphur-crested Cockatoo *Cacatua galerita*		X				
LORIINAE						
Rainbow Lorikeet *Trichoglossus haematodus*		X	X			
Scaly-breasted Lorikeet *Trichoglossus chlorolepidotus*		X	X		X	
POLYTELITINAE						
Australian King-Parrot *Alisterus scapularis*		X				
PLATYCERCINAE						
Eastern Rosella *Platycercus eximius*			X	X	X	
CUCULIDAE						
Fan-tailed Cuckoo *Cuculus flabelliformis*		X	X			
Pheasant Coucal *Centropus phasianinus*					X	
STRIGIDAE						
Southern Boobook *Ninox novaeseelandiae*		X	X			
TYTONIDAE						
Barn Owl *Tyto alba*					X	
Masked Owl *Tyto novaehollandiae*		X				
PODARGIDAE						
Tawny Frogmouth *Podargus strigoides*		X			X	
ALCEDINIDAE						
Azure Kingfisher *Alcedo azurea*						X
Laughing Kookaburra *Dacelo novaeguineae*	X	X	X		X	
Forest Kingfisher *Todiramphus macleayii*				X		
Sacred Kingfisher *Todiramphus sanctus*			X			
Rainbow Bee-eater *Merops ornatus*					X	
Dollarbird *Eurystomus orientalis*			X			
PITTIDAE						
Noisy Pitta *Pitta versicolor*	X					

Birds Recorded From Habitats Within The Study Area (cont'd)

R = rainforest, M = moist eucalypt; D = dry eucalypt;S=swamp sclerophyll
G = grassland/disturbed/open; W = wetland.

Species	R	M	D	S	G	W
MALURIDAE						
Superb Fairy-wren *Malurus cyaneus*		X	X		X	
Variegated Fairy-wren *Malurus lamberti*		X	X		X	
Red-backed Fairy-wren *Malurus melanocephalus*					X	
PARDALOTIDAE						
Spotted Pardalote *Pardalotus punctatus*		X	X			
Striated Pardalote *Pardalotus striatus*		X	X			
White-browed Scrubwren *Sericornis frontalis*	X	X	X		X	
Large-billed Scrubwren *Sericornis magnirostris*	X					
White-throated Gerygone *Gerygone olivacea*		X	X			
Brown Thornbill *Acanthiza pusilla*	X	X	X		X	
Striated Thornbill *Acanthiza lineata*		X	X			
MELIPHAGIDAE						
Little Wattlebird *Anthochaera lunulata*			X			
Noisy Friarbird *Philemon corniculatus*		X	X			
Blue-faced Honeyeater *Entomyzon cyanotis*					X	
Noisy Miner *Manorina melanocephala*		X	X	X	X	
Lewin's Honeyeater *Meliphaga lewinii*	X	X			X	
Yellow-faced Honeyeater *Lichenostomus chrysops*		X	X			
White-throated Honeyeater *Melithreptus albogularis*		X	X			
Brown Honeyeater *Lichmera indistincta*			X			
Eastern Spinebill *Acanthorhynchus tenuirostris*		X	X			
Scarlet Honeyeater *Myzomela sanguinolenta*	X	X	X			
PETROICIDAE						
Rose Robin *Petroica rosea*	X	X	X			
Eastern Yellow Robin *Eopsaltria australis*	X	X	X			

Birds Recorded From Habitats Within The Study Area (cont'd)

R = rainforest, M = moist eucalypt; D = dry eucalypt;S=swamp sclerophyll
G = grassland/disturbed/open; W = wetland.

Species	R	M	D	S	G	W
ORTHONYCHIDAE						
Logrunner *Orthonyx temminckii*	X					
CINCLOSOMATIDAE						
Eastern Whipbird *Psophodes olivaceus*	X	X			X	
PACHYCEPHALIDAE						
Crested Shrike-tit *Falcunculus frontatus*		X				
Golden Whistler *Pachycephala pectoralis*	X	X	X		X	
Rufous Whistler *Pachycephala rufiventris*	X	X	X		X	
Little Shrike-thrush *Colluricincla megarhyncha*	X					
Grey Shrike-thrush *Colluricincla harmonica*	X	X	X			
DICRURIDAE						
Black-faced Monarch *Monarcha melanopsis*	X					
Spectacled Monarch *Monarcha trivirgatus*	X	X				
White-eared Monarch *Monarcha leucotis**	X					
Leaden Flycatcher *Myiagra rubecula*	X	X	X			
Restless Flycatcher *Myiagra inquieta*					X	
Magpie-lark *Grallina cyanoleuca*					X	
Rufous Fantail *Rhipidura rufifrons*	X	X				
Grey Fantail *Rhipidura fuliginosa*	X	X	X		X	
Willie Wagtail *Rhipidura leucophrys*					X	
Spangled Drongo *Dicrurus bracteatus*	X	X				
CAMPEPHAGIDAE						
Black-faced Cuckoo-shrike *Coracina novaehollandiae*		X	X		X	
Varied Triller *Lalage leucomela*	X	X				
Cicadabird *Coracina tenuirostris*		X				
ORIOLIDAE						
Olive-backed Oriole *Oriolus sagittatus*		X	X	X		
Figbird *Sphecotheres viridis*		X			X	

Birds Recorded From Habitats Within The Study Area (cont'd)

R = rainforest, M = moist eucalypt; D = dry eucalypt;S=swamp sclerophyll G = grassland/disturbed/open; W = wetland.

Species	R	M	D	S	G	W
ARTAMIDAE						
White-breasted Woodswallow *Artamus leucorynchus*					X	
Grey Butcherbird *Cracticus torquatus*	X	X	X		X	
Pied Butcherbird *Cracticus nigrogularis*		X	X	X	X	
Australian Magpie *Gymnorhina tibicen*					X	
Pied Currawong *Strepera graculina*		X	X		X	
CORVIDAE						
Torresian Crow *Corvus orru*	X	X	X	X	X	
PTILONORHYNCHIDAE						
Satin Bowerbird *Ptilonorhynchus violaceus*	X	X				
Green Catbird *Ailuroedus crassirostris*	X					
PLOCEIDAE						
Red-browed Firetail *Neochmia temporalis*	X	X			X	
MOTACILLIDAE						
Richard's Pipit *Anthus novaeseelandiae*					X	
DICAEIDAE						
Mistletoebird *Dicaeum hirundinaceum*	X	X	X	X		
HIRUNDINIDAE						
Welcome Swallow *Hirundo neoxena*					X	
Tree Martin *Hirundo nigricans*			X		X	
Fairy Martin *Hirundo ariel*					X	
SYLVIIDAE						
Tawny Grassbird *Megalurus timoriensis*					X	
Golden-headed Cisticola *Cisticola exilis*					X	
Clamorous Reed-Warbler *Acrocephalus stentoreus*					X	
ZOSTEROPIDAE						
Silvereye *Zosterops lateralis*	X	X	X		X	
STURNIDAE						
Common Starling *Sturnus vulgaris*❖					X	
Total	35	60	47	9	60	16

Key * Denotes Threatened Species under the TSC Act, 1995
❖ Introduced

Additional Bird Species Recorded Within Or Adjacent To The Study Area In Previous Years For Unrelated Projects (Habitat Information Not Available)

Species
Darter *Anhinga melanogaster*
Pied Cormorant *Phalacrocorax varius*
Australian Pelican *Pelecanus conspicillatus*
Nankeen Night Heron *Nycticorax caledonicus*
Osprey *Pandion haliaetus**
Square-tailed Kite *Lophoictinia isura**
Collared Sparrowhawk *Accipiter cirrhocephalus*
Brown Falcon *Falco berigora*
Nankeen Kestrel *Falco cenchroides*
Peaceful Dove *Geopelia striata*
Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus*
Little Lorikeet *Glossopsitta pusilla*
Pheasant Coucal *Centropus phasianinus*
Brush Cuckoo *Cacomantis variolosus*
Shining Bronze-Cuckoo *Chrysococcyx lucidus*
Common Koel *Eudynamys scolopacae*
Channel-billed Cuckoo *Scythrops novaehollandiae*
White-throated Nightjar *Eurostopodus mystacalis*
Australian Owlet-nightjar *Aegotheles cristatus*
White-throated Needletail *Hirundapus caudacutus*
White-throated Treecreeper *Cormobates leucophaeus*
Striped Honeyeater *Plectorhyncha lanceolata*
White-checked Honeyeater *Phylidonyris nigra*
Grey-crowned Babbler *Pomatostomus temporalis*
Double-barred Finch *Taeniopygia bichenovii*
Chestnut-breasted Mannikin *Lonchura castaneothorax*

Key

* Denotes Threatened Species under the TSC Act, 1995.

1.4 MAMMALS

Mammals Recorded From Habitats Within The Study Area

Family Name Scientific Name	Common Name	Methodology	Number of Captures & location of records
Tachyglossidae			
Tachyglossus aculeatus	Short-beaked Echidna	O	Eviron Rd
Dasyuridae			
Antechinus stuartii	Brown Antechinus	E	(2) Yelgun
Peramelidae			
Isoodon macrourus	Northern Brown Bandicoot	Cge,Ht	Taggets Hill (1, Cge), Yelgun (Ht, O), Kanes Rd (Ht), Sleepy Hollow (Ht, O)
Perameles nasuta	Long-nosed Bandicoot	O, Ht	Taggets Hill (Ht, O), Yelgun (Ht), Sleepy Hollow (Ht), Wooyung Rd (Ht)
Phascolarctidae			
Phascolarctos cinereus	**Koala**	O	Taggets Hill
Petauridae			
Petaurus breviceps	Sugar Glider	O	Eviron Rd, Taggets Hill, Kanes Rd
Pseudocheiridae			
Pseudocheirus peregrinus	Common Ringtail Possum	O	Hulls Rd
Phalangeridae			
Trichosurus caninus	Mountain Brushtail Possum	O, Cge	Taggets Hill (1, Cge, O)
Trichosurus vulpecula	Common Brushtail Possum	O, Cge, Ht	Taggets Hill (1, Cge), Hulls Rd (Ht), Kanes Rd (Ht), Yelgun (Ht)
Macropodidae			
Wallabia bicolor	Swamp Wallaby	O, Ht	Taggets Hill (Ht), Yelgun (Ht, O), Sleepy Hollow (Ht, O), Kanes Rd (Ht)
Pteropidae			
Pteropus alecto	**Black Flying Fox**	O	Burringbar Ck

Mammals Recorded From Habitats Within The Study Area (cont'd)

Family Name Scientific Name	Common Name	Methodology	Number of Captures & location of records
Pteropus poliocephalus	Grey-headed Flying Fox	O	Yelgun, Kanes Rd, Cudgen Rd
Molossidae			
Nyctinomus australis	White-striped Mastiff Bat	Ana	Taggets Hill
Mormopterus sp. 1	A Freetail Bat	Ana	Eviron Rd
Vespertilionidae			
Miniopterus australis	**Little Bentwing-bat**	Ana, Ha	Yelgun (71,Ha), Sleepy Hollow (1, Ha). Taggets Hill (Ana). Yelgun (Ana)
Miniopterus schreibersii	**Common Bentwing-bat**	Ana	Taggets Hill, Eviron Rd
Myotis adversus	**Large-footed Myotis**	Ha	(4) Sleepy Hollow
Nyctophilus bifax	**Northern Long-eared Bat**	Ha	(2) Eviron Rd, (1) Cudgen Rd, (3) Kanes Rd.
Vespadelus regulus	Forest Bat	Ana	Eviron Rd
Muridae			
Mus musculus❖	House Mouse	E	(1) Wooyung Rd
Rattus fuscipes	Bush Rat	E	(15) Wooyung Rd, (10) Yelgun, (13) Taggets Hill
Rattus lutreolus	Swamp Rat	E	(3) Kanes Rd
Rattus rattus❖	Black Rat	E	(4) Wooyung Rd, (2) Kanes Rd
Melomys cervinipes	Fawn-footed Melomys	E	(1) Sleepy Hollow
Canidae			
Vulpes vulpes❖	Fox	O	(1) Sleepy Hollow
Leporidae			
Lepus capensis❖	Brown Hare	O	Kanes Rd

Bold - Threatened Species as defined by the TSC Act (1995).

Key

O	Direct Observation	Ana	Anabat Detection
C	Identification by Call	Ha	Harp Trap Capture
E	Elliott Trapping	HT	Hair Tube
Cge	Cage trapping	Anec	Anecdotal Record
		❖	Introduced

Report to:

Sinclair Knight Merz

Proposed Pacific Highway Upgrade

Yelgun to Chinderah

July 1998

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Introduction

The Ecology Lab Pty Ltd was requested by Sinclair Knight Merz to submit a literature review of the fish fauna of the Tweed area, far north coast of NSW. In particular, information relating to threatened fish in the area that may be affected by the proposed Pacific Highway upgrade between Yelgun and Chinderah, near Tweed Heads. This report deals with the fish fauna of the waterways potentially affected by the development, primarily the Tweed River and a number of creeks north of Yelgun. It also includes a preliminary Eight Point Test, as required under the Fisheries Management Amendment Act 1997, for any threatened species likely to be found in the area.

Description of the Study Area

The northern section of the proposed road is bounded by the Tweed River, with the main area of interest being the southern bank downstream of Murwillumbah and the small creeks and drains which flow into it. Also of interest are a number of mountain creeks which flow to the ocean. These include Sheens, Clothiers and Yelgun creeks (minor creeks) and Mooball, Cudgera and Cudgen Creeks (major creeks).

Fish Communities

The freshwater fish fauna of New South Wales comprises 83 species in 33 families (Table 1, Faragher and Harris 1994), 58 of which potentially occur in the area of interest (i.e. the north coast). Seven of these species are introduced, while one (*Bidyanus bidyanus*, silver perch) is a translocated species, i.e. native to Australia but not the north coast. The proposed highway route also crosses estuarine reaches of the Tweed River. Any attempt to describe the fish fauna of waterways along the route should therefore consider estuarine species.

Few fish surveys have been done in this area. A number of Ecology Lab studies have been done in the area, including surveys of Cudgen Creek and Lake (TEL 1991), the Tweed River between Broadwater and Tonys Bar (TEL 1990a) and the Tweed River estuary (TEL 1990b). The Tweed studies revealed a diverse estuarine fauna, including some catadromous species and many commercial fish (Table 2). The estuarine fish fauna is probably similar to other estuaries in the region such as the Clarence and Richmond. Studies on these systems have been published (see West 1992, Harris and Gehrke 1997). The study of Cudgen Lake also resulted in a substantial fish list which included some primarily freshwater species in addition to the estuarine fauna (Table 3).

Species of special interest

Most of the fish listed in Tables 1-3 are widespread throughout river drainages of the far north coast. Some, however, require special mention because of their lifecycle requirements or status as threatened species.

Migratory species

Australian bass (*Macquaria novemaculeata*), freshwater herring (*Potamalosa richmondia*), striped mullet (*Mugil cephalus*) and freshwater mullet (*Myxus petardi*) are catadromous, migrating to the estuary to spawn, then returning to freshwater as juveniles and adults (Faragher and Harris 1994). These species require free passage along the river in order to complete their breeding cycle.

Threatened species

A number of freshwater species are regarded as threatened and are therefore protected by either State or Commonwealth legislation. There are various classifications under threatened, including: "endangered", taxa which have suffered a population decline over all or most of their range, whether the causes of this decline are known or not and which are in danger of extinction in the near future; and "vulnerable", taxa that are not presently endangered but which are at risk by having small populations and/or by occupying restricted habitats susceptible to rapid environmental change and/or populations which are declining at a rate that would render them endangered in the near future (Pollard *et al.* 1990).

Four species of fish have been have been declared as threatened species under new NSW Fisheries legislation, requiring that the fish and their habitats need special consideration in planning decisions (Smith and Pollard 1998). Three of these are found in the northern NSW – southern QLD region, potentially in waterways in the path of the highway extension, and are discussed below.

The Eastern Freshwater Cod (*Maccullochella ikei*) is listed as an "endangered" species under both the NSW Fisheries Management Act 1994 and the Commonwealth Endangered Species Protection Act 1992. It is totally protected by Fisheries legislation. Prior to 1988 it was found only in the upper reaches of the Clarence River system, but has since been stocked into the Richmond River. Although *M. ikei* has not been recorded from the Tweed River or any part of the study area, it must be noted that its capture is prohibited in the eastern drainage system from the Macleay River to the QLD border (Rowland 1996).

The Oxleyan Pygmy Perch (*Nannoperca oxleyana*) is listed as "endangered" under the recently amended NSW Fisheries Management Act and as "vulnerable" under the Commonwealth Endangered Species Protection Act 1992. The species is recorded only from southeastern QLD and northern NSW. In NSW it is known from one lake in Bundjalung National Park south of the Richmond River, and has formerly been recorded at Coraki on the Richmond River and in Lake Hiawatha near Grafton (McDowall 1996, Smith and Pollard 1998). Its current status in these latter two areas is unknown. The potential range of the species does, however, encompass the areas proposed for the highway extension, although we were unable to obtain details of any other sites in NSW. *N. oxleyana* has been found only in streams, swampy areas and two lakes in coastal heathlands, usually in dense aquatic vegetation in slow moving or still, acidic waters (pH 5.4-5.7). The Oxleyan pygmy perch is threatened by habitat destruction, water pollution and the presence of *Gambusia* species (McDowall 1996).

The Honey Blue-eye (*Pseudomugil mellis*) is described as "vulnerable" under both NSW State and Commonwealth legislation schedules. This small species has a very restricted range, confined to south-eastern QLD, from Brisbane to Bundaberg (McDowall 1996, Merrick and Schmida 1984), although Smith and Pollard (1998) suggest that it has previously been recorded from far northern NSW. Further investigation would be required to clarify distribution south of the QLD border. *P. mellis* may be affected by the highway proposal if it is found on the NSW north coast.

Other species

Three other freshwater species rate special mention due to their status according to the Australian Society for Fish Biology (ASFB). The first is the silver perch (*Bidyanus bidyanus*)

whose natural distribution is restricted but is a common aquaculture species and has been stocked in northern NSW river drainages (Faragher and Harris 1994). This species is considered to be reduced in numbers but are not protected under NSW legislation (Smith and Pollard 1998). Fishing restrictions apply to silver perch and they can only be captured in the backed up waters of dams or reservoirs, i.e. areas where they have been stocked for recreational fishing purposes. Second, the eastern form of the freshwater catfish (*Tandanus tandanus*) occurs in the drainages of northern NSW. Recent genetic data on this species indicates that more than one species may exist (Jerry and Woodland 1997), resulting in a classification of "uncertain status" for the taxa (Faragher and Harris 1994, Smith and Pollard 1998). The third species is the southern purple-spotted gudgeon (*Mogurnda adspersa*) which is listed as "restricted" by ASFB (Faragher and Harris 1994). This species is found locally in coastal streams from northern NSW to northern QLD and is believed to have declined due to the presence of *Gambusia* sp. (McDowall 1996).

There are no threatened or protected estuarine fish species that are likely to be affected by the highway extension.

Fisheries Management Amendment Act 1997 – The "Eight Point Test"

The Eight Point Test is a series of questions, the answers to which assist in determining whether a planned action will significantly affect threatened species, populations or ecological communities or their habitats. Unless further evidence for the honey blue-eye occurring in northern NSW comes to light, the Oxleyan pygmy perch is the only threatened species that may be affected by the RTA proposal. Please note that no populations have been located in the Tweed River or nearby creeks, however, the potential range does include the study area. What follows is a preliminary eight point test based on our initial literature search. Due to the paucity of information on this species and the limited time frame of this desktop study, it is recommended that a more intensive literature search and/or field investigation is conducted during the determination period.

From our limited knowledge of the Oxleyan pygmy perch, the eight points (in italics) are addressed, in a preliminary sense, according to Schedule 1 of the Fisheries Management Amendment Act 1997:

(i) *In the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.*
Habitat destruction and pollution (or reduced water quality) are major threats to this species. The proposed road design is such that all waterways will be bridged or culverts provided which will not impede flow or restrict fish passage, and will not result in destruction of habitat. The construction methods used include sedimentation controls and other features which are designed to minimise impacts on water quality in the adjacent creeks and waterways.

(ii) *In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised.*
There are no endangered populations listed on the schedules of the Fisheries Management Amendment Act 1997.

(iii) *In relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or*

removed.
There are no threatened populations or ecological communities on the schedules of the Fisheries Management Amendment Act 1997.
For the Oxleyan Pygmy Perch, a "significant area of known habitat" will not be modified or removed. The road design is such that the habitat of this species, if it is found in the area of the proposed road, would be unaffected. The road design features and runoff controls discussed earlier will be in place to minimise any potential impact on habitat.

(iv) *Whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community.*
Populations of the Oxleyan Pygmy Perch are small, scattered and not well documented. However, should any populations of this species be found in the area, they will not be affected because the proposed road design will not impede flow or restrict fish passage (all waterways will be bridged or culverts provided).

(v) *Whether critical habitat will be affected.*
There are no critical habitats listed on the schedules of the Fisheries Management Amendment Act 1997.

(vi) *Whether a threatened species, population or ecological community, or their habitats are adequately represented in conservation reserves (or other similar protected areas) in the region.*
This species in not represented in conservation reserves or any similar protected areas within NSW. The range of the Oxleyan Pygmy Perch includes a lake in Bundjalung National Park (northern NSW), but this area is not designed to protect fish.

(vii) *Whether the action proposed is of a class of action that is recognised as a threatening process.*
The proposed action is not classed as threatening under the Fisheries Management Amendment Act 1997.

(viii) *Whether any threatened species or ecological community is at the limit of its known distribution.*
The Oxleyan Pygmy Perch has a very restricted range in southern Queensland and northern NSW. In the area of the proposed roadworks it is considered to be at the limit of its known distribution.

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Table 1: Representation of fishes in New South Wales North coast fresh waters (after Faragher and Harris, 1994).

Family	Species
Ambassidae	*Ambassis agassizi*
	Ambassis nigripinnis
Anguillidae	*Anguilla australis*
	Anguilla reinhardtii
Apogonidae	*Glossamia aprion*
Ariidae	*Arius graffei*
Atherinidae	*Atherinosoma microstoma*
	Craterocephalus marjoriae
	Craterocephalus stercusmuscarum
Belonidae	*Strongylura krefftii*
Chanidae	*Chanos chanos*
Clupeidae	*Nematalosa erebi*
	Potamalosa richmondia
Cyprinidae	*Carissius auratus*
	Cyprinus carpio
Eleotridae	*Butis butis*
	Gobiomorphus australis
	Gobiomorphus coxii
	Hypseleotris compressa
	Hypseleotris klunzingeri
	Hypseleotris sp 2
	Mogurnda adspersa
	Philypnodon grandiceps
	Philypnodon sp1
Gadopsidae	*Gadopsis marmoratus*
Galaxiidae	*Galaxias maculatus*
	Galaxias olidus
Gobiidae	*Arenigobius bifrenatus*
	Pseudogobius olorum
	Redigobius macrostoma
Hemihamphidae	*Arramphus sclerolepis*
Kuhliidae	*Nannoperperca oxleyana*
Lutjanidae	*Lutjanus argentimaculatus*
Megalopidae	*Megalops cyprinoides*
Melanotaeniidae	*Melanotaenia duboulayi*
	Pseudomugil signifer
	Rhadinocentrus ornatus
Monodactylidae	*Monodactylus argenteus*
Mugilidae	*Liza argentea*
	Mugil cephalus
	Myxus elongatus
	Myxus petardi
	Valamugil georgii
Percichthyidae	*Maccullochella ikei*
	Macquaria ambigua
	Macquaria colonorum
	Macquaria novemaculeata

Table 2: Fish species recorded in Tweed River estuary (from TEL 1990a, 1990b).

Family	Species
Ambassidae	*Ambassis jacksoniensis*
	Ambassis marianus
Atherinidae	Unidentified atherinid
Bothidae	*Pseudorhombus* sp.
Clupeidae	*Heklotsichthys castelnaui*
Eleotridae	*Philypnodon grandiceps*
	Philypnodon sp
Engraulidae	*Engraulis australis*
	Engraulis sp
Gerridae	*Gerres ovatus*
Girellidae	*Girella tricuspidata*
Gobiidae	Arenigobius bifrenatus
	Arenigobius frenatus
	Bathygobius cf *kreffti*
	Favonigobius exquisitus
	Favonigobius tamarensis
	Parkraemaria cf *ornata*
	Gobiopterus semivestita
	Pseudogobius olorum
	Redigobius macrostoma
	Unidentified goby
Hemirhamphidae	*Arrhampus sclerolepis*
	Hyporhampus regularis
Melanotaeniidae	*Pseudomugil signifer*
Monocanthidae	*Meuschenia trachylepis*
Monodactylidae	*Monodactylus argenteus*
Mugilidae	*Liza argentea*
	Mugil cephalus
	Myxus elongatus
	Unidentified mugilid
Percichthyidae	*Macquaria novemaculeata*
Platycephalidae	*Platycephalus fuscus*
	Platycephalus sp.
Pomatomidae	*Pomatomas saltator*
Scatophagidae	*Scatophagus argus*
Scorpaenidae	*Centropogon australis*
	Notesthes robusta
Sillaginidae	*Sillago ciliata*
Soleidae	*Achlyopa nigra*
	Aseraggodes macleayanus
Sparidae	*Acanthopagrus australis*
Syngnathidae	*Stigmatopora nigra*
	Urocampus carinirostris
Teraponidae	*Pelates quadrilineatus*
Tetraodontidae	*Torquigener pleurostictus*
	Unidentified tetraodontid

Table 3: Fish species recorded in Cudgen Creek and River (from TEL 1991).

Family	Species
Ambassidae	*Ambassis jacksoniensis*
	Ambassis marianus
Anguillidae	*Anguilla* sp
Atherinidae	*Atherinomorus ogilbyi*
	Craterocephalus fluviatilis
	Craterocephalus marjoriae
Belonidae	*Tylosaurus macleayanus*
Callionymidae	*Repomucenus calcaratus*
Clupeidae	*Heklotsichthys castelnaui*
	Potamalosa richmondia
Dasyatidae	*Dasyatis fluviorum*
Eleotridae	*Gobiomorphus coxii*
	Hypseleotris compressa
	Hypseleotris galii
	Philypnodon grandiceps
	Philypnodon sp
Elopidae	*Elops australis*
Gerridae	*Gerres ovatus*
Girellidae	*Girella tricuspidata*
Gobiidae	*Favonigobius exquisitus*
	Favonigobius lateralis
	Favonigobius tamarensis
	Pseudogobius olorum
	Redigobius macrostoma
Hemirhamphidae	*Arrhampus sclerolepis*
	Hyporhampus regularis
Melanotaeniidae	*Pseudomugil signifer*
Mondactylidae	*Monodactylus argenteus*
Mugilidae	*Liza argentea*
	Mugil cephalus
	Myxus elongatus
Percichthyidae	*Macquaria novemaculeata*
Platycephalidae	*Platycephalus arenarius*
	Platycephalus fuscus
Plotosidae	*Tandanus tandanus*
Poeciliidae	*Gambusia affinus*
Scorpaenidae	*Centropogon australis*
	Notesthes robusta
Sillaginidae	*Sillago ciliata*
Sparidae	*Rhabdosargus sarba*
	Acanthopagrus australis
Teraponidae	*Terapon jarbua*
Tetraodontidae	*Tetractenos hamiltoni*
	Torquigener pleurogramma
	Unidentified tetraodontid