Karuah to Bulahdelah

PACIFIC HIGHWAY UPGRADING

VOLUME 1

EXECUTIVE SUMMARY
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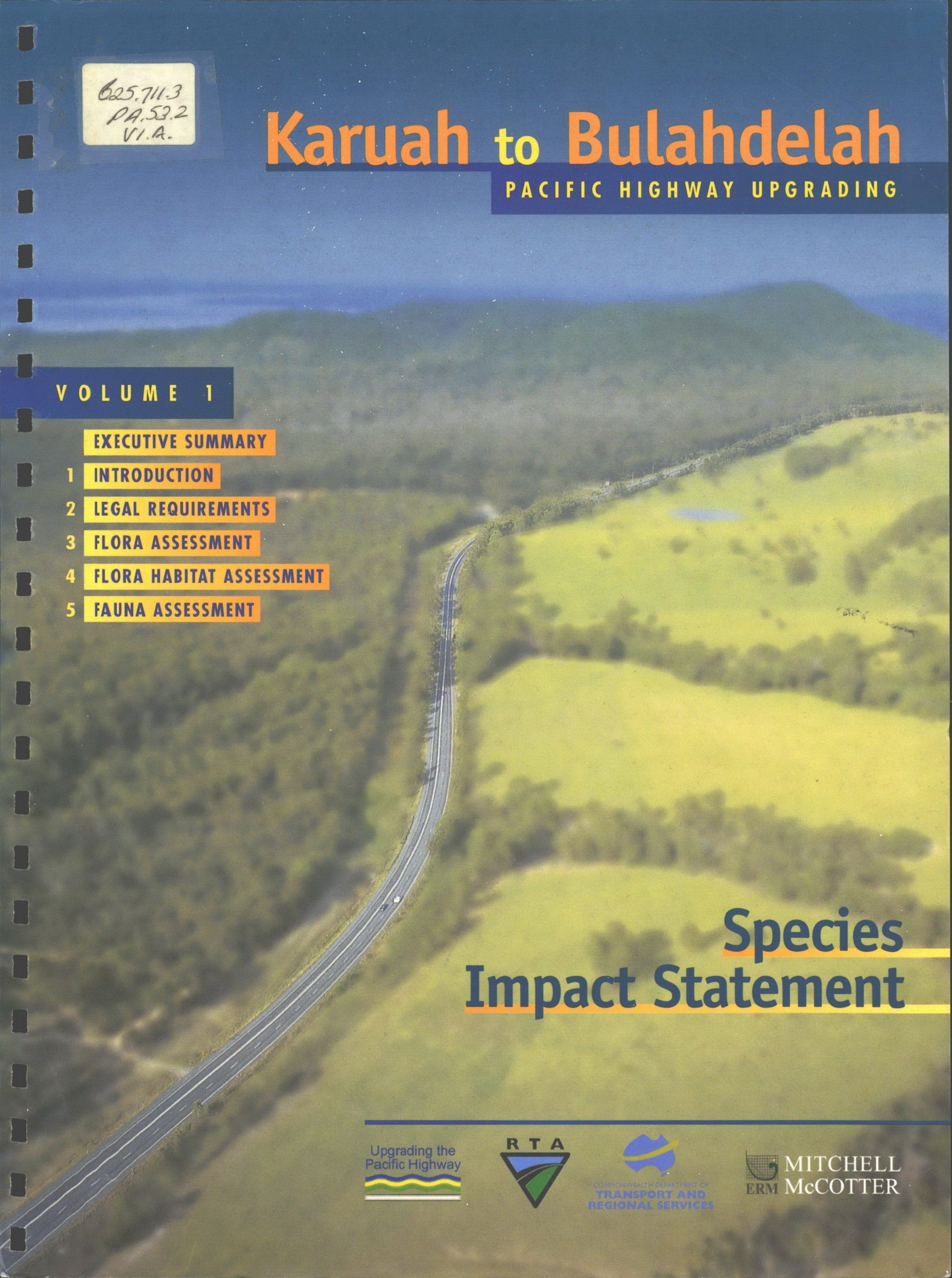
Species Impact Statement



Upgrading the Pacific Highway
RTA
COMMONWEALTH DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES
ERM MITCHELL McCOTTER

KARUAH TO BULAHDELAH PACIFIC HIGHWAY UPGRADING

Species Impact Statement

For:
NSW ROADS AND TRAFFIC AUTHORITY

May, 1999
38067SIS

CERTIFICATION

This is to certify that this Species Impact Statement has been prepared in accordance with the requirements of Section 109, 110 and 111 of the *Threatened Species Conservation Act 1995*, the requirements notified by the Director-General of NSW National Parks and Wildlife Service, and with regard to those matters identified by Section 5A of the *Environmental Planning and Assessment Act 1979*.

The mitigation measures included in this report have been developed in consultation with the RTA and National Parks and Wildlife Service.

The curriculum vitae of the following team members are included in *Appendix B*.

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Report No. 38067SIS

This report was prepared in accordance with the scope of services set out in the contract between ERM Mitchell McCotter Pty Ltd ACN 002 773 248 (ERMMM) and the NSW Roads and Traffic Authority (RTA). To the best of our knowledge, the proposal presented herein accurately reflects the RTA's intentions when the report was printed. However, the application of conditions of approval or impacts of unanticipated future events could modify the outcomes described in this document. In preparing the report, ERMMM used data, surveys, analyses, designs, plans and other information provided by the individuals and organisations referenced herein. While checks were undertaken to ensure that such materials were the correct and current versions of the materials provided, except as otherwise stated, ERMMM did not independently verify the accuracy or completeness of these information sources.

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ERM Mitchell McCotter Quality System

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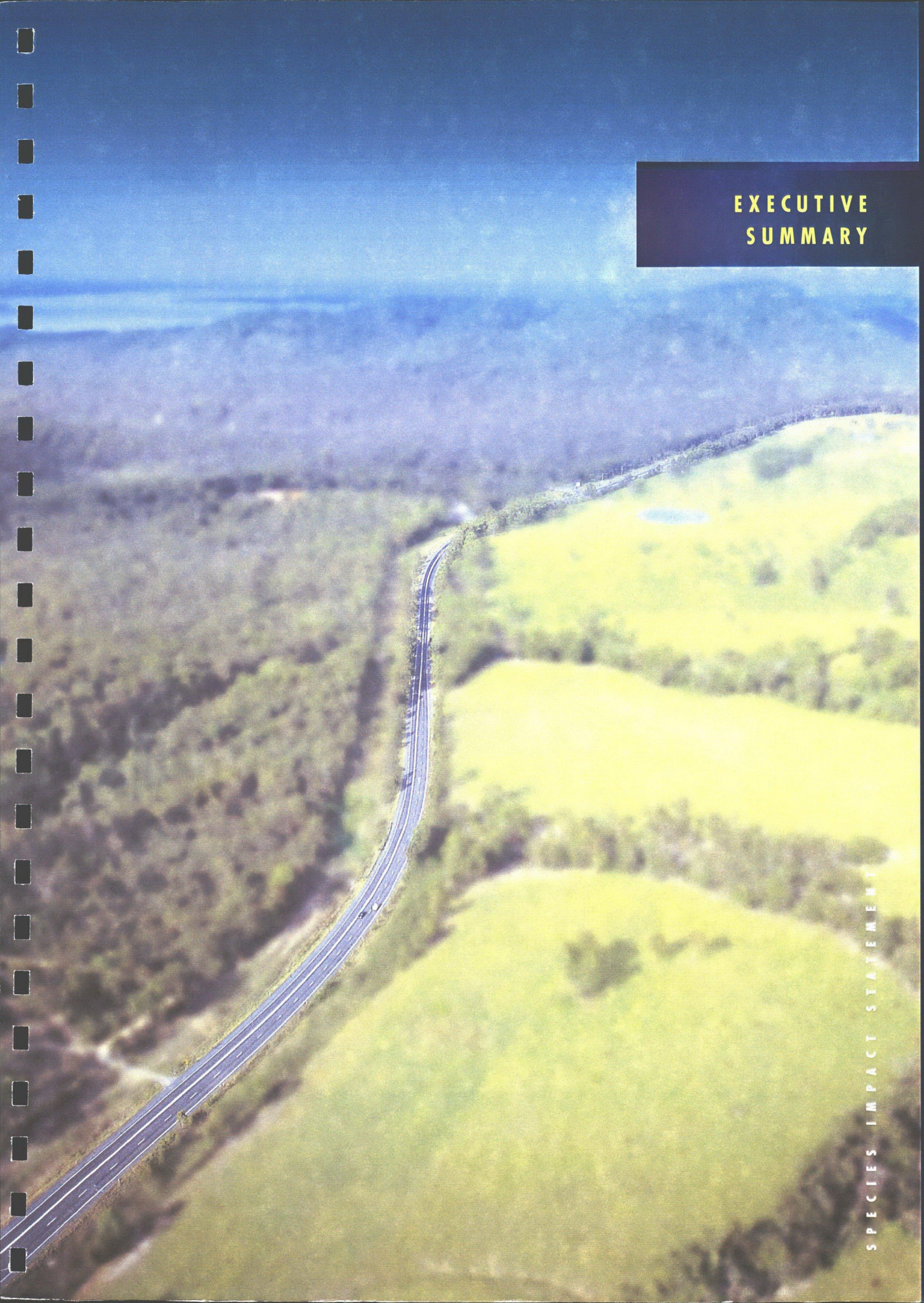


EXECUTIVE SUMMARY

SPECIES IMPACT STATEMENT

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

PURPOSE

The purpose of this Species Impact Statement (SIS) is to assess the likely impacts on threatened and regionally significant species that could arise from the proposed Upgrading of the Pacific Highway between Karuah and Bulahdelah in the mid north coast region of New South Wales. For the purposes of this report, "threatened species" are those specified in Parts 1 or 4 or in Schedule 2 of the *Threatened Species Conservation* (TCS) *Act, 1995*.

The list of threatened and significant species that are the subjects of this SIS was derived in consultation with the New South Wales National Parks and Wildlife Service (NPWS), and by reviewing flora and fauna surveys conducted along and near the proposed Upgrade. This SIS has been prepared in accordance with Sections 109 and 110 of the TSC Act (1995) and the requirements of the Director-General of the NPWS pursuant to Section 111 of the TSC Act (1995).

Key objectives of the investigation were to:

- map and describe the plant communities and fauna habitats occurring in the area along and near the proposed route of the Pacific Highway Upgrade between Karuah and Bulahdelah;
- determine the likelihood of occurrence of threatened flora and fauna species, populations or communities as listed under the TSC Act (1995), and regionally significant species;
- assess the potential significance of cumulative impacts of the proposed Upgrade on any threatened or regionally significant flora or fauna species and populations; and
- obtain sufficient data to enable appropriate measures to be developed and implemented so as to protect and enhance the survival of threatened flora and fauna populations along the route of the Upgrade and the immediate environs.

BACKGROUND

The Commonwealth and NSW Governments have committed $2.2 billion to major upgrading of the Pacific Highway between Hexham and the Queensland border over a 10-year period.

As part of this major Upgrade strategy, the Road Traffic Authority (RTA) has completed the concept design for the 36.75 km section of the Pacific Highway between the townships of Karuah and Bulahdelah. The design proposes the construction of two carriageways and removal of the existing carriageway along the Pacific Highway between points about four kilometres north of the Karuah Bridge (at Karuah) and 1.5 kilometres south of the Myall River Bridge (at Bulahdelah). The proposal includes construction of new intersections, rest areas and new bridges at Bulga and Bundabah Creeks. The "study area", described in detail in *Section 1.3*, is defined as a 200 m wide corridor of land along the proposed route of the 36.75 km Upgrade.

Assessments of the likely impacts on threatened species were made previously by ERM Mitchell McCotter (1998) who addressed Section 5A of the *Environmental Planning and Assessment Act 1979* ("Eight Part Test of Significance"). The Eight Part Test concluded that no significant impacts were likely on threatened species because:

- the proposed development was relatively small compared with the extent of unmodified habitat to remain in the locality; and

- extensive mitigation measures are incorporated into the project and are to be implemented by the RTA to ameliorate adverse impacts from the Upgrade proposal.

Special consideration was given to the potential impacts of the proposal on threatened frog species, koalas, regent honeyeaters and sugar gliders, and threatened plant species, which are likely to be found along the proposed Upgrade route. These species were deemed to be potentially impacted upon by habitat clearance, erosion, sedimentation and/or colliding with highway traffic.

This SIS has been prepared in order to more fully evaluate the impacts of the proposal on species of conservation significance and to propose detailed mitigation measures. The preparation of a SIS should not be interpreted to imply that the earlier conclusions in the Eight Part Test are now invalid. The SIS has been prepared as a precautionary measure and the conclusions arising from the assessment indicate that no likely significant impacts on threatened species would occur provided that mitigation measures are implemented.

PROPOSED DEVELOPMENT

The Upgrade would involve clearing of approximately 123 hectares of native vegetation, consisting of mostly dry open forest (84 hectares) and woodland (27 hectares). Approximately six hectares of closed forest, five hectares of shrubland and 1.2 hectares of swamp forest will also be cleared.

A number of major mitigation measures have been included in the proposed development and are likely to be very important in protecting threatened and regionally significant species. These are described in the final section of the Executive Summary.

METHODS

Fauna and flora surveys were conducted within the study area in compliance with the recommendations from the Director-General of the National Parks and Wildlife Service. The resultant survey effort for threatened and regionally significant species targeted all of the species that were deemed likely to occur within habitats present in the study area. Survey methods for threatened flora and for mapping fauna habitats are described in *Chapter 4*, and survey effort and methods for detecting threatened fauna are summarised in *Table 5.3* of the SIS.

Additional information about threatened species in the locality was obtained through literature reviews of previous surveys, consultation with local public authorities, individuals and interest groups and searches of the NPWS Wildlife Atlas and State Forests of NSW databases.

RESULTS OF SURVEYS

Investigations for the SIS indicate that 15 threatened fauna species, one threatened plant species and one regionally significant plant species are known to occur in the study area. An additional 14 threatened fauna species, five threatened plant species, two endangered plant species and two regionally significant plant species are likely to occur in the study area based on existence of suitable habitat. These are listed in the tables below.

THREATENED, RARE AND REGIONALLY SIGNIFICANT SPECIES LIKELY TO OCCUR IN THE STUDY AREA

FAUNA SPECIES

Class	Scientific Name	Common Name	Record Status	Recorded Location	Likeli-hood of Occur-rence
Amphibians	*Litoria brevipalmata*	Green-thighed frog	P; C	NR	known to occur
Reptiles	*Hoplocephalus stephensii*	Stephen's banded snake	none		high
	Hoplocephalus bitorquatus	Pale-headed snake	none		high
Mammals	*Phascogale tapoatafa*	Brush-tailed phascogale	none		moderate
	Phascolarctos cinereus	Koala	P; C	WG; NW; JC; NW Rock; BC; FCT; NV; NR; MK	known to occur
	Dasyurus maculatus	Spotted-tailed quoll	C	NW	known to occur
	Petaurus norfolcensis	Squirrel glider	P		known to occur
	Petaurus australis	Yellow-bellied glider	P		known to occur
	Potorous tridactylus	Long-nosed potoroo	C	GGG	known to occur

FAUNA SPECIES

Class	Scientific Name	Common Name	Record Status	Recorded Location	Likeli-hood of Occur-rence
	Planigale maculata	Common planigale	none		high
	Mormopterus norfolkensis	Eastern freetail bat	P; C	BG	known to occur
	Miniopterus australis	Little bent-wing bat	C	BC; JC2	known to occur
	Miniopterus schreibersii	Large bent-wing bat	C	BC; JC2	known to occur
	Myotis adversus	Large-footed myotis	C	JC1	known to occur
Aves	*Burhinus grallarius*	Bush stone-curlew	none		low - moderate
	Calyptorhynchus lathami	Glossy black-cockatoo	P; C	throughout	known to occur
	Lophoictinia isura	Square-tailed kite	none		high
	Tyto novaehollandiae	Masked owl	P; C		known to occur
	Ninox strenua	Powerful owl	none	NW	moderate-high
	Ninox connivens	Barking owl	none		high

FAUNA SPECIES

Class	Scientific Name	Common Name	Record Status	Recorded Location	Likeli-hood of Occur-rence
	Tyto capensis	Eastern grass owl	P		known to occur
	Neophema pulchella	Turquoise parrot	none		moderate - high
	Lathamus discolor	Swift parrot	none		moderate - high
	Xanthomyza phrygia	Regent honeyeater	none		moderate
	Ixobrychus flavicollis	Black bittern	none		high
	Epippiorhynchus asiaticus	Black-necked stork	P		known to occur
	Ptilinopus magnificus	Superb fruit-dove	none		low - moderate
	Ptilinopus regina	Rose-crowned fruit-dove	none		low - moderate
	Ptilinopus magnificus	Wompoo fruit-dove	none		low - moderate

Key: P Previous record C Recorded during surveys

FLORA SPECIES

Scientific Name	TSC listing	ESP listing	RoTAP classification	Likelihood of Occurrence
Plectranthus suaveolens	Not listed	Not listed	3KC-	High. Known to occur in the locality.
Eucalyptus glaucina	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VCa	High. Known to occur in the locality.
Tetratheca juncea	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VCa	Recorded within the study area.
Prostanthera densa	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VC-	High. Known to occur in the locality.
Syzygium paniculatum	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VCi	High. Known to occur in the locality.
Melaleuca groveana	Schedule 2 - Vulnerable	Not listed	3RC-	High. Known to occur in the locality.
Asperula asthenes	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VC-	High. Known to occur in the locality.
Eucalyptus fergusonii ssp. fergusonii	Not listed	Not listed	3KC-	Recorded within the study area.
Grevillea guthrieana	Not listed	Part 1 - Endangered	3V	High. Known to occur in the locality.
Macrozamia pauli-guilemimim ssp flexuosa	Not listed	Part 1 - Endangered	2K	High. Known to occur in the locality.
Callistemon acuminatus	Not listed	Not listed	3RC-	High. Known to occur in the locality
Goodenia fordiana	Not listed	Not listed	2RC-	High. Known to occur in the locality.

Notes: 1. *ESP Act = Endangered Species Protection Act, 1992.*

2. *TSC Act = Threatened Species Conservation Act, 1995.*

3. *RoTAP = Rare or Threatened Australian Plant (Briggs and Leigh 1996)*

Key to Briggs and Leigh (1996)

Distribution Category

2 *geographic range less than 100 km*

3 *geographic range more than 100 km*

Conservation Status

E Endangered - species in serious risk of disappearing from the wild state within one to 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 threatened 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.

K Poorly known - taxon that is suspected, but not definitely known, to belong to one of the above categories. At present, accurate field distribution information is inadequate..

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.

Although about 123 hectares of native vegetation would be cleared for the proposed Upgrade, nearly all of this habitat is already moderately to severely degraded from existing impact processes. These processes include agricultural and forest activities, and the construction and use of the existing Pacific Highway. Consequently, it is expected that the threatened and regionally significant species would use these areas less than other more intact habitat in adjacent areas.

The greatest impacts of the proposed Upgrade are likely to be a further reduction of the effectiveness of wildlife corridors in the dispersal of threatened species, removal of existing and potential food trees, and changes to the hydrology and/or water quality in areas alongside the road. Therefore, mitigation measures have been tailored more directly at the amelioration of impacts on threatened and regionally significant species considered likely to have the highest potential to be impacted upon. These are the Green-thighed Frog *Litoria brevipalmata*, Koala *Phascolarctos cinereus*, Regent Honeyeater *Xanthomyza phrygia*, Squirrel Glider *Petaurus norfolcensis* and the plant species *Tetratheca juncea* and *Eucalyptus fergusonii* ssp. *fergusonii*. For this reason, the best practice mitigation measures listed below and described in detail in *Chapter 7* have been designed to minimise impacts upon the habitats of these species, especially on the roadsides and on or near wetlands and creeks.

MITIGATION MEASURES

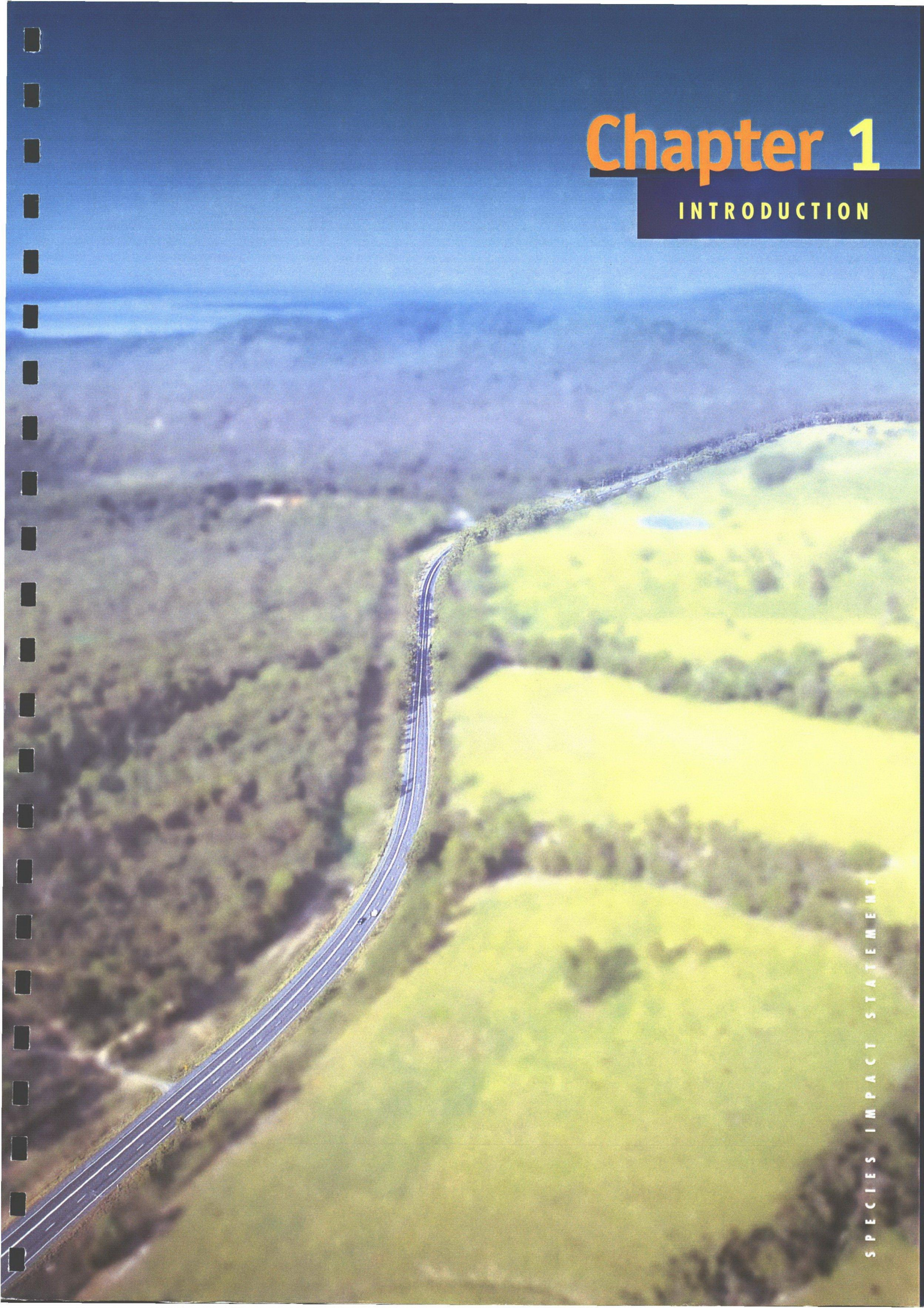
The following best practice mitigation measures are designed to minimise impacts upon the habitats of threatened and regionally-significant species, especially on the roadsides and on or near wetlands and creeks:

- provision of compensatory habitat within the locality for the natural dispersal of threatened and regionally significant species and transplantation of plants such as *Tetratheca juncea*;
- where possible, avoidance or minimum clearance of areas of conservation significance;
- rehabilitation of some cleared areas through planting of locally native vegetation, especially plants that provide food, breeding sites and shelter for threatened and regionally significant fauna;
- provision of road underpasses (culverts and bridges) and an overpass (bridge) in strategic locations where the Upgrade is known to pass through wildlife corridors, particularly corridors of koala movement;

- construction of exclusion fences along sections of the highway where there is an elevated risk of wildlife road strikes;
- provision of roadside warning signs for motorists at locations along the highway where there are frequent or large volumes of wildlife pedestrian movement;
- implementation of a sediment control plan that makes extensive provision for minimisation of erosion and protection of wetlands and streams, particularly frog habitats; and
- implementation of a medium to long-term monitoring program along the route of the Upgrade to ensure the effectiveness of proposed mitigation measures on the management of threatened and regionally significant species in the locality.

Chapter 1

INTRODUCTION



Chapter 1

INTRODUCTION

This chapter identified the purpose of the Species Impact Statement and describes the background to the study. The study area is defined and the proposed Upgrade described.

1.1 PURPOSE

The purpose of this Species Impact Statement (SIS) is to provide an assessment of the impacts on threatened and regionally significant species of the proposed Upgrading of the Pacific Highway between Karuah and Bulahdelah. The SIS assessment was prepared in response to Section 5a of the *Environmental Planning and Assessment Act, 1979*. The SIS provides a detailed assessment of the impacts of the proposed Upgrade on threatened species listed in the *Threatened Species Conservation Act, 1995*, and on regionally significant species. The SIS complies with the requirements of the TSC Act and with the requirements of the Director General of the National Parks and Wildlife Service (hereafter referred to as the DG's requirements). These requirements appear in *Appendix A*. All definitions applicable to this SIS are listed in *Chapter 2*.

1.2 STUDY BACKGROUND

1.2.1 General

In January 1996, the Commonwealth and NSW State Governments announced the largest peace-time civil construction project in Australia's history since the building of the Snowy Mountains hydro-electric scheme, with the announcement that $2.2 billion would be made available for major upgrading of the Pacific Highway between Hexham and the Queensland border over a ten year period.

As part of the major upgrading strategy, the RTA has completed the concept design for the 36.75 km section of the Pacific Highway between the townships of Karuah and Bulahdelah (*Figure 1.1*). During 1998 a Review of Environmental Factors (REF) was prepared to assess the environmental impacts of the proposed Upgrading. This included the preparation of an eight part test of significance to determine whether or not the proposed Upgrade would have a significant impact on threatened species or their habitats. The REF assessed the construction of an additional carriageway and rehabilitation of the existing road. The REF for the highway upgrade was reviewed

by the RTA towards the end of 1998. The decision report for the REF concluded that flora and fauna issues had not been addressed to the fullest extent possible. Consequently, it was recommended to proceed to the preparation of an Environmental Impact Statement (EIS). Furthermore, following the preparation of the REF, NPWS released habitat models predicting the occurrence of a large number of species of conservation significance in close proximity to the proposed Upgrade. Giving consideration to these models and following further consultation with the National Parks and Wildlife Service it was also decided to prepare a Species Impact Statement (SIS).

Following the decision to prepare an EIS and SIS, the scope of the further studies was determined. Included in the assessment process was a Value Management Study (VMS) undertaken to bring together various stakeholder perspectives which need to be reflected in the project; review the work undertaken to date and develop a preferred direction to complete the planning phase of the project.

The outcome of the VMS was to proceed with the assessment of the impact of constructing two dual carriageways separated by a vegetated median along the length of the study corridor and adjacent to the existing carriageway.

The revised Upgrading involves the construction of two carriageways and removal of the existing carriageway along the Pacific Highway between a point about four kilometres north of the Karuah bridge and a point about 1.5 kilometres south of the Myall River Bridge at Bulahdelah. The proposed Upgrade includes construction of new intersections, rest areas and new bridges at Bulga and Bundabah Creeks.

The RTA is the proponent and the nominated determining authority for the proposal. The Minister for Urban Affairs & Planning is the approving authority. The Director General of the NPWS is required to give concurrence to the proposal before approval of its construction can be given.

1.2.2 Regional Forestry Agreement Areas

A portion of Nerong State Forest has been set aside as part of the Regional Forestry Agreement for inclusion in the Comprehensive, Adequate and Representative (CAR) system and has recently been gazetted as an extension to Myall Lakes National Park (*Figure 1.2*). The reasons for the gazettal of this area are unclear, however it is presumed this area is of conservation value, particularly in respect to its proximity to the previous area of Myall Lakes National Park. Portions of both of this Park would be directly affected by the proposed Upgrade, through clearing, edge effects and increased barrier effects. The impacts of the Upgrade on these areas have been addressed throughout this SIS.

MITCHELL
ERM McCOTTER

KARUAH TO BULAHDELAH LOCALITY

LOCATION OF STUDY AREA

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Figure 1.1 LOCALITY PLAN

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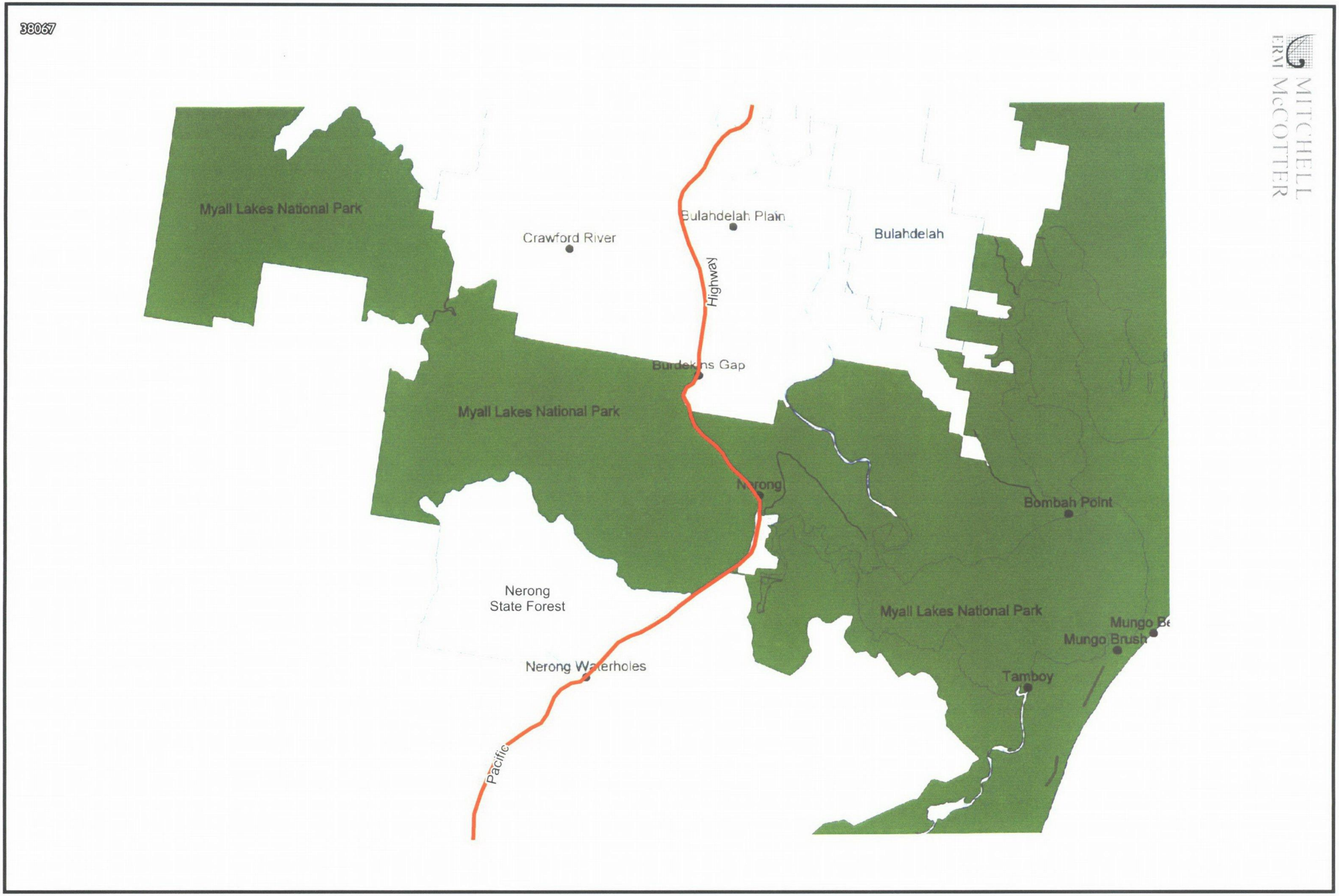

Figure 1.2 MYALL LAKES NATIONAL PARK

1.3 THE STUDY AREA AND SUBJECT SITE

The study area covered by the proposed Upgrade is a corridor of land located between the townships of Bulahdelah and Karuah on the mid north coast of NSW. The 36.75 km route of the proposed Upgrade is illustrated in *Figure 1.3*.

The study area is defined as a 1 kilometre wide corridor extending both sides of the existing section of the Pacific Highway for a distance of 500 m. The subject site is the area that would be directly disturbed by the proposed Upgrade

Further characteristics of the study area and subject site are described further below.

1.3.1 Landform and Geology

The study area contains three physiographic regions: the Karuah Mountains; the Coweambah Hills; and the Nerong Hills (Murphy 1995).

At the southern end of the study corridor lie the Karuah Mountains. These mountains are steep, cone-shaped hills with an elevation of 100 to 260 m. They occur on siliceous Carboniferous Nerong volcanics that consist of ignimbrites. Narrow, peaked crests, long steep-sided slopes and narrow incised drainage lines are typical landform elements.

The Coweambah Hills dominate the centre portion of the study area. They comprise gently undulating to rolling rises to steep low hills on predominantly folded and faulted Carboniferous sediments and volcanics. Steep to rolling hills grade into long, gently undulating footslopes with large drainage plains and ill-defined drainage lines. This landform unit covers the majority of the study area.

On Carboniferous and Permian aged rocks in the north of the study corridor, lie the Nerong Hills, a complex array of steep hills. They include volcanic flows of the Nerong Volcanics and Alum Mountain Volcanics as well as extensively folded sedimentary rocks with strong north-west to south-east aligned strike ridges and steeply dipping slopes.

The region around the study area consists of two distinct geological formations which are described in Mitchell McCotter (1986) and TCM (undated). These formations are the Nerong Volcanics and the Wootton Beds.

The section of the study area south of Bulga Creek is underlayed by the Nerong Volcanics. These rocks include rhyolite, basalt, andesite, tuff, toscanite, tuffaceous sandstone and other volcanic rocks. Near the surface, rocks from this formation are generally highly fractured and jointed, and a substantial degree of weathering has occurred along these planes of weakness.

North of Bulga Creek to Nerong, the study area is underlayed by a formation of sedimentary rocks known as the Wootton Beds. This formation includes conglomerate, sandstone, tillite, shale, mudstone and colitic limestone. These rocks have also been highly fractured and weathered.

The study area traverses the western extent of Quaternary unconsolidated sediments along low lying areas around Viney Creek, Split Yard Creek and north of the Booral Road intersection. These sediments include estuarine clays, marine sands and carbonaceous cemented sands (also known as *indurated sands*).

Other geological formations in the study area include the Conger Formation, Alum Mountain Volcanics, Crawford Formation and the Bulahdelah Formation. These geological units are generally comprised of sandstones and conglomerates and only occur in a small portion of the study area.

1.3.2 Soils

A total of five soil landscape groups occur within the study area. The general pattern is of poorly drained soil with variable soil textures, and that have a predominantly acid soil reaction. Each of the five soils landscapes are discussed below and are related to the vegetation types occurring throughout the study area.

Transferral landscapes can be found at Grey Gum Gully, Mount Karuah, the upper and lower reaches of Bulga Creek, Bundabah Creek, Station Creek, Viney Creek, Nerong Waterholes, Yard Creek, Jacks Creek and surrounding a number of unnamed creeks/intermittent drainage lines. This soil landscape is the most common in the study area and is generally characterised by undulating plains and rises on the McInnes geological formation. It has a slope gradient of less than five percent and a local relief of less than 10 m. This landscape group is characterised by seasonal waterlogging and acid soils of low fertility. The group underlies predominantly uncleared *Angophora costata/Eucalyptus* woodland (DLWC 1995) and closed forest types.

Residual landscapes can be found at North Arm Cove, Bulga Creek and on a number of undulating hills throughout the study area. The group is characterised by hills on ignimbrites of the Nerong Volcanics geological formation. Broad crests, gently inclined slopes and narrow drainage lines occur and minor rocky peaked crests occur throughout the group. It is characterised by partially cleared to extensively cleared Eucalypt/Angophora open forest to Eucalypt tall closed forest. This group has a high erosion hazard and acid soils of low fertility with dense, slowly permeable subsoils with localised shrink swell potential, localised flooding and seasonal waterlogging (DLWC 1995).

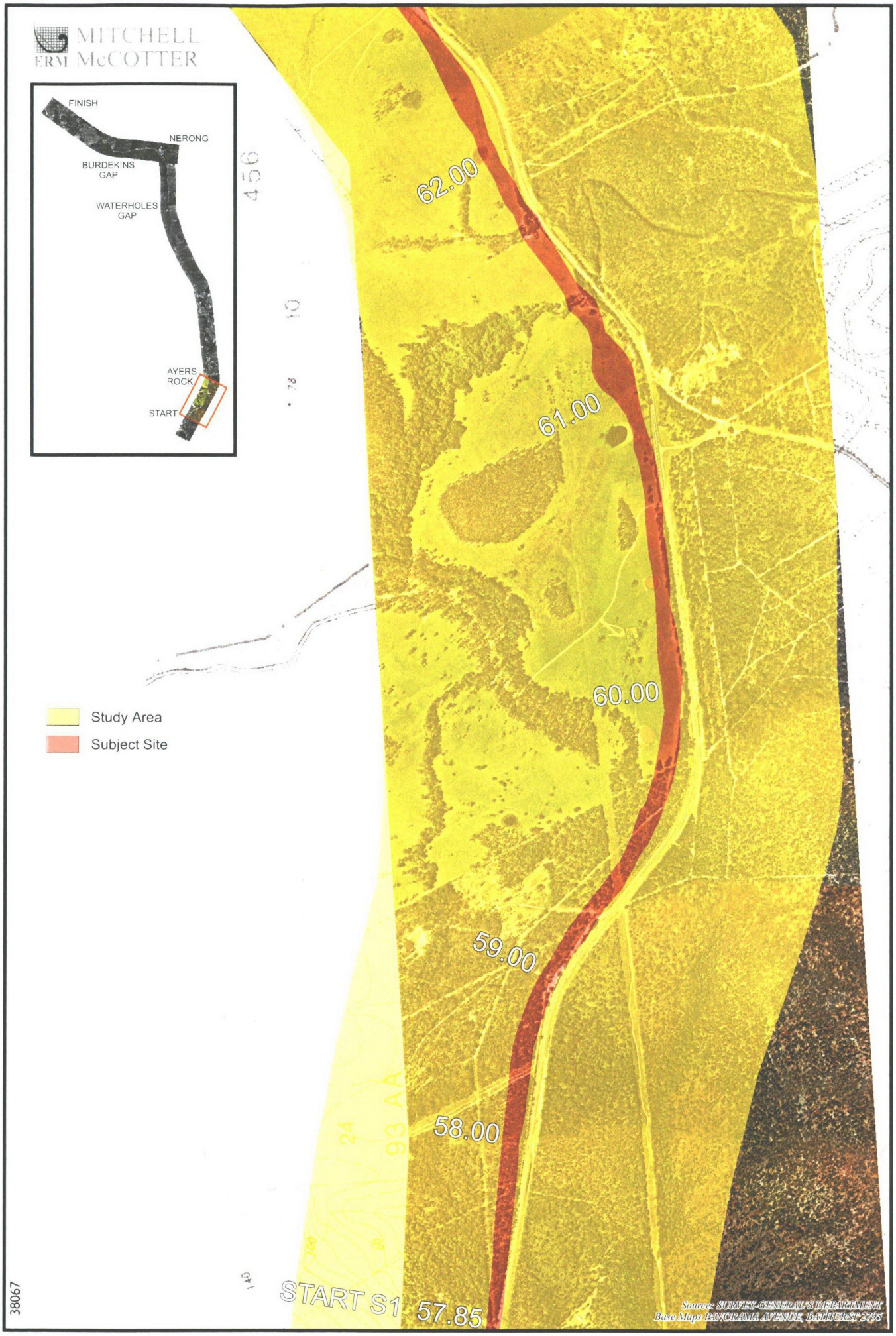

Figure 1.3a STUDY AREA / SUBJECT SITE

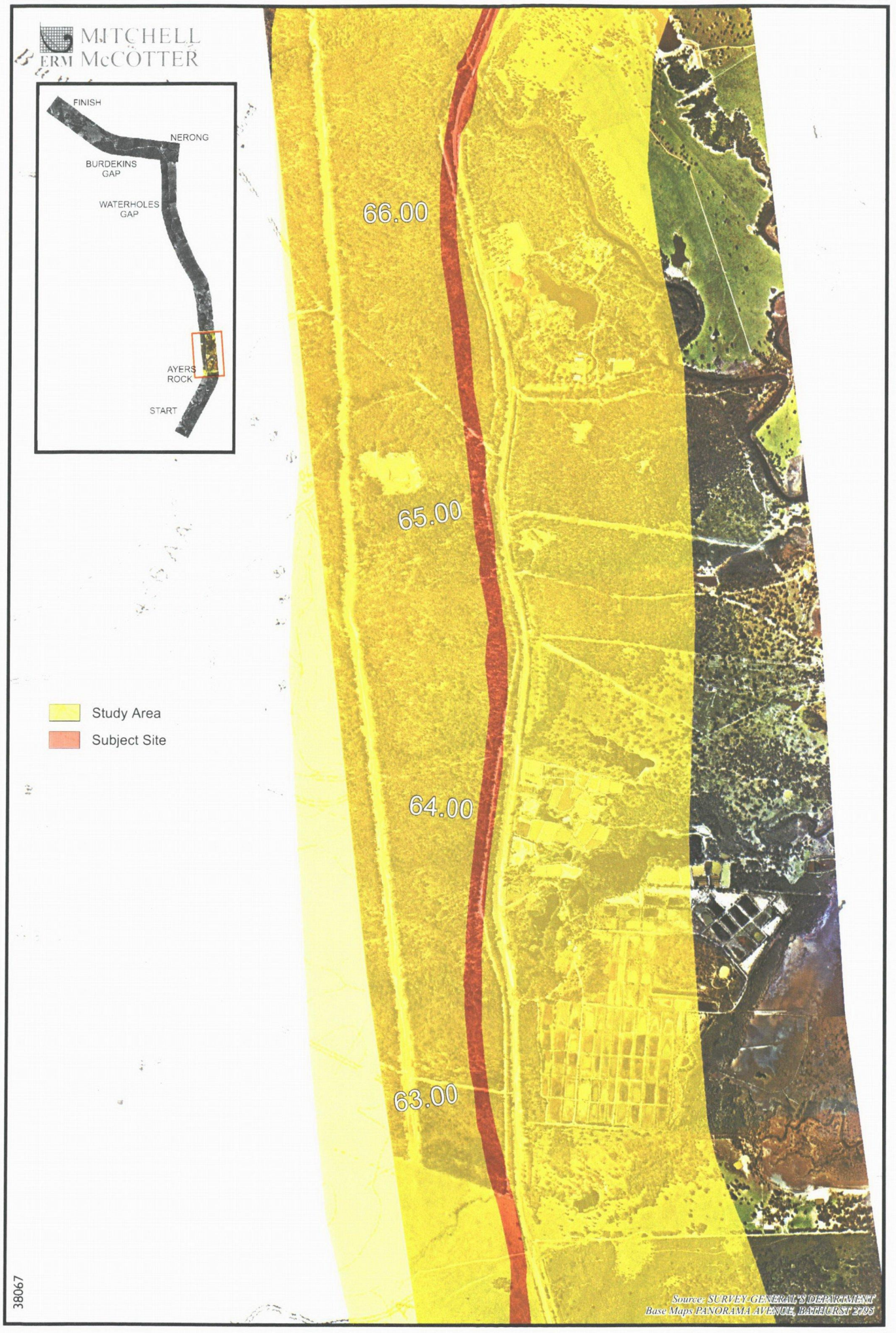

Figure 1.3b STUDY AREA / SUBJECT SITE

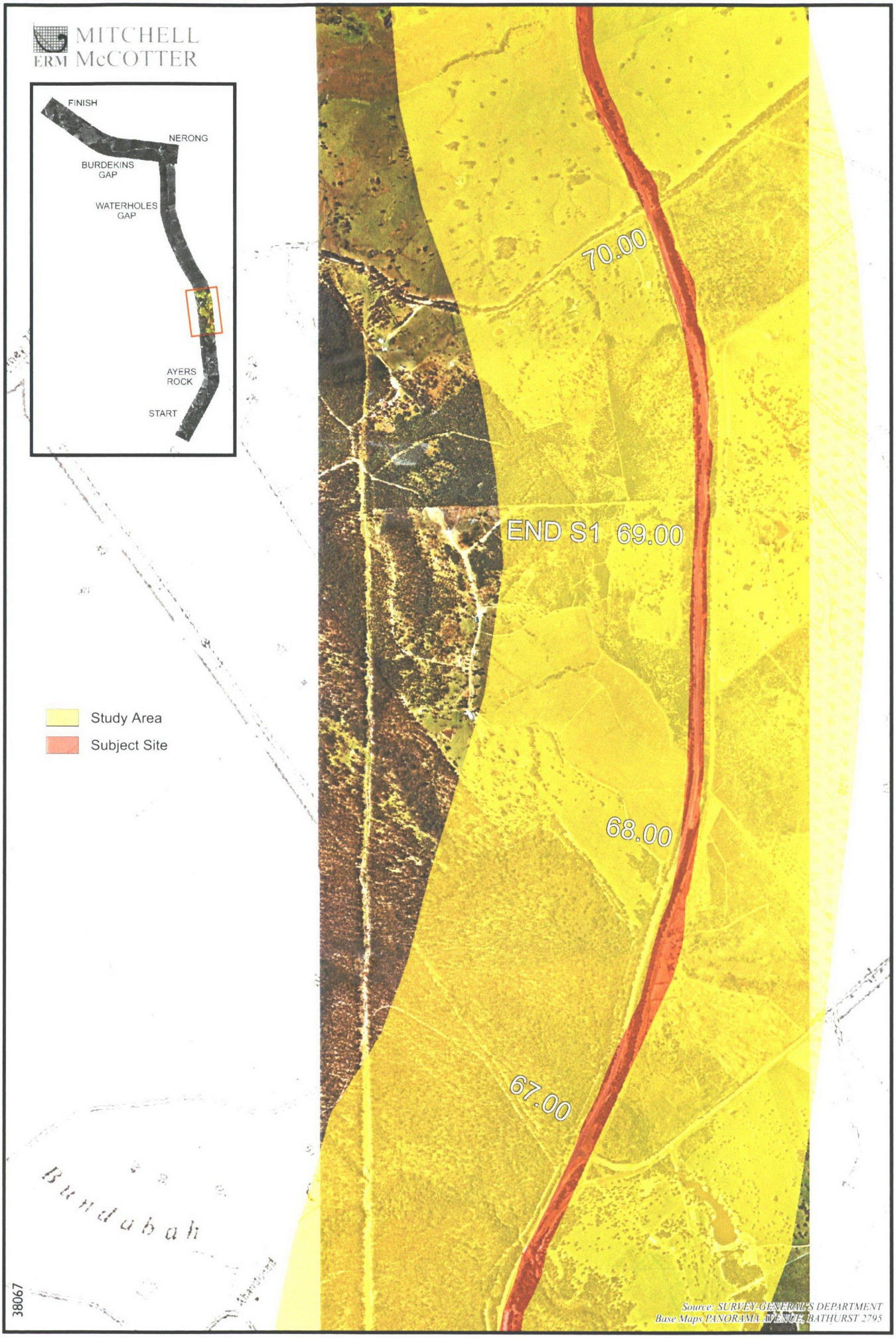

Figure 1.3c STUDY AREA - SUBJECT SITE

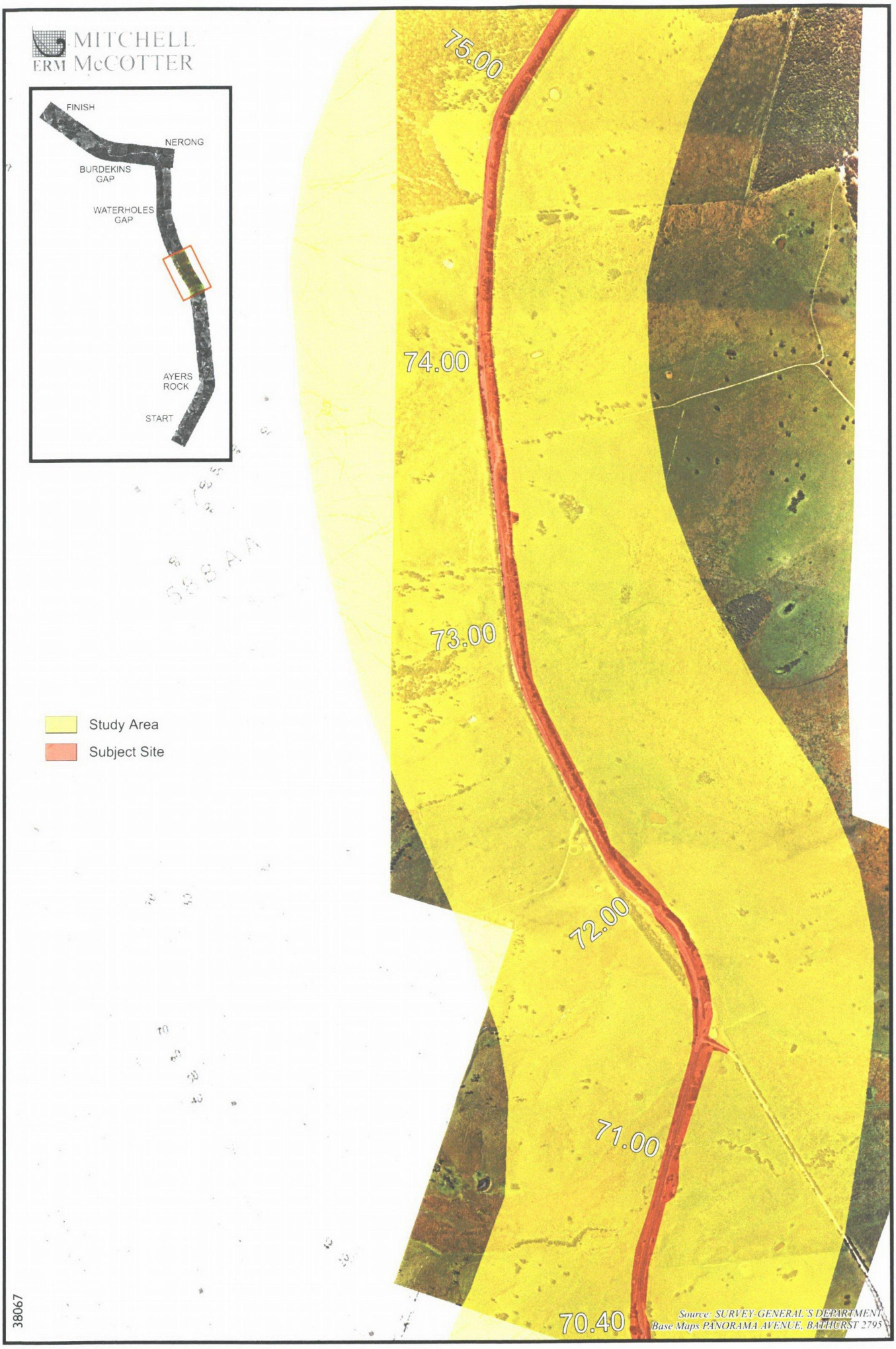

Figure 1.3d STUDY AREA / SUBJECT SITE

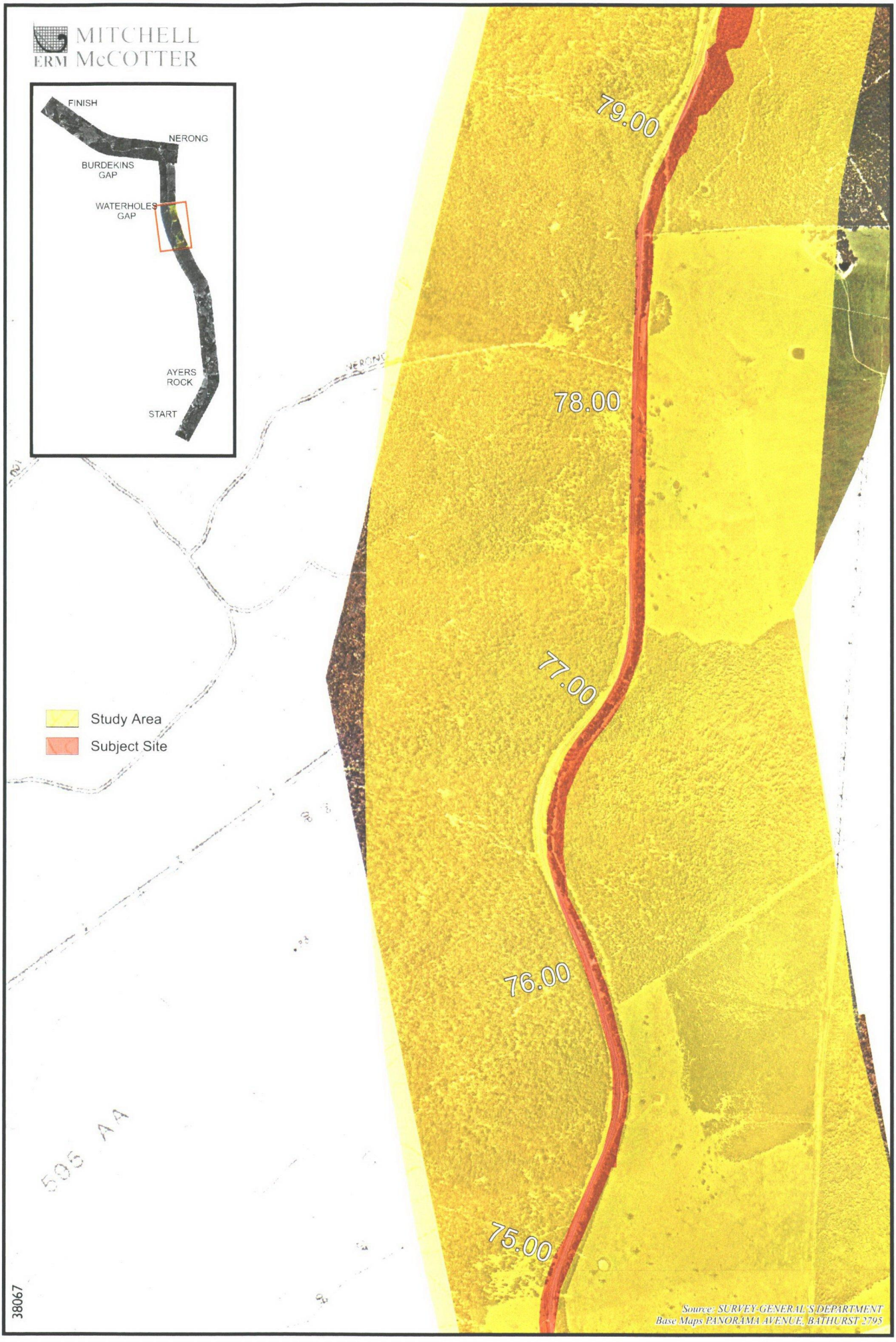

Figure 1.3e STUDY AREA / SUBJECT SITE

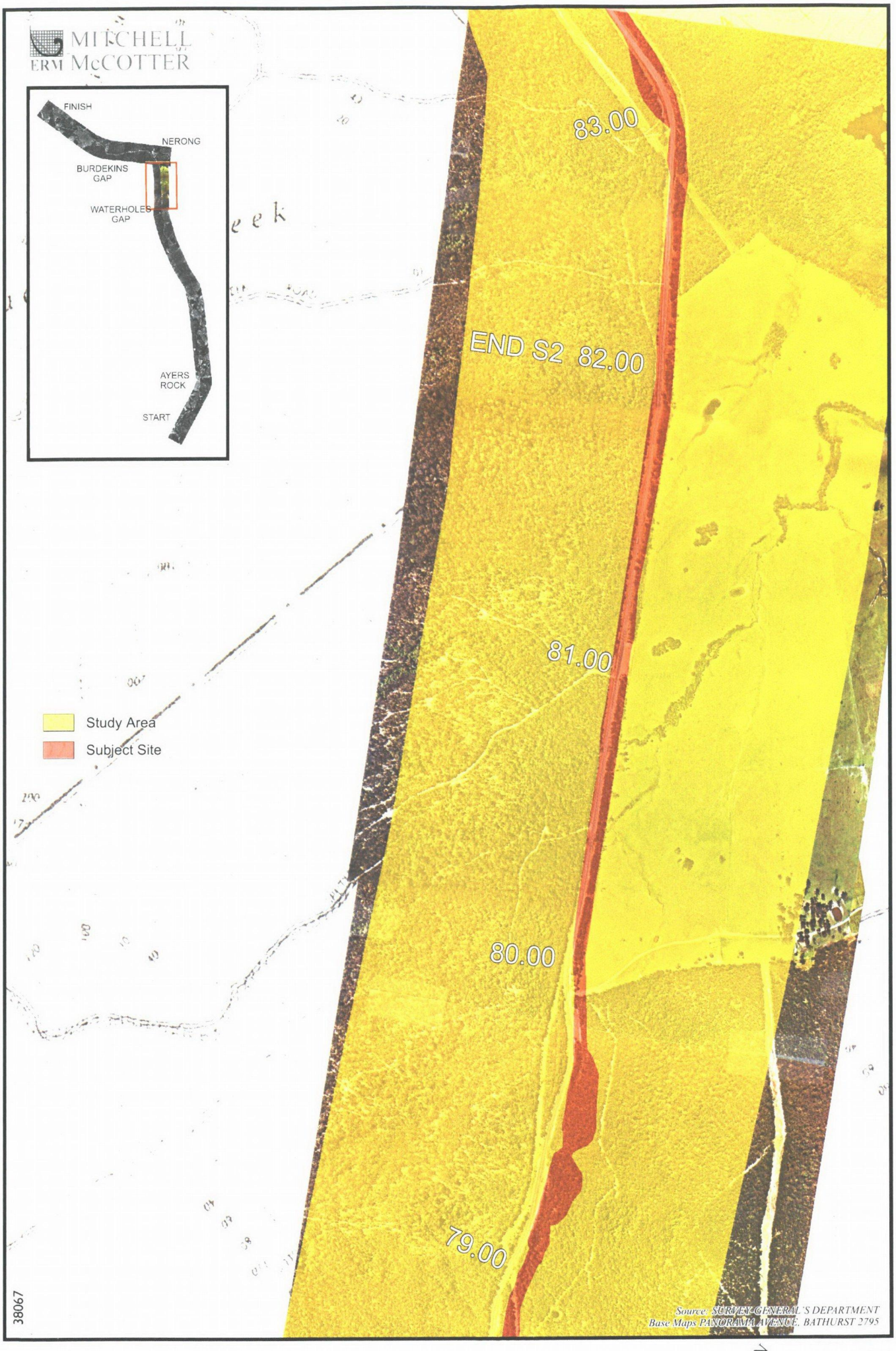

Figure 1.3f STUDY AREA / SUBJECT SITE

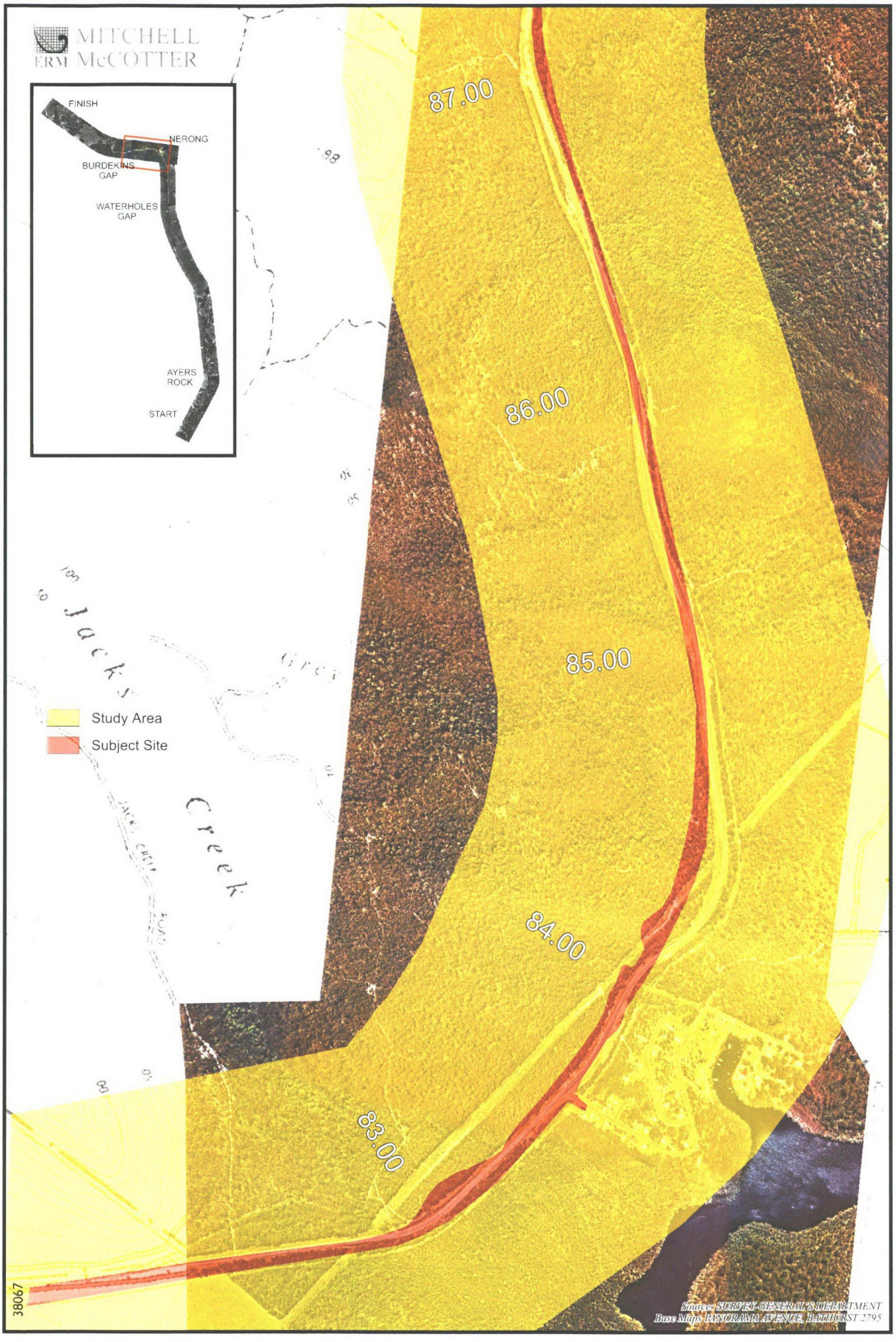

Figure 1.3g STUDY AREA / SUBJECT SITE

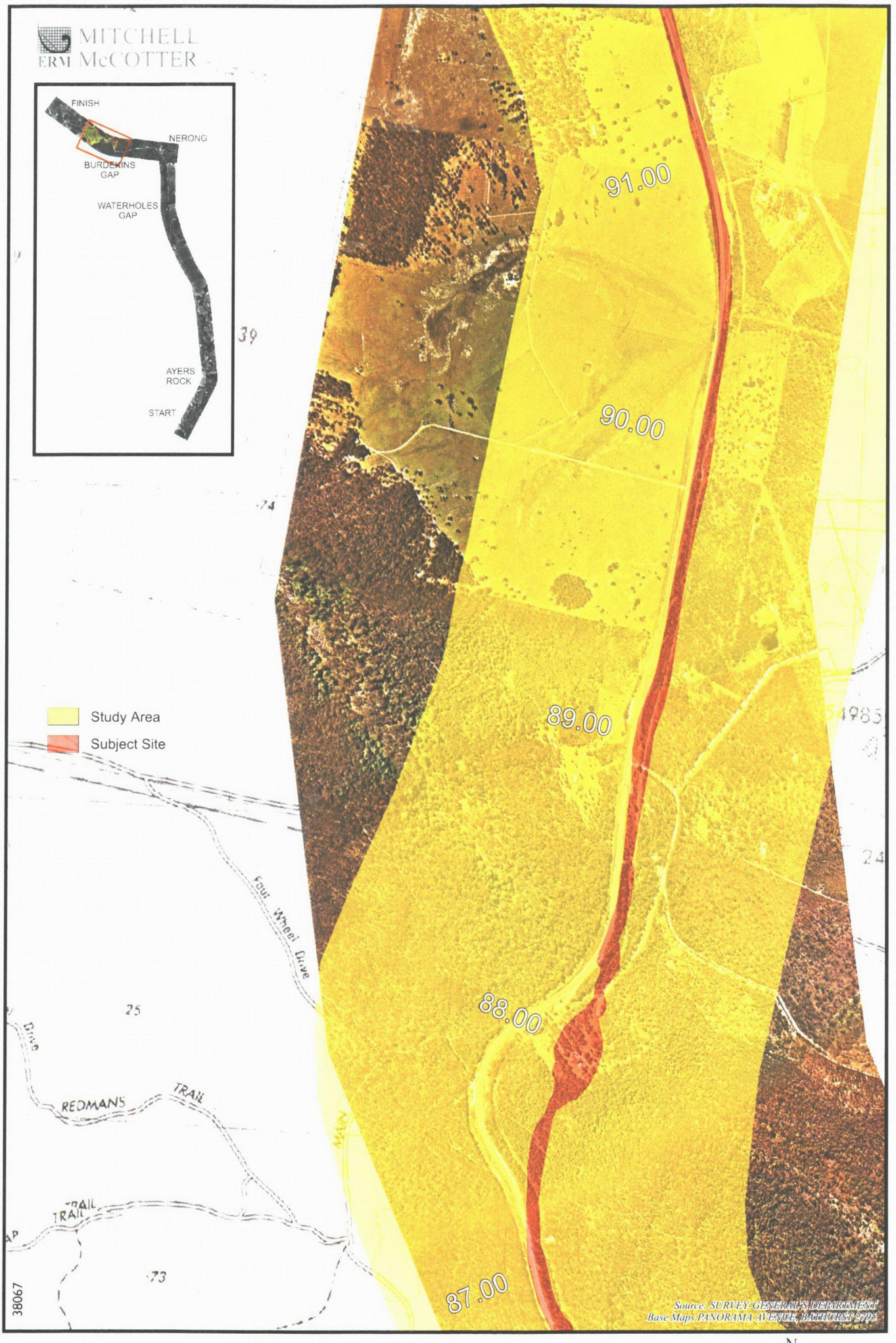

Figure 1.3h STUDY AREA / SUBJECT SITE

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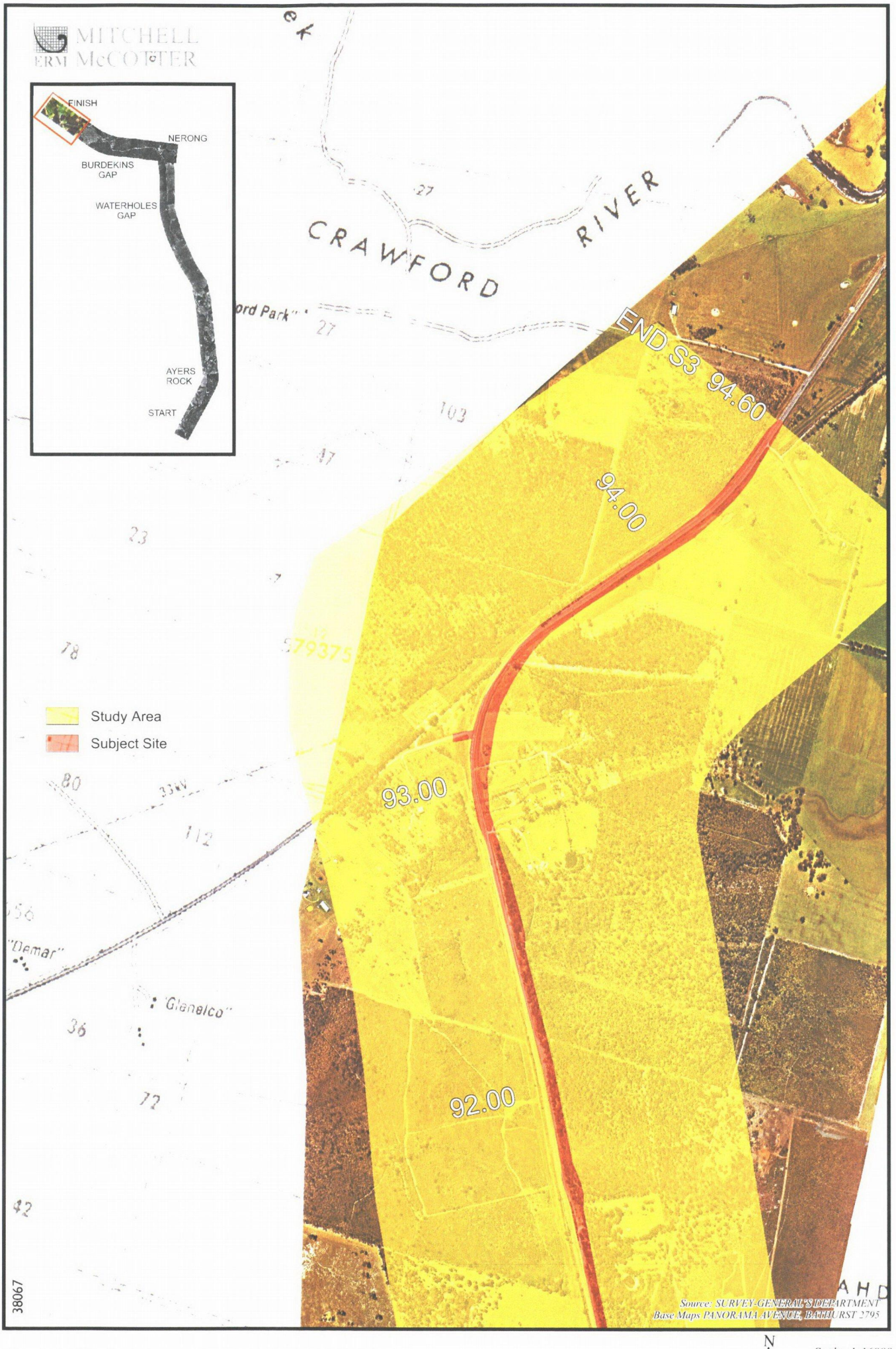

Figure 1.3i STUDY AREA / SUBJECT SITE

Estuarine landscapes occur at Bundabah Creek and in the upper reaches of the Bombah Broadwater. They are characterised by broad flat swampy ground and river channels. Slope gradients within this group are usually less than one percent and have an elevation between one and three metres. The soils are deep and very poorly drained. This group underlies predominantly cleared Casuarina/Melaleuca swamp forest with minor areas of tall open forest (DLWC 1995).

Lacastrine landscapes occur at Nerong Waterholes and have formed as a result of the infilling of Pleistocene lagoons and estuaries. Slope gradients within this landscape are usually less than two percent, with the local relief generally being below two metres. The elevation of this group varies between seven and nine metres ASL. Gilgai depressions and cracking black earth occur occasionally and are subject to seasonal or permanent waterlogging and permanent high water tables. This group underlies predominantly cleared swamp forest (DLWC 1995).

Erosional landscapes occur at Nerong and on numerous slopes and crests throughout the study area. This group consists of undulating low hills on the McInnes geological formation. Slope gradients are usually less than 15 % with local relief to 30 m. Broad crests, convex moderately inclined sideslopes and narrow drainage lines characterise the landscape. The landscape consists of localised waterlogged and shallow soils of low fertility. It is overlayed by predominantly uncleared woodland with a shrubby understorey (DLWC 1995).

1.3.3 Climate

The climate of the region varies from humid sub-tropical on the coast to dry temperate inland. The region lies in a zone of interaction between two air masses, the sub-tropical high pressure cells originating over the mainland, and the sub-polar low pressure cells generated over the southern oceans. The movement of these two systems can result in unpredictable climate changes (TCM undated).

i. Temperature and Humidity

The temperature range experienced along the Pacific Highway is primarily influenced by latitude and proximity to the Pacific Ocean. The area in which the proposed Upgrade is located has a mean daily maximum ranging from 21.5C to 24C, and minimum mean daily temperature of between 14.3C to 12C (TCM undated). The annual mean daily temperature ranges are indicative of the moderating coastal influence. Further inland greater variations between maximum and minimum readings.

The humidity of the area ranges between 76% and 73% relative humidity at 9.00 am, and between 65% and 57% relative humidity at 3.00 pm. The variation in relative humidity is highly dependent on location.

ii. Rainfall

Rainfall across the region is variable. Along the coast, the highest amount of rainfall falls in autumn and early winter. Further inland from the coast, rainfall peaks in summer, with secondary peaks often being experienced in winter. There is a marked reduction in rainfall from east to west. The average annual rainfall is approximately 1,200 mm per year.

iii. Wind Speed and Direction

Synoptic scale features are the main influence on wind patterns experienced along the extent of the route. The eastward progression of high pressure systems generally brings easterly winds in summer and westerly winds in winter.

The northern section of the study area is also influenced by tropical disturbances and trade winds, which tend to increase the incidence of north-easterly and south easterly winds throughout the year.

The general wind pattern experienced along the length of the route shows a winter dominance of westerly winds, and the easterly trade winds prevailing throughout the remainder of the year. Localised variations in this generalised wind pattern are likely to occur along the length of the route due to differences in topography and nature of the land surrounding each location.

iv. Fog and Frost Occurrence

Generally, frosts are uncommon along the Pacific Highway. The close proximity of the road to the Pacific Ocean provides a warming influence, generally preventing temperatures from dropping to freezing point.

Fogs may be experienced on as many as 20 occasions throughout a year at some locations along the Pacific Highway. Generally, the incidence of fog increases with distance away from the coast, as land surface cooling causes air above the ground to cool. This cold air then pools into valleys and may cool to such an extent that fog forms. The incidence of fogs is expected to vary along the length of the Upgrade according to topography and the nature of the land surrounding each location. Areas located further from the coast are likely to experience fogs more often than those located directly along the coastline.

1.3.4 Vegetation

Nine forest types, based on Research Note Number 17 standard, (Forestry Commission of NSW 1989b) and 36 vegetation communities (determined following the classification scheme of Walker and Hopkins 1990) were identified occurring adjacent to the existing highway.

These forest types and vegetation communities are described further in *Section 3.3.*

1.4 DESCRIPTION OF THE PROPOSAL

1.4.1 Proposal Components

The proposed Upgrade extends between 57.85 km and 94.60 km north of Newcastle. It starts approximately four km north of the bridge over the Karuah River and finishes at a point about 1.5 kilometres south of the bridge over the Myall River at Bulahdelah. The Upgrade would be 36.75 km in length.

Due to the length of the proposed Upgrade, the concept design is divided into three approximately equal sections to allow detailed design and environmental assessment to proceed simultaneously. The sections also form logical divisions for managing construction contracts (RTA 1999). These sections are:

- Section 1: Southern End to Viney Creek Road, 57.85 km to 69.00 km.
- Section 2: Viney Creek Road to Waterholes Gap,69.60 km to 82.00 km.
- Section 3: Waterholes Gap to Northern End, 82.00 km to 94.60 km.

The details of the proposed Upgrade are shown in *Figure 1.4.* A description of each section as outlined in *Working Paper 1,* is provided below.

i. Section 1

The proposed Upgrade would start to the east of the hard rock quarry access road, north of a section of the existing highway that has been recently upgraded with passing lanes. It would rise gradually to the east, and then descend to Bulga Creek. The Upgrade traverses mildly hilly terrain between Bulga and Bundabah creeks before rising to the hill at Viney Creek Road.

The new carriageways and controlled access road boundary (referred to as the *CAR boundary*) would be located to the north west of the existing carriageway for a distance of eight kilometres between the start and a point near Bundabah Creek. Between Bundabah Creek and the end of Section 1, north of Tea Gardens Road intersection, duplication would be generally along the existing road alignment. The CAR boundary would extend slightly to the south east of the existing road reserve boundary in some locations.

The CAR boundary would be widened to accommodate a proposed rest area north of Bulga Creek at 62.20 km, for southbound vehicles.

ii. Section 2

From the hill near Viney Creek Road, the Upgrade would descend to Old Tea Gardens Road and then cross level terrain to Nerong Forest Road. It would then rise steeply to cross Waterholes Gap.

The proposed Upgrade would generally follow the existing road reserve. However, the CAR boundary would be widened at Waterholes Gap and near 76.70 km to accomodate deep cuttings and an improved horizontal alignment. The old highway would be utilised for a northbound rest area at 76.70 km.

iii. Section 3

From the start of Section 3, near Waterholes Gap, the proposed Upgrade would descend. It would then rise briefly after Jacks Creek Bridge and descend to a low point at the Nerong Village intersection. After rising to the north of Nerong Village, the Upgrade would descend to a relatively flat section south of Burdekin's Gap. It would then climb steeply at Burdekin's Gap and descend to a level plain, ending at the Myall River floodplain.

From Waterholes Gap to Burdekin's Gap, the alignment generally follows the existing highway. In the area approaching Nerong Village, the proposed CAR boundary extends to the west of the existing road reserve to improve horizontal and vertical alignment.

The alignment of the proposed duplication deviates to the east by up to 300 m between 87.50 km and 88.50 km to improve alignment at Burdekin's Gap. Between Burdekin's Gap and the end of Section 3, the alignment generally follows the existing highway for the final six kilometres. The CAR boundary extends slightly to the east in some locations to accommodate new carriageways.

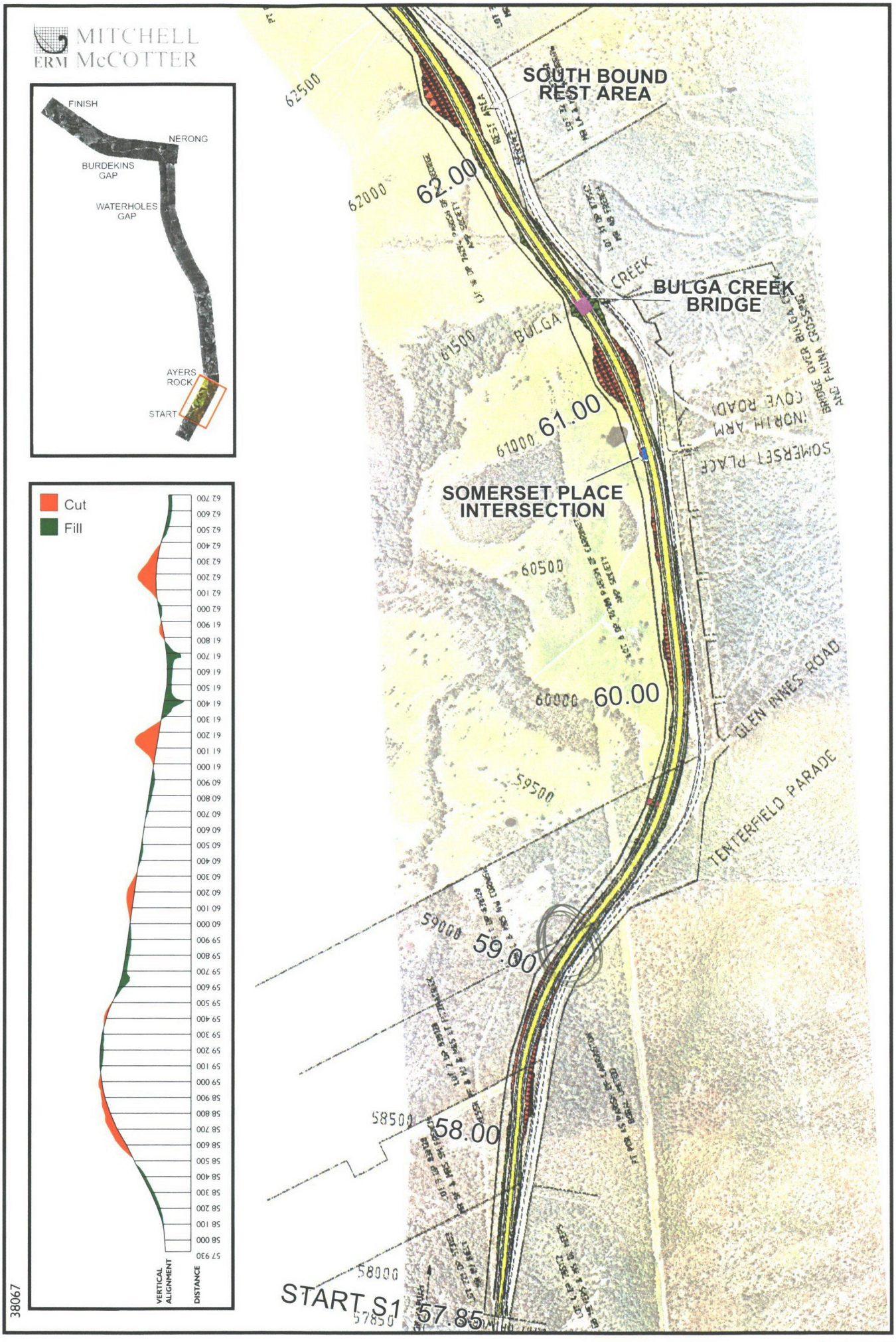

Figure 1.4a PROPOSED UPGRADE

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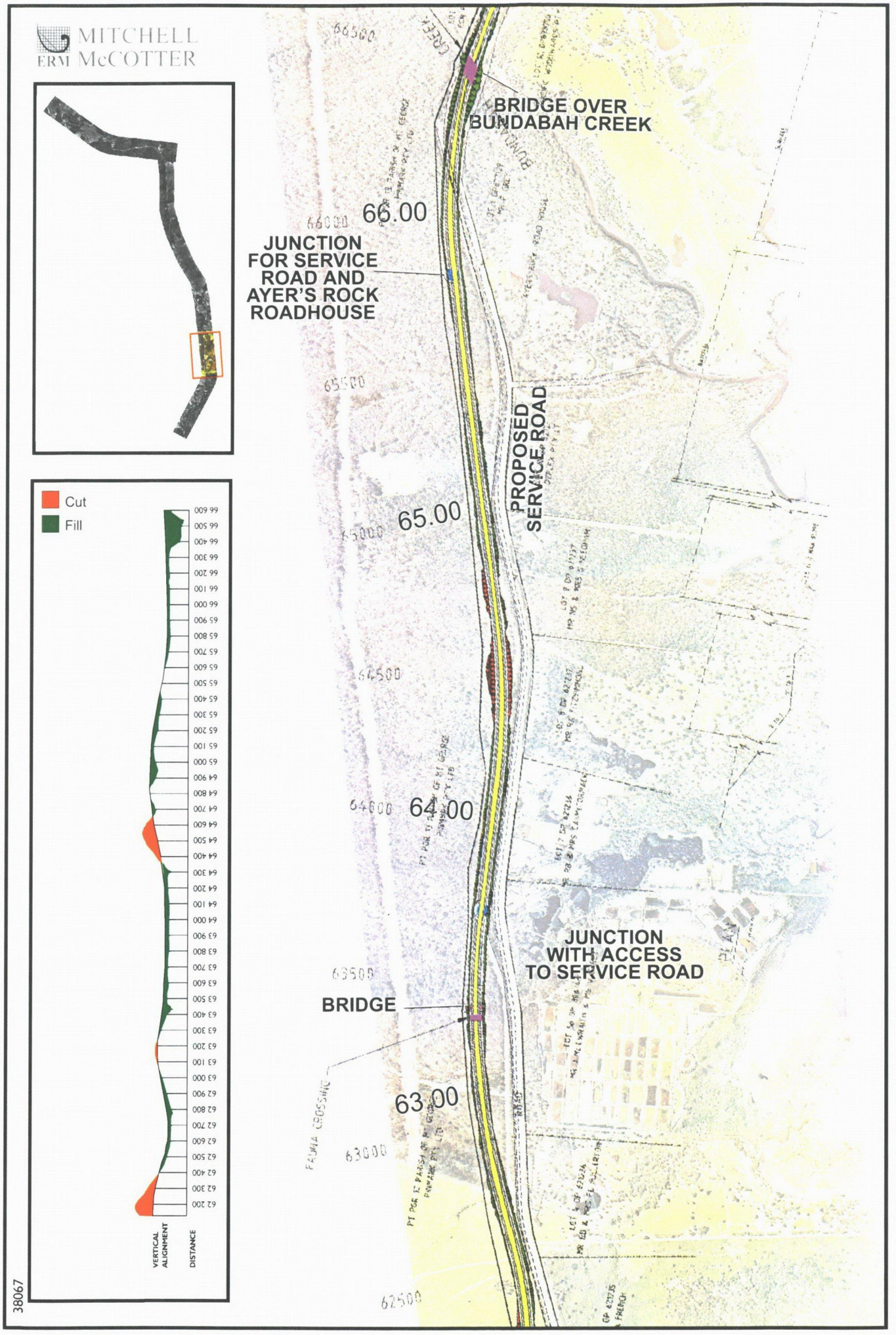

Figure 1.4b PROPOSED UPGRADE

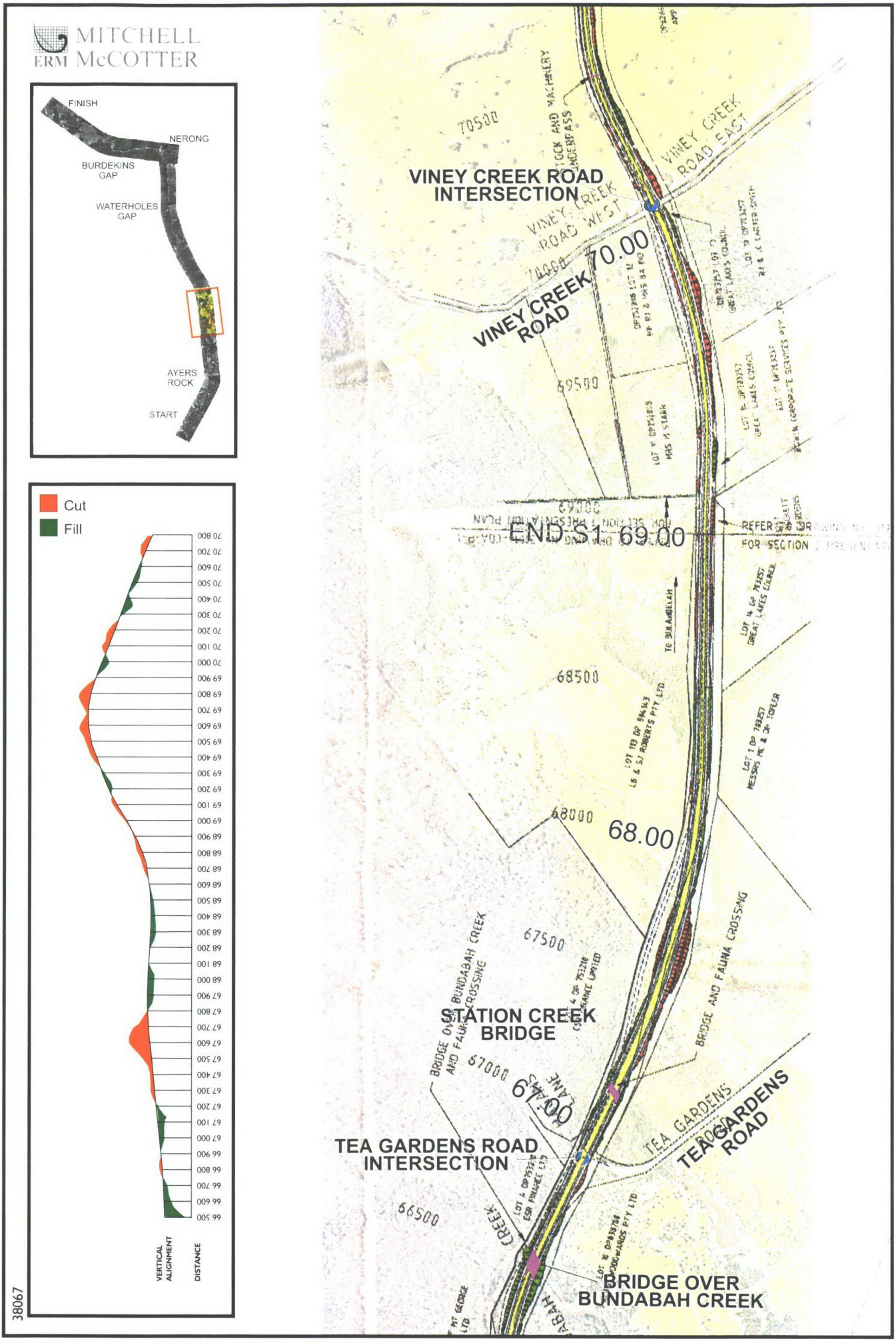

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Figure 1.4c PROPOSED UPGRADE

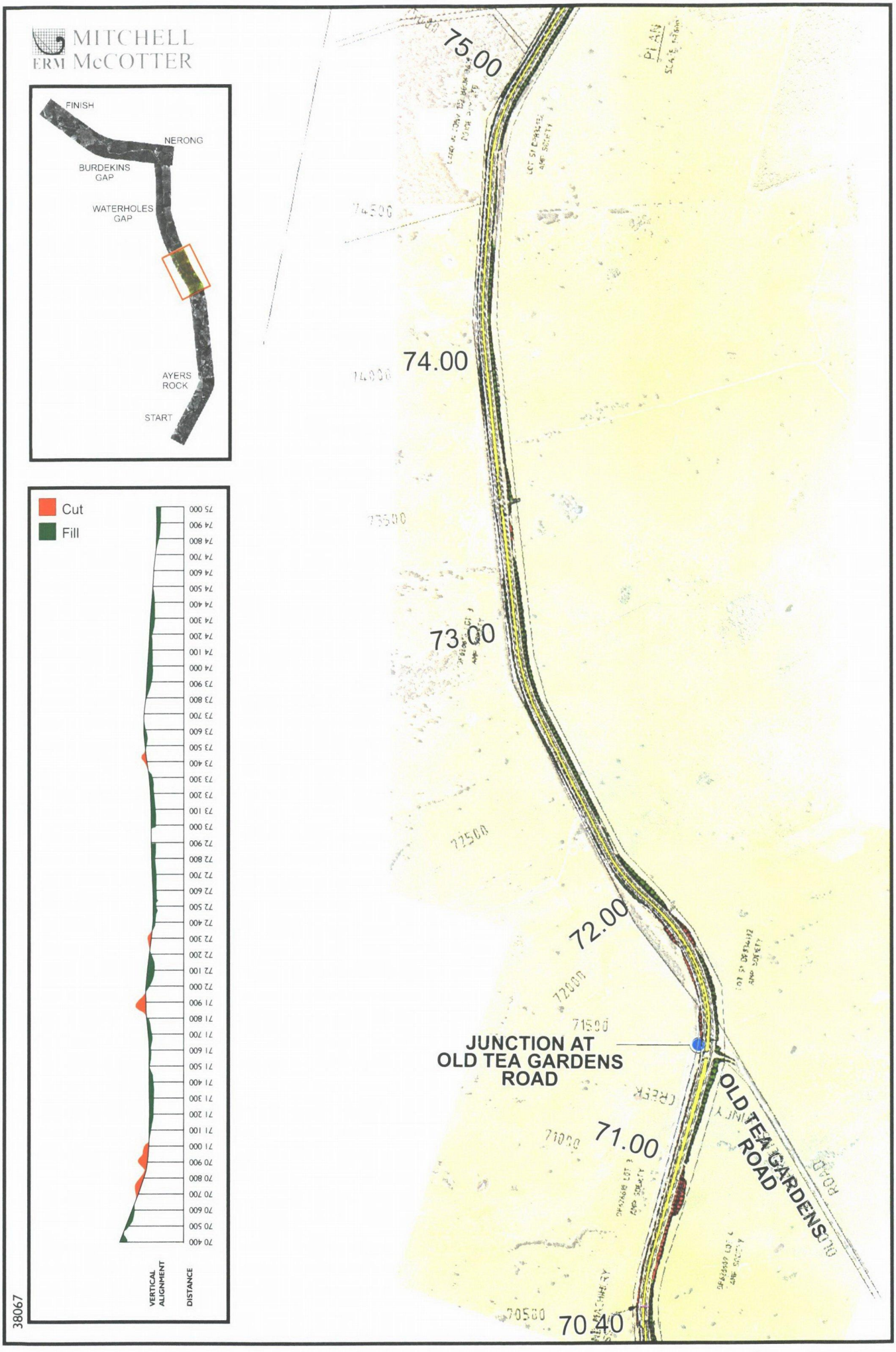

Figure 1.4d PROPOSED UPGRADE

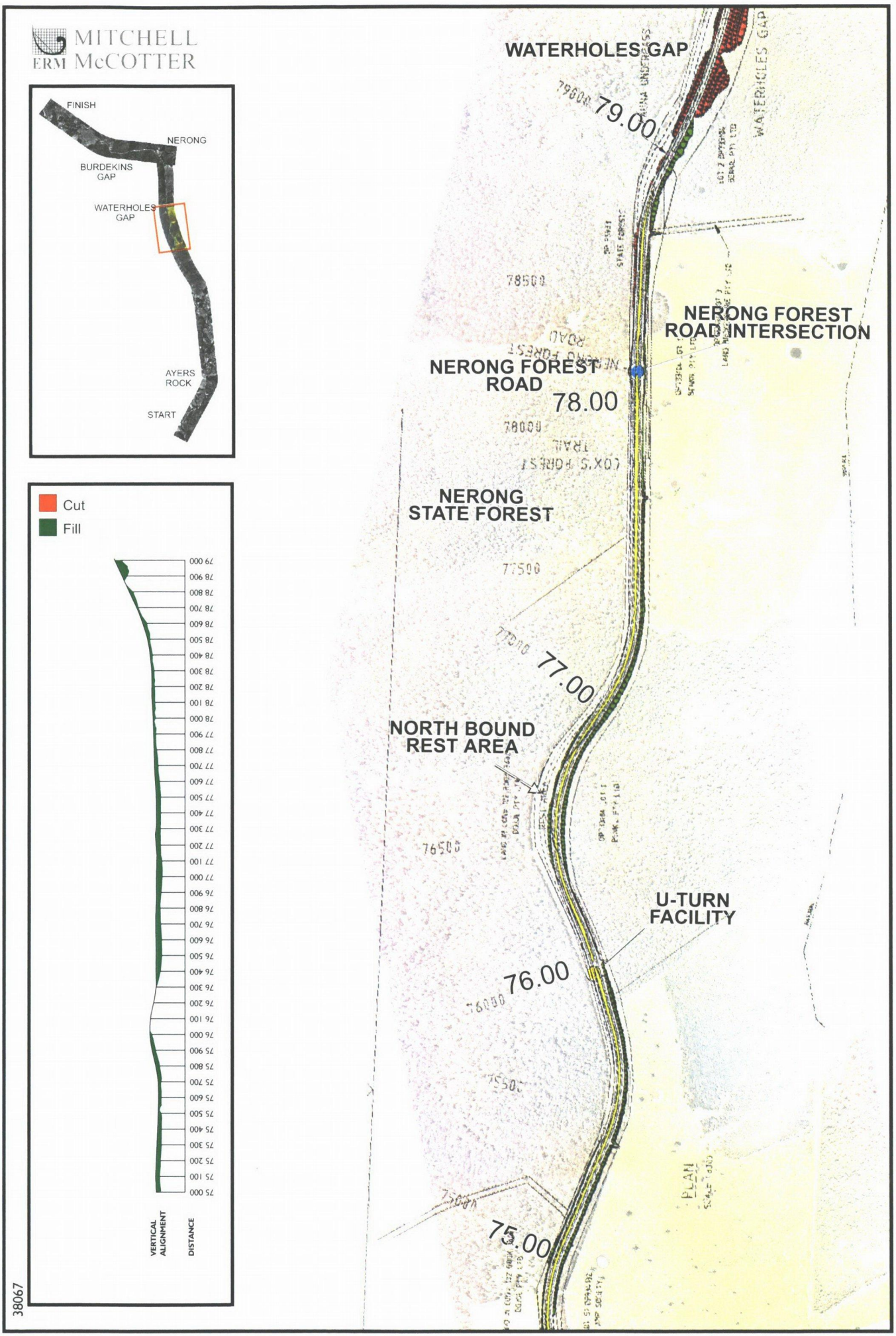

Figure 1.4e PROPOSED UPGRADE

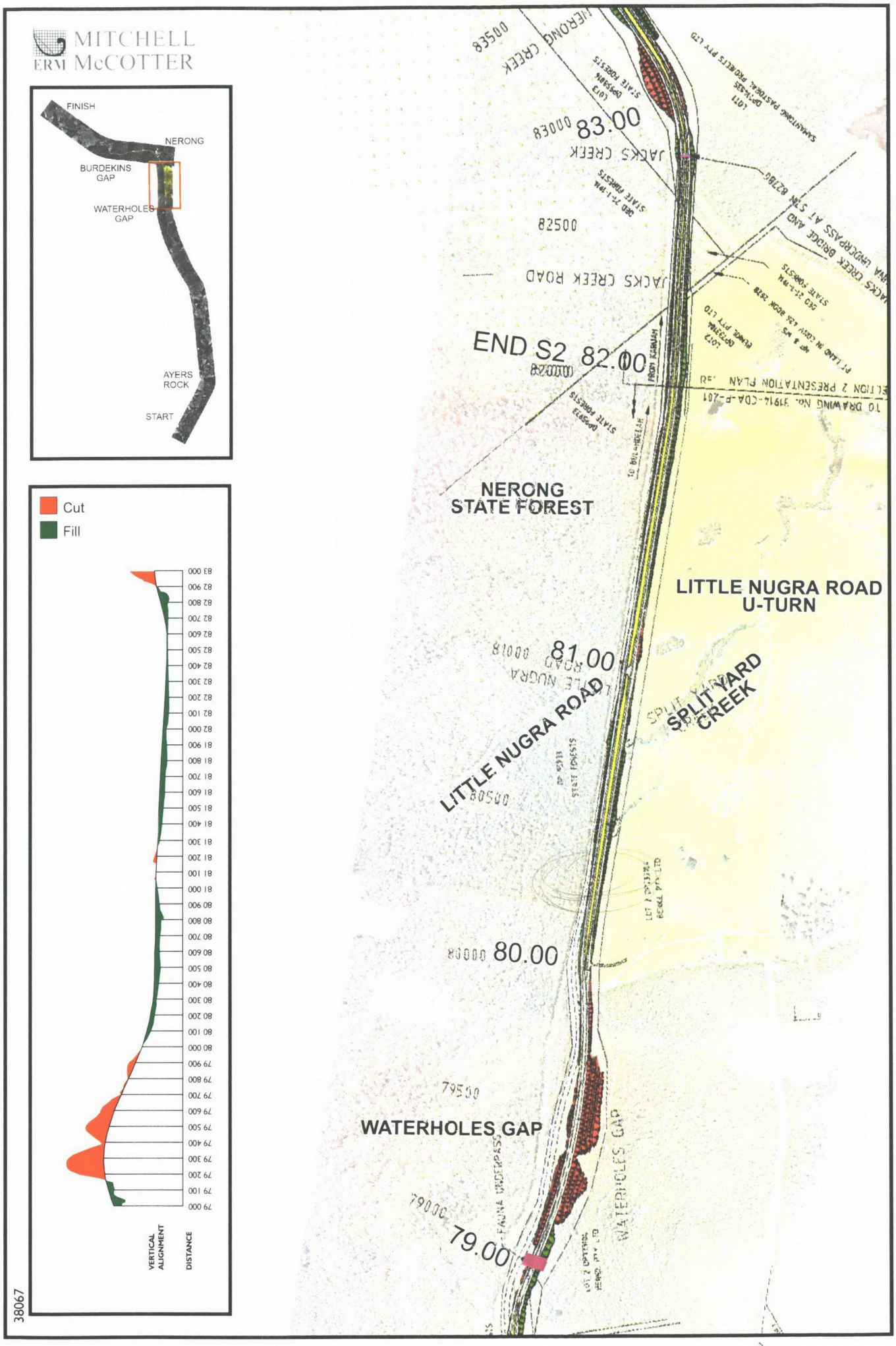

Figure 1.4f PROPOSED UPGRADE

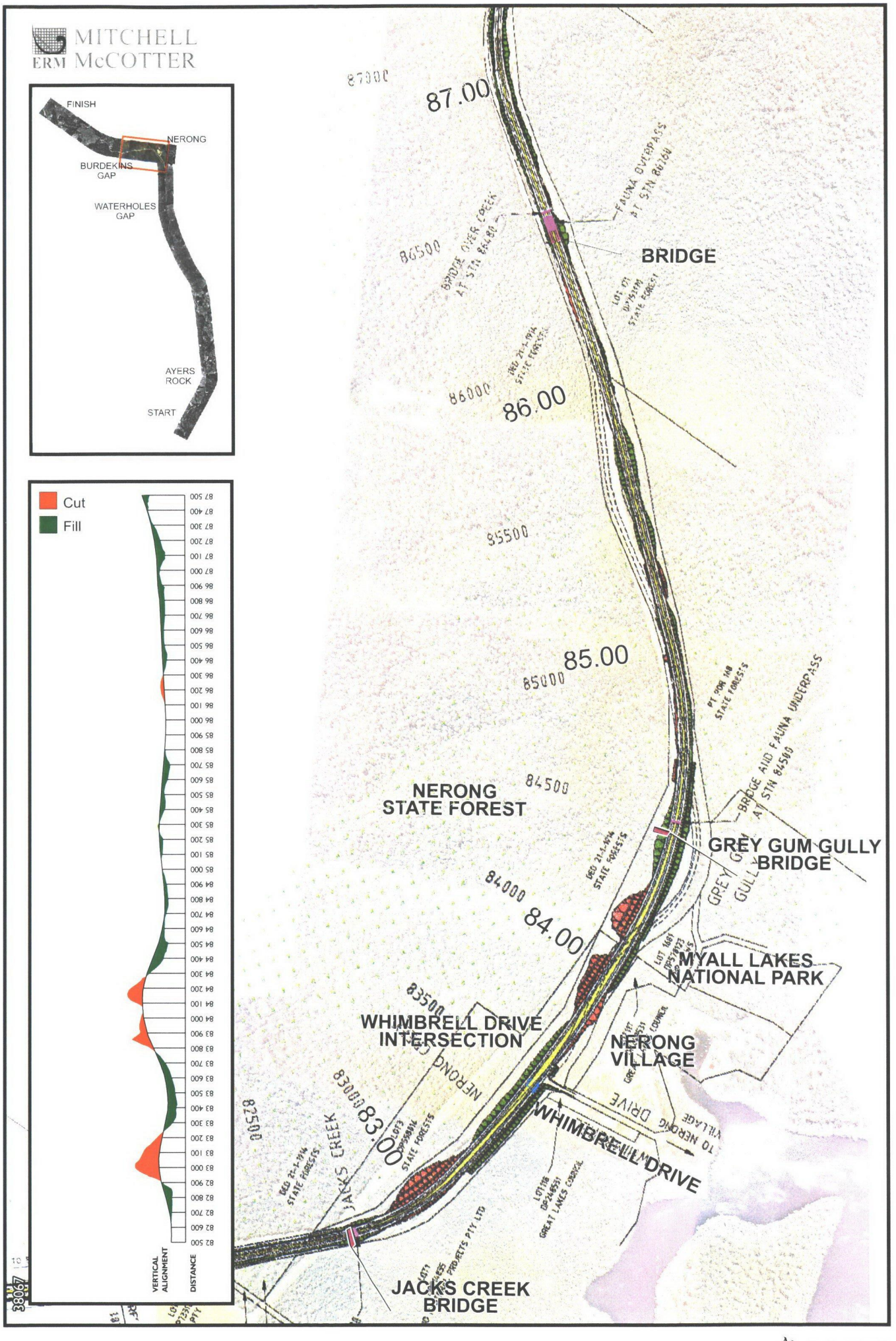

Figure 1.4g PROPOSED UPGRADE

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Scale: 1:16000

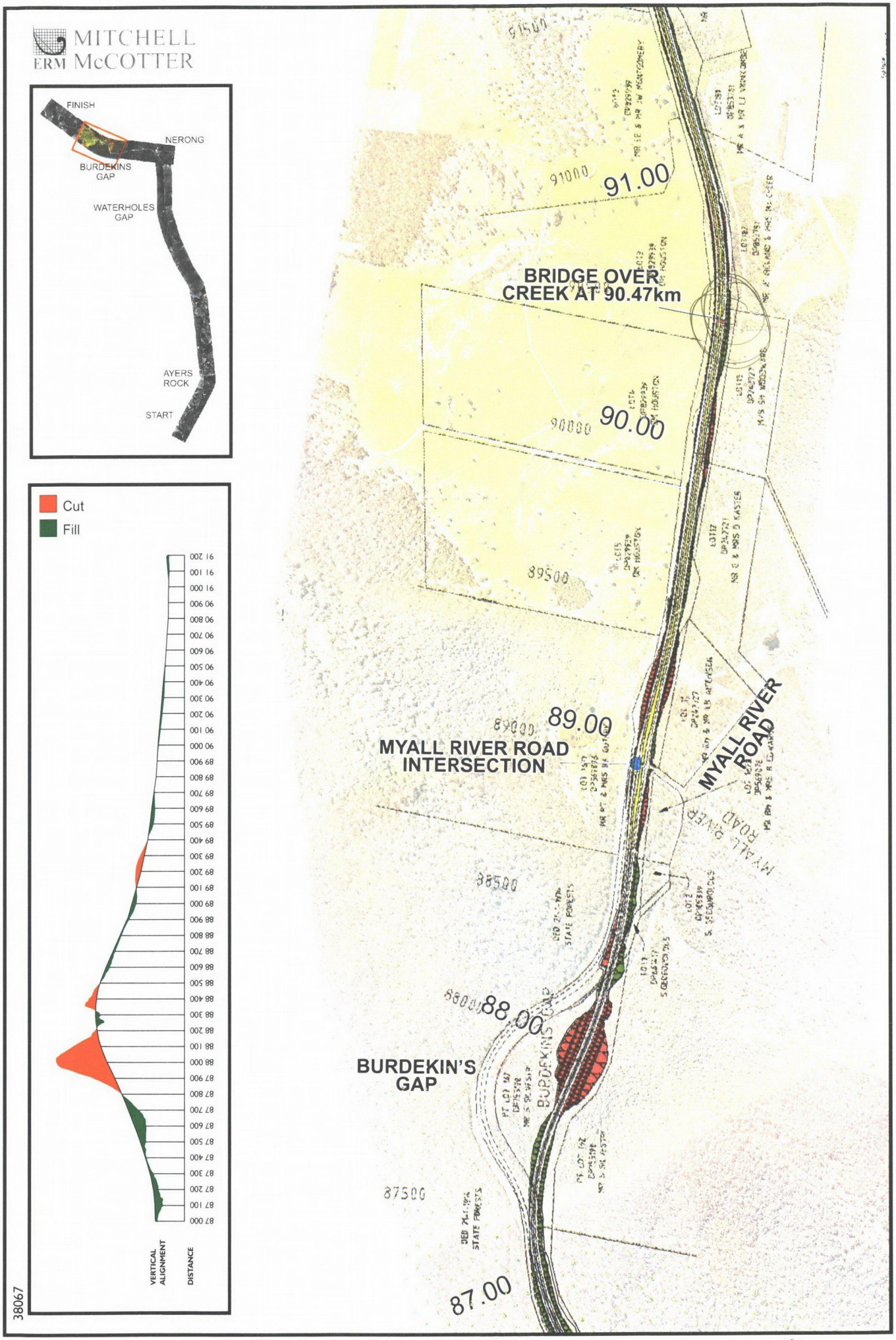


Figure 1.4h PROPOSED UPGRADE

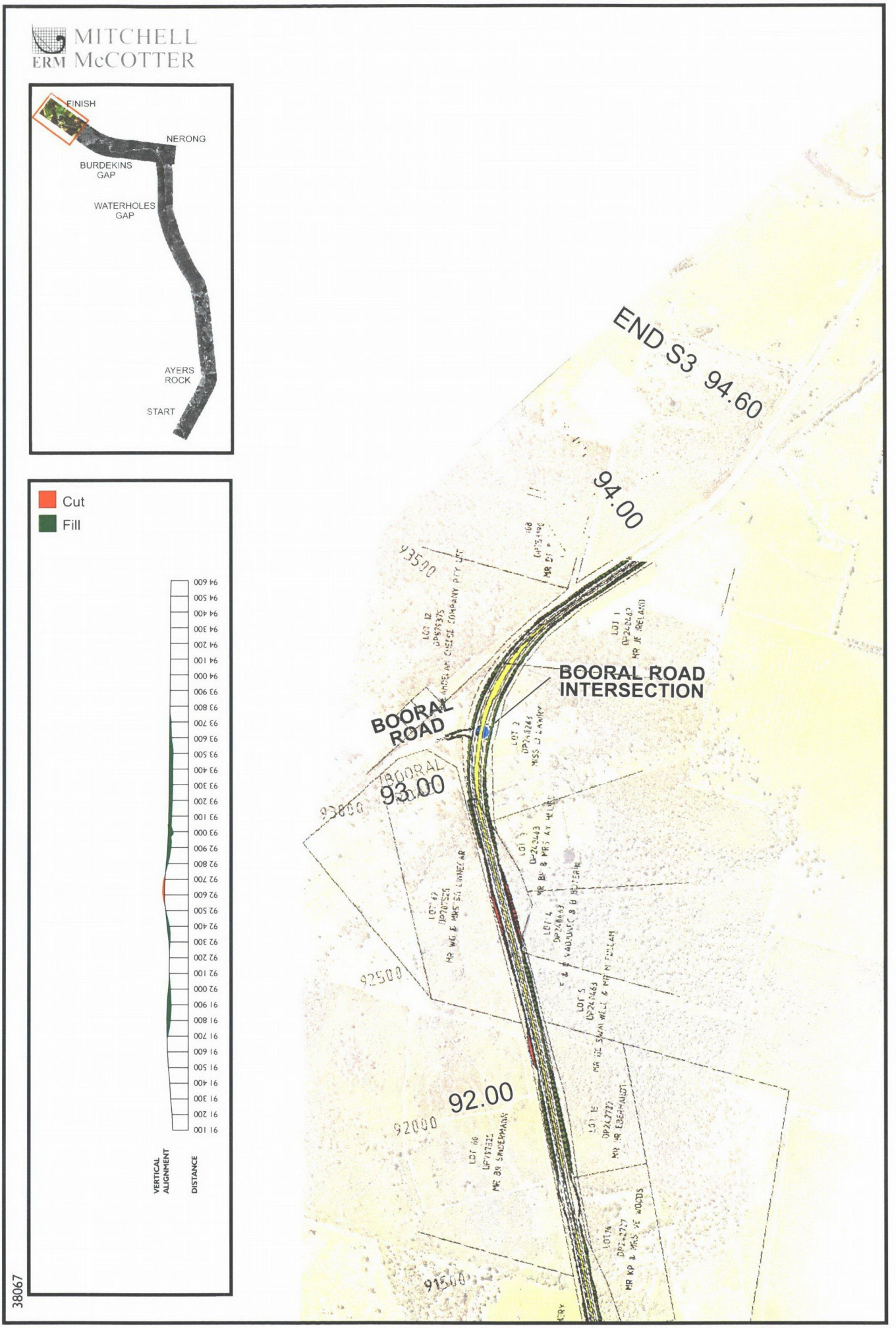


Figure 1.4i PROPOSED UPGRADE

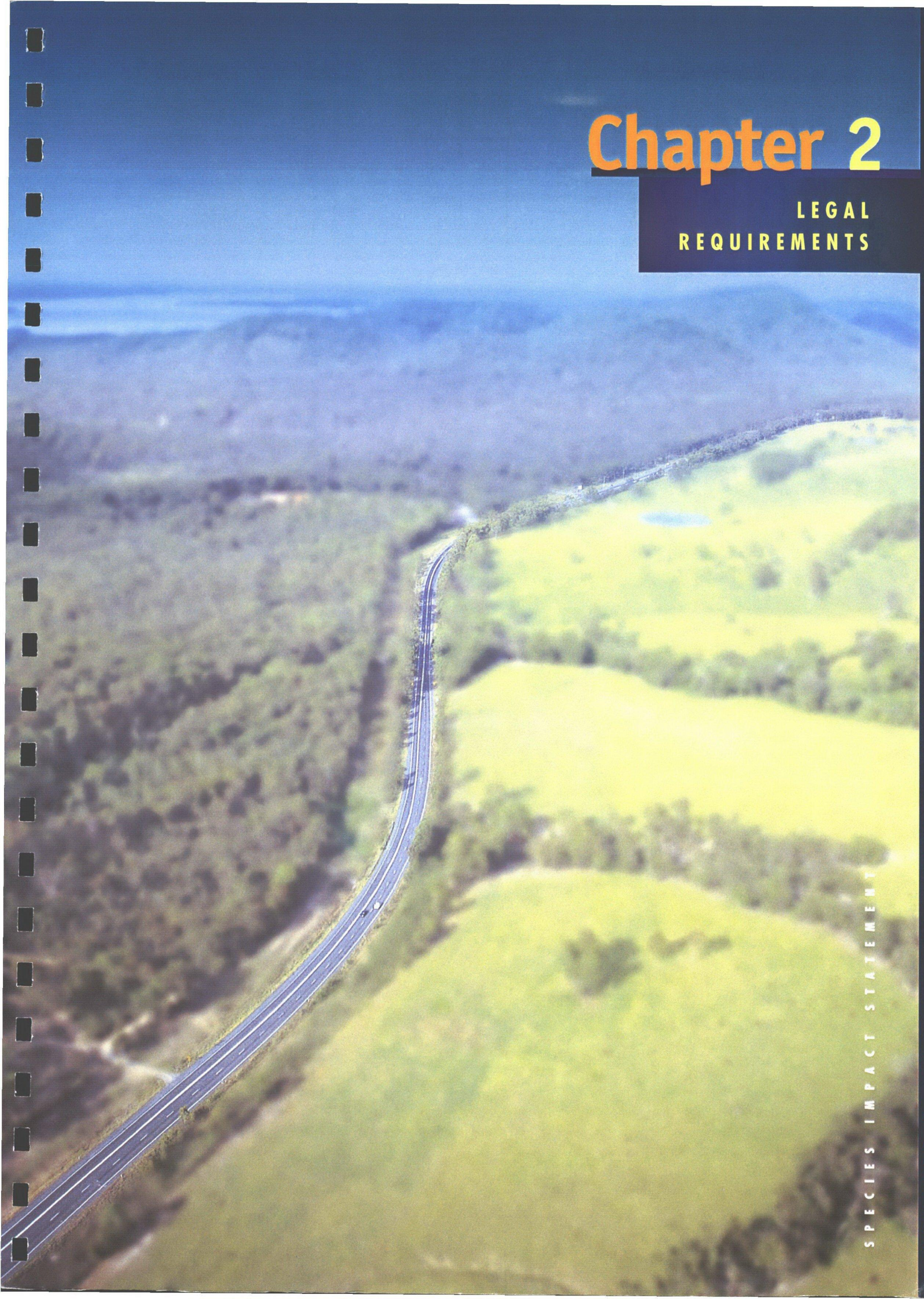
N

Scale: 1:16000

1.4.2 Staging and Timing of Construction

The proposed Upgrade would be constructed in stages, which are detailed in *Section 5.3* of *Working Paper No.1.* Construction work on the proposed Upgrade would commence in late 1999 with progression through to the end of 2006. The development program for the proposed Upgrade is anticipated to be:

Investigation and Design	Early 1998 to Early 2000
Public Utility Adjustments	Late 1999 to end 2000
Property Acquisitions	Late 1997 to End 2000
Construction Section 1	Mid 2001 to Early 2003
Construction Section 2	Late 1999 to Late 2001
Construction Section 3	Early 2003 to end 2006
Project Finalisation	End 2006



Chapter 2

LEGAL REQUIREMENTS

Chapter 2

LEGAL REQUIREMENTS

This chapter outlines the legislative requirements for the preparation of this SIS. The study area, subject site, locality, sub-region and region to which the study applies are also defined. The species considered in the SIS are also identified.

2.1 REQUIREMENTS FOR A SPECIES IMPACT STATEMENT

2.1.1 *Legislative Requirements*

This SIS has been undertaken in accordance with Sections 109 and 110 of the *Threatened Species Conservation Act 1995* (TSC Act), which describe the form and content of an SIS. The Director-General's requirements for the proposal, pursuant to Section 111 of the TSC Act have also been addressed in this report.

Table 2.1 details the contents of the SIS in accordance with Section 110 of the TSC Act and indicates the sections in this report in which they can be found. *Table 2.1* also details the matters to be addressed in this SIS in accordance with the Director-General's requirements and indicates the sections in this report in which they can be found.

Table 2.1 CHAPTERS IN THIS REPORT ADDRESSING SECTION 110 OF THE TSC ACT 1995

Matter to be Addressed	Section in Which Matter is Addressed
(1) A species impact statement must include a full description of the action proposed, including its nature, extent, location, timing and layout and, to the fullest extent practicable, the information referred to in this section.	*Section 1.4*
(2) A species impact statement must include the following information as to threatened species and populations:	
(a) a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action;	*Sections 3.3.5 and 4.3*
(b) an assessment of which threatened species or populations known or likely to be present in the area are likely to be affected by the action;	*Sections 6.4 and 6.5*
(c) for each species or population likely to be affected, details of its local, regional	*Appendix D*

Table 2.1 CHAPTERS IN THIS REPORT ADDRESSING SECTION 110 OF THE TSC ACT 1995

Matter to be Addressed	Section in Which Matter is Addressed
and statewide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or threat abatement plan applying to it;	
(d) an estimate of the local or regional abundance of those species or populations;	
(e) a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action;	*Not required.*
(f) a full description of the type, location, size and condition of the habitat (including critical habitat) of those species and populations and details of the distribution and condition of similar habitats in the region;	
(g) a full assessment of the likely effect of the action on those species and populations, including, if possible, the quantitative effect of local populations in the cumulative effect in the region;	*Chapter 8*
(h) a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development;	*Chapter 8*
(i) a full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those matters;	*Chapter 2.10*
(j) a list of any other approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population.	*Chapter 7*
(3) A species impact statement must include the following information as to ecological communities:	*Not required as indicated by NPWS*
(a) a general description of the ecological community present in the area that is the subject of the action and in any area that is likely to be affected by the action;	*Not required as indicated by NPWS*
(b) for each ecological community present, details of its local, regional and state-wide conservation status, the key threatening processes generally affecting it, its habitat requirements and any recovery plan or any threat abatement plan applying to it;	*Not required as indicated by NPWS*
(c) a full description of the type, location, size and condition of the habitat of the ecological community and details of the distribution and condition of similar habitats in the region;	*Not required as indicated by NPWS*
(d) a full assessment of the likely effect of the action on the ecological	*Not required as indicated by*

Table 2.1 CHAPTERS IN THIS REPORT ADDRESSING SECTION 110 OF THE TSC ACT 1995

Matter to be Addressed	Section in Which Matter is Addressed
community, including, if possible, the quantitative effect of local populations in the cumulative effect in the region;	*NPWS*
(e) a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons for justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development;	*Not required as indicated by NPWS*
(f) a full description and justification of the measures proposed to mitigate any adverse effect of the action on the ecological community, including a compilation (in a single section of the statement) of those measures;	*Not required as indicated by NPWS*
(g) a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the ecological community.	*Not required as indicated by NPWS*
(4) A species impact statement must include details of the qualification and experience in threatened species conservation of the person preparing the statement and of any other person who has conducted research or investigations relies on in preparing the statement.	*Appendix B*
(5) The requirements of subsections (2) and (3) in relation to information concerning the statewide conservation status of any species or population, or any ecological community, are taken to be satisfied by the information in that regard supplied to the principal author of the species impact statement by the National Parks and Wildlife Service, which information that Service is by this subsection authorised and required to provide.	*Appendix D*

2.1.2 *Study Team*

The persons involved in the field investigations, report writing, desktop research and liaison were suitably qualified. A list of the study team and their *curricula vitae* are presented in *Appendix B.*

2.2 NPWS DIRECTOR-GENERAL'S REQUIREMENTS

The Director-General (DG) requires that this SIS meets all of the matters specified in Section 109 and 110 of the TSC Act with the exception of those matters listed in

Section 2.1.1 above. In addition, the DG requires that the matters described in *Table 2.2* be addressed.

Furthermore, the DG has requested that this SIS be formatted to reflect the sections and subsections provided in Sections 109 and 110 of the TSC Act and the DG's requirements. The DG's requirements were used as a basis in preparing the format of this SIS. In some circumstances the requirements requested information that was better presented and/or discussed in other sections of the documents so as to enable a more structured report. Consequently, it was agreed with NPWS (L. Baker, NPWS, pers. comm.) that necessary changes to the requested format were acceptable provided that a table, outlining the DG's requirements and chapters where they are addressed, was included. This table is presented below (*Table 2.2*).

Table 2.2 CHAPTERS IN THIS REPORT ADDRESSING THE DIRECTOR GENERAL'S REQUIREMENTS

Matters To Be Addressed	***Chapters In Which The Matters Are Addressed***
1. Description	
This includes the following information:	
Study Area	
All maps should be presented at the same scale so that they can be overlain.	
1.1 The nature of the action proposed must be detailed. This must include the timetable for the carrying out of the proposed development, the number of hectares affected, the number of hectares of each vegetation type within the study area, details of the location of any auxiliary infrastructure and all components of the proposed development.	*Section 1.4*
1.2 A vegetation map of the study area must be provided. This map will show the location and type of vegetation communities present within the study area and the scale of the map. The map must be presented in colour. The vegetation units mapped should follow a standard classification such as Walker and Hopkins (1990), and include dominant species in each vegetation unit.	*Figure 3.3 in Section 3.3*
1.3 An aerial photograph (or reproduction of such a photograph), preferably colour, of the locality must be provided, separate to the vegetation map. This aerial photograph should be clearly marked with the study area and the scale of the photograph, and the location of the proposal.	*Figure 1.3 in Section 1.3*
1.4 A topographic map of the locality at an appropriate scale must be provided. This map will detail the location of the proposal, major land tenure units such as National Parks, Nature Reserves and State Forests, boundaries of the study area and areas of high human activity such as townships, regional centres and major roads.	*Appendix C*
1.5 In defining the study area consideration shall be given to possible indirect effects of	*Chapter 6*

Table 2.2 CHAPTERS IN THIS REPORT ADDRESSING THE DIRECTOR GENERAL'S REQUIREMENTS

Matters To Be Addressed	*Chapters In Which The Matters Are Addressed*
the development on the area surrounding the subject site, for example habitat fragmentation, vegetation corridors, altered hydrology regimes, soil erosion or pollution and increased human presence.	
1.6 In describing the study area, consideration must be given to the previous land uses and the effect of these land uses on the study area. Relevant historical events may include sandmining, fore history, clearing, logging, recreational use and agricultural activities. Reference to the land zoning or any proposed rezoning, and any government planning initiatives (eg Interim Deferred Forest Areas and the subsequent State Forest estate identified to become part of the reserve system under the Government's Upper and Lower North East forestry decision, reserve proposals, etc.) which may impact on the study area or adjacent lands must be made.	*Chapter 6*
Threatened and Significant Species Habitat Assessment	
1.7 A list of subject species must be provided. In determining these species, consideration shall be given to the habitat types present within the study area, records of subject species in the locality and their known distribution. Note: Subject Species includes species that are not listed in the TSC Act, but are considered to be of regional or local significance. Criteria to be used to identify include those outlined by Sheringham and Westaway (1995).	*Chapter 2*
1.8 The subject species must include, but need not be limited to, the following species:	*Chapter 2*
• *Green-thighed frog* Litoria brevipalmata;	
• *Green and golden bell frog* Litoria aurea;	
• *Stuttering frog* mixophyes balbus;	
• *Giant barred frog* Mixophyes iteratus;	
• *Wallum froglet* Crinia tinnula;	
• *Brush-tailed phascogale* Phascogale tapoatafa;	
• *Koala* Phascolarctos cinereus	
• *Spotted-tailed quoll* Dasyurus maculatus	
• *Squirrel glider* Petaurus norfolcensis	
• *Yellow-bellied glider* Petaurus autralis	
• *Eastern chestnut mouse* Pseudomys gracilicaudatus	
• *Long-nosed potoroo* Potorous tridactylus	
• *Red-legged pademelon* Thylogale stigmatica	
• *Common Wombat* Vombatus ursinus	

Table 2.2 CHAPTERS IN THIS REPORT ADDRESSING THE DIRECTOR GENERAL'S REQUIREMENTS

Matters To Be Addressed	*Chapters In Which The Matters Are Addressed*
• *Common Planigale* Planigale maculata	
• *All microchiropteran bats, but particularly:*	
• *Golden-tipped bat* Kerivoula papuensis	
• *Eastern freetail bat* Mormopterus norfolkensis	
• *Little bent-wing bat* Miniopterus australis	
• *Bush stone-curlew* Burhinus grallarius	
• *Glossy Black-cockatoo* Calyptorhynchus lathami	
• *Osprey* Pandion haliaetus	
• *Square-tailed kite* Lophoictinia isura	
• *Masked owl* Tyto novaehollandiae	
• *Sooty owl* Tyto tenebricosa	
• *Powerful owl* Ninox strenua	
• *Turquoise Parrot* Neophema pulchella	
• *Swift parrot* Lathamus discolor	
• *Regent honeyeater* Xanthomyza phrygia	
• *Black bittern* Ixobrychus flavicollis	
• *Black-necked stork* Ephippiorhynchus asiaticus	
• *Comb-crested jacana* Jacana gallinacea	
• *Superb fruit-dove* Ptilinopus magnificus	
• *Rose-crowned fruit-dove* Ptilinopus regina	
• *Wompoo fruit-dove* Ptilinopus magnificus	
• *Stephen's banded snake* Hoplocephalus stephensii	
• *Pale headed snake* Hoplocephalus bitorquatus	
• Eucalyptus fergusonii *ssp.* fergusonii	
• Grevillea guthrieana	
• Macrozamia pauli-guiliemimim *ssp.* flexuosa	
• Plectranthus suaveolens	
• Tetratheca juncea	
1.9 A description of the habitat requirements of subject species must be provided. Particular attention must be paid to the subject species listed in 1.8 above.	*Chapter 4; Appendix D*

Table 2.2 CHAPTERS IN THIS REPORT ADDRESSING THE DIRECTOR GENERAL'S REQUIREMENTS

Matters To Be Addressed	*Chapters In Which The Matters Are Addressed*
1.10 The habitat of each species found within the study area must be represented on a map of the study area. NPWS predicted habitat models (contained at Appendix E of this SIS) should be used as an indication of the presence of suitable habitat for subject species in the locality.	*Figure 4.1*
1.11 A description of fauna and flora habitat components such as frequency and size of tree hollows and stags, density of understorey vegetation, substrate and presence and nature of wetlands, rock outcrops etc. must be given. The location of tree hollows and stags within the study area must be mapped. The condition of the habitat within the study area must be discussed, including the prevalence of introduced species. *The importance of the study area for all lifecycle stages of the subject species in the locality shall be identified and discussed. Particular attention must be given to which areas are used by the following species including identification of the purposes for which these areas are used (eg. roosting, feeding, nesting or breeding etc):* • *Green thighed frog* Litoria brevipalmata • *Green and golden bell frog* Litoria aurea • *Stuttering frog* Mixophyes balbus • *Wallum froglet* Crinia tinnula • *Brush-tailed phascogale* Phascogale tapoatafa • *Koala* Phascolarctos cinereus • *Squirrel glider* Petaurus norfolcensis • *Yellow-bellied glider* Petaurus australis • *Eastern chestnut mouse* Pseudomys gracilicaudatus • *Bush stone-curlew* Burhinus grallarius • *Golden tipped bat* Kerivoula papuensis • *Stephen's banded snake* Hoplocephalus stephensii • Eucalyptus fergusonii *ssp* fergusonii • Grevillea guthrieana • Macrozamia pauli-guiliemimim *ssp* flexuosa • Plectranthus suaveolens • Tetratheca juncea ***Survey Methods*** *1.12 A fauna and flora survey is to be conducted in the study area. Additional targeted*	

Table 2.2 CHAPTERS IN THIS REPORT ADDRESSING THE DIRECTOR GENERAL'S REQUIREMENTS

Matters To Be Addressed	*Chapters In Which The Matters Are Addressed*
surveys must be conducted for all affected species. As a minimum, survey methods must follow those detailed, unless justification for variation from these methods can be provided to the satisfaction of NPWS. Field survey and identification of species and habitat must be undertaken by suitably qualified and experienced persons. Species of taxonomic uncertainty must be confirmed by a recognised authority such as the Australian Museum or NSW National Herbarium.	
1.13 A full description of the methods used in the fauna and flora surveys and habitat assessment must be provided, including survey techniques employed, number and location of traps and transects, size of survey sites, dates of surveys, the time spent on surveys and prevailing weather conditions. Where appropriate this information must be provided in map format at the same scale as the previous maps. Surveys must be undertaken at the time of year when the subject species are most likely to be detected and, where possible, in appropriate climatic conditions. A table must be provided indicating compliance with the survey methods outlined.	*Chapter 5*
1.14 The time of the year for each component of the survey, prevailing weather conditions and limitations of survey techniques employed must be considered and discussed with respect to the results of the survey.	*Chapter 5*
1.15 Areas which may act as local or regional corridors between the study area and other areas of likely habitat for subject species must be identified and described. A map showing identified corridors must be provided.	*Figure 4.1*
1.16 A full list of protected fauna and native plant species (as defined by the National Parks and Wildlife Act 1974*) found during the course of surveys must be included. Such information is indicative of the habitat quality of the site. This list must indicate the significance of each species, whether the species is introduced, and the survey site location or habitat in which each species was recorded.*	*Chapter 5: Appendix D; Appendix H*
Survey Results and Discussion	
1.17 The location of the subject species recorded during the SIS survey and other recent surveys where available, must be represented on a map of the study area. The map base must include the topographic features shown on the vegetation map and be provided in map format at the same scale as previous maps.	*Figure 4.1; Chapter 5*
1.18 Where available, information provided for each subject species must include the name, date recorded, name of person who made the record, type of record (eg scat identification, trapped, sighted), specific use of habitat (eg nesting, roosting, foraging), and number of individuals recorded.	*Appendix D; Appendix H*
1.19 Discussion and justification must be included in determining which of the subject	*Chapter 3; Chapter 4*

Table 2.2 CHAPTERS IN THIS REPORT ADDRESSING THE DIRECTOR GENERAL'S REQUIREMENTS

Matters To Be Addressed	*Chapters In Which The Matters Are Addressed*
species are regarded as affected species for the purpose of the SIS.	
2. Assessment of Likely Impacts	
This section expands upon Section 110(2) of the TSC Act, points (b), (c) and (g).	*Chapter 3; Chapter 6*
The assessment matters listed below must be addressed:	
2.1 For each affected species, the SIS shall state the following • *the location, nature and extent (numbers of hectares) of each vegetation community to be removed or modified;* • *the location, nature and extent (numbers of hectares) of habitat removal or modification which may result from the proposed action;* • *discuss the potential impact of the removal or modification of the vegetation communities and habitat;* • *the likely contribution of the proposed action to all threatening processes (not restricted to key threatening processes) acting on populations of those species in the locality; and* • *a description of the level of the representation of affected species, or their habitats, within conservation reserves (or other similar protected areas) in the sub-region and locality.*	
2.3 A discussion of other populations of affected species in the locality must be provided particularly in regard to their long term security ie: the land zoning, land tenure and land management practices. The relative significance of the subject site for affected species in the locality must be discussed in light of the above.	*Chapter 4; Chapter 6; Chapter 7*
2.4 If local or regional habitat corridors for affected species area present within the subject site, the impact of the proposal on these areas must be discussed. Impacts of barrier effects must be discussed for both flora and fauna.	*Chapter 6*
2.5 Consideration must be given to possible indirect effects of the activity on the area surrounding the subject site, for example, edge effects on vegetation and habitat, altered hydrological regimes, soil erosion or pollution.	*Chapter 6*
3. Mitigation	
The following issues must be addressed:	
3.1 Where a draft recovery plan prepared in accordance with the NSW TSC Act is relevant to any affected species, consideration must be given to the information contained in these plans and whether any draft recovery plan recommendation is applicable to the proposal.	*n/a*
3.2 In discussing alternatives to the proposal, justification must be provided for the	*Chapter 8*

Table 2.2 CHAPTERS IN THIS REPORT ADDRESSING THE DIRECTOR GENERAL'S REQUIREMENTS

Matters To Be Addressed	*Chapters In Which The Matters Are Addressed*
decision to select the current proposal, in terms of relative impacts on affected species.	
3.3 Detail must be provided of the measures proposed to mitigate the effect of the proposal. Measures for minimising the number of road kills of affected species should be identified. These may include fauna over or underpasses, exclusion fencing, tunnels, retention of median vegetation for arboreal species. Other mitigation measures should be identified including appropriate revegetation and habitat restoration in adjacent areas and/or provision of compensatory habitat. The techniques used must employ current best practice and be supported by a literature review.	*Chapter 7*
3.4 Proposals for monitoring the effectiveness of the proposed mitigation measures and the impact of the proposal on affected species, must be provided and discussed. Details of such monitoring must be provided including site location, frequency of monitoring and duration of program. A discussion of possible options for changes to mitigation measures in the light of monitoring results must be included.	*Chapter 7*
3.5 Details of any habitat restoration or improvement programs proposed for the study area must be provided, including the proposed time frame for habitat restoration/improvement, and the likely impact on flora and fauna, particularly during the time between the impact on the habitat and any habitat restoration/improvement. Habitat restoration and rehabilitation works should commence before project completion.	*Chapter 7*
4. Additional Information	
4.1 A list of approvals required must be provided, including:	*Chapter 2*
• *any consents required under Part IV of the* Environmental Planning and Assessment Act 1979 *including the name of the consent authority and when it is proposed to make the development application; or*	
• *any approvals required under Part V of the Environmental Planning and Assessment Act 1979 including the name of the determining authority(ies), the basis for approval and when these approvals are proposed to be obtained.*	
4.2 Flora and fauna locality data recorded during surveys must be provided.	*Appendix H*

2.3 DEFINITIONS

The following definitions are applicable to these Requirements and the SIS:

- ***abundance*** means a quantification of the population of the species or community;
- ***activity*** has the same meaning as in the *Environmental Planning as Assessment Act 1979;*
- ***affected species*** means subject species likely to be affected by the proposal;
- ***conservation status*** is regarded as the degree of representation of a species or community in formal conservation reserves;
- ***development*** has the same meaning as the *Environmental Planning and Assessment Act 1979;*
- ***Director-General*** means the Director-General of National Parks and Wildlife;
- ***locality*** means the area within a 10 km radius of the study area (refer to *Section 2.4* below);
- ***NPWS*** means the NSW National Parks and Wildlife Service.
- ***region*** means, for the purposes of the provision in which it is used, a bioregion defined in a national system of bioregionalisation that is determined (by the Director-General by order published in the Gazette) to be appropriate for those purposes. If the bioregion occurs partly outside New South Wales, the region consists only of so much of the bioregion as occurs within New South Wales (refer to *Section 2.6* below);
- ***significant species*** means species not listed in the TSC Act but considered to be of regional or local significance;
- ***subregion*** means an area based around Raymond Terrace to the south and Bulahdelah to the north. Catchment or sub-catchment boundaries may be used to help define the sub-region (refer to *Section 2.5* below);
- ***study area*** is the subject site and any additional areas which are likely to be affected by the proposal, either directly or indirectly;
- ***subject site*** means the area which is proposed for development/activity;
- ***subject species*** means those threatened and significant species which are considered known or likely to occur in the study area. These are listed in *Section 2.7* below.

- ***threatening process*** includes all processes considered to be threatening, not limited to key threatening processes as defined in the TSC Act.

All other definitions are the same as those contained in the TSC Act.

2.4 THE STUDY AREA AND SUBJECT SITE

The study area and subject site are defined and described in *Section 1.3.*

2.5 THE LOCALITY

The Director-General's Requirements for the SIS (*Appendix A*) defines the *"locality"* as *"the area within a 10 km radius of the study area"*. *Section 1.4* of the Director-General's Requirements states that a topographic map of the locality must be provided at an appropriate scale. Due to the extensive size of the study area, this topographic map has been provided on a scale of 1:25,000. As well as being illustrated on this map, major land tenure units (of potential conservation significance) including National Parks, Nature Reserves and State Forests are discussed in the following sections. This topographic map is attached at *Appendix C.*

2.6 THE SUB-REGION

The sub-region has been defined to enable the assessment of the representativeness and reservation of habitat on a more detailed scale. NPWS has defined the sub-region as an area between the Williams River catchment in the south and Wang Wauk River catchment in the north. This area has been further delineated by determination of catchment boundaries, and is illustrated in *Figure 2.1.*

2.7 THE REGION

As defined in the NSW TSC Act (1995), the region means a bioregion defined in a national system of bioregionalisation which is determined by the Director-General of NPWS. In May 1996 the Director-General gave notice pursuant to section 4 (1) of the TSC Act 1995, and section 4 (6A) of the EP&A Act 1979, that the national system of biogeographic regionalisation, identified in *An Interim Biogeographic Regionalisation for Australia: A Framework for Setting Priorities in the National Reserves System Cooperative Program* (Thackway and Cresswell (eds) 1995) is appropriate for the purposes of the provisions in which the term 'region' is used.

Figure 2.1 THE SUB-REGION

N

Not to Scale

The Sub-region within which the study area is located falls within both the North Coast region (NNC) and the Sydney Basin region (SB). The NSW North Coast region has been given the IBRA code NNC, whereas the Sydney Basin region has the IBRA code of SB. The boundaries of these regions are illustrated on the map "Boundaries of IBRA Regions", (Thackway and Cresswell 1995), Map Version 4.0, as illustrated in *Figure 2.2.*

The North Coast region is characterised by a humid climate, hills coastal plains and sand dunes; *Eucaluptus - Lophostemon confertus* tall open forests, *Eucalyptus* opn forests and woodlands, rainforest often with *Araucanc Cunninghamii* (complex notophyll and microphyll vine forest), *Melaleuca quinquenervia* wetlands and heaths (Thackway and Cresswell (eds) 1995).

The Sydney Basin region is characterised by mesozoic sandstones and shales; dissected plateaus, forests, woodlands and heaths; skeletal soils, sands and podzolics [Thackway and Cresswell (eds) 1995].

2.8 SPECIES CONSIDERED

The list of threatened species that are the subjects of this SIS are listed below. It was derived in consultation with the NSW NPWS, by examination of NPWS and NSW State Forests threatened species records made within the region and assessment of the habitats of the study area.

In accordance with Section 110 of the TSC Act (1995) and the NPWS Director-General requirements, species profiles have been prepared for each species potentially affected by the proposed Upgrade. These are contained in *Appendix D.*

Species profiles provide detailed information on ecological requirements and other characteristics such as:

- statewide, regional, sub-regional and local abundance and conservation status;
- habitat requirements, including home range, feeding, roosting and breeding requirements;

This information has been used to assist in assessing impacts of the proposed Upgrade on each of the subject species and in developing appropriate mitigation measures.

A list of the subject species is provided in *Table 2.3.*

Table 2.3 THREATENED AND SIGNIFICANT SPECIES KNOWN OR CONSIDERED LIKELY TO OCCUR WITHIN THE STUDY AREA

Family/Common Name	Scientific Name	Status
FLORA		
	*Plectranthus suaveolens**	RoTAP
MYRTACEAE	*Eucalyptus glaucina**	V
	Eucalyptus fergusonii subsp *fergusonii***	RoTAP
	*Callistemon acuminatus**	RoTAP
	*Melaleuca groveana**	V
PROTEACEAE	*Grevillea guthrieana**	RoTAP
	*Tetratheca juncea***	V
	*Prostanthera densa**	V
	*Syzygium paniculatum**	V
	*Asperula asthenes**	V
	Macrozamia pauli-guilemimim subsp *flexuosa**	RoTAP
	*Goodenia fordiana**	RoTAP
FAUNA		
AMPHIBIANS		
Green-thighed frog	*Litoria brevipalmata***	V
Green and Golden Bell frog	*Litoria aurea*	E
Stuttering frog	*Mixophyes balbus*	V
Giant Barred frog	*Mixophyes iteratus*	V
Wallum froglet	*Crinia tinnula*	V
REPTILES		
Stephen's banded snake	*Hoplocephalus stephensii**	V
Pale-headed snake	*Hoplocephalus bitorquatus**	V
MAMMALS		
Brush-tailed phascogale	*Phascogale tapoatafa**	V
Koala	*Phascolarctos cinereus***	V
Common wombat	*Vombatus ursinus**	
Spotted-tailed quoll	*Dasyurus maculatus***	V
Squirrel glider	*Petaurus norfolcensis***	V
Yellow-bellied glider	*Petaurus australis***	V

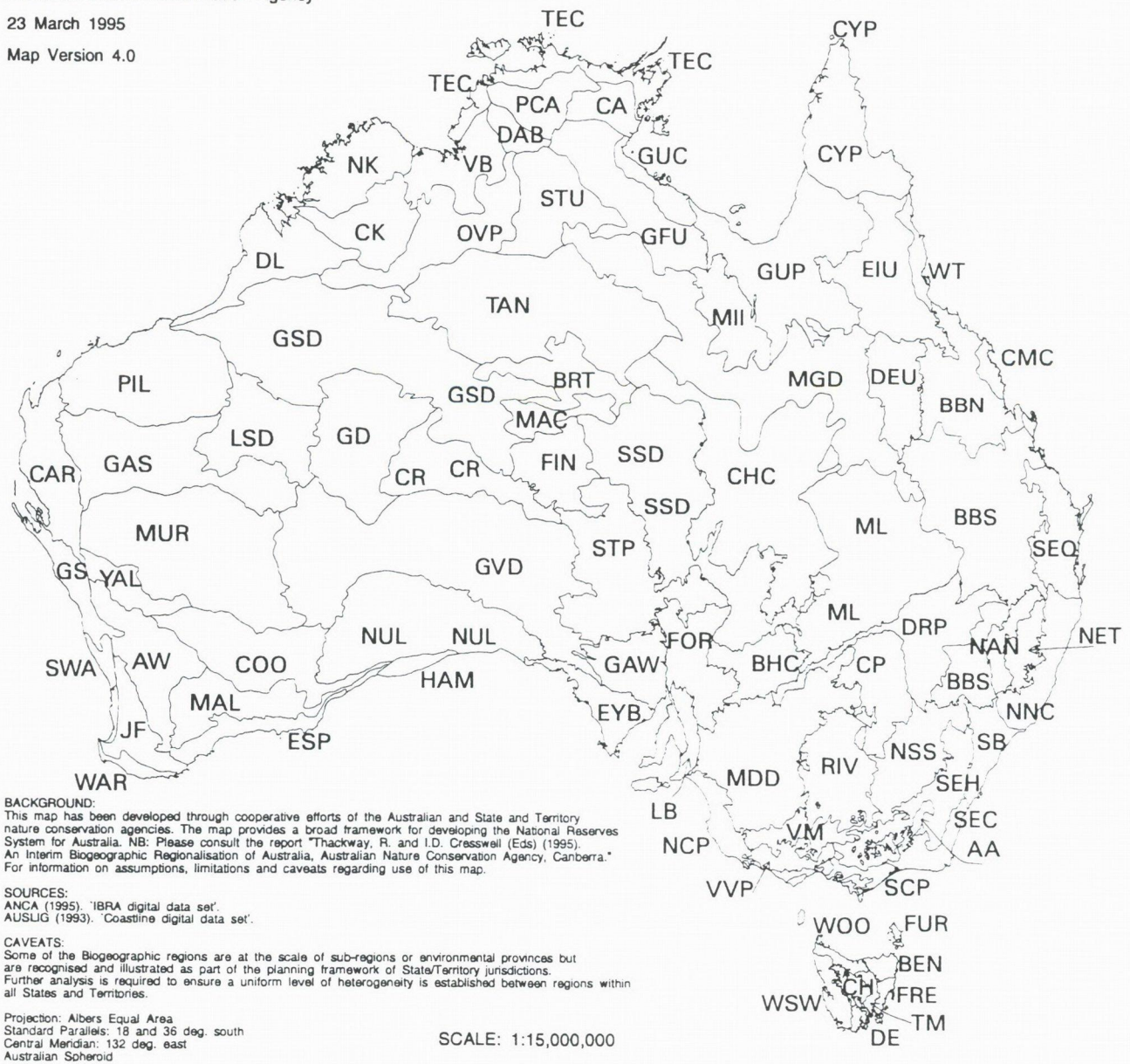
38067

Boundaries of IBRA Regions

Australian Nature Conservation Agency

23 March 1995

Map Version 4.0



BACKGROUND:
This map has been developed through cooperative efforts of the Australian and State and Territory nature conservation agencies. The map provides a broad framework for developing the National Reserves System for Australia. NB: Please consult the report "Thackway, R. and I.D. Cresswell (Eds) (1995). An Interim Biogeographic Regionalisation of Australia, Australian Nature Conservation Agency, Canberra." For information on assumptions, limitations and caveats regarding use of this map.

SOURCES:
ANCA (1995). 'IBRA digital data set'.
AUSLIG (1993). 'Coastline digital data set'.

CAVEATS:
Some of the Biogeographic regions are at the scale of sub-regions or environmental provinces but are recognised and illustrated as part of the planning framework of State/Territory jurisdictions. Further analysis is required to ensure a uniform level of heterogeneity is established between regions within all States and Territories.

Projection: Albers Equal Area
Standard Parallels: 18 and 36 deg. south
Central Meridian: 132 deg. east
Australian Spheroid

SCALE: 1:15,000,000

IBRA CODE: IBRA NAME
AA: Australian Alps
AW: Avon Wheatbelt
BBN: Brigalow Belt North
BBS : Brigalow Belt South
BEN: Ben Lomond
BHC: Broken Hill Complex
BRT: Burt Plain
CA: Central Arnhem
CAR: Carnarvon
CH: Central Highlands
CHC: Channel Country
CK: Central Kimberley
CMC: Central Mackay Coast
COO: Coolgardie
CP: Cobar Peneplain
CR: Central Ranges
CYP: Cape York Peninsula
DAB: Daly Basin
DE: D'Entrecasteaux
DEU: Desert Uplands
DL: Dampierland
DRP: Darling Riverine Plains
EIU: Einasleigh Uplands
ESP: Esperance Plains
EYB: Eyre and Yorke Blocks
FIN: Finke
FOR: Flinders and Olary Ranges
FRE: Freycinet
FUR: Furneaux
GAS: Gascoyne
GAW: Gawler
GD: Gibson Desert
GFU: Gulf Fall and Uplands
GS: Geraldton Sandplains
GSD: Great Sandy Desert
GUC: Gulf Coastal
GUP: Gulf Plains
GVD: Great Victoria Desert
HAM: Hampton
JF: Jarrah Forest
LB: Lofty Block
LSD: Little Sandy Desert
MAC: MacDonnell Ranges
MAL: Mallee
MDD: Murray-Darling Depression
MGD: Mitchell Grass Downs
MII: Mount Isa Inlier
ML: Mulga Lands
MUR: Murchison
NAN: Nandewar
NCP: Naracoorte Coastal Plain
NET: New England Tableland
NK: Northern Kimberley
NNC: NSW North Coast
NSS: NSW South western Slopes
NUL: Nullarbor
OVP: Ord-Victoria Plains
PCA : Pine-Creek Arnhem
PIL: Pilbara
RIV: Riverina
SB: Sydney Basin
SCP: South east Coastal Plain
SEC: South East Corner
SEH: South Eastern Highlands
SEQ : South Eastern Queensland
SSD: Simpson-Strzelecki Dunefields
STP: Stony Plains
STU: Sturt Plateau
SWA: Swan Coastal Plain
TAN: Tanami
TEC: Top End Coastal
TM: Tasmanian Midlands
VB: Victoria Bonaparte
VM : Victorian Midlands
VVP: Victorian Volcanic Plain
WAR: Warren
WOO: Woolnorth
WSW: West and South West
WT: Wet Tropics
YAL: Yalgoo

MITCHELL ERM McCOTTER

Figure 2.2 BOUNDARIES OF IBRA REGIONS

Table 2.3 THREATENED AND SIGNIFICANT SPECIES KNOWN OR CONSIDERED LIKELY TO OCCUR WITHIN THE STUDY AREA

Family/Common Name	Scientific Name	Status
Eastern chestnut mouse	*Pseudomys gracilicaudatus*	V
Long-nosed potoroo	*Potorous tridactylus***	V
Red-legged pademelon	*Thylogale stigmatica*	V
Common planigale	*Planigale maculata**	V
Golden tipped bat	*Kerivoula papuensis*	V
Eastern freetail bat	*Mormopterus norfolkensis***	V
Little bent-wing bat	*Miniopterus australis***	V
Large bent-wing bat	*Miniopterus schreibersii***	V
Large footed myotis	*Myotis adversus***	V
AVIFAUNA		
Bush stone-curlew	*Burhinus grallarius**	E
Glossy black-cockatoo	*Calyptorhynchus lathami***	V
Osprey	*Pandion haliaetus*	V
Square-tailed kite	*Lophoictinia isura**	V
Masked owl	*Tyto novaehollandiae***	V
Sooty owl	*Tyto tenebricosa*	V
Eastern grass owl	*Tyto Capensis***	V
Powerful owl	*Ninox strenua**	V
Barking owl	*Ninox connivens**	V
Turquoise parrot	*Neophema pulchella**	V
Swift parrot	*Lathamus discolor**	V
Regent honeyeater	*Xanthomyza phrygia**	E
Black bittern	*Ixobrychus flavicollis**	V
Black-necked stork	*Epippiorhynchus asiaticus***	E
Comb-crested jacana	*Jacana gallinacea*	V
Superb fruit-dove	*Ptilinopus magnificus**	V
Rose-crowned fruit-dove	*Ptilinopus regina**	V
Wompoo fruit dove	*Ptilinopus magnificus**	V

Notes: *E= Listed as endangered on Schedule 1 of the Threatened Species Conservation Act 1995.*

V= Listed as vulnerable on Schedule 2 of the Threatened Species Conservation Act 1995.

RoTAP = Rare or Threatened Australian Plant with Regional, State or National Significance but not listed on TSC Act (1995).

***= Species detected in the study area.*

**= Species not detected in the study area, but expected to occur based upon data from adjacent areas and habitats present in the study area.*

Fauna species without status are considered to have conservation significance at a regional, state or national level, but are not listed on the TSC Act (1995).

2.9 LIMITATIONS AND MODIFICATIONS TO SIS REQUIREMENTS

The Director General has stated that the following Section 110 matters need not be addressed in the SIS:

- All reference to endangered populations and endangered ecological communities. The TSC Act does not currently list any endangered populations or ecological communities within the locality.
- Section 110(2)(e). This section is a replication of 110(2)(a).
- All references to critical habitat. There is currently no declared critical habitat in NSW.
- Section 110(2)(g). The matters raised in this section of the Act have been clarified by the requirements outlined in the Director-General's requirements.

2.10 COMMONWEALTH GOVERNMENT REQUIREMENTS

2.10.1 Endangered Species Protection Act (1992)

The Endangered Species Protection Act (1992) applies to the proposed Upgrade because the actions, approvals or decisions to be applied could threaten with extinction, or significantly impede the recovery of a listed species or ecological community.

The objects of this Act are to:

- promote the recovery of species and ecological communities that are endangered or vulnerable;
- prevent other species and ecological communities from becoming endangered;

- reduce conflict in land management through readily understood mechanisms relating to the conservation of species and ecological communities that are endangered or vulnerable;
- provide for public involvement in, and promote public understanding of, the conservation of such species and ecological communities; and
- encourage cooperative management for the conservation of such species and ecological communities.

The proposed Upgrade is consistent with the objects of this Act.

2.10.2 *Australian Heritage Commission Act (1975)*

The provisions of the Act enabled the formation of the Australian Heritage Commission. The function of the Commission is to advise the Commonwealth Government on matters relating to the National Estate which (Woodward Clyde 1998). Its primary role is to maintain the Register of the National Estate identifies important sites for the natural and cultural/built environment (Woodward Clyde 1998).

The Commission was consulted during the preparation of the SIS and no places on the Register have been identified within the study area.

2.10.3 *Environment Protection (Impact of Proposals) Act (1974)*

The objective of this Act is to ensure, to the greatest extent possible, that matters affecting the environment to a significant extent are fully examined and taken into account in relation to the:

- formulation of proposals;
- carrying out of works and other projects;
- negotiation, operation and enforcement of agreements and arrangements (including agreements and arrangements with, and with authorities of, the States);
- making of, or the participation in the making of, decisions and recommendations; and

- incurring of expenditure by, or on behalf of, the Australian Government and authorities of Australia, either alone or in association with any other government, authority, body or person.

The proposal satisfies this objective.

2.10.4 *Other Issues of Commonwealth Importance*

In addition to the above mentioned legislation, other issues of Commonwealth importance are required to be considered.

The National Wetlands Program was established in January 1989 to address issues regarding the loss and degradation of wetland habitats in Australia. The program is a cooperative project between the Commonwealth, State and Territory governments, intended to promote the conservation and better management of Australia's wetlands and to ensure that Australia meets its obligations under the Ramsar Convention. One element of the National Wetlands Program has been the preparation of A Directory of Important Wetlands in Australia (ANCA 1996) which lists wetlands of national significance. Within NSW, 94 wetlands have been included in the Directory (Woodward Clyde/Landmark Ecological Services 1998). Myall Lakes, a wetland of national significance is approximately 0.5 kilometres to the east of the proposed Upgrade at Nerong Village.

Australia is a Contracting Party to the Ramsar Convention on Wetlands of International Importance. The RAMSAR Convention addresses Australia's obligations to wetlands of international importance. There are 45 wetlands in Australia currently listed on the RAMSAR Convention listing, however none of these wetlands are located within, or in close proximity to the study area.

Other international agreements include the Japan-Australia and China-Australia Migratory Bird Agreements (JAMBA and CAMBA). *Appendix F* contains a list of JAMBA and CAMBA species potentially occurring within the study area and their likely sensitivity to the development.

2.11 ADDITIONAL INFORMATION AND REQUIRED APPROVALS

An Environmental Impact Statement (EIS) has been prepared to assess the impacts of the proposed Upgrade and determine the mitigation actions that are necessary to ensure protection of the environment during construction and operation of the proposal. The EIS is accompanied by a series of Working Papers that address specific environmental issues. These Working Papers are:

- No 1 Preferred Concept and Design Report (RTA 1999).
- No 2 Transportation, Traffic and Economic Assessment (ERM Mitchell McCotter 1999a).
- No 3 Noise Assessment (ERM Mitchell McCotter 1999b).
- No 4 Air Quality Assessment (ERM Mitchell McCotter 1999c).
- No 5 Water Quality and Hydrology Assessment (ERM Mitchell McCotter 1999d).
- No 6 Archaeological Assessment (ERM Mitchell McCotter 1999e).
- No 7 Aquatic Fauna and Habitat Assessment (ERM Mitchell McCotter 1999f).
- No 8 Soils and Geotechnical Assessment (ERM Mitchell McCotter 1999g).
- No 9 Visual and Landscape Assessment (ERM Mitchell McCotter 1999h).
- No 10 Consultation (ERM Mitchell McCotter 1999i).

A number of these working papers have used in the preparation of this SIS.

2.11.1 Required Approvals

All activities carried out for the proposed Upgrade must comply with the relevant provisions of certain NSW legislation and regulations. Those requirements are described in *Table 2.4*.

Table 2.4 APPROVALS UNDER NSW ACTS

Act	Authority	Requirements
National Parks and Wildlife Act 1974	National Parks and Wildlife Service	Require consent, with or without salvage, prior to destroying or disturbing Aboriginal relics or places under S90.
Clean Waters Act 1970	Environment Protection Authority	The RTA would liaise with the EPA to determine arrangements for a pollution control approval and licence required to construct, and discharge from, pollution control structures.
Clean Air Act 1961	Environment Protection Authority	Scheduled premises, such as concrete batch plants, fuel burning equipment and premix bitumen plants, require licences to operate. Generally, licences are issued for specific plants which can be moved and used according to licence conditions. The Act also regulates air quality and emissions such as dust.
Noise Control Act 1975	Environment Protection Authority	The proposed Upgrade is not a scheduled premise and would not require approval or licensing. Construction noise is regulated, where practical, by the EPA's Environment Noise Control Manual. Individual fixed and mobile plant may also require licences to operate.
Environmentally Hazardous Chemicals Act 1985	Environment Protection Authority	Requires that the keeping or distribution of certain chemicals that are notified from time to time by the EPA is licensed under the Act.
Pollution Control Act 1975	Environment Protection Authority	The Act provides for the issue of a single approval or licence under the above four Acts.

Table 2.4 APPROVALS UNDER NSW ACTS

Act	Authority	Requirements
Waste Minimisation and Management Act 1995	Environment Protection Authority	Certain activities, including crushing or grinding works are controlled waste facilities and require a licence to operate. Concrete batch plants are exempt from licensing but must comply with requirements of the Act. Licences are also required for generating or storing certain hazardous wastes which would include the contractor's site compound and a concrete batch plant.
Soil Conservation Act 1938	Department of Land and Water Conservation	Requires a permit to clear vegetation on land with slopes greater than 18°.
Native Vegetation Conservation Act 1997	Department of Land and Water Conservation	Requires development consent from the Minister of LaWC for clearing on State protected land. This clearing includes trees, understorey plants, groundcover and wetland plants. No development consent is required for vegetation clearance to facilitate road works by a road authority.
Rivers & Foreshore Improvements Act 1948	Department of Land and Water Conservation	Requires a permit for excavation within 40 m of the bed or banks of a river or lake under Part 3A. The RTA benefits from an exemption under S22H.
Water Act 1912	Department of Land and Water Conservation	Licenses are required to be obtained for extraction of water or realignment of stream beds. In this case, this would apply to removal of water for dust control or compaction, or stream re-alignment for culvert installation/bridge construction.

Table 2.4 APPROVALS UNDER NSW ACTS

Act	Authority	Requirements
Fisheries Management Act 1994	NSW Fisheries	Give notice for dredging or reclamation in any waters under S199. Obtain permit prior to construction if passage of fish obstructed in creeks or flowing streams of water under S219.
Heritage Act 1977	NSW Heritage Office	Require excavation permit for disturbing sites known or suspected to contain relics.
Local Government Act 1993	Great Lakes Council	Require approvals for site buildings and effluent disposal.
Bush Fires Act 1949	Great Lakes Council	Require permits prior to burning during prescribed periods.

Chapter 3

FLORA ASSESSMENT

Chapter 3

FLORA ASSESSMENT

This chapter describes the methodology for the flora assessment of the study area and details the results of the flora survey undertaken. Vegetation communities in the study area are detailed and their conservation significance discussed. Rare, threatened and regionally significant flora species identified during the survey or likely to occur in the study area are also identified and discussed.

3.1 BACKGROUND TO THE FLORA STUDY

Flora investigations have been undertaken within the study area for the preparation of a Review of Environmental Factors (REF) and for this Species Impact Statement (SIS). Furthermore, other ecological studies pertaining to the proposed Upgrade have been completed within and closely adjacent to the study area. This SIS considers the results of all available information from previous investigations.

The methods used for the flora survey conducted for this SIS (including those of the REF) are provided below.

3.2 METHODOLOGY

Flora surveys were conducted over 20 days in December 1997, January, July, October and November 1998.

The primary objectives of the flora survey were:

- to map and describe the vegetation communities occurring within the study area using the classification scheme of Walker and Hopkins (1990) as a basis;
- to compile a list if flora occurring in the vegetation communities, identifying any threatened, nationally, regionally or locally significant species and communities; and
- to assess the likely impacts of the proposed development and formulate recommendations for minimising impacts on the flora in the study area.

3.2.1 *Aerial Photograph Interpretation and Vegetation Community Mapping*

Air photograph interpretation (API) of vegetation initially involved the examination of 1:8,000 scale aerial photographs to delineate vegetation polygons (textural and colour differences). It is involved examination of NPWS habitat models (*Appendix E*) and qualitative field observations to identify broad vegetation communities within a one kilometres corridor adjacent to the existing road alignment (that is, 500 m on either side of the existing road).

Vegetation maps were drafted at a scale of 1:16,000. Mapping was undertaken up to a distance of 500 m on either side of the existing road alignment. Mapping accuracy was maintained at a high standard for approximately 300 m, however beyond this distance, mapping was undertaken with less detail and accuracy, due mainly to time constraints.

3.2.2 *Plot and Opportunistic Surveys*

Plot surveys (20 x 20 m) and opportunistic transects (using the random meander method outlined in Cropper 1993) were used to verify forest types and vegetation communities identified during API (whilst taking into consideration physical site attributes, including aspect, slope and elevation). All communities identified during API were visited and sampled either opportunistically or via structured survey plots. A total of 32 sites were surveyed by structured methods (plots being located in the most common communities and/or those that are likely to be impacted in some way by the proposed upgrade). Plot surveys and the opportunistic recording path are illustrated on *Figure 3.1*.

Plant species lists were compiled for each plant community visited. A list of flora species recorded during the field investigations is located at *Appendix G*. Species identification was made using a variety of texts, including Robinson (1994), Tame (1992), Williams *et al.* (1984), Auld and Medd (1987), Brooker and Kleinig (1996), Brooker *et al.* (1997) and Harden (1990 - 1993). Plant species nomenclature is based on Harden (1990 - 1993).

The vegetation structure within each plant community was described using the system developed by Walker and Hopkins (1990). This method uses growth form, height and crown cover of the dominant taxa in each of the strata layers that are identifiable (Hunter 1998a).

The quality of vegetation communities up to 500 m from either side of the highway was assessed by considering the following criteria:

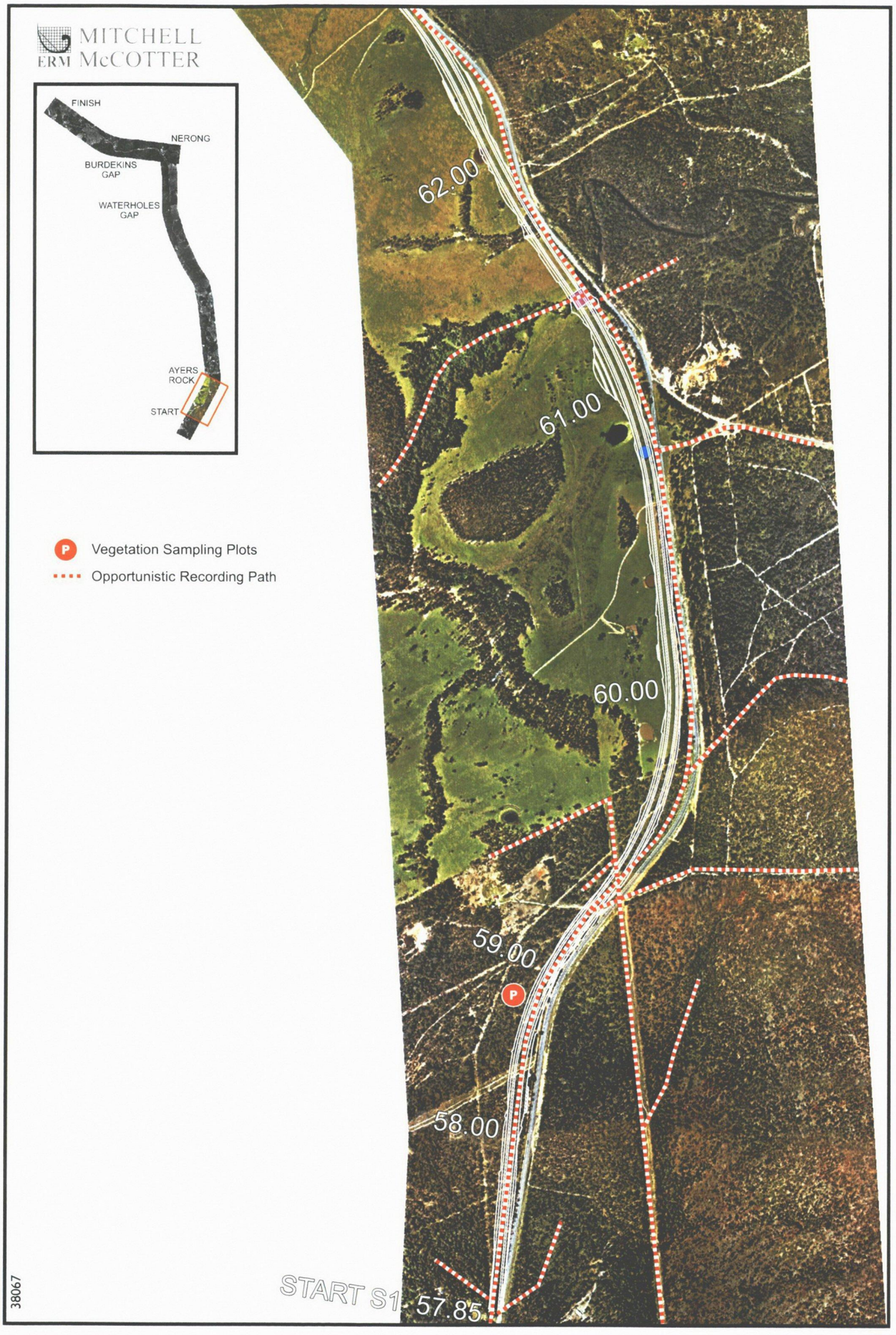


Figure 3.1a LOCATION OF VEGETATION SAMPLING PLOTS AND OPPORTUNISTIC RECORDING PATH

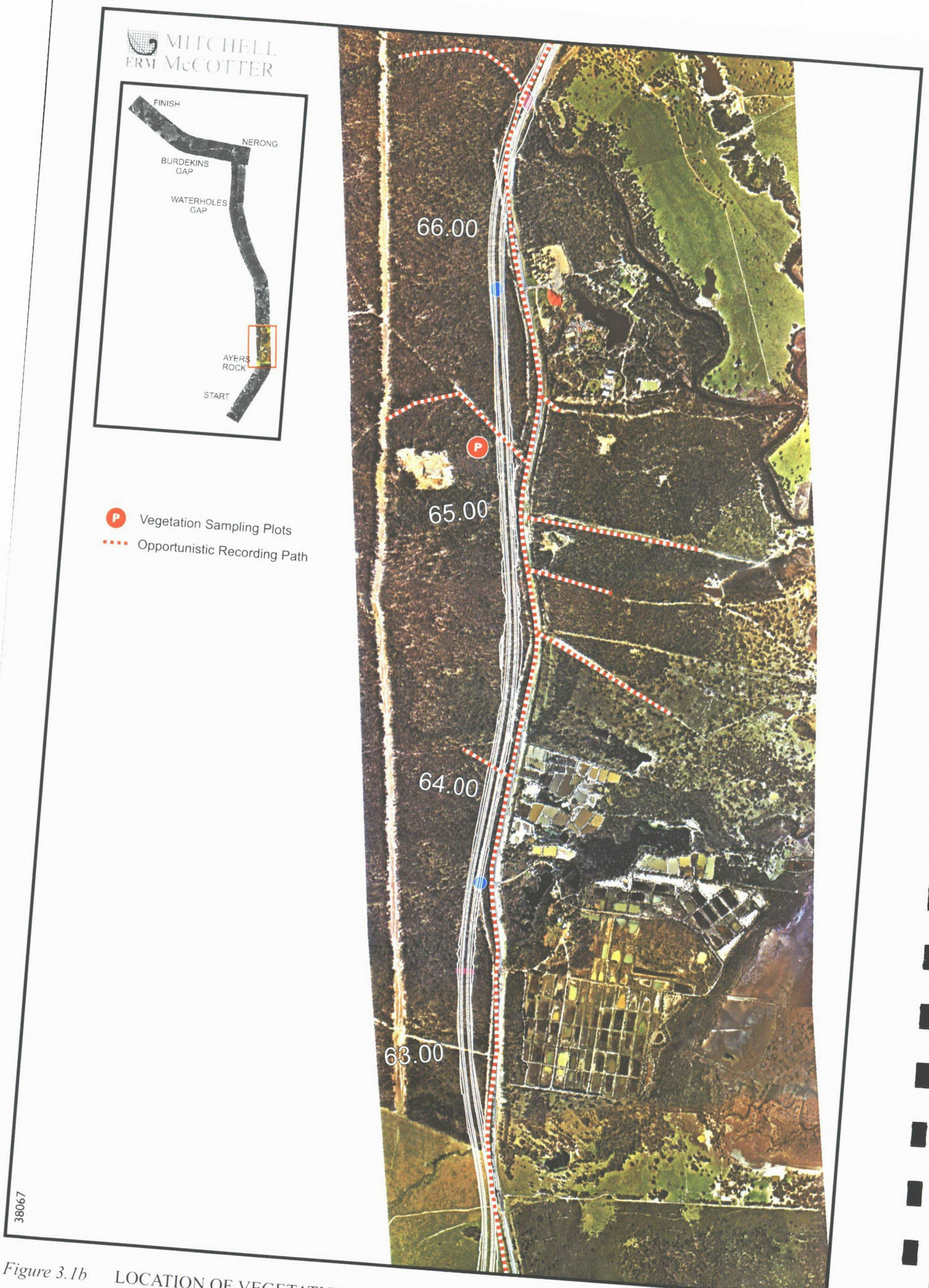


Figure 3.1b LOCATION OF VEGETATION SAMPLING PLOTS AND OPPORTUNISTIC RECORDING PATH

Scale: 1:16000

Figure 3.1c LOCATION OF VEGETATION SAMPLING PLOTS AND OPPORTUNISTIC RECORDING PATH

Figure 3.1d LOCATION OF VEGETATION SAMPLING PLOTS AND OPPORTUNISTIC RECORDING PATH

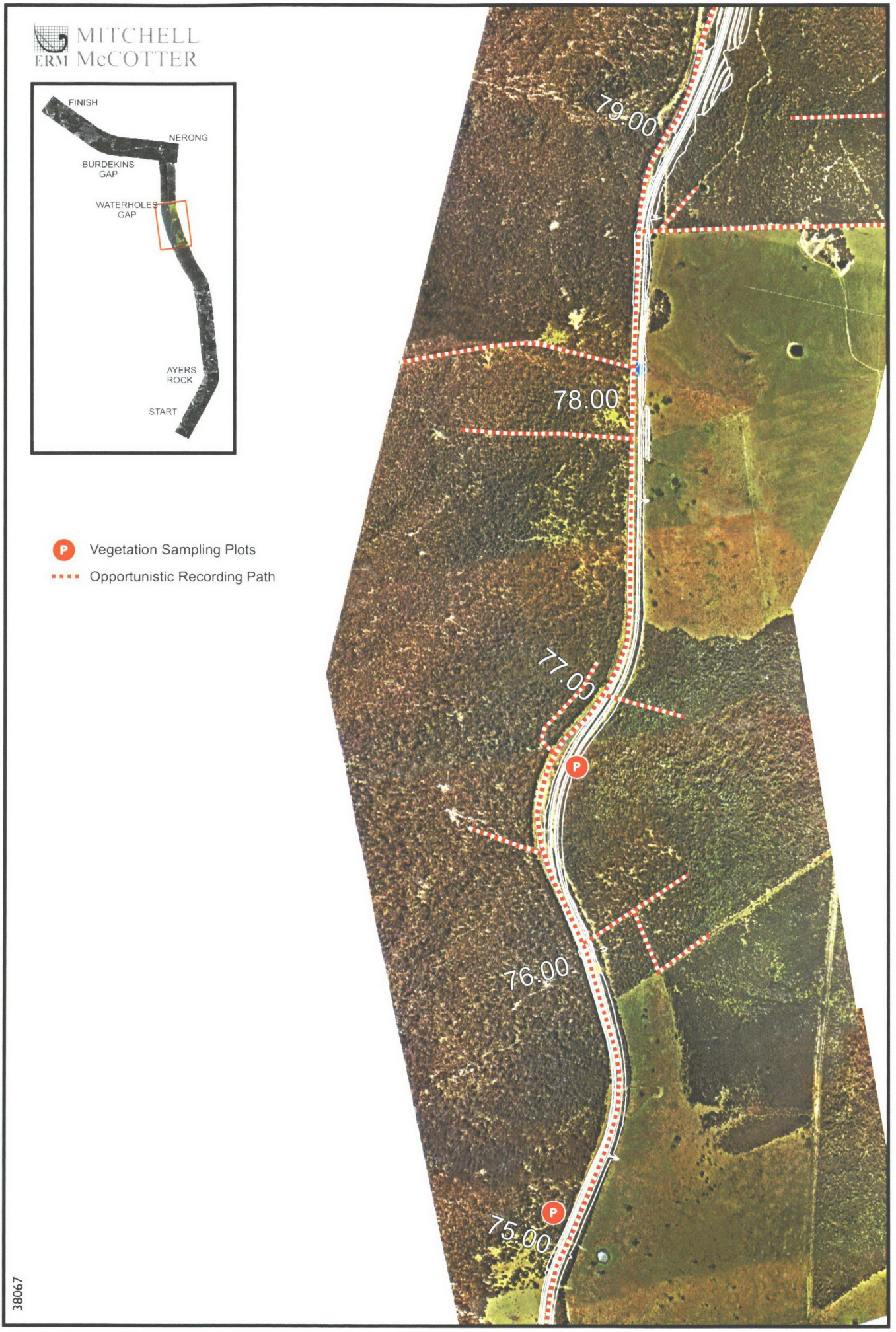


Figure 3.1e LOCATION OF VEGETATION SAMPLING PLOTS AND OPPORTUNISTIC RECORDING PATH

Scale: 1:16000

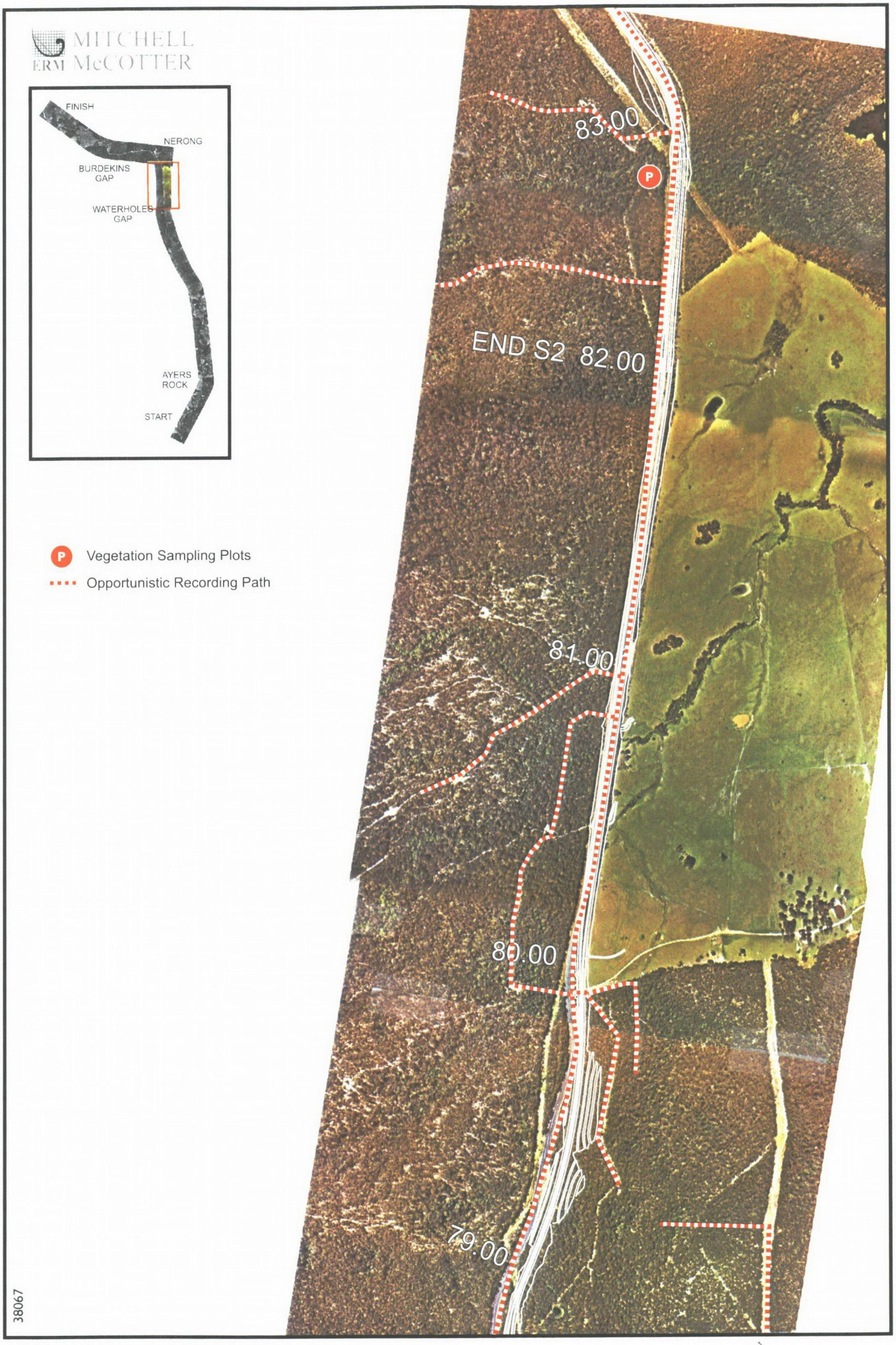


Figure 3.1f LOCATION OF VEGETATION SAMPLING PLOTS AND OPPORTUNISTIC RECORDING PATH

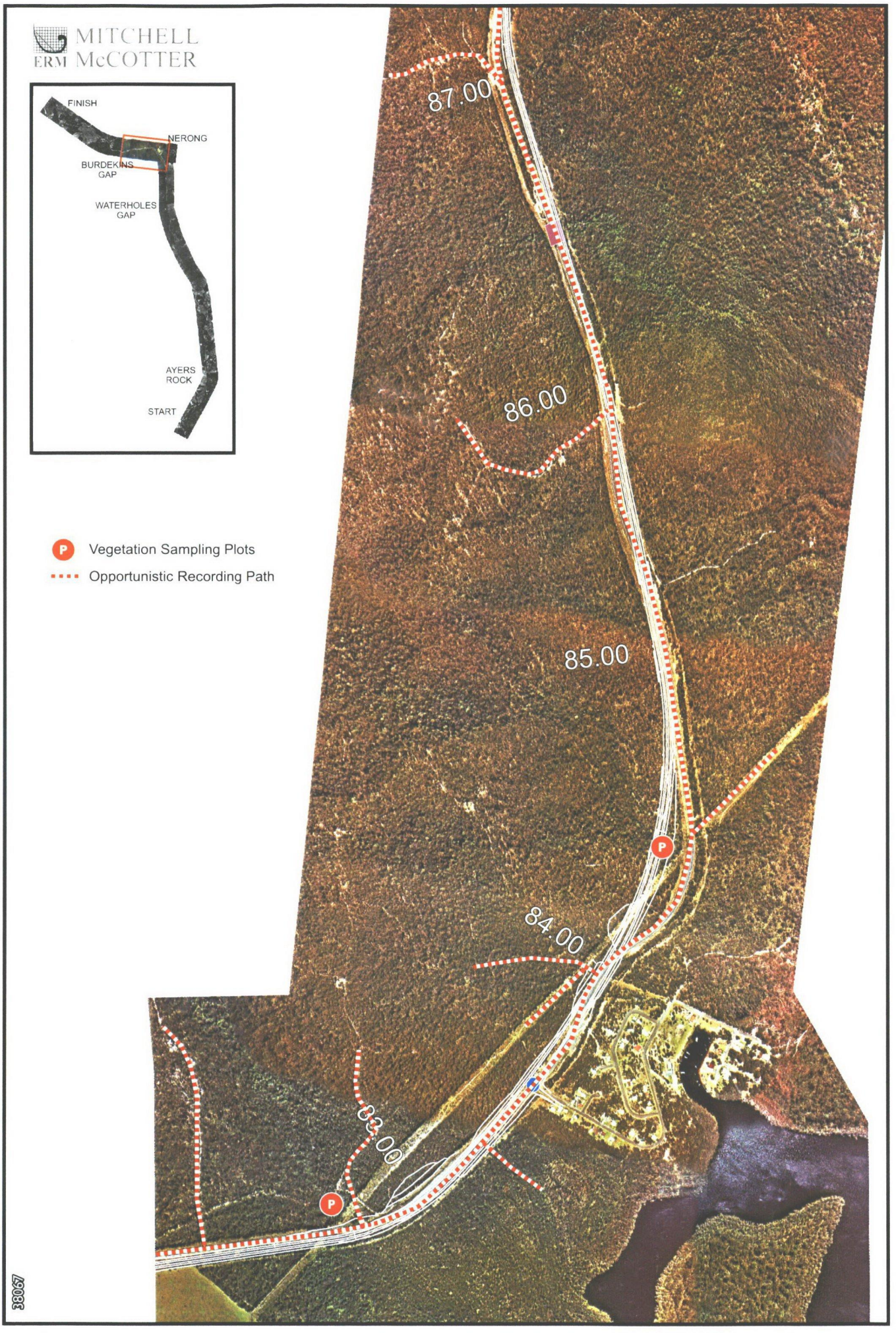


Figure 3.1g LOCATION OF VEGETATION SAMPLING PLOTS AND OPPORTUNISTIC RECORDING PATH

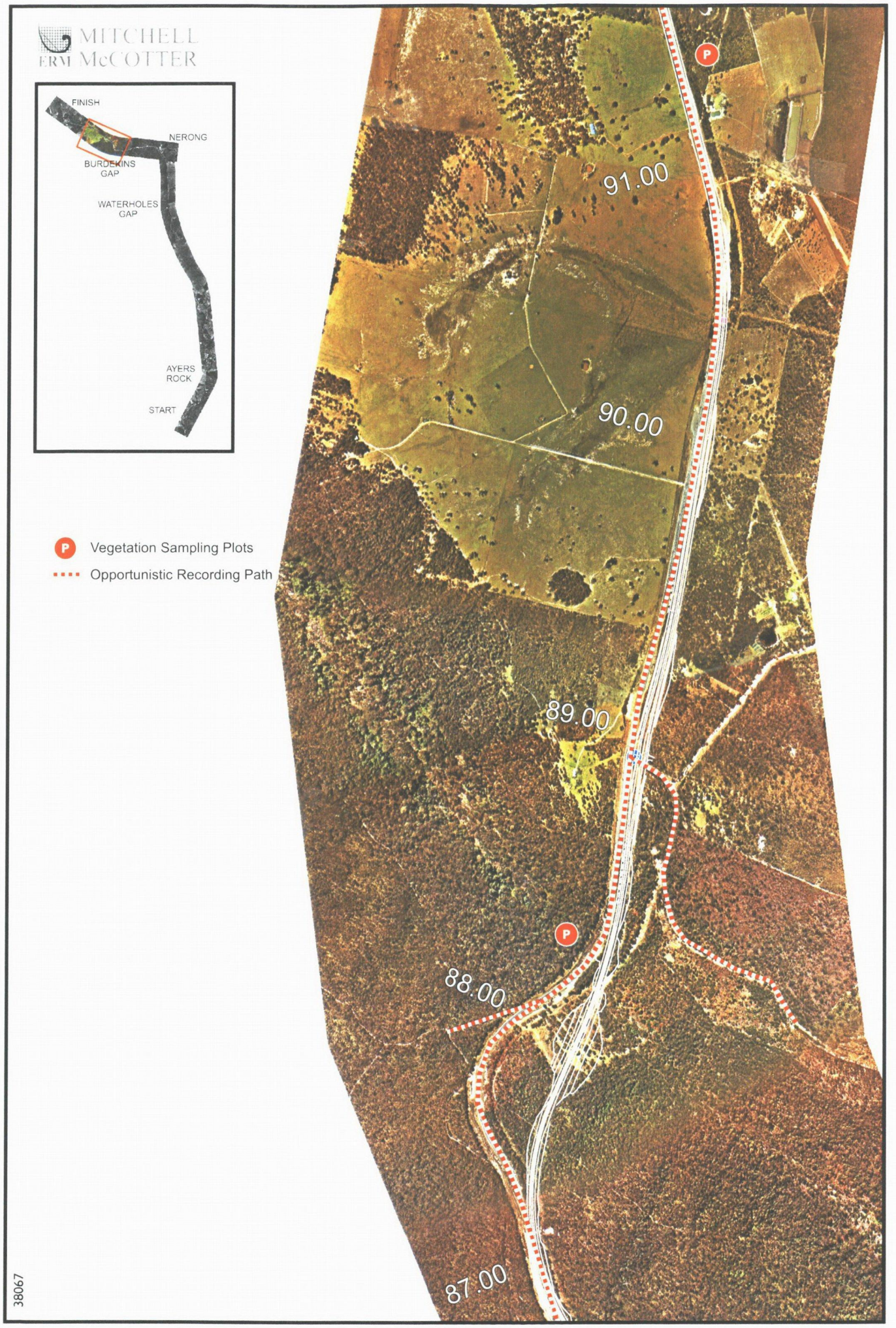


Figure 3.1h LOCATION OF VEGETATION SAMPLING PLOTS AND OPPORTUNISTIC RECORDING PATH

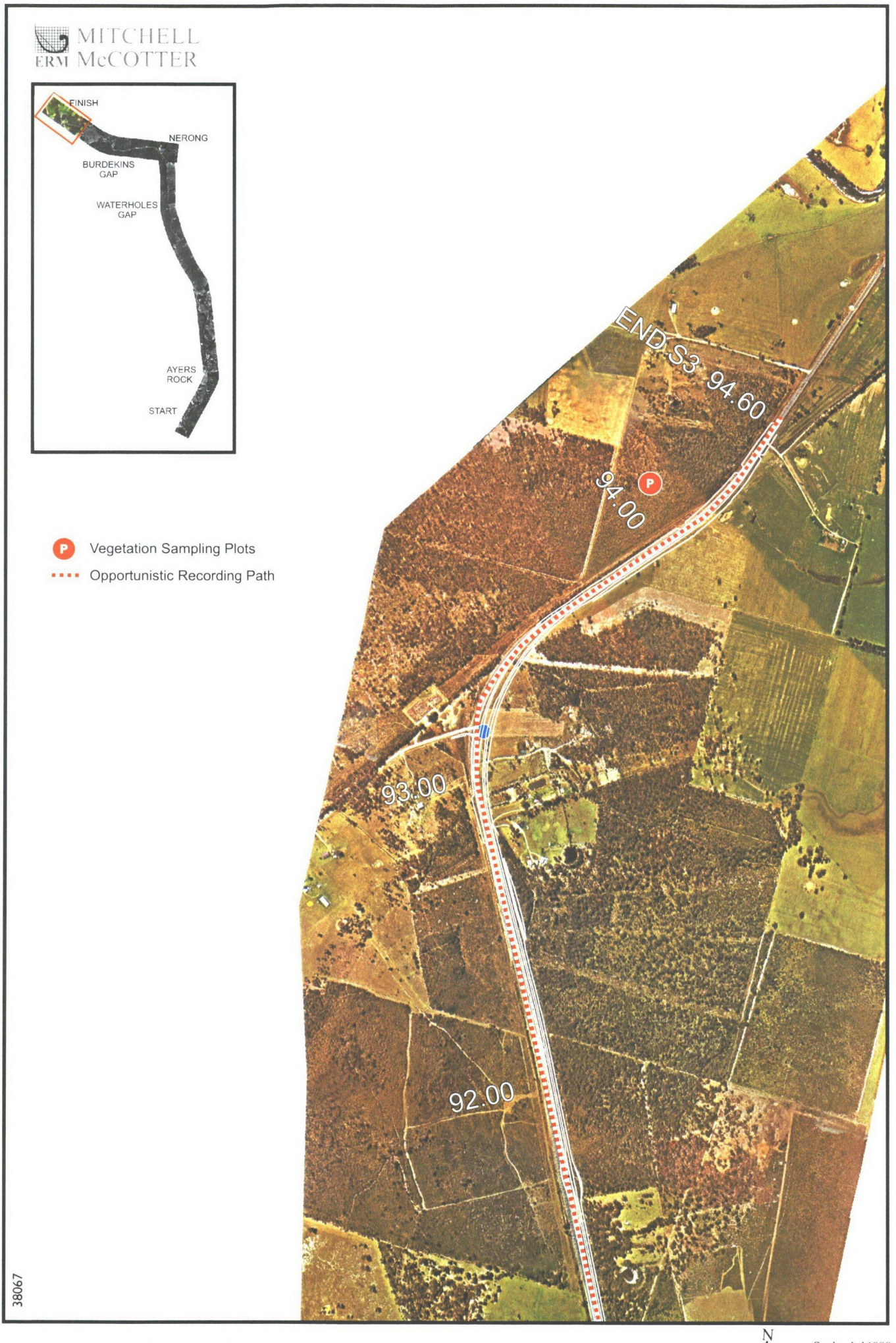


Figure 3.1i LOCATION OF VEGETATION SAMPLING PLOTS AND OPPORTUNISTIC RECORDING PATH

- extent of weed infestation;
- information about fire history;
- evidence of anthropogenic disturbances; and
- fragmentation.

3.2.3 *Threatened, Rare and Regionally Significant Plant Species*

Three main sources of information were used to determine taxa of national and state significance found within the study area These included the national list of rare or threatened Australian plants (RoTAP) (Briggs and Leigh 1996), the NSW Threatened Species Conservation (TSC) Act (1995) and the Commonwealth Endangered Species Protection (ESP) Act (1992).

Protected native flora species (as defined by the National Parks and Wildlife Act 1974) were noted when observed. The DG's requirements state that the presence of these species is indicative of the habitat quality of the site.

Furthermore, potential habitats and known occurrences of significant species within the study area were determined from the following sources:

- the knowledge of botanists undertaking the field studies;
- liaison with NPWS and NSW State Forests staff who possess a comprehensive knowledge of the area;
- perusal of NPWS habitat models (contained at *Appendix E);*
- NSW NPWS Wildlife Atlas Database (NPWS 1997 and 1998), including listings of Rare or Threatened Australian Plants (RoTAPs) and species listed on the schedules to the TSC Act previously found in the locality; and
- a review of literature documenting findings of research conducted in the locality.

Targeted flora surveys were conducted in habitats deemed suitable for threatened, rare and regionally significant plant species, particularly those areas under direct threat by the proposed upgrading. The random meander technique was selected to sample the study area in search of significant plant species potentially occurring. This method ensured that the full range of potential habitats for threatened species occurring within the alignment were sampled (Cropper 1993).

Where threatened species were found, such as *Tetratheca juncea,* supplementary field studies were undertaken to establish base line data that can be used in future monitoring programs. In an effort to determine the size of the *Tetratheca juncea* populations on both the eastern and western side of the existing highway adjacent to Mount Karuah;

1. the extent of the populations were determined by traversing the sites in all directions;

2. the perimeter of the populations was determined, surveyed and marked on a map;

3. random quadrats were placed within the population area and the number of individuals in each were counted. The quadrat size utilised was 5 x 40 m (200 m^2); and

4. following plant counting, the average number of plants per quadrat was used to calculate the number of individuals per hectare.

The location of sampling sites for the *T. juncea* populations are illustrated in *Figure 3.2.*

3.2.4 Assessment of Conservation Significance

The conservation status of each vegetation community was determined from reference to a number of key texts. These included Forestry Commission of NSW (1989a and 1989b), Hager and Benson (1994), Specht *et al.* (1995) and other relevant reference material gathered as part of the literature search.

3.3 RESULTS

3.3.1 Mapping

Nine forest types based on Research Note Number 17 standard, (Forestry Commission of NSW 1989b) and 36 vegetation communities (determined following the classification scheme of Walker and Hopkins 1990) were identified occurring adjacent to the existing highway as documented in *Table 3.1.* The distribution and extent of the vegetation communities are illustrated in *Figure 3.3.*

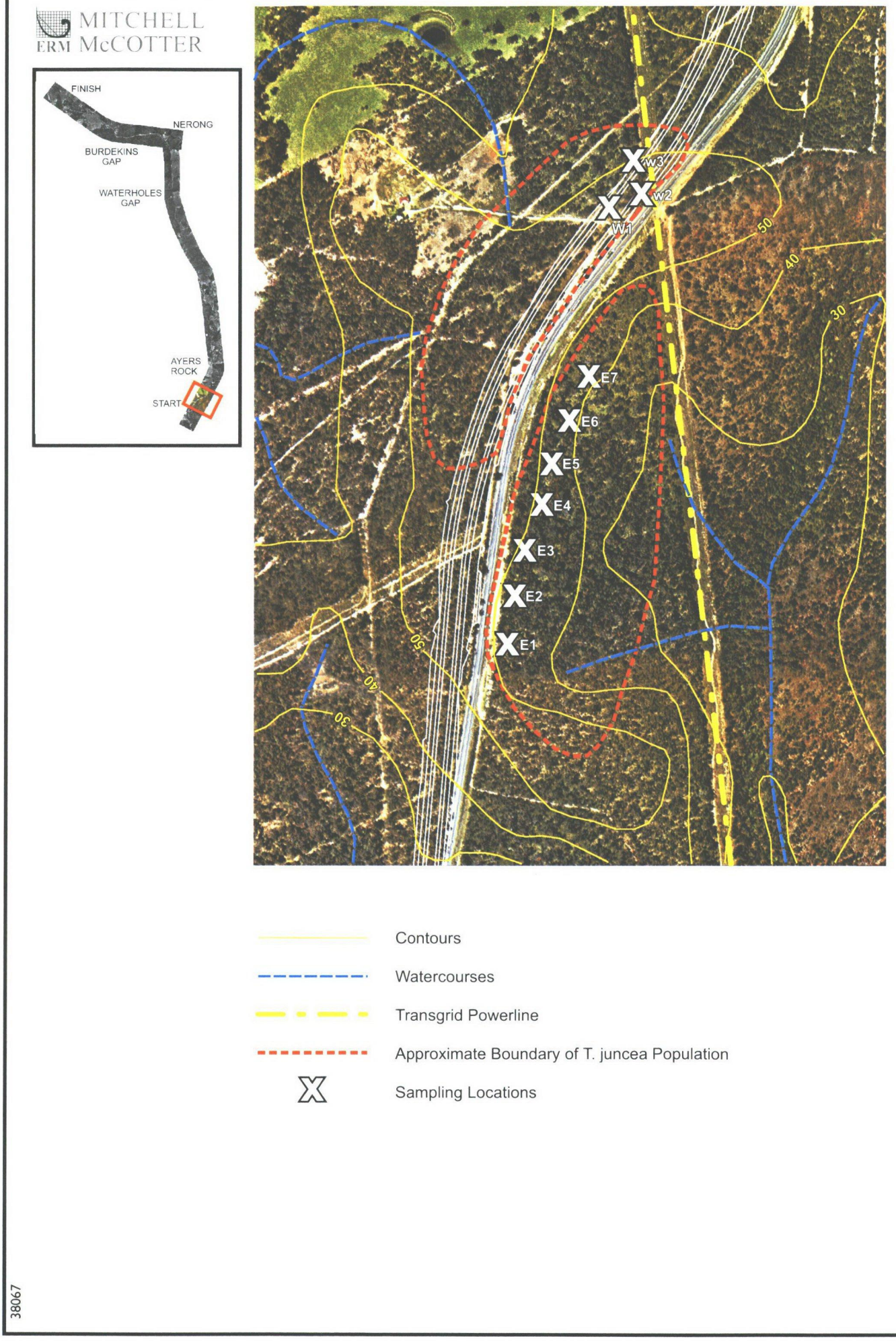


Figure 3.2 THE LOCATION OF T. JUNCEA SAMPLING SITES, AND DISTRIBUTION AND EXTENT OF T. JUNCEA POPULATIONS

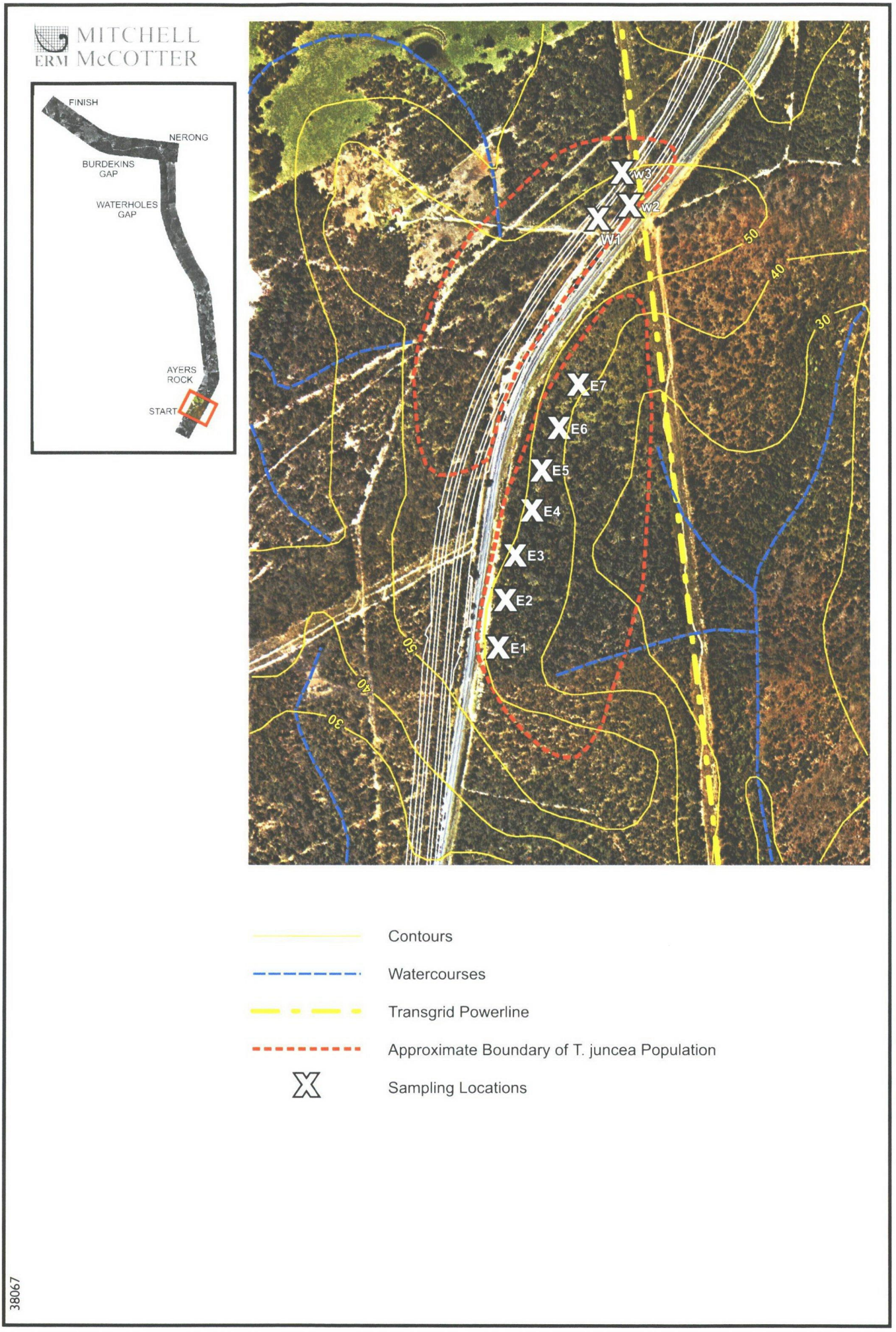


Figure 3.2 THE LOCATION OF T. JUNCEA SAMPLING SITES, AND DISTRIBUTION AND EXTENT OF T. JUNCEA POPULATIONS

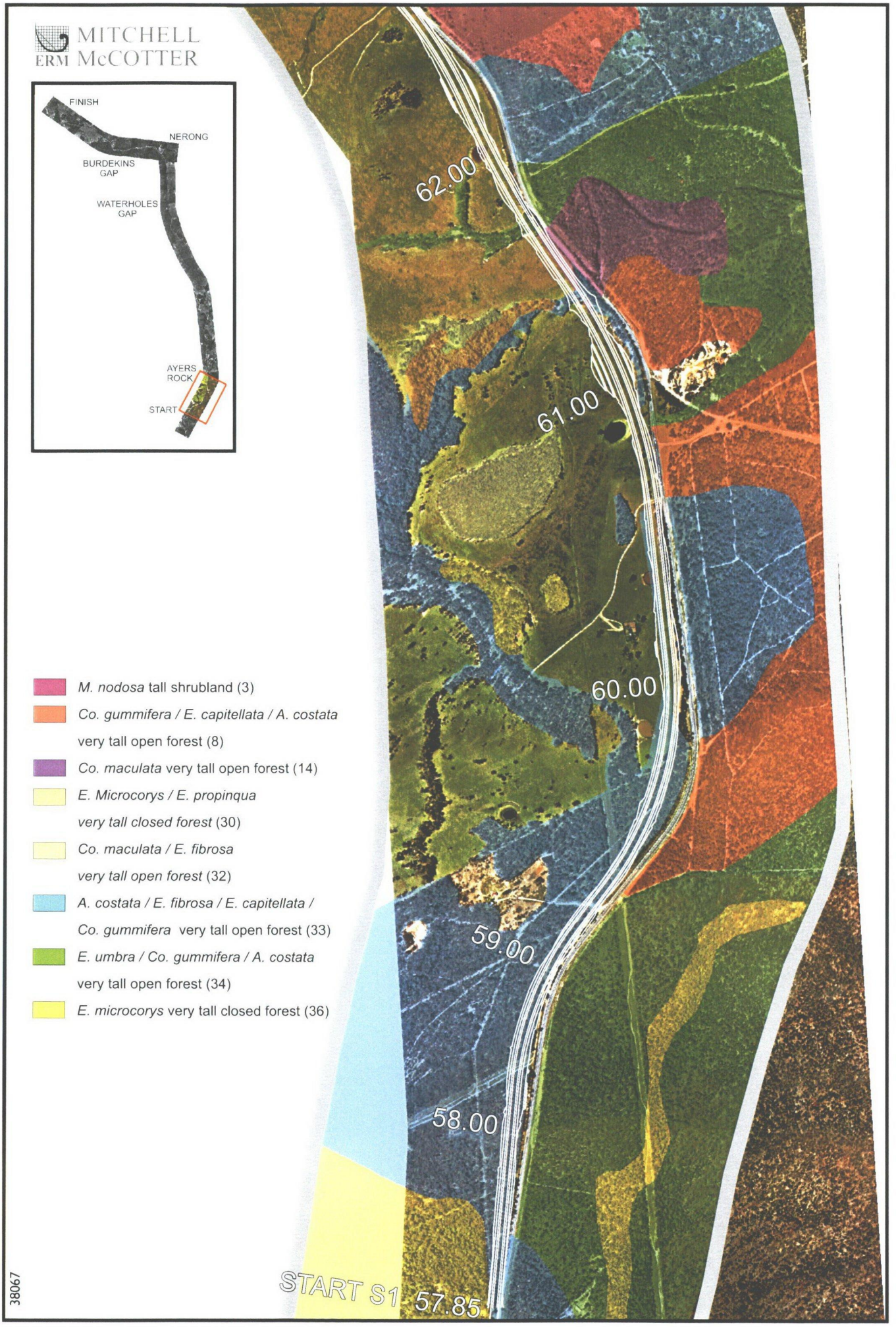


Figure 3.3a VEGETATION COMMUNITIES WITHIN THE STUDY AREA

Scale: 1:16000

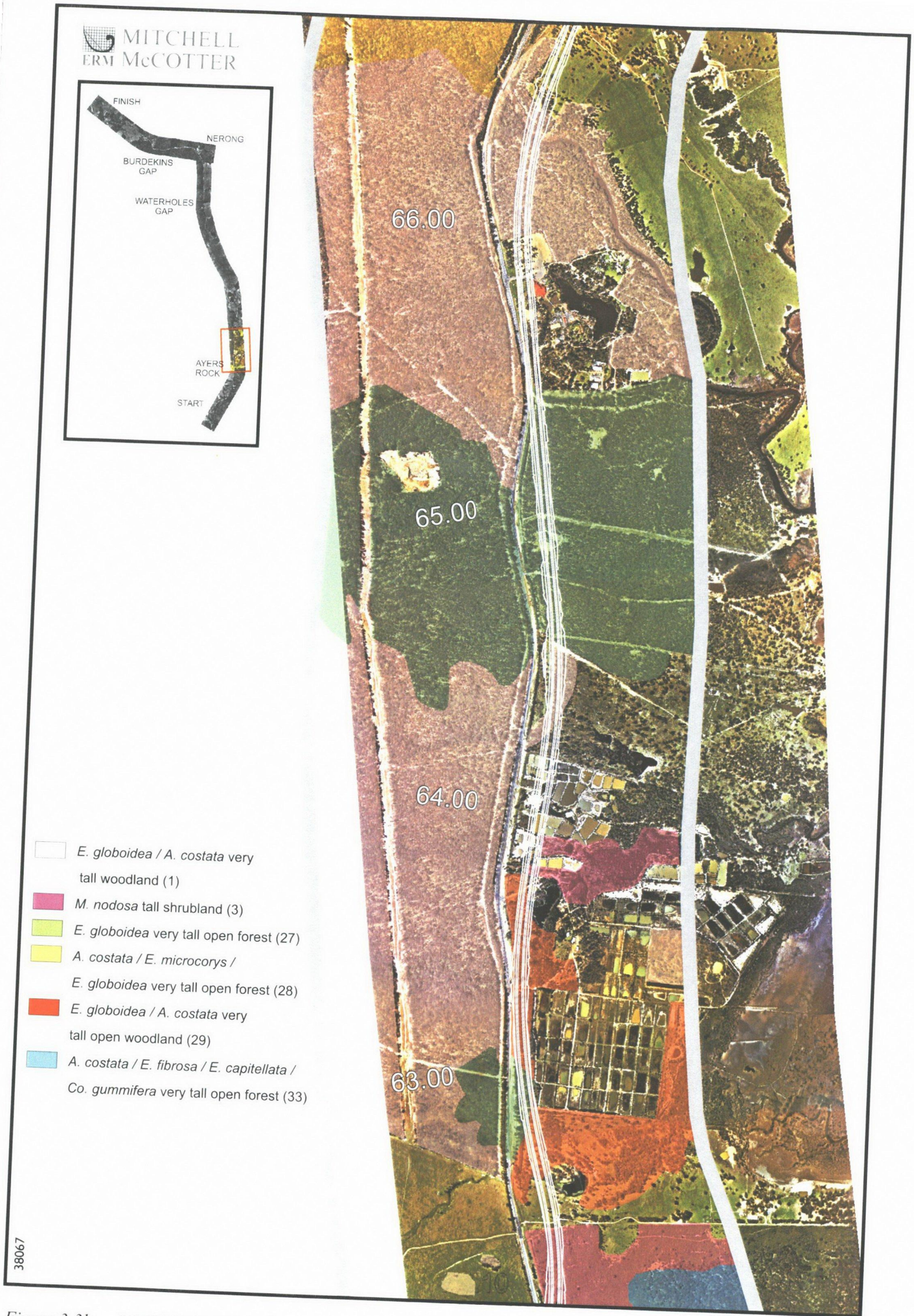


Figure 3.3b VEGETATION COMMUNITIES WITHIN THE STUDY AREA

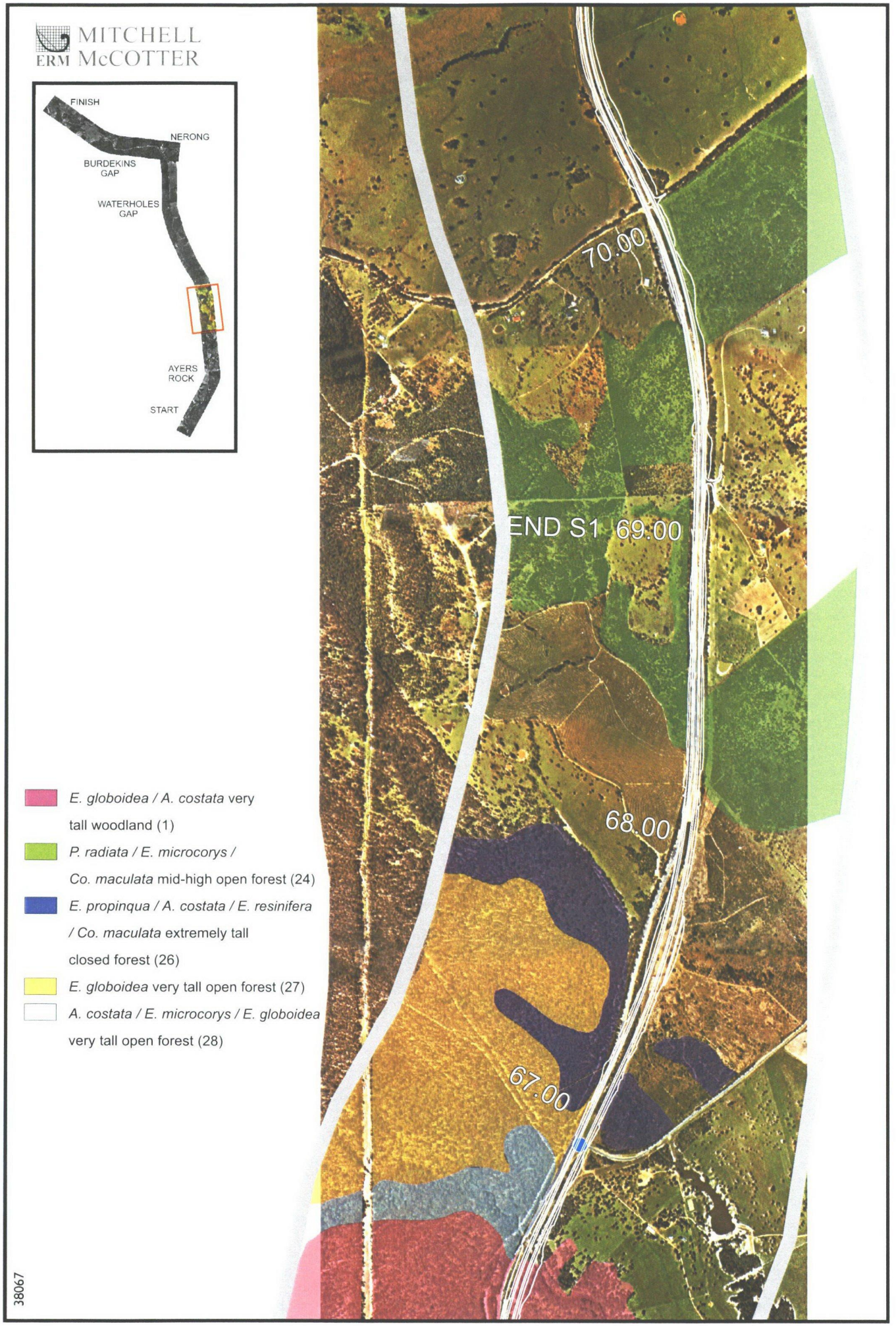


Figure 3.3c VEGETATION COMMUNITIES WITHIN THE STUDY AREA

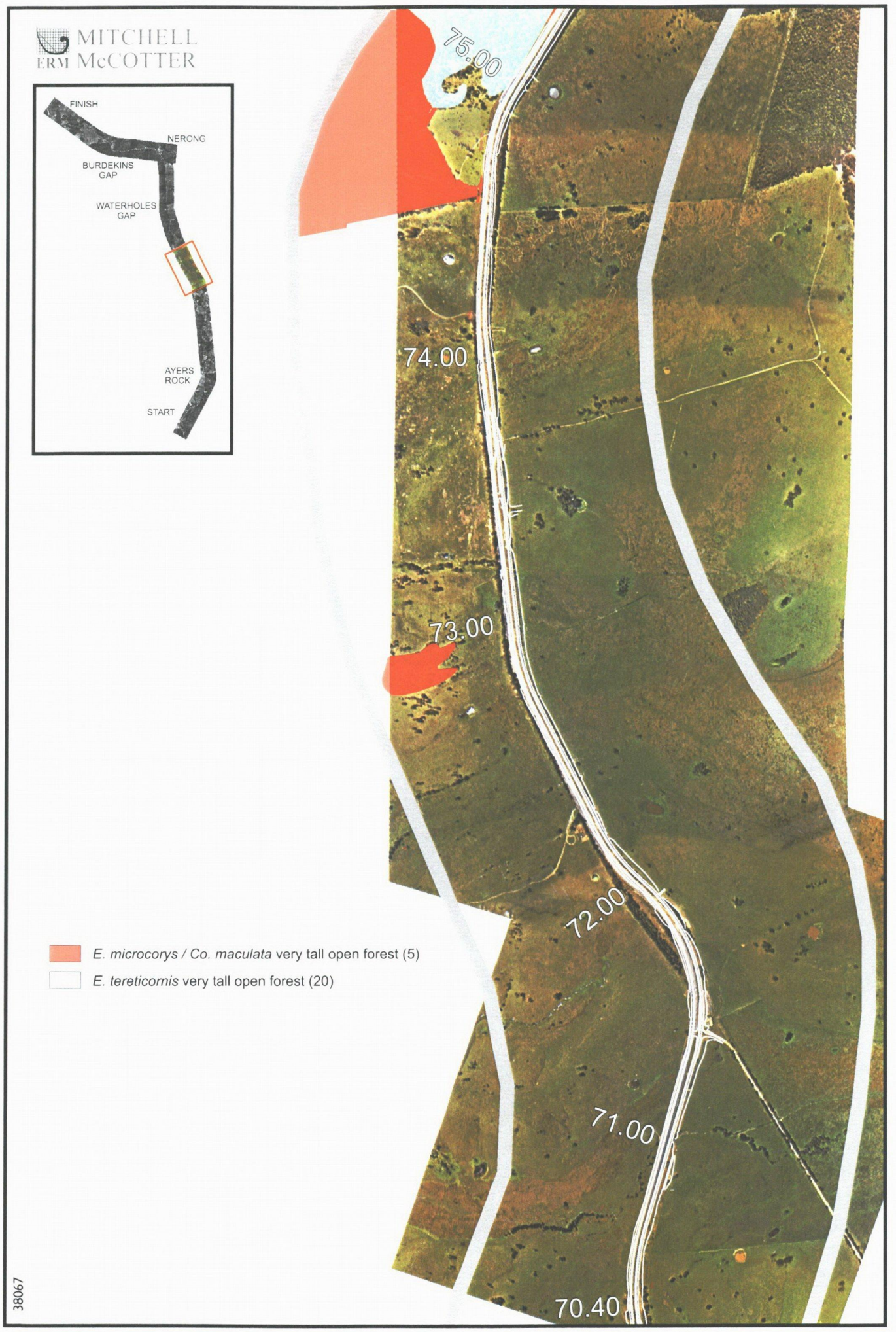


Figure 3.3d VEGETATION COMMUNITIES WITHIN THE STUDY AREA

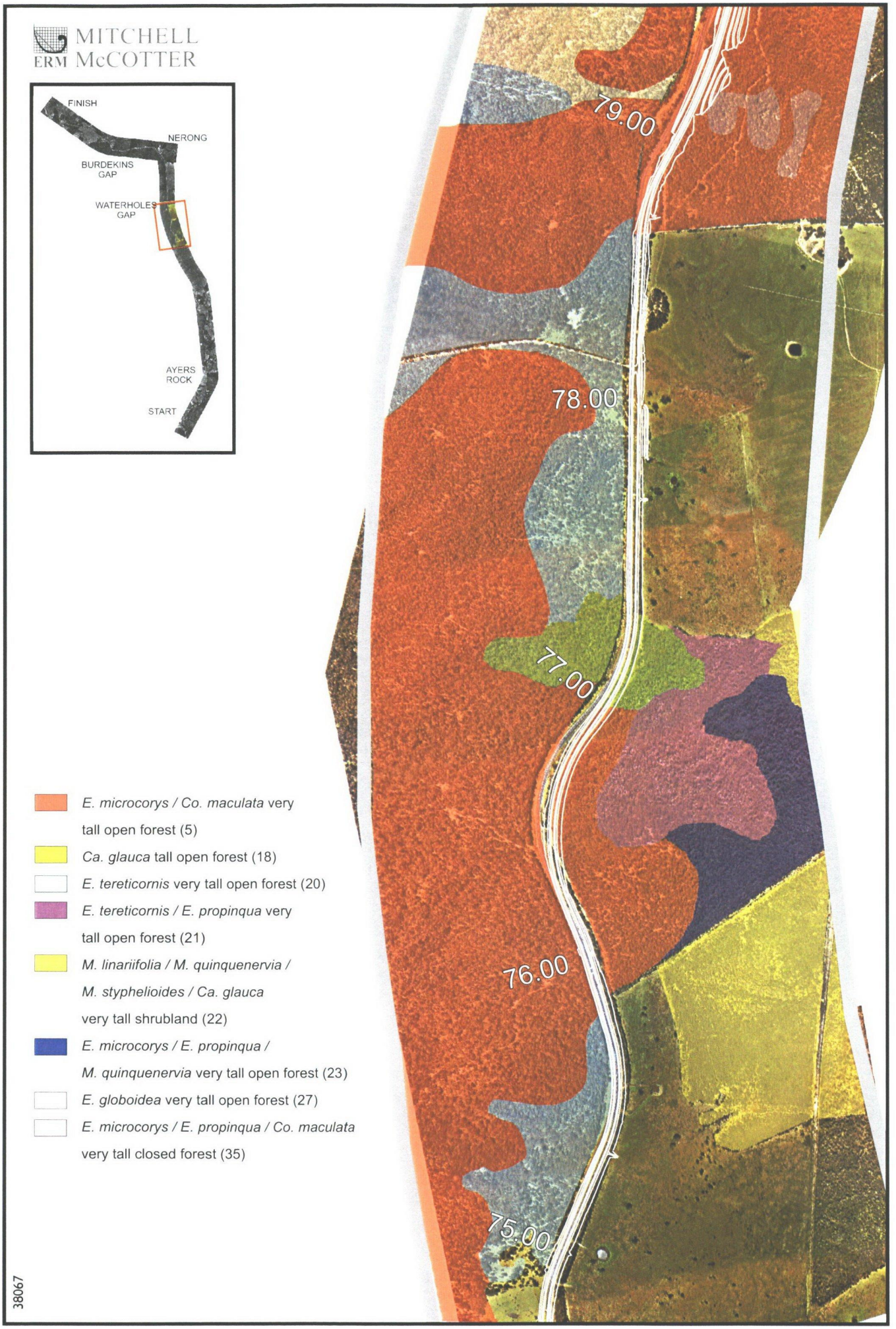


Figure 3.3e VEGETATION COMMUNITIES WITHIN THE STUDY AREA

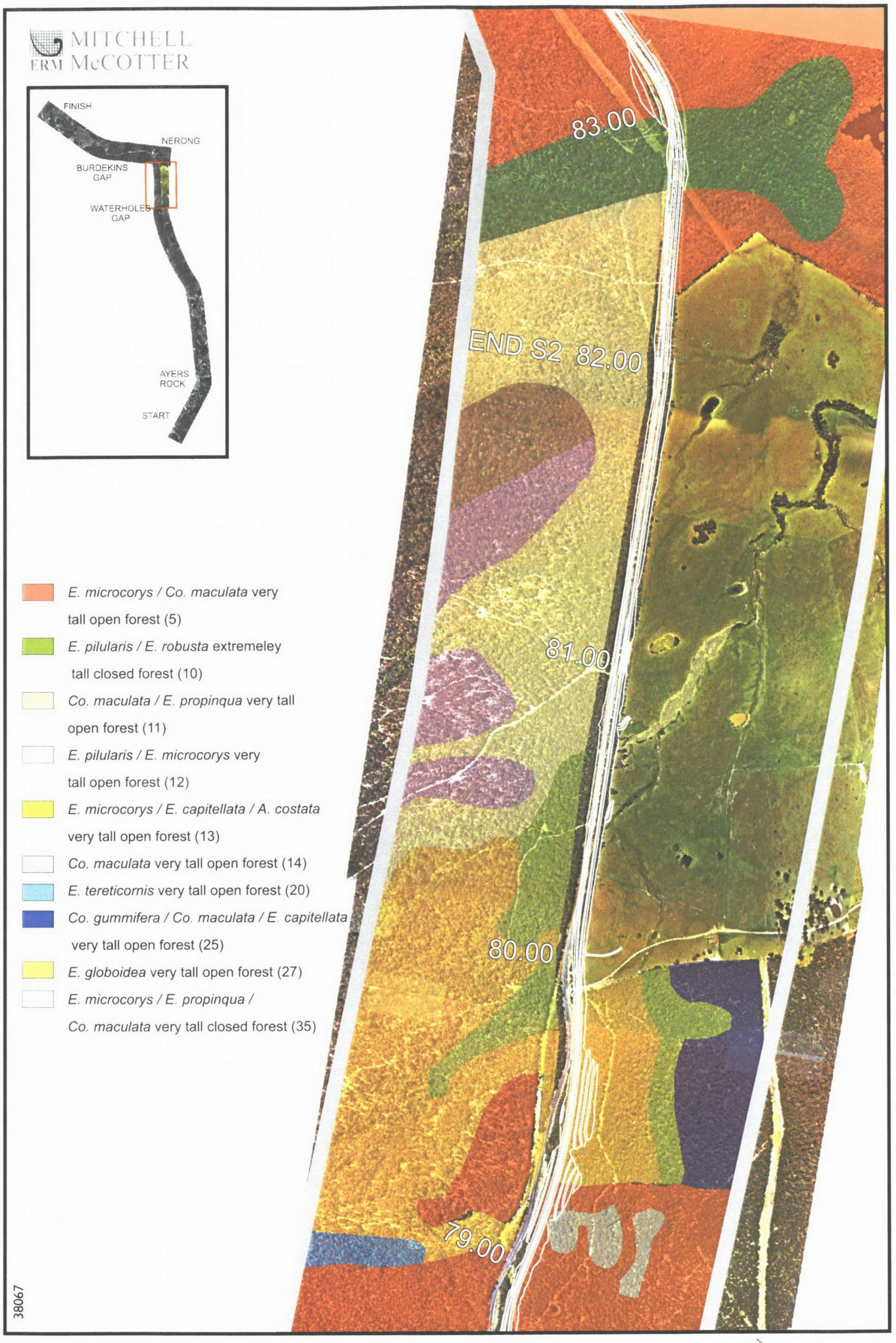


Figure 3.3f VEGETATION COMMUNITIES WITHIN THE STUDY AREA

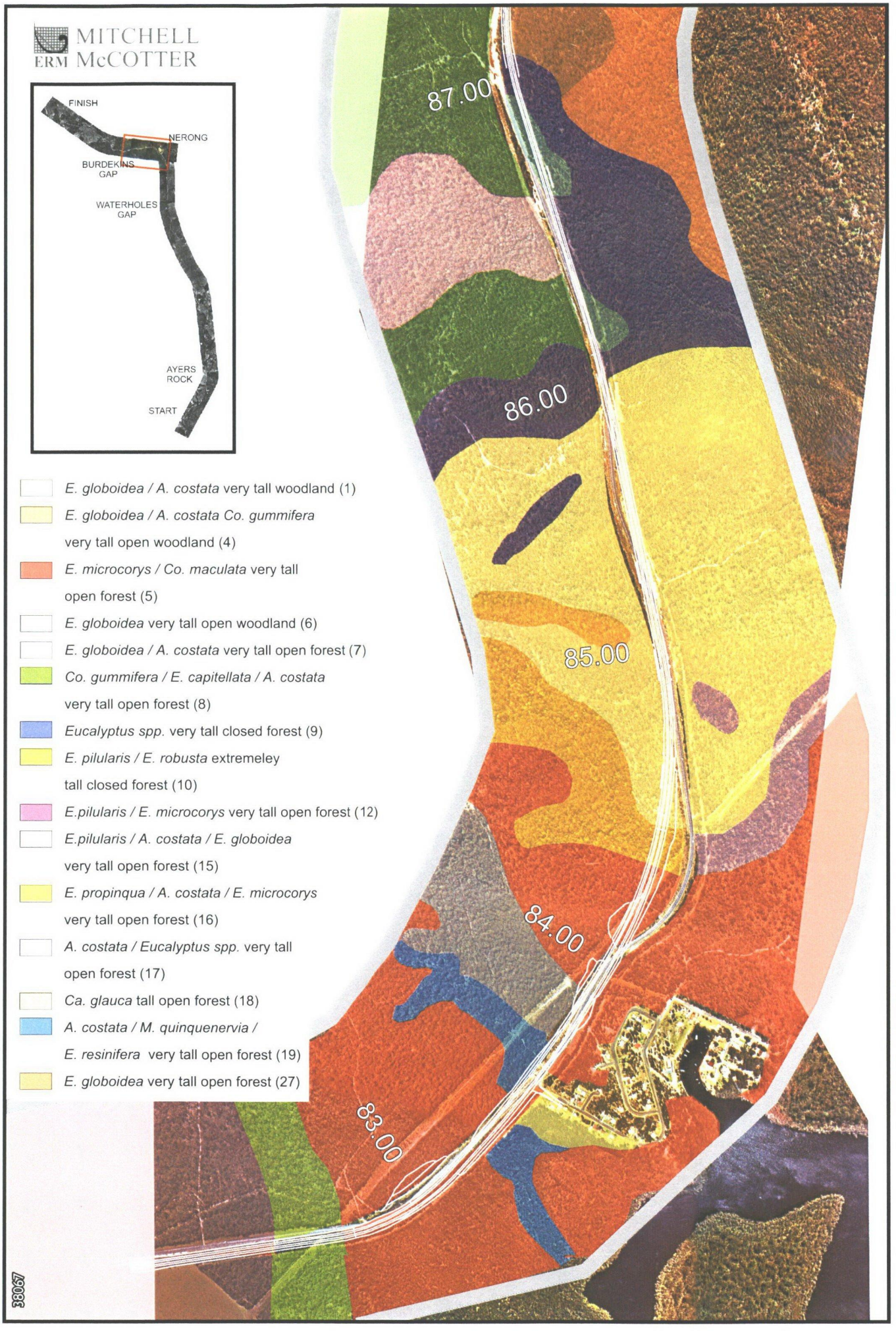


Figure 3.3g VEGETATION COMMUNITIES WITHIN THE STUDY AREA

N

Scale: 1:16000

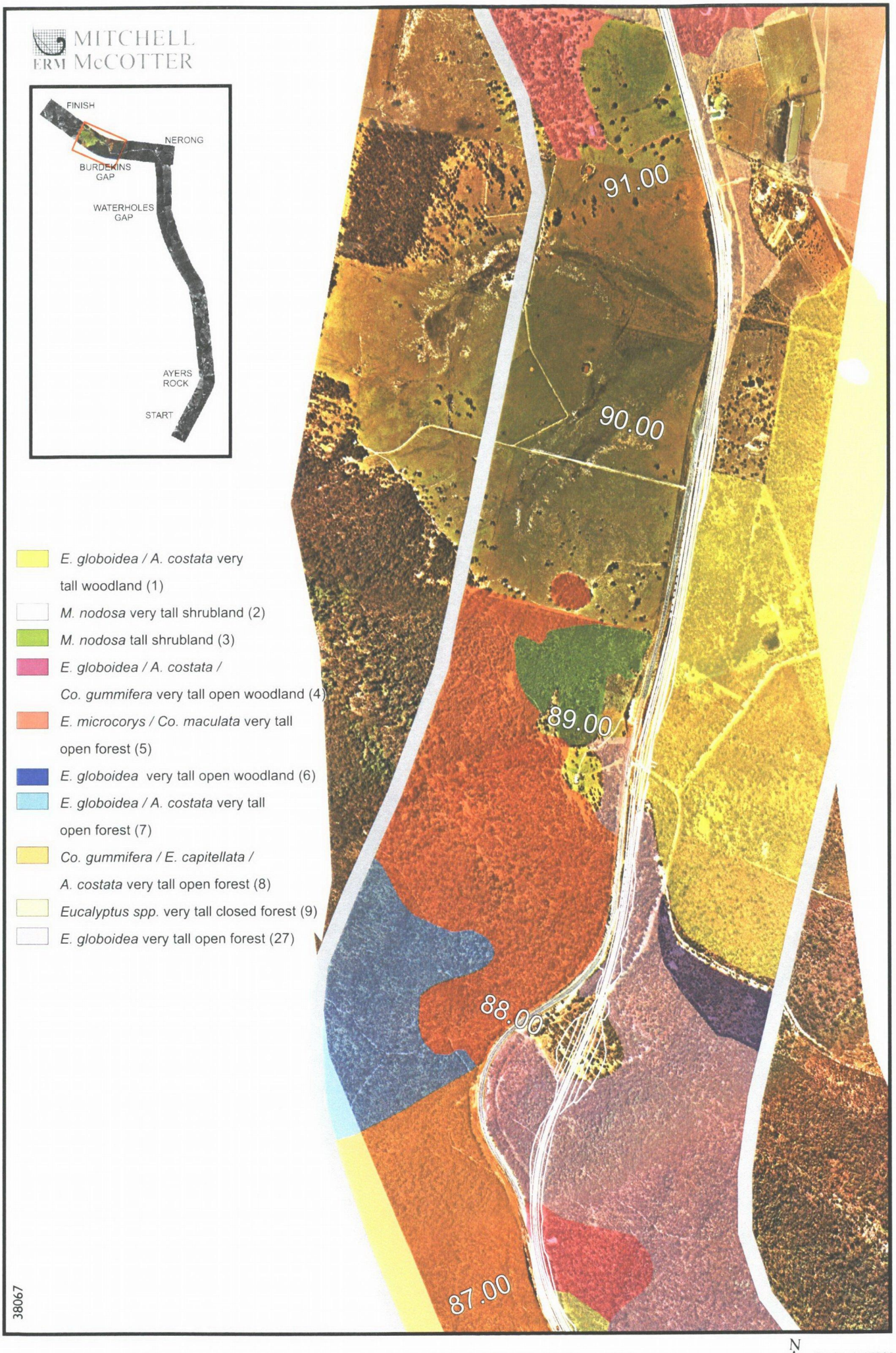


Figure 3.3h VEGETATION COMMUNITIES WITHIN THE STUDY AREA

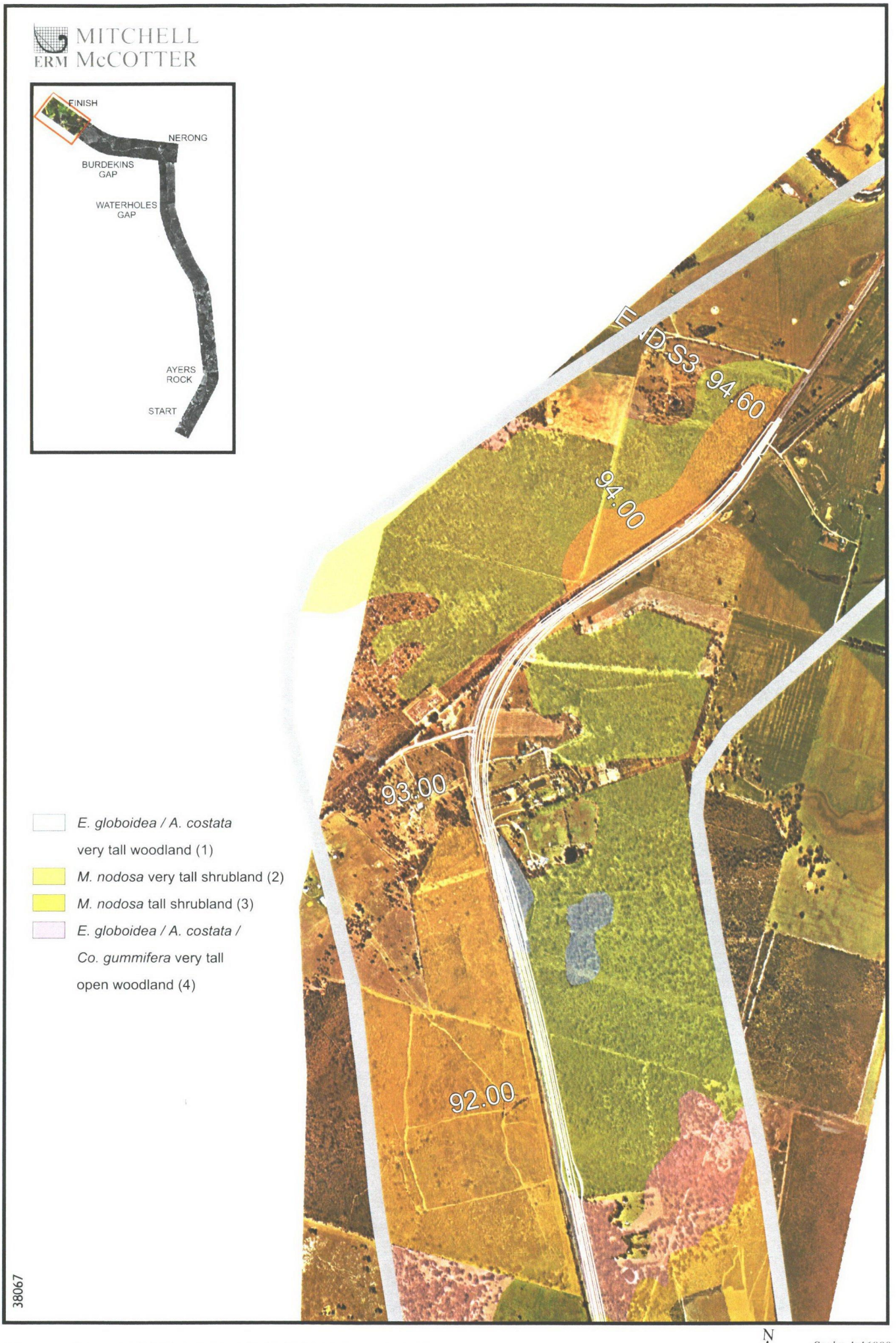


Figure 3.3i VEGETATION COMMUNITIES WITHIN THE STUDY AREA

Table 3.1 FOREST TYPES AND VEGETATION COMMUNITIES

Forest Types	Vegetation Community	Mapping Code	Extent within Study Area (Ha)	Percentage of Study Area (%)
1. Tall Shrubland	*Melaleuca nodosa* tall shrubland	3	27.1	0.72
2. Very Tall Shrubland	*M. linariifolia/M. quinquenervia/M. styphelioides/Casuarina glauca* very tall shrubland	22	21	0.56
	M. nodosa very tall shrubland	2	96.9	2.58
3. Very Tall Open Woodland	*Eucalyptus globoidea/Angophora costata/Corymbia gummifera* very tall open woodland.	4	32.4	0.86
	E. globoidea very tall open woodland	6	7.2	0.19
	E. globoidea/A. costata very tall open woodland	29	18	0.48
4. Very Tall Woodland	*E. globoidea/A. costata* very tall woodland	1	355.6	9.48
5. Mid-High Open Forest	*Pinus radiata/E. microcorys/Co. maculata* mid-high open forest	24	82.1	2.19
6. Tall Open Forest	*Ca. glauca* tall open forest	18	3.1	0.08
7. Very Tall Open Forest	*E. globoidea/A. costata* very tall open forest	7	39.6	1.06
	E. microcorys/Co. maculata very tall open forest	5	383.9	10..24
	Co. gummifera/E. capitellata/A. costata very tall open forest	8	55.3	1.47
	Co. maculata/E. propinqua very tall open forest	11	6.9	0.18
	E. pilularis/E. microcorys very tall open forest	12	69.1	1.84
	E. microcorys/E. capitellata/A. costata very tall open forest	13	20.8	0.55
	Co. maculata very tall open forest	14	29.2	0.77
	E. pilularis/A. costata/E. globoidea very tall open forest	15	10.5	0.28

Table 3.1 FOREST TYPES AND VEGETATION COMMUNITIES

Forest Types	Vegetation Community	Mapping Code	Extent within Study Area (Ha)	Percentage of Study Area (%)
	E. propinqua / A. costata / E. microcorys very tall open forest	16	20.5	1.49
	A. costata / Eucalypt spp very tall open forest	17	10.7	0.28
	A. costata / M. quinquenervia / E. resinifera very tall open forest	19	11.1	0.30
	E. umbra/Co. gummifera/A. costata very tall open forest	34	81.9	2.18
	E. tereticornis very tall open forest	20	55.5	1.48
	E. microcorys / E. propinqua / M. quinquenervia very tall open forest	23	6.9	0.18
	Co. gummifera / Co. maculata / E. capitellata very tall open forest	25	7.6	0.20
	A. costata/E. microcorys/E. globoidea very tall open forest	28	69	1.84
	A. costata / E. microcorys very tall open forest	31	n/a	
	Co. maculata / E. fibrosa very tall open forest	32	4.1	0.11
	A. costata / E. fibrosa / E. capitellata / Co. gummifera very tall open forest	33	118.9	3.17
	E. globoidea very tall open forest	27	244.9	6.53
	E. tereticornis/E. propinqua very tall open forest	21	19.2	0.51
8. Very Tall Closed Forest	*Eucalypt* spp. very tall closed forest	9	44.1	1.18
	E. microcorys / E. propinqua very tall closed forest	30	2.6	0.07
	E. microcorys/E. propinqua/Co. maculata very tall closed forest	35	1.8	0.05
	E. microcorys very tall closed forest	36	21.3	0.57
9. Extremely Tall Closed Forest	*E. pilularis / E. robusta* extremely tall closed forest	10	30.2	0.81
	E. propinqua / A. costata / E. resinifera / Co. maculata extremely tall closed forest	26	22.1	0.59

3.3.2 *Forest Types and Vegetation Communities*

The nine forest types and 36 vegetation communities identified occurring within the study area are discussed below. The discussion covers structural and floristic composition, condition, taxa of conservation significance and the number of hectares to be removed or modified by the proposed Upgrade.

i. Tall Shrubland

a. ***Melaleuca nodosa* tall shrubland (map code 3)**

A moist tall shrubland that occurs in lower lying areas predominantly in the northern end of the proposed upgrade. Composition of this forest has changed significantly from a eucalypt dominated forest to a *Melaleuca* shrubland, due to logging/clearing practices.

- Structure

Overstorey: the canopy extends to a maximum height of three metres and is dominated by ball honeymyrtle (*Melaleuca nodosa*), with smooth-barked apple (*Angophora costata*) being an occasional emergent species to a height of 20 m. The overstorey has a percentage cover of approximately 80%.

Understorey: the understorey is generally absent due to the density of the over-storey cover. Where an understorey does occur, it is dominated by juvenile ball honeymyrtle (*M. nodosa*), Sydney golden wattle (*Acacia longifolia*) and narrow-leaved geebung (*Persoonia linearis*).

Groundcover: the groundcover is dense (approximately 75 to 85 %) and consists of a variety of native grasses including kangaroo grass (*Themeda australis*), wallaby grass (*Danthonia* sp.), tufted hedgehog grass (*Echinopogon caespitosus*), plume grass (*Dichelachne* sp.), pigeon grass (*Setaria* sp.) and blady grass (*Imperata cylindrica*). Other common groundcover species include blue-flax lily (*Dianella caerulea*), hardenbergia (*Hardenbergia violaceae*), bracken fern (*Pteridium esculentum*) and kurnell curse (*Hydrocotyle bonariensis*).

- Condition

Weeds are common in this community. Some areas have been, and are still most likely to be subject to grazing by stock and frequent low intensity fire. Although the community is fragmented in some places by private roads, there are generally few tracks present. There are few tree hollows present.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

2.38 hectares.

ii. Very Tall Shrubland

a. ***Melaleuca linariifolia/M. quinquenervia/M. styphelioides/Casuarina glauca* very tall shrubland (map code 22)**

- Structure

Overstorey: This community is dominated by *M. linariifolia, M. quinquenervia, M. styphelioides* and *C. glauca*. The overstorey extends to a maximum height of six m and has a cover of approximately 60% (mid-dense).

Midstorey: The midstorey is absent.

Understorey: Due to the density of the overstorey vegetation, the understorey is extremely sparse having a percentage cover of approximately five to 10 %. It extends to a maximum height of one metre and is dominated by a variety of juvenile overstorey species.

Groundcover: The groundcover is rated as sparse in this community and is dominated by a range of grasses.

- Condition

Weeds are relatively common in this community, including lantana (*Lantana camara*) and blackberry (*Rubus discolor*). Tree hollows are absent due to previous logging practices. It has been recently burnt as is evident by charred trunks. Tracks are common and evidence exists of cattle grazing.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

b. ***Melaleuca nodosa* very tall shrubland (map code 2)**

- Structure

Overstorey: The overstorey in this community extends to a height of six m and is dominated by ball honeymyrtle (*Melaleuca nodosa*) with smooth-barked apple (*Angophora costata*) being an occasional emergent species to a height of 20 m. The overstorey has a percentage cover of approximately 75 %.

Midstorey: The midstorey is absent.

Understorey: The understorey is generally absent due to the density of the overstorey. Where an understorey does occur, it is dominated by juvenile ball honeymyrtle (*M. nodosa*), Sydney golden wattle (*Acacia longifolia*) and narrow-leaved geebung (*Persoonia linearis*).

Groundcover: The groundcover is moderate to dense (50-60%) and consists of a variety of grasses including kangaroo grass (*Themeda australis*), wallaby grass (*Danthonia* sp.), tufted hedgehog grass (*Echinopogon caespitosus*), plume grass (*Dichlachne* sp.), pigeon grass (*Setaria* sp.) and blady grass (*Imperata cylindrica*). Other common groundcover species include blue-flax lily (*Dianella caerulea*), hardenbergia (*Hardenbergia violaceae*), bracken fern (*Pteridium esculentum*) and kurnell curse (*Hydrocotyle bonariensis*).

- Condition

Weeds are common in this community. Some areas have been subject to grazing by stock and frequent low intensity fires. Few tracks are present.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

2.84 hectares.

iii. Very Tall Open Woodland

a. ***Eucalyptus globoidea/Angophora costata/Corymbia gummifera* very tall open woodland (map code 4)**

- Structure

Overstorey: This community extends to a maximum height of 30 m and is dominated by stringybark (*E. globoidea*), smooth-barked apple (*A. costata*) and red bloodwood (*C. gummifera*). The canopy cover is sparse.

Midstorey: The midstorey in this community is dominated by forest oak (*Allocasuarina torulosa*) and juvenile overstorey species. It extends to a maximum height of 15 m and is rated as sparse.

Understorey: The understorey extends to a maximum height of three metres and is dominated by smooth geebung (*Persoonia linearis*), mountain devils (*Lambertia formosa*), hill banksia (*Banksia spinulosa*), common hop bush (*Dodonaea triquetra*) and prickly moses (*Acacia ulicifolia*).

Groundcover: The groundcover is moderate in density and extends to a height of 70 m. It is dominated by mat-rush (*Lomandra longifolia*), forest grass trees (*Xanthorrhoea resinosa*) and a variety of grasses.

- Condition

Weeds are relatively common in this community and include lantana (*Lantana camara*) and bracken fern (*Pteridium esculentum*). The presence of burnt tree boles in some areas suggests that this vegetation type is subject to occasional fires of moderate intensity.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

1.03 hectares.

b. ***Eucalyptus globoidea* very tall open woodland (map code 6)**

- Structure

Overstorey: This community is dominated by stringybark (*E. Globoidea*). Red bloodwood (*Corymbia gummifera*) and smooth-barked apple (*Angophora costata*) occur occasionally. The overstorey layer extends to a maximum height of 25 m and the canopy cover is sparse.

Midstorey: The midstorey extends to a height of 12 m and is dominated by prickly-leaved tea tree (*Melaleuca styphelioides*) and forest oak (*Allocasuarina torulosa*), with juvenile overstorey species occurring intermittently.

Understorey: The understorey is sparse to moderate, with commonly occurring species being black wattle (*Acacia irrorata*), lemon-scented tea tree (*Leptospermum polygalifolium*), snow-in-summer (*Melaleuca linariifolia*), large mock olive (*Notelaea longifolia*), pink lantana (*Lantana camara*) and breynia (*Breynia oblongifolia*).

Groundcover: Groundcover is moderate to dense, and consists primarily of grasses and other species including mat-rush (*Lomandra longifolia*), blady grass (*Imperata cylindrica*), rib-wort (*Plantago* sp.), native violet (*Viola hederaceae*), einadia (*Einadia hastata*) and blackberry (*Rubus* sp.).

- Condition

Weeds are relatively sparse in this community, although roadside weeds such as giant parramatta grass (*Sporobolus* sp.), cobblers pegs (*Bidens pilosa*) and purple top (*Verbena bonariensis*) are common on the forest fringe. Some areas on private property are currently subject to cattle grazing. The presence of burnt tree trunks suggests occasional or frequent low intensity fires. Although the community is fragmented in some places by private or forestry roads, there are few tracks present. Previous logging activity is evident by the presence of sawn stumps and an absence of mature or dead trees in the canopy. There are few medium and large hollows occurring in this community.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

c. ***Eucalyptus globoidea/Angophora costata* very tall open woodland (map code 29)**

- Structure

Overstorey: This community extends to a maximum height of 25 m and is dominated by stringybark (*E. globoidea*) and smooth-barked apple (*A. costata*). Sydney peppermint (*E. piperita*) occasionally occurs as a sub-dominant species in this community. The canopy cover is rated as sparse.

Midstorey: The midstorey in this community is dominated by forest oak (*A. torulosa*) and juvenile overstorey species. It extends to a maximum height of 15 m. It is rated as sparse.

Understorey: The understorey extends to a maximum height of three metres and is dominated by common hop-bush (*Dodonaea triquetra*), prickly moses (*Acacia ulicifolia*), smooth geebung (*Persoonia linearis*), mountain devils (*Lambertia formosa*), hill banksia (*Banksia spinulosa*) and sandfly zieria (*Zieria smithii*).

Groundcover: The groundcover is moderately dense and extends to a height of 70 m. It is dominated by a variety of grass species, including wallaby grass (*Danthonia* sp.), kangaroo grass (*Themeda australis*), and blady grass (*Imperata cylindrica*). Mat rush (*Lomandra longifolia*), purple flag (*Patersonia glabrata*) and blue flax-lily (*Dianella caerulea*) also occur commonly.

- Condition

Weeds are relatively sparse in this community although roadside weeds such as paspalum (*Paspalum* sp.), cobblers pegs (*Bidens pilosa*) and purple top (*Verbena bonariensis*) are common in the forest fringe. Some areas on private property are grazed by stock. The presence of burnt tree trunks in some areas is indicative of fire. Although this community is fragmented in some places by private roads, there are few tracks present. Previous logging activity is evident by the presence of sawn stumps and an absence of mature or dead trees in the canopy and there is a notable absence of medium to large hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

iv. *Very Tall Woodland*

a. ***Eucalyptus globoidea/A. costata* very tall woodland (map code 1)**

- Structure

Overstorey: This community extends to a maximum height of 35 m and is dominated by stringybark (*E. globoidea*) and smooth-barked apple (*A. costata*). The canopy cover is sparse.

Midstorey: The midstorey in this community is dominated by forest oak (*Allocasuarina torulosa*). It extends to a maximum height of 20 m and is moderately sparse.

Understorey: The understorey extends to a maximum height of 4.5 metres and is dominated by smooth geebung (*Persoonia linearis*), mountain devils (*Lambertia formosa*), geebung (*P. levis*), juvenile forest oak (*A. littoralis*), common hop bush (*Dodonaea triquetra*) and hill banksia (*Banksia spinulosa*).

Groundcover: The groundcover is moderate in density and extends to a height of 50 m. It is dominated by mat-rush (*Lomandra longifolia*), fish bones (*L. obliqua*), blue flax lily (*Dianella caerulea*) and forest grass trees (*Xanthorrhoea resinosa*).

- Condition

Weeds are relatively common in this community, including lantana (*Lantana camara*) and blackberry (*Rubus* sp.). Tree hollows are sparse and evidence exists of previous extensive clearing practices. Tracks are common and the area is grazed by cattle.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

25.44 hectares.

v. *Mid-high Open Forest*

a. ***Pinus radiata/Eucalyptus microcorys/Corymbia maculata* mid-high open forest (map code 24)**

- Structure

Overstorey: This community is the result of regrowth in a former pine plantation. The dominant species are pine trees (*P. radiata*), tallowwood (*E. microcorys*) and spotted gum (*C. maculata*). It extends to a maximum height of 10 m. It is moderately dense.

Midstorey: A midstorey is absent.

Understorey: The understorey is extremely sparse, however, where it occurs it is dominated by overstorey species (saplings) which extend to a maximum height of two metres.

Groundcover: A groundcover is generally absent, and where it occurs it is dominated by a variety of grasses.

- Condition

This community can be considered to be a disclimax community. It is dominated by an introduced species (*P. radiata*). Species diversity is low due primarily to the effects of the toxin present in the pine needles which restricts the growth of many plant species.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

4.76 hectares.

vi. Tall Open Forest

a. ***Casuarina glauca* tall open forest (map code 18)**

- Structure

Overstorey: This community is dominated by river oak (*Casuarina glauca*). Swamp mahogany (*Eucalyptus robusta*) occasionally occurs as an emergent species that extends to a maximum height of 30 m. The canopy however only extends to a height of 20 m. It is moderately dense.

Midstorey: Generally, a midstorey is absent, however occasional juvenile swamp mahogany (*E. robusta*) and river oak (*C. glauca*) occur to a height of 10 m.

Understorey: The understorey is generally composed of willow bottlebrush (*Callistemon salignus*) and saw sedge (*Gahnia sieberana*). A number of epiphytes

(namely staghorns) and vines and creepers (including *Stephania japonica* and *Hardenbergia violaceae* grow amongst the understorey.

Groundcover: The groundcover is moderate to dense and consists primarily of grasses and sedges including mat-rush (*Lomandra longifolia*), nut grass (*Cyperus brevifolius*) and blady grass (*Imperata cylindrica*). Other species include buttercup (*Ranunculus* sp.), native violet (*Viola hederaceae*), white root (*Pratia purpurescens*) and centella (*Centella asiatica*).

- Condition

Few weeds exist in this community, except on the forest fringe where purple top (*Verbena bonariensis*), giant parramatta grass (*Sporobolus* sp.) and verbena (*Verbena officianalis*) occur. Very few hollows exist in this community and leaf and other ground litter are sparse. The community occurs adjacent to the village of Nerong and so rubbish occurs throughout.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

1.23 hectares.

vii. Very Tall Open Forest

a. ***Eucalyptus globoidea/Angophora costata* very tall open forest (map code 7)**

This is one of the most common communities (associations) occurring along the existing highway.

- Structure

Overstorey: The dominant species in the overstorey is smooth-barked apple (*Angophora costata*) and white stringybark (*Eucalyptus globoidea*), followed by red bloodwood (*Corymbia gummifera*) and blue-leaved stringybark (*E. agglomerata*). Other canopy species that intermittently occur are pink bloodwood (*C. intermedia*), spotted gum (*C. maculata*), tallowwood (*E. microcorys*), grey ironbark (*E. placita*), brown stringybark (*E. capitellata*) and thin-leaved stringybark (*E. eugenioides*). The overstorey extends to a maximum height of 25 m.

Midstorey: The midstorey is absent.

Understorey: The understorey varies from sparse to dense and extends to a maximum height of 1.5 metres. Common species include prickly moses (*Acacia ulicifolia*), Sydney golden wattle (*A. longifolia*), hill banksia (*Banksia spinulosa*), common hop-bush (*Dodonaea triquetra*) and matchheads (*Comesperma ericinum*).

Groundcover: Groundcover extends to a maximum height of 60 cm and is moderate to dense, containing species such as mat-rush (*Lomandra longifolia*), fish-bones (*L. obliqua*), shivery grass (*Briza maxima*), coral heath (*Epacris microphylla*) and woolly xanthosia (*Xanthosia pilosa*).

- Condition

Weeds are relatively common in this community, particularly roadside weeds along the forest fringe. Lantana (*Lantana camara*) and blackberry (*Rubus ulmifolius*) are also scattered throughout the community. Some areas of this community fringing the roadside showed signs of recent and frequent fires, as indicated by reduced species diversity and fire-tolerant species being dominant in the understorey. The understorey is dominated by immature trees, with a distinct lack of mature trees with hollows, hence indicative of past canopy thinning. The largest portion of this community occurs in Nerong State Forest. Within the Nerong State Forest, fragmentation of the community by tracks is generally limited to within 150 m of the road reserve. However, fragmentation due to the cutting of roads and previous clearing of forest contained on privately owned property is extensive in some areas, particularly toward the southern end of the proposed Upgrade. The plant species diversity within this community is generally low due to past disturbance.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

1.57 hectares.

b. ***Eucalyptus microcorys/Corymbia maculata* very tall open forest (map code 5)**

- Structure

Overstorey: The canopy of this community ranges between 25 and 30 m high with an estimated cover of 40%. The dominant canopy species are tallowwood (*E. Microcorys*) and spotted gum (*C. maculata).* Mistletoes (*Amyema* sp.) occur throughout portions of this community.

Midstorey: The midstorey is five to eight metres high, with an estimated cover of 30%. The dominant species are prickly-leaved tea tree (*Melaleuca styphelioides*), broad-leaved paperbark (*M. quinquenervia*) and black she-oak (*Allocasuarina littoralis*).

Understorey: The understorey is sparse to moderate and consists of such species as cherry ballart (*Exocarpos cupressiformis*), snow-in-summer (*M. linariifolia*) and hakea (*Hakea dactyloides*).

Groundcover: The groundcover is sparse to moderate, with an estimated cover of approximately 30%. The dominant species is mat-rush (*Lomandra longifolia*), with nut grass (*Cyperus brevifolius*), fish bones (*L. obliqua*), breynia (*Breynia oblongifolia*), coral heath (*Epacris microphylla*) and native violet (*Viola hederaceae*) also occurring commonly.

- Condition

Weeds are relatively sparse in this community although roadside weeds such as clover (*Trifolium* sp.), bushy starwort (*Aster subulatus*) and michaelmas daisy (*A. novi - belgi*) are common on the forest fringe. Some areas are currently subject to cattle grazing. The presence of burnt tree trunks in some areas suggests that this community is subject to occasional moderate intensity fires. The community is fragmented in some places by cattle tracks. Previous logging activity is evident by the presence of sawn stumps, and a general paucity of mature and dead trees in the canopy. Medium to large hollows occur occasionally.

- Taxa of conservation significance

The RoTAP species *Eucalyptus fergusonii* ssp. *fergusonii* was recorded occurring on the mid to upper slopes within this community.

- Number of hectares to be removed

15.1 hectares.

c. ***Corymbia gummifera/Eucalyptus capitellata/Angophora costata* very tall open forest (map code 8)**

- Structure

Overstorey: The canopy is dominated by red bloodwood (*C. gummifera*), stringybark (*E. capitellata*) and smooth-barked apple (*A. costata*). It extends to a maximum height of 25 m and is moderately dense.

Midstorey: The midstorey is dominated by forest oak (*Allocasuarina torulosa*) and juvenile overstorey species. It ranges in height from 10 to 15 m. Other species

occurring include prickly-leaved tea tree (*Melaleuca styphelioides*) and ball honeymyrtle (*M. nodosa*).

Understorey: The understorey is generally moderately dense and consists of a variety of species including mountain devils (*Lambertia formosa*), hill banksia (*Banksia spinulosa*), geebung (*Persoonia* spp.) and cherry ballart (*Exocarpos cupressiformis*).

Groundcover: The groundcover is dominated by mat-rush (*Lomandra longifolia*), forest grass trees (*Xanthorrhoea resinosa*) and blady grass (*Imperata cylindrica*).

- Condition

Weeds are sparse in this community, although roadside weeds such as paspalum (*Paspalum* sp.), cobblers pegs (*Bidens pilosa*) and purple top (*Verbena bonariensis*) are common on the forest fringe. It is likely that this community has been subject to occasional fires. It is fragmented by a network of small roads and has been heavily logged in the past.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

1.73 hectares.

d. ***Corymbia maculata/Eucalyptus propinqua* very tall open forest (map code 11)**

- Structure

Overstorey: The canopy of this community ranges between 25 and 30 m with an estimated cover of 50 %. The dominant canopy species are spotted gum (*C. maculata*) and grey gum (*E. propinqua*).

Midstorey: The midstorey is five to eight metres tall, with an estimated cover of approximately 30%. The dominant species are ball honeymyrtle (*Melaleuca nodosa*) and black she-oak (*Allocasuarina littoralis*).

Understorey: The understorey is sparse to moderate and consists of such species as cherry ballart (*Exocarpos cupressiformis*), snow-in-summer (*M. linariifolia*) and hakea (*Hakea dactyloides*).

Groundcover: The groundcover is sparse to moderate, with an estimated cover of approximately 30%. The dominant species are mat-rush (*Lomandra longifolia*), with nut grass (*Cyperus brevifolius*), fish bones (*L. obliqua*), breynia (*Breynia oblongifolia*) and coral heath (*Epacris microphylla*).

- Condition

Weeds are relatively sparse in this community, although roadside weeds such as paspalum (*Paspalum* sp), cobblers pegs (*Bidens pilosa*) and purple top (*Verbena bonariensis*) are common on the forest fringe. Some areas on private property are currently subject to grazing by stock. The presence of burnt tree trunks in some areas suggests that this vegetation is subject to occasional or frequent low intensity fire. Although this community is fragmented in some places by private roads there are few tracks present. Previous logging activity is evident by the presence of sawn stumps, and an absence of mature and dead trees in the canopy and there is a notable absence of medium to large hollows.

- Taxa of conservation significance

The RoTAP *Eucalyptus fergusonii* ssp *fergusonii* was recorded occurring within this community on the mid to upper slopes.

- Number of hectares to be removed

Nil.

e. ***Eucalyptus pilularis/E. microcorys* very tall open forest (map code 12)**

- Structure

Overstorey: The overstorey in this community is dominated by blackbutt (*E. pilularis*) and tallowwood (*E. microcorys*) which extend to a maximum height of 35 m. The overstorey is rated on moderately dense.

Midstorey: The midstorey in this community ranges in height from 10 to 15 m. A number of species occur including black she-oak (*Allocasuarina littoralis*), juvenile overstorey species, black wattle (*Calicoma serratifolia*) and cheese tree (*Glochidion ferdinandi*).

Understorey: The understorey is comprised of bush peas (*Pultenaea* spp.), myrtle wattle (*Acacia myrtifolia*), muttonwood (*Rapanea variabilis*), lily pily (*Acmena smithii*) and juvenile cheese tree (*Glochidion ferdinandi*).

Groundcover: The groundcover extends to a height of one metre and dominant species include creeping christian (*Commelina cyanea*), white root (*Pratia purpurescens*), maidenhair fern (*Adiantum aethiopicum*), mat-rush (*Lomandra longifolia*) and *Hibbertia* spp.

- Condition

Weeds are relatively common in this community, including lantana (*Lantana camara*) and bracken fern (*Pteridium esculentum*). Tree hollows are sparse and evidence exists of previous extensive clearing practices. Tracks are common and the area is grazed by cattle.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

4.01 hectares.

f. ***Eucalyptus microcorys/Eucalyptus capitellata/Angophora costata* very tall open forest (map code 13)**

- Structure

Overstorey: The canopy of this community ranged in height between 25 and 30 m with an estimated cover of 45%. The dominant canopy species are tallowwood (*Eucalyptus microcorys*), stringybark (*E. capitellata*) and smooth-barked apple (*Angophora costata*).

Midstorey: The midstorey is five to eight m high, with an estimated cover of approximately 30%. It is dominated by forest oak (*Allocasuarina torulosa*) and juvenile canopy species. Willow bottlebrush (*Callistemon salignus*) and cherry ballart (*Exocarpos cupressiformis*) also occur commonly.

Understorey: The understorey is sparse to moderate and consists of bracken fern (*Pteridium esculentum*), *Pultenaea* sp., immature smooth geebung (*Persoonia linearis*) and sandfly zieria (*Zieria smithii*).

Groundcover: The groundcover is sparse to moderate, with an estimated cover of approximately 30%. The dominant species is mat rush (*Lomandra longifolia*), with nut-grass (*Cyperus brevifolius*), breynia (*Breynia oblongifolia*) and *Phyllanthus* sp. occurring commonly.

- Condition

Weeds are relatively sparse in this community, although roadside weeds such as purple top (*Verbena bonariensis*), verbena (*V. officianalis*), giant Parramatta grass (*Sporobolus* sp.) and clover (*Trifolium* spp.) are common along tracks and on the forest fringe. Some areas are currently grazed by stock. The presence of well burnt tree trunks in some areas suggests that this community is subject to occasional moderate intensity fires. The community is fragmented in some places by tracks. Previous logging activity is evident with mature trees being sparse.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed.

Nil.

g. ***Corymbia maculata* very tall open forest (map code 14)**

- Structure

Overstorey: This community is dominated by spotted gum (*Corymbia maculata*). It extends to a maximum height of 25 m and is moderately dense.

Midstorey: The midstorey in this community is sparse and where it occurs it consists of juvenile spotted gum and black she oak (*Allocasuarina littoralis*).

Understorey: The understorey of this community is also sparse, attributable to previous clearing practices and cattle grazing. Where an understorey does occur it is dominated by common hop bush (*Dodonaea triquetra*) and a number of Acacia species.

Groundcover: Groundcover is generally dominated by a number of grasses including blady grass (*Imperata cylindrica*) and whisky grass (*Andropogon virginicus*). Bracken fern (*Pteridium esculentum*) also occurs frequently.

- Condition

Weeds are relatively sparse in this community. The presence of burnt tree boles in some areas suggest that this vegetation type is subject to occassional fires of moderate intensity. The community suffers from minor fragmentation caused by the construction of tracks and fences. Previous logging activity is evident by the presence of sawn stumps, and an absence of mature and dead trees in the canopy. There is a notable absence of medium to large hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

h. ***Eucalyptus pilularis/Angophora costata/Eucalyptus globoidea* very tall open forest (map code 15)**

- Structure

Overstorey: This community, which extends to a maximum height of 35 m, is dominated by blackbutt (*E. pilularis*), smooth-barked apple (*A. costata*) and stringybark (*E. globoidea*). It is moderately dense.

Midstorey: The midstorey of this community is dominated by juvenile overstorey species that range in height from 10 to 15 m.

Understorey: The understorey of this community comprises prickly moses (*Acacia ulicifolia*), hill banksia (*Banksia spinulosa*), common hop bush (*Dodonaea triquetra*) and matchheads (*Comesperma ericinum*). It grows to a maximum height of two metres.

Groundcover: The groundcover grows to a maximum height of 60 cm and is rated as dense. The dominant species are mat-rush (*Lomandra longifolia*), fish-bones (*L. obliqua*), shivery grass (*Briza maxima*), coral heath (*Epacris microphylla*) and woolly xanthosia (*Xanthosia pilosa*).

- Condition

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community. Number of hectares to be removed

3.6 hectares.

i. ***Eucalyptus propinqua/Angophora costata/E. microcorys* very tall open forest (map code 16)**

This vegetation type is restricted to relatively fertile and well drained sites along the proposed Upgrade.

- Structure

Overstorey: The overstorey is 25 to 30 m high and provides approximately 50 % cover. The dominant canopy species are grey gum (*Eucalyptus propinqua*), smooth

barked apple (*Angophora costata*) and tallowwood (*E. microcorys*). Other canopy species that occur occasionally are grey gum (*E. punctata*), spotted gum (*Corymbia maculata*) and cabbage gum (*E. amplifolia*).

Midstorey: The midstorey is eight to 12 m high and provides approximately 40% cover. The dominant midstorey species include prickly-leaved tea-tree (*Melaleuca styphelioides*), forest oak (*Allocasuarina torulosa*) with juvenile canopy species occurring intermittently.

Understorey: The understorey is sparse to moderate, with commonly occurring species being black wattle (*Acacia irrorata*), lemon-scented tea-tree (*Leptospermum polygalifolium*), snow-in-summer (*Melaleuca linariifolia*), large mock olive (*Notelaea longifolia*) pink lantana (*Lantana camara*) and breynia (*Breynia oblongifolia*).

Groundcover: The groundcover is moderately dense, with blady grass (*Imperata cylindrica*) being the dominant species. Other commonly occurring species include prickly rasp fern (*Doodia aspera*), small sickle fern (*Pellaea falcata* var. *nana*), blue flax-lily (*Dianella caerulea*), dwarf trumpet (*Brunoniella pumilio*), muttonwood (*Rapanea variablis*), blackthorn (*Bursaria spinosa*), zieria (*Zieria smithii*), common buttercup (*Ranunculus lappaceus*) and rib-wort (*Plantago debilis*).

- Condition

Weeds are relatively common in this community, including lantana (*Lantana camara*) and bracken (*Pteridium esculentum*). The presence of burnt tree boles in some areas suggests that this vegetation type is subject to occasional fires of moderate intensity. The community suffers from minor fragmentation caused by fire trails. Previous logging activity is evident by the presence of sawn stumps and an absence of mature and dead trees in the canopy and there is a notable absence of medium to large hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

1.6 hectares.

j. ***Angophora costata/Eucalypt* spp. very tall open forest (map code 17)**

- Structure

Overstorey: The dominant species in the overstorey are smooth-barked apple (*Angophora costata*), tallowwood (*Eucalyptus microcorys*), Sydney peppermint (*E.*

piperita), brown stringybark (*E. capitellata*) and grey ironbark (*E. paniculata*). The overstorey extends to a maximum height of 30 m.

Midstorey: The midstorey is dominated by cherry ballart (*Exocarpos cupressiformis*), black she-oak (*Allocasuarina littoralis*) and smooth geebung (*Persoonia levis*). It extends to a maximum height of 12 m.

Understorey: The understorey varies from sparse to dense and extends to a maximum height of 2.5 metres. Common species include forest grass trees (*Xanthorrhoea resinosa*), Sydney golden wattle (*Acacia longifolia*), hill banksia (*Banksia spinulosa*), common hop bush (*Dodonaea triquetra*) and matchheads (*Comesperma ericinum*).

Groundcover: Groundcover extends to a maximum height of 60 m and is moderate to dense, containing species such as mat rush (*Lomandra longifolia*), fish bones (*L. Obliqua*), shivery grass (*Briza* spp.) and woolly xanthosia (*Xanthosia pilosa*).

- Condition

Weeds are relatively common in this community, including lantana (*Lantana camara*) and bracken fern (*Pteridium esculentum*). Tree hollows are sparse and evidence exists of previous extensive clearing practices. Tracks are common and the area is grazed by stock.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

k. ***Angophora costata/Melaleuca quinquenervia/Eucalyptus resinifera* very tall open forest (map code 19)**

l.

- Structure

Overstorey: This is a moist community that lies directly adjacent to the existing highway at the township of Nerong. It is dominated by smooth-barked apple (*Angophora costata*), broad-leaved paperbark (*Melaleuca quinquenervia*) and red mahogany (*Eucalyptus resinifera*). Other species that occur include large fruited grey gum (*E. canaliculata*) and grey gum (*E. propinqua*). The canopy in this community extends to a maximum height of 30 m and has a percentage cover of approximately 40%.

Midstorey: The midstorey extends to a height of approximately 10 m and is dominated by swamp oak (*Casuarina glauca*) and broad-leaved paperbark (*Melaleuca quinquenervia*).

Understorey: The understorey is sparse in this community. Where it occurs it is dominated by saw sedge (*Gahnia aspera*).

Groundcover: The groundcover is approximately 50 m high in this community and is dominated by various sedges, rushes and grasses.

- Condition

Weeds are sparse throughout this community, except on the forest fringe where purple top (*Verbena bonariensis*), verbena (*V. officianalis*) and Parramatta grass (*Sporobolus* sp.) occur. Tracks are sparse, however rubbish occurs throughout.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

0.97 hectares.

m. ***Eucalyptus umbra/Corymbia gummifera/Angophora costata* very tall open forest (map code 34)**

- Structure

Overstorey: The overstorey is 25 to 30 m high and provides approximately 50 % cover. The dominant canopy species are broad-leaved white mahogany (*Eucalyptus umbra*), red bloodwood (*Corymbia gummifera*) and smooth-barked apple (*Angophora costata*). Sydney peppermint (*E. piperita*) and red ironbark (*E. fibrosa*) occurred less commonly.

Midstorey: The midstorey extends to a maximum height of 10 m and is dominated by forest oak (*Allocasuarina torulosa*) and juvenile canopy species. It is rated as sparse.

Understorey: The understorey ranges from sparse to dense and is dominated by *Pultenaea* sp., Gymea lily (*Doryanthes excelsa*) and lemon-scented tea-tree (*Leptospermum polygalifolium*).

Groundcover: The groundcover is moderately dense with blady grass (*Imperata cylindrica*) being the dominant species. Other commonly occurring species include prickly rasp fern (*Doodia aspera*), small sickle fern (*Pellaea falcata* var. *nana*), blue flax-lily (*Dianella caerulea*), dwarf trumpet (*Brunoniella pumilio*), muttonwood (*Rapanea variabilis*), blackthorn (*Bursaria spinosa*), sandfly zieria (*Zieria smithii*), common buttercup (*Ranunculus lappaceus*) and ribwort (*Plantago debilis*).

- Condition

Weeds are relatively common in this community including lantana (*Lantana camara*), and bracken fern (*Pteridium esculentum*). The presence of burnt tree boles in some areas suggests that this vegetation type is subject to occasional fires of moderate intensity. Previous logging activity is evident by the presence of sawn stumps, and an absence of mature and dead trees in the canopy. There is a notable lack of medium to large hollows, and there appears to be a low to moderate level of biodiversity within this community.

- Taxa of conservation significance

Tetratheca juncea occurs in this community amongst blady grass and other groundcover species where the understorey was sparse to absent.

- Number of hectares to be removed

0.67 hectares.

n. ***Eucalyptus tereticornis* very tall open forest (map code 20)**

This is a moist open forest of limited extent that occurs on wetter poorly drained clay soils of the study area.

- Structure

Overstorey: The canopy extends to a maximum height of 30 m and is dominated by forest red gum (*Eucalyptus tereticornis*) and with the occasional occurrence of cabbage gum (*E. amplifolia*). Other canopy species include grey ironbark (*E. paniculata*), grey gum (*E. canaliculata*).

Midstorey: A midstorey is generally absent.

Understorey: The understorey varies from sparse to dense. The dominant species are swamp oak (*Casuarina glauca*) and prickly-leaved paperbark (*Melaleuca styphelioides*). Other species that occur occasionally include swamp paperbark (*M. ericifolia*), ball honeymyrtle (*M. nodosa*), snow in summer (*M. linariifolia*) and sieber's paperbark (*M. sieberi*).

Groundcover: Groundcover is moderate to dense, and consists primarily of grasses and sedges including species such as mat-rush (*Lomandra longifolia*), nut grass (*Cyperus brevifolius*), saw sedge (*Gahnia sieberana*) and blady grass (*Imperata cylindrica*). Other species that occur occasionally include ribwort (*Plantago debilis*), native violet (*Viola hederaceae*), einadia (*Einadia hastata*), centella (*Centella asiatica*) and blackberry (*Rubus ulmifolius*).

- Condition

Weeds are relatively sparse in this community, although roadside weeds such as paspalum (*Paspalum* sp.), cobblers pegs (*Bidens pilosa*) and purple top (*Verbena bonariensis*) are common of the forest fringe. Some areas on private property are currently subject to grazing by stock. The presence of burnt tree trunks in some areas suggests that this vegetation is subject to occasional or frequent low intensity fire. Although the community is fragmented in some placed by private or forestry roads, there are few tracks present. Previous logging activity is evident by the presence of sawn stumps, and an absence of mature and dead trees in the canopy and there is a notable absence of medium to large hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

o. ***Eucalyptus microcorys/E. propinqua/M. quinquenervia* very tall open forest (map code 23)**

This community occurs in low lying portion of the alignment, particularly in the central and southern sections.

- Structure

Overstorey: The canopy ranges in height between 25 and 30 m with an estimated cover of approximately 40%. The dominant canopy species are grey gum (*Eucalyptus propinqua*), tallowwood (*E. Microcorys*) and broad-leaved tea-tree (*Melaleuca quinquenervia*). Smooth-barked apple also occasionally occurs. Epiphytes, namely elkhorns (*Platycerium bifurcatum*) occur in portions of this community.

Midstorey: The midstorey is five to eight metres high, with an estimated cover of approximately 30 %. The dominant species are prickly-leaved tea-tree (*Melaleuca styphelioides*) broad-leaved paperbark (*M. quinquenervia*) and ball honeymyrtle (*M. nodosa*).

Understorey: The understorey is sparse to moderate and consists of such species as cherry ballart (*Exocarpos cuppresiformis*), snow-in-summer (*Melaleuca linariifolia*), black wattle (*Acacia irrorata*) and *Hakea* sp.

Groundcover: The groundcover is sparse to moderate, with an estimated cover of approximately 30%. The dominant species is mat-rush (*Lomandra longifolia*), with saw sedge (*Gahnia sieberana*), nut grass (*Cyperus brevifolius*), orange thorn (*Citriobatus pauciflorus*), coral heath (*Epacris microphylla*) and native violet (*Viola hederaceae*) also occurring commonly.

- Condition

Weeds are sparse in this community, although roadside weeds such as clover (*Trifolium* spp.), bushy starwort (*Aster subulatus*) and michaelmas daisy (*Aster novi-belgii*) are common on the forest fringe. Some areas are currently subject to cattle grazing. The presence of burnt tree trunks in some areas suggests that this community is subject to occasional moderate intensity fire. The community is fragmented in some places by tracks used by cattle. Previous logging activity is evident by the presence of sawn stumps, and a general paucity of mature and dead trees in the canopy. Medium to large hollows exist within this vegetation community, although not in abundance. There appears to be a moderate level of plant species diversity within this community.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

p. ***Corymbia gummifera/C. maculata/E. capitellata* very tall open forest (map code 25)**

- Structure

Overstorey: The overstorey in this community is 25 to 30 m high and provides approximately 45 % cover. The dominant canopy species are red bloodwood (*Corymbia gummifera*), spotted gum (*C. maculata*) and brown stringybark (*Eucalyptus capitellata*).

Midstorey: The midstorey is eight to 10 m high and provides approximately 40 % cover. The dominant midstorey species include black she-oak (*Allocasuarina littoralis*) and juvenile canopy species.

Understorey: The understorey is sparse to moderate, with commonly occurring species being black wattle (*Acacia irrorata*), lemon-scented tea-tree (*Leptospermum polygalifolium*), snow-in-summer (*Melaleuca linariifolia*), coral heath (*Epacris microphylla*) and matchheads (*Compesperma ericinum*).

Groundcover: The groundcover is moderately dense, with blady grass (*Imperata cylindrica*) being the dominant species. Other commonly occurring species include prickly rasp fern (*Doodia aspera*), small sickle fern (*Pellaea falcata*), blue flax lily (*Dianella caerulea*), purple flag (*Patersonia glabrata*), blackthorn (*Bursaria spinosa*) and common buttercup (*Ranunculus lappaceus*).

- Condition

Weeds are relatively sparse in this community. The presence of burnt tree boles in some areas suggests that this vegetation type is subject to occasional fires of moderate intensity. The community suffers from minor fragmentation caused by the construction of tracks and roads. Previous logging activity is evident by the presence of sawn stumps, and an absence of mature and dead trees in the canopy. There is a notable absence of medium to large hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

q. ***Angophora costata/Eucalyptus microcorys/Eucalyptus globoidea* very tall open forest (map code 28)**

- Structure

Overstorey: This community extends to a maximum height of 30 m and is dominated by stringybark (*Eucalyptus globoidea*), tallowwood (*E. microcorys*) and smooth-barked apple (*Angophora costata*). The canopy cover is moderately dense.

Midstorey: The midstorey in this community is dominated by forest oak (*Allocasuarina torulosa*) and juvenile overstorey species. It extends to a maximum height of 15 metres and is sparse.

Understorey: The understorey extends to a maximum height of three metres and is dominated by common hop bush (*Dodonaea triquetra*), prickly moses (*Acacia ulicifolia*), smooth geebung (*Persoonia linearis*), mountain devils (*Lambertia formosa*), hill banksia (*Banksia spinulosa*) and sandfly zieria (*Zieria smithii*).

Groundcover: The groundcover is moderately dense and extends to a height of 70 m. It is dominated by a variety of grass species, including wallaby grass (*Danthonia* sp.), kangaroo grass (*Themeda australis*) and blady grass (*Imperata cylindrica*). Mat rush (*Lomandra longifolia*), purple flag (*Patersonia glabrata*) and blue flax lily (*Dianella caerulea*) also occur commonly.

- Condition

Weeds are relatively sparse in this community although roadside weeds such as paspalum (*Paspalum* sp.), cobblers pegs (*Bidens pilosa*) and purple top (*Verbena bonariensis*) are common on the forest fringe. Some areas on private property are currently subject to grazing by stock. The presence of burnt tree trunks in some areas is indicative of fire. Although tracks and roads fragment this community, there are few tracks present. Previous logging activity is evident by the presence of sawn stumps and an absence of mature and dead trees in the canopy and there is a notable absence of medium to large hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

0.21 hectares.

r. ***Angophora costata/Eucalyptus microcorys* very tall open forest (map code 31)**

- Structure

Overstorey: The overstorey is 25 to 30 m high and provides approximately 50% cover. The dominant canopy species are smooth-barked apple (*Angophora costata*) and tallowwood (*E. microcorys*). Other species that occur occasionally are grey gum (*E. propinqua*) and stringybark (*E. globoidea*).

Midstorey: The midstorey extends to approximately 10m high and provides approximately 35% cover. The dominant midstorey species are prickly leaved tea tree (*M. styphelioides*), forest oak (*Allocasuarina torulosa*) with juvenile canopy species occurring intermittently.

Understorey: The understorey is sparse to moderate, with commonly occurring species being black wattle (*Acacia irrorata*), lemon-scented tea tree (*Leptospermum polygalifolium*), snow-in-summer (*Melaleuca linariifolia*), large mock olive (*Notelaea longifolia*), pink lantana (*Lantana camara*) and breynia (*Breynia oblongifolia*).

Groundcover: The groundcover is moderately dense, with blady grass (*Imperata cylindrica*) being the dominant species. Other commonly occurring species include prickly rasp fern (*Doodia aspera*), small sickle fern (*Pellaea falcata* var. *nana*), blue flax-lily (*Dianella caerulea*), common buttercup (*Ranunculus lappaceus*) and rib-wort (*Plantago debilis*).

- Condition

Weeds are relatively common in this community including lantana (*Lantana camara*) and bracken fern (*Pteridium esculentum*). The presence of burnt trees in some areas suggests that this vegetation type is subject to occasional fires of moderate intensity. The community suffers from minor fragmentation by tracks and roads. Previous logging activity is evident by the presence of sawn stumps and an absence of mature and dead trees in the canopy and there is a notable absence of medium to large hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

s. ***Corymbia maculata/Eucalyptus fibrosa* very tall open forest (map code 32)**

- Structure

Overstorey: The overstorey is 25 to 30 m high and provides approximately 45% cover. The dominant canopy species are spotted gum (*Corymbia maculata*) and red ironbark (*Eucalyptus fibrosa*). Other species that occur occasionally include grey gum (*Eucalyptus propinqua*).

Midstorey: The midstorey is eight to 10 m high and provides approximately 15% cover. The dominant species are juvenile canopy species and occasional black she-oak (*Allocasuarina littoralis*).

Understorey: The understorey is sparse and where it occurs mat rush (*Lomandra longifolia*) is the most common species.

Groundcover: The groundcover in this community is very sparse, a result of grazing cattle. The most common species are introduced grass species used for pasture improvement purposes, such as kikuyu (*Penisetum clandestinum*) and common couch.

- Condition

This community has been altered extensively in the past by logging and pasture improvement works. The canopy has been thinned and the undergrowth almost completely removed. Fires are likely to be frequent, but of a low intensity. Fires would be lit for the purpose of 'rubbish' control and for the instigation of new grass growth to be exploited by stock.

- Taxa of conservation significance

No taxa of conservation significance were recorded occurring in this community.

- Number of hectares to be removed

Nil.

t. ***Angophora costata/Eucalyptus fibrosa/E. capitellata/Corymbia gummifera* very tall open forest (map code 33)**

- Structure

Overstorey: The canopy ranges in height between 25 and 30 m with an estimated cover of approximately 45%. The dominant canopy species include smooth-barked apple (*Angophora costata*), red ironbark (*Eucalyptus fibrosa*), brown stringybark (*Eucalyptus capitellata*) and red bloodwood (*Corymbia gummifera*). Sydney peppermint (*Eucalyptus piperita*) occasionally occurs in this community.

Midstorey: The midstorey is five to eight metres high with an estimated cover of 30%. The dominant species are prickly leaved tea tree (*Melaleuca styphelioides*), broad-leaved paperbark (*Melaleuca quinquenervia*) and ball honeymyrtle (*Melaleuca nodosa*).

Understorey: The understorey is sparse to moderate and consists of such species as cherry ballart (*Exocarpos cupressiformis*), dogwood (*Jacksonia scoparia*), snow-in-summer (*Melaleuca linariifolia*), black wattle (*Acacia irrorata*) and hakea (*Hakea dactyloides*).

Groundcover: The groundcover is moderate to dense, with an estimated cover of 85%. The dominant species is mat rush (*Lomandra longifolia*), and with a number of native grasses being common.

- Condition

Weeds are relatively sparse in this community, although roadside weeds such as clover (*Trifolium* spp.), verbena (*Verbena officianalis*) and giant parramatta grass (*Sporobolus* sp.) are common on the forest edge. The presence of burnt tree trunks in some areas suggests that this community is subject to occasional moderate intensity fire. The community is fragmented is some places by tracks and roads. Previous logging activity is evident by the presence of sawn stumps, and a general paucity of mature and dead trees in the canopy. Medium to large hollows exist within this vegetation community, although not in abundance.

- Taxa of conservation significance

Tetratheca juncea was observed occurring within this community on the western side of the existing alignment.

- Number of hectares to be removed

14.78 hectares.

u. ***Eucalyptus globoidea* very tall open forest (map code 27)**

- Structure

Overstorey: This community is dominated by stringybark (*Eucalyptus globoidea*). Red bloodwood (*Corymbia gummifera*) and smooth-barked apple (*Angophora costata*) occur occasionally. The overstorey layer extends to a maximum height of 30 m and the canopy cover is moderately dense.

Midstorey: The midstorey extends to a height of 12 m and is dominated by prickly-leaved tea tree (*Melaleuca styphelioides*) and forest oak (*Allocasuarina torulosa*), with juvenile overstorey species occurring occasionally.

Understorey: The understorey is sparse to moderate, with commonly occurring species being black wattle (*Acacia irrorata*), lemon-scented tea tree (*Leptospermum polygalifolium*), snow in summer (*Melaleuca linariifolia*), mountain devils (*Lambertia formosa*) and hill banksia (*Banksia spinulosa*).

Groundcover: Groundcover is moderate to dense, and consists primarily of grasses and other species including mat rush (*Lomandra longifolia*), blady grass (*Imperata cylindrica*), native violet (*Viola hederacea*) and a variety of *Poa* species.

- Condition

Weeds are relatively sparse in this community, although roadside weeds such as giant Parramatta grass (*Sporobolus* sp.), cobblers pegs (*Bidens pilosa*), purple top (*Verbena bonariensis*) and scotch thistle (*Cirsium vulgare*) are common on the forest

fringe. Some areas on private property are currently subject to cattle grazing. The presence of burnt tree trunks suggests occasional low intensity fires. Although the community is fragmented in some places by private of forestry roads, there are few tracks present. Previous logging activity is evident by the presence of sawn stumps and an absence of mature or dead trees in the canopy. There are few medium and large hollows occurring in this community.

- Taxa of conservation significance

Eucalyptus fergusonii spp *fergusonii* was recorded occurring within this community.

- Number of hectares to be removed

21.1 hectares.

v. ***Eucalyptus tereticornis/Eucalyptus propinqua* very tall open forest (map code 21)**

- Structure

Overstorey: The overstorey in this community is dominated by forest red gum (*Eucalyptus tereticornis*) and grey gum (*Eucalyptus propinqua*) which extend to a maximum height of 30 m. The overstorey is moderately dense.

Midstorey: The midstorey in this community ranged in height between eight and 10 m. A number of species occur, including forest oak (*Allocasuarina torulosa*) and juvenile canopy species. The midstorey is rated as sparse.

Understorey: The understorey is generally sparse and is dominated by saw sedge (*Gahnia aspera*) and saplings of the overstorey species.

Groundcover: The groundcover is moderately dense and is dominated by a number of sedges, rushes and grasses which are suited to moist conditions.

- Condition

This community has been extensively altered in the past, primarily as a result of logging practices and the construction of logging tracks and roads. Weeds are relatively sparse. Bracken fern (*Pteridium esculentum*) sometimes occurs.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

viii. Very Tall Closed Forest

a. ***Eucalyptus* spp. very tall closed forest (map code 9)**

- Structure

Overstorey: The overstorey of this community is comprised of a mixed stand of eucalypts. Species include blackbutt (*Eucalyptus pilularis*), Sydney blue gum (*Eucalyptus saligna*), grey gum (*Eucalyptus propinqua*), brown stringybark (*Eucalyptus capitellata*) and tallowwood (*Eucalyptus microcorys*). The dense overstorey extends to a height of 30 m.

Midstorey: The midstorey in this community ranges in height between 15 and 20 m. It is dominated by black wattle (*Callicoma serratifolia*), juvenile canopy species and cabbage trees palms (*Livistona australis*).

Understorey: The understorey is comprised of immature cabbage tree palms (*Livistona australis*), lily pily (*Acmena smithii*), cheese tree (*Glochidion ferdinandi*) and false bracken fern (*Calochlaena dubia*). Numerous vines and creepers twine their way through the understorey including climbing sarsparilla (*Smilax glyciphylla*), love creeper (*Glycine* clandestina) and monkey rope (*Stephania japonica*). It extends to a height of approximately five metres.

Groundcover: The groundcover extends to a height of 40 m and dominant species include creeping christian (*Commelina cyanea*), white root (*Pratia purpurescens*), maidenhair fern (*Adiantum aethiopicum*) mat rush (*Lomandra longifolia*) and twining guinea flower (*Hibbertia dentata*).

- Condition

Weeds are sparse in this community, except where outbreaks of bracken fern (*Pteridium esculentum*) occur. The presence of burnt tree boles in some areas suggests that this vegetation type is subject to occasional low intensity fires. The community suffers from minor fragmentation by tracks. Previous logging activity is evident by the presence of sawn stumps, and an absence of mature and dead hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

1.66 hectares.

b. ***Eucalyptus microcorys/E. propinqua* very tall closed forest (map code 30)**

- Structure

Overstorey: The canopy ranges in height between 25 and 30 m with an estimated cover of approximately 65 %. The dominant canopy species are tallowwood (*Eucalyptus microcorys*) and grey gum (*Eucalyptus propinqua*).

Midstorey: The mid-storey is 10 to 12 m high, with an estimated cover of approximately 35%. The dominant species are prickly-leaved tea tree (*Melaleuca styphelioides*), black she-oak (*Allocasuarina littoralis*) broad-leaved paperbark (*Melaleuca quinquenervia*) and ball honeymyrtle (*Melaleuca nodosa*).

Understorey: The understorey is sparse to moderate and consist of such species as cherry ballart (*Exocarpos cupressiformis*), snow in summer (*Melaleuca linariifolia*), black wattle (*Acacia irrorata*) and juvenile black she-oak (*Allocasuarina littoralis*).

Groundcover: The groundcover is moderate to dense, with an estimated cover of approximately 80%. The dominant species is mat rush (*Lomandra longifolia*), with saw sedge (*Gahnia sieberana*), nut grass (*Cyperus brevifolius*), orange thorn (*Citriobatus pauciflorus*), coral heath (*Epacris microphylla*) and native violet (*Viola hederaceae*) also occurring commonly.

- Condition

Weeds are sparse in this community, although roadside weeds such as clover (*Trifolium* spp.), bushy starwort (*Aster subulatus*) and michaelmas daisy (*Aster novibelgii*) are common on the forest fringe. Some areas are currently subject to cattle grazing. The presence of burnt tree trunks in some areas suggests that this community is subject to occasional moderate intensity fire. The community is fragmented in some places by tracks used by cattle. Previous logging activity is evident by the presence of sawn stumps, and a general paucity of mature and dead trees in the canopy. Medium to large hollows exist within this vegetation community, although not in abundance.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

c. ***Eucalyptus microcorys/Eucalyptus propinqua/Corymbia maculata* very tall closed forest (map code 35)**

- Structure

Overstorey: The overstorey is 25 to 30 m high and provides approximately 70% cover. The dominant canopy species are tallowwood (*Eucalyptus microcorys*), grey gum (*Eucalyptus propinqua*) and spotted gum (*Corymbia maculata*).

Midstorey: The midstorey is eight to 10 m high and provides approximately 35% cover. The dominant species are juvenile canopy species and occasional black she-oak (*Allocasuarina littoralis*) and lemon-scented tea tree (*Leptospermum polygalifolium*).

Understorey: The understorey is moderate and is dominated by saw sedge (*Gahnia aspera*) and lantana (*Lantana camara*).

Groundcover: The groundcover in this community is moderately dense. It is dominated by mat rush (*Lomandra longifolia*). Other species include blady grass (*Imperata cylindrica*), prickly rasp fern (*Doodia aspera*), blue flax lily (*Dianella caerulea*) and common buttercup (*Ranunculus lappaceus*) as well as a variety of herbs and grasses.

- Condition

Weeds are relatively common in this community including lantana (*Lantana camara*) and bracken fern (*Pteridium esculentum*). The presence of burnt trees in some areas suggests that this vegetation type is subject to occasional fires of moderate intensity. The community suffers from minor fragmentation by tracks and roads. Previous logging activity is evident by the presence of sawn stumps, and an absence of mature and dead trees in the canopy. There is a notable absence of medium to large hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

d. ***Eucalyptus microcorys* very tall closed forest (map code 36)**

- Structure

Overstorey: The canopy is dominated by tallowwood (*Eucalyptus microcorys*) with the occasional occurrence of grey gum (*Eucalyptus propinqua*). The canopy extends to a maximum height of 35 m and has a cover of approximately 75%.

Midstorey: The midstorey is dominated by forest oak (*Allocasuarina torulosa*) and extends to a maximum height of 15 metres.

Understorey: The understorey varies from sparse to dense. The dominant species are juvenile forest oak (*Allocasuarina torulosa*), smooth geebung (*Persoonia linearis*), *Leucopogon juniperinus,* bush peas (*Pultenaea* spp.) and hill banksia (*Banksia spinulosa*).

Groundcover: The groundcover is moderately dense and extends to a height of 50 m. It is dominated by a variety of grasses including wallaby grass (*Danthonia* sp.), kangaroo grass (*Themeda australis*) and blady grass (*Imperata cylindrica*). Mat rush (*Lomandra longifolia*), purple flag (*Patersonia glabrata*) and blue flax lily (*Dianella caerulea*) also occur commonly.

- Condition

Weeds are relatively sparse in this community although roadside weeds such as paspalum (*Paspalum* sp.), cobblers pegs (*Bidens pilosa*) and giant Parramatta grass (*Sporobolus* sp.) are common on the forest fringe. Some areas are grazed by stock. The presence of burnt tree trunks in some areas is indicative of fire. Although this community is fragmented in some placed by private roads, there are few tracks present. Previous logging activity is evident by the presence of sawn stumps and an absence of mature or dead trees in the canopy. There is a notable absence of medium and large hollows.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

Nil.

ix. Extremely Tall Closed Forest

a. ***Eucalyptus pilularis/E. robusta* extremely tall closed forest (map code 10)**

- Structure

Overstorey: This community extends to a maximum height of 40 m and is dominated by blackbutt (*Eucalyptus pilularis*) and swamp mahogany (*Eucalyptus robusta*). The canopy cover is dense at approximately 75%. Grey gum (*Eucalyptus propinqua*) occasionally occurs throughout the canopy.

Midstorey: The midstorey in this community ranges high between 15 and 20 m. It is dominated by black wattle (*Callicoma serratifolia*), juvenile canopy species, cabbage tree palms (*Livistona australis*) and cheese tree (*Glochidion ferdinandi*).

Understorey: The understorey is comprised of juvenile cabbage tree palms (*Livistona australis*), lily pily (*Acmena smithii*), sandpaper fig (*Ficus coronata*), cheese tree (*Glochidion ferdinandi*) and saw sedge (*Gahnia aspera*). The understorey extends to a height of five metres.

Groundcover: The groundcover extends to a height of 40 cm and dominant species include false bracken fern (*Calochlaena dubia*), mat rush (*Lomandra longifolia*), maidenhair fern (*Adiantum aethiopicum*) and a number of grass species.

- Condition

Weeds are sparse in this community, except where outbreaks of bracken fern (*Pteridium esculentum*) and lantana (*Lantana camara*) occur. The presence of burnt tree boles in some areas suggests that this vegetation type is subject to occasional low intensity fires. The community suffers from minor fragmentation by tracks. Previous logging activity is evident by the presence of sawn stumps, however occasional medium to large hollows remain in the canopy.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

0.76 hectares.

b. ***Eucalyptus propinqua/Angophora costata/E. resinifera/Corymbia maculata*** **extremely tall closed forest (map code 26)**

- Structure

Overstorey: The canopy of this community ranges in height between 35 and 40 m with an estimated cover of 70%. The dominant canopy species are grey gum (*Eucalyptus propinqua*), smooth-barked apple (*Angophora costata*), red mahogany (*Eucalyptus resinifera*) and spotted gum (*Corymbia maculata*).

Midstorey: The midstorey is 10 to 15 m high, with an estimated cover of approximately 30%. It is dominated by forest oak (*Allocasuarina torulosa*) and juvenile canopy species. Willow bottlebrush (*Callistemon salignus*) and cherry ballart (*Exocarpos cupressiformis*) also commonly occur.

Understorey: The understorey is sparse to moderate and consists of bracken fern (*Pteridium esculentum*), bush peas (*Pultenaea* spp.), wedge pea (*Gompholobium pinnatum*), immature smooth geebung (*Persoonia levis*) and sandfly zieria (*Zieria smithii*).

Groundcover: The groundcover is sparse to moderate, with an estimated cover of approximately 30%. The dominant species is mat rush (*Lomandra longifolia*) with blady grass (*Imperata cylindrica*) and kangaroo grass (*Themeda australis*) occurring commonly.

- Condition

This community has been extensively altered in the past, primarily as a result of logging practices and the construction of logging tracks and roads. Weeds are relatively common. Bracken fern (*Pteridium esculentum*) is common in the understorey.

- Taxa of conservation significance

No taxa of conservation significance were recorded within this community.

- Number of hectares to be removed

3.26 hectares.

The above information has been considered in the following sections detailing the conservation value of the vegetation communities.

3.3.3 *Conservation Status of Recorded Communities*

The conservation status of the vegetation communities recorded in the study area has been determined using a number of key references including Hager and Benson (1994), Specht *et al.* 1995), Forestry Commission (1989b) and RACAC (undated). Conservation status is based on the same or equivalent vegetation community/type protected in reserves.

Table 3.2 CONSERVATION STATUS OF VEGETATION COMMUNITIES

Vegetation Community	Conservation Status According to Hager and Benson (1994)	Conservation Status According to Specht *et al.* (1995)	Forestry Commission (1989b)	RACAC (undated)
Melaleuca nodosa tall shrubland	Similar to WTF003b which is adequately conserved.	No information	No information	No information
M. linariifolia/M. quinquenervia/M. styphelioides/Casuarina glauca very tall shrubland	Similar to W00Zb which is adequately conserved.	Similar to T354c - reasonably conserved.	Similar to forest type 31. Largely confined to seaboard locations in NSW, including the Myall Lakes area. This forest type has been extensively cleared.	No information
M. nodosa very tall shrubland	Similar to WTF003b which is adequately conserved.	No information	No information	No information
Eucalyptus globoidea/Angophora costata/Corymbia gummifera very tall open woodland	Similar to EF117c which is not/poorly conserved; similar to EF331c which is inadequately conserved and to EF146i which is adequately reserved.	Similar to T706 which is adequately conserved. Also similar to T349 which is reasonably conserved.	Similar to forest type 127 which is widespread on the south coast but extends into the southern part of the north coast. Also similar to type 41 which is widespread on deep sand deposits.	Similar to smooth-barked apple - Sydney peppermint - stringybark - 59%. Also similar to stringybark - apple - 61%.
E. globoidea very tall open woodland	Similar to EF117c which is is not/poorly conserved.	Similar to T706 which is adequately conserved.	Similar to forest type 127 which is widespread on the south coast andextends into the southern part of the north coast.	Equivalent to dry grassy stringybark - 112%
E. globoidea/A. costata very tall open woodland	Similar to EF117c which is not/poorly conserved. Also similar to EF146i which is adequately conserved.	Similar to T706 which is adequately conserved. Also similar to EF146i which is adequately conserved.	This is similar to forest type 127 which is widespread on the south coast and extends into the southern part of the North Coast. Also	Equivalent to stringybark - apple - 61%

Table 3.2 CONSERVATION STATUS OF VEGETATION COMMUNITIES

Vegetation Community	Conservation Status According to Hager and Benson (1994)	Conservation Status According to Specht *et al.* (1995)	Forestry Commission (1989b)	RACAC (undated)
			similar to type 41 which is widespread on deep sand deposits.	
E. globoidea/A. costata very tall woodland	Similar to EF117c which is not/poorly conserved. Also similar to EF146i which is adequately conserved.	Similar to T706 which is adequately conserved. Also similar to EF146i which is adequately conserved.	This is similar to forest type 127 which is widespread on the south coast and extends into the southern part of the North Coast. Also similar to type 41 which is widespread on deep sand deposits.	Equivalent to stringybark - apple - 61%
Pinus radiata/E. microcorys/C. maculata mid-high open forest	No information	No information	This is a modified (harvested) version of forest type 218 (Forestry Plantations).	No information
C. glauca tall open forest	Similar to WTF001b which is adequately conserved.	Similar to CW19d which is adequately conserved	Similar to forest type 32. Occurs along coastal areas of NSW, particularly near estuaries including the Myall Lakes area.	Equivalent to swamp oak - 43%. Also similar to casuarina woodland - 80%
E. globoidea/A. costata very tall open forest	Similar to EF117c which is not/poorly conserved. Also similar to EF146i which is adequately conserved.	Similar to T706 which is adequately conserved. Also similar to T349 which is reasonably conserved.	This is similar to forest type 127 which is most widespread on the South Coast, but extends into the southern parts of the north coast. Also similar to type 41 which is widespread on deep sand deposits.	Equivalent to stringybark - apple - 61%
E. microcorys/C. maculata very tall open forest	Similar to EF040a which is not/poorly conserved.	Similar to T706d which is reasonably conserved and T707f	This is similar to forest type 70. It is widespread throughout the	No information

Table 3.2 CONSERVATION STATUS OF VEGETATION COMMUNITIES

Vegetation Community	Conservation Status According to Hager and Benson (1994)	Conservation Status According to Specht *et al.* (1995)	Forestry Commission (1989b)	RACAC (undated)
		which is adequately conserved.	coastal districts, usually ate elevations below 300 m.	
C. gummifera/E. capitellata/A. costata very tall open forest	Similar to EF331c which is inadequately conserved.	Similar to T706 which is adequately conserved.	Similar to forest type 106, with red bloodwood becoming dominant rather than Sydney Peppermint. This community is very common in the Sydney District and it occurs north of the central coast.	No information
C. maculata/E. propinqua very tall open forest	Similar to EF040a and EF040d which are not/poorly conserved	Similar to T707f which is adequately conserved	This is similar to forest type 74 and is widespread on the South Coast. It extends to the north of the State.	Equivalent to foothills grey - gum - spotted gum - 94%
E. pilularis/E. microcorys very tall open forest	Similar to EF145b which is not/poorly conserved	Similar to T707 which is poorly conserved, and T710 and T710e which are adequately conserved	This is similar to forest type 37. It is widely distributed and can be found from the central South Coast northwards into Queensland.	Equivalent to dry grassy blackbutt - tallowwood - 35%
E. microcorys/E. capitellata/A. costata very tall open forest	Similar to EF117c which is not/poorly conserved. Also similar to EF146i which is adequately conserved.	Similar to T706 which is adequately conserved. Also similar to T349 which is reasonably conserved.	This is similar to forest type 127. It is widespread on the South Coast and extends into the southern part of the North Coast. Also similar to type 41 which is widespread on deep sand deposits.	No information
C. maculata very tall open forest	Similar to EF040a which is not/poorly conserved	Similar to T706d which is reasonably conserved and T707f	This is similar to forest type 70. It is widespread throughout the	No information

Table 3.2 CONSERVATION STATUS OF VEGETATION COMMUNITIES

Vegetation Community	Conservation Status According to Hager and Benson (1994)	Conservation Status According to Specht *et al.* (1995)	Forestry Commission (1989b)	RACAC (undated)
		which is adequately conserved	coastal districts usually at elevations below 300 m.	
E. pilularis/A. costata/E. globoidea very tall open forest	Similar to EF146h which is adequately conserved.	Similar to T706 which is adequately conserved. Also similar to T349 which is reasonably conserved.	This is similar to forest type 42 which is found in the Central Coast from near Bulahdelah in the north to Bateman's Bay in the south. It is particularly common in the Sydney area.	Similar to stringybark - apple - 61%. Also similar to blackbutt - Sydney peppermint - smooth-barked apple - 80%.
E. propinqua/A. costata/E. microcorys very tall open forest	Similar to EF165a which is adequately conserved.	Similar to T707 which is poorly conserved	No information	Similar to dry grassy tallowwood - grey gum - 77%. Also similar to grey gum - stringybark - apple - 544%
A. costata/Eucalypt spp. very tall open forest	No information	Similar to T706 which is adequately conserved. Also similar to T350e which is adequately conserved.	This is similar to forest type 105. This type is found scattered through the coastal districts and examples occur in the Myall Lakes area.	Similar to mixed moist hardwood - 28%
A. costata/M. quinquenervia/E. resinifera very tall open forest	Similar to EF203b which is adequately conserved.	Similar to T354 which is adequately conserved. Also similar to T354c which is reasonably conserved.	This is similar to forest type 105. This type is found scattered through the coastal districts and examples occur in the Myall Lakes area.	No information
E. umbra/Co. gummifera/A.	Similar to EF203b which is	Similar to T711b which is poorly	Similar to forest type 126. In its	No information

Table 3.2 CONSERVATION STATUS OF VEGETATION COMMUNITIES

Vegetation Community	Conservation Status According to Hager and Benson (1994)	Conservation Status According to Specht *et al.* (1995)	Forestry Commission (1989b)	RACAC (undated)
costata very tall open forest	adequately reserved. Also similar to EF331c which is inadequately reserved.	to reasonably conserved in NSW.	various forms it occurs from the central South Coast to the North Coast.	
E. tereticornis very tall open forest	Similar to EF050a which is inadequately reserved.	According to Specht *et al* (1995) this community is not conserved in NSW.	According to Forestry Commission (1989) this forest type is one of the most common along the NSW coast. It is similar to forest type 92.	Equivalent to eastern red gums - 95%
E. microcorys/E. propinqua/M. quinquenervia very tall open forest	Similar to EF075a which is not/poorly conserved. Also similar to WT002a which is adequately conserved.	Similar to T707 which is poorly conserved.	No information	Similar to dry grassy tallowwood - grey gum - 77%
C. gummifera/C. maculata/E. capitellata very tall open forest	No information	Similar to T706d and T349 which are reasonably conserved.	This is similar to forest type 126. In its various forms it occurs from the central South Coast to the North Coast.	No information
A. costata/E. microcorys/E. globoidea very tall open forest	Similar to EF117c which is not/poorly conserved. Also similar to EF146i which is adequately conserved.	Similar to T706 which is adequately conserved. Also similar to EF146i which is adequately conserved.	No information.	Similar to stringybark - apple - 61%
A. costata/E. microcorys very tall open forest	Similar to EF117c which is not/poorly conserved. Also similar to EF146i which is adequately conserved.	Similar to T706 which is adequately conserved.	No information	No information

Table 3.2 CONSERVATION STATUS OF VEGETATION COMMUNITIES

Vegetation Community	Conservation Status According to Hager and Benson (1994)	Conservation Status According to Specht *et al.* (1995)	Forestry Commission (1989b)	RACAC (undated)
C. maculata/E. fibrosa very tall open forest	Similar to EF040e which is inadequately conserved.	No information.	This is similar to forest type 70. It is widespread throughout coastal districts, usually below elevations of 300 m.	Equivalent to hunter spotted gum - ironbark - 17%.
A. costata/E. fibrosa/E. capitellata/C. gummifera very tall open forest	Similar to EF117c which is not/poorly conserved; to EF331c which is inadequately conserved and EF146i which is adequately reserved.	Similar to T706 which is adequately conserved. Also similar to T349 which is reasonably conserved.	This is similar to forest type 127. The type is most widespread on the south coast, but extends into the southern part of the North Coast. Also similar to type 41 which is widespread on deep sand deposits.	Similar to ironbark - stringybark - 236%. Also similar to sandstone ironbark - 411%.
E. globoidea very tall open forest	Similar to EF117c which is not/poorly conserved.	Similar to T706 which is adequately conserved.	Similar to forest type 127 which is widespread on the south coast and extends into the southern part of the north coast.	No information
E. tereticornis/E. propinqua very tall open forest	Similar to EF050f which is not/poorly conserved.	No information	Similar to forest type 92 which occurs frequently within most of the coastal districts within NSW.	Equivalent to lowland red gum - 31%
Eucalypt spp very tall closed forest	No information	Similar to T707b which is reasonably to adequately conserved.	Similar to forest type 37 which has a wide distribution on the north coast.	No information
E. microcorys/E. propinqua very tall closed forest	Similar to EF165a which is adequately conserved.	Similar to T707 which is poorly conserved	This is similar to forest type 45 and it is not widespread.	Equivalent to dry grassy tallowwood - grey gum - 77%
E. microcorys/E. propinqua/C.	Similar to EF040d which is	Similar to T707 which is poorly	Similar to forest type 45 which is	No information

Table 3.2 CONSERVATION STATUS OF VEGETATION COMMUNITIES

Vegetation Community	Conservation Status According to Hager and Benson (1994)	Conservation Status According to Specht *et al.* (1995)	Forestry Commission (1989b)	RACAC (undated)
maculata very tall closed forest	not/poorly conserved.	conserved.	not widespread.	
E. microcorys very tall closed forest	Equivalent to EF165a which is adequately conserved.	No information	Similar to forest type 45 which is not widespread.	Equivalent to tallowwood - 49%
E. pilularis/E. robusta extremely tall closed forest	Similar to EF099a which is adequately conserved. Also similar to EF145a which is not/poorly/inadequately conserved.	Similar to T354b which is reasonably conserved.	This is similar to forest type 36. It is found from the central South Coast northwards into Queensland.	No information
E. propinqua/A. costata/E. resinifera/C. maculata extremely tall closed forest	Similar to EF040d which is not/poorly conserved. Also similar to EF096b which is inadequately conserved and to EF165a which is adequately conserved.	Similar to T707 which is poorly conserved.	This is similar to forest type 60. It is found at altitudes to above 300m in the North Coast and Central Coast Regions.	Similar to foothills grey gum - spotted gum - 94%

Note: Reference to Hagar and Benson (1994), Specht et a (1995), Forestry Commission (1989b) and RACAC (undated) to explain the definition of various community types listed.

3.3.4 *Number of Hectares to be Removed*

Table 3.3 indicates the area (in hectares) to be removed of each vegetation community occurring within the study area. The table allows a comparison between area to be removed from each community with conservation status. Conservation status has been determined from reference to RACAC (undated) as this is the most recent information pertaining to the conservation status of plant communities within NSW. Where few similarities to the RACAC classification scheme were observable, conservation status was determined by reference to three other key texts (as well as RACAC), including Forestry Commission (1989b), Hager and Benson (1994) and Specht *et al.* (1995) which have been summarised in *Table 3.2* above.

Table 3.3 SUMMARY OF HECTARES TO BE REMOVED AND CONSERVATION STATUS OF VEGETATION COMMUNITIES

Community	Map Code	Conservation Status	Number of Hectares to be Removed
Melaleuca nodosa tall shrubland	3	2	2.38
M. linariifolia/M. quinquenervia/M. styphelioides/Casuarina glauca very tall shrubland	22	2	nil
M. nodosa very tall shrubland	2	2	2.84
Eucalyptus globoidea/Angophora costata/Corymbia gummifera very tall open woodland	4	1	1.03
E. globoidea very tall open woodland	6	2	nil
E. globoidea/A. costata very tall open woodland	29	1	nil
E. globoidea/A. costata very tall woodland	1	1	25.44
Pinus radiata/E. microcorys/Co. maculata mid-high open forest	24	nd	4.76
Ca. glauca tall open forest	18	1	1.23
E. globoidea/A. costata very tall open forest	7	1	1.57
E. microcorys/Co. maculata very tall open forest	5	1	15.1
Co. gummifera/E. capitellata/A. costata very tall open forest	8	2	1.73
Co. maculata/E. propinqua very tall open forest	11	1	nil
E. pilularis/E. microcorys very tall open forest	12	1	4.01
E. microcorys/E. capitallata/A. costata very tall open forest	13	2	nil

Table 3.3 SUMMARY OF HECTARES TO BE REMOVED AND CONSERVATION STATUS OF VEGETATION COMMUNITIES

Community	Map Code	Conservation Status	Number of Hectares to be Removed
Co. maculata very tall open forest	14	1	nil
E. pilularis/A. costata/E. globoidea very tall open forest	15	2	3.6
E. propinqua/A. costata/E. microcorys very tall open forest	16	1	1.6
A. costata/Eucalypt spp very tall open forest	17	1	nil
A. costata/M. quinquenervia/E. resinifera very tall open forest	19	2	1.0
E. umbra/Co. gummifera/A. costata very tall open forest	34	1	0.7
E. tereticornis very tall open forest	20	1	nil
E. microcorys/E. propinqua/M.quinquenervia very tall open forest	23	1	nil
Co. gummifera/Co. maculata/E. capitellata very tall open forest.	25	1	nil
A. costata/E.microcorys/E.globoidea very tall open forest	28	1	0.21
A. costata/E.microcorys very tall open forest	31	1	nil
Co. maculata/E. fibrosa very tall open forest	32	1	nil
A. costata/E. fibrosa/E. capitellata/Co. gummifera very tall open forest	33	2	14.78
E. globoidea very tall open forest	27	2	21.1
E. tereticornis/E. propinqua very tall open forest	21	1	nil
Eucalypt spp. very tall closed forest	9	nd	1.66
E. microcorys/E. propinqua very tall closed forest	30	1	nil
E. microcorys/E. propinqua/Co. maculata very tall closed forest	35	1	nil
E. microcorys very tall closed forest	36	1	nil
E. pilularis/E. robusta extremely tall closed forest	10	1	0.76
E. propinqua/A. costata/E. resinifera/Co. maculata extremely tall closed forest.	26	1	3.26

Table 3.3 SUMMARY OF HECTARES TO BE REMOVED AND CONSERVATION STATUS OF VEGETATION COMMUNITIES

Community	Map Code	Conservation Status	Number of Hectares to be Removed
Other unclassified Strip Vegetation	n/a	nd	13.9
		Total	122.66 hectares.

Conservation Codes (modified from Hager and Benson 1994 and RACAC undated)

1 Inadequately conserved (including those communties where conservation targets have not been met).

2 Adequately conserved

nd Not determined due to lack of data

From the information contained within the above table, it is evident that a large majority of the vegetation communities occurring within the study area are of conservation significance. Of the total amount of forest to be cleared for the proposed upgrade (122.66 hectares) approximately 54.91 hectares of forest is considered to be of conservation significance.

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

The significant flora species listed in *Table 3.4* are those that are known or likely to occur within the study area. The location of all previous and new threatened species records within the study area are illustrated in *Figure 4.1*.

Table 3.4 THREATENED, RARE AND REGIONALLY SIGNIFICANT FLORA SPECIES LIKELY TO OCCUR IN THE STUDY AREA

Scientific Name	TSC listing	ESP listing	RoTAP classification	Likelihood of Occurrence
Plectranthus suaveolens	Not listed	Not listed	3KC-	High. Known to occur in the locality.
Eucalyptus glaucina	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VCa	High. Known to occur in the locality.
Tetratheca juncea	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VCa	Recorded within the study area.
Prostanthera densa	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VC-	High. Known to occur in the locality.
Syzygium paniculatum	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VCi	High. Known to occur in the locality.
Melaleuca groveana	Schedule 2 -	Not listed	3RC-	High. Known to occur in

Table 3.4 THREATENED, RARE AND REGIONALLY SIGNIFICANT FLORA SPECIES LIKELY TO OCCUR IN THE STUDY AREA

Scientific Name	TSC listing	ESP listing	RoTAP classification	Likelihood of Occurrence
	Vulnerable			the locality.
Asperula asthenes	Schedule 2 - Vulnerable	Part 2 - Vulnerable	3VC-	High. Known to occur in the locality.
Eucalyptus fergusonii ssp. fergusonii	Not listed	Not listed	3KC-	Recorded within the study area.
Grevillea guthrieana	Not listed	Part 1 - Endangered	3V	High. Known to occur in the locality.
Macrozamia pauli-guilemimim ssp flexuosa	Not listed	Part 1 - Endangered	2K	High. Known to occur in the locality.
Callistemon acuminatus	Not listed	Not listed	3RC-	High. Known to occur in the locality
Goodenia fordiana	Not listed	Not listed	2RC-	High. Known to occur in the locality.

Notes: *1. ESP Act = Endangered Species Protection Act, 1992.*

2. TSC Act = Threatened Species Conservation Act, 1995.

3. RoTAP = Rare or Threatened Australian Plant (Briggs and Leigh 1996)

Key to Briggs and Leigh (1996)

Distribution Category

2 geographic range less than 100 km

3 geographic range more than 100 km

Conservation Status

E Endangered - species in serious risk of disappearing from the wild state within one to 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 threatened 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.

K Poorly known - taxon that is suspected, but not definitely known, to belong to one of the above categories. At present, accurate field distribution information is inadequate..

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.

3.3.6 *Habitat of Threatened Flora Species Known or Likely to Occur*

Table 3.5 lists flora species of conservation significance that are known or likely to occur within the study area, and the vegetation communities in which they potentially occur. Following the *Tabe 3.5* is a discussion on the habitat requirements for each species.

Table 3.5 SPECIES OF CONSERVATION SIGNIFICANCE AND VEGETATION COMMUNITIES IN WHICH THEY ARE KNOWN TO OR POTENTIALLY OCCUR IN THE STUDY AREA

Species	Vegetation Community
Asperula asthenes	*Eucalyptus* spp very tall closed forest
	E microcorys/E propinqua very tall closed forest
	E microcorys/E propinqua/Corymbia maculata very tall closed forest
	E microcorys very tall closed forest
	E pilularis/E robusta extremely tall closed forest
	E propinqua/A costata/E resinifera/Co maculata extremely tall closed forest
	Casuarina glauca tall open forest
	E tereticronis very tall open forest
	E tereticornis/E propinqua very tall open forest
Callistemon acuminatus	*Melaleuca nodosa* tall shrubland
	M linariifolia/M quinquenervia/M styphelioides/Ca glauca very tall shrubland
	M nodosa very tall shrubland
	E globoidea very tall open forest
	E microcorys/Co maculata very tall open forest
	Co maculata very tall open forest
	Co maculata/E propinqua very tall open forest
Eucalyptus fergusonii ssp *fergusonii*	*E globoidea* very tall open forest#
	E microcorys/Co maculata very tall open forest#
	Co maculata/E propinqua very tall open forest#

Table 3.5 SPECIES OF CONSERVATION SIGNIFICANCE AND VEGETATION COMMUNITIES IN WHICH THEY ARE KNOWN TO OR POTENTIALLY OCCUR IN THE STUDY AREA

Species	Vegetation Community
Eucalyptus glaucina	*E tereticronis* very tall open forest
	E tereticornis/E propinqua very tall open forest
Goodenia fordiana	This species potentially occurs within all sclerophyll communities of the study area.
Grevillea guthrieana	*E microcorys/E propinqua/Corymbia maculata* very tall closed forest
	E propinqua/A costata/E resinifera/Co maculata extremely tall closed forest
	E tereticornis very tall open forest
	E tereticornis/E propinqua very tall open forest
Macrozamia pauli-guilielmi ssp *flexuosa*	May occur in a variety of the dry sclerophyll forest types. Particularly:
	Co maculata very tall open forest
	Co maculata/E fibrosa very tall open forest
Melaleuca groveana	*M nodosa* very tall shrubland
	M linariifolia/M quinquenervia/M styphelioides/Ca glauca very tall shrubland
	M nodosa very tall shrubland
	E umbra/Co gummifera/A costata very tall open forest
	E globoidea/A costata very tall open forest
	E globoidea/A costata very tall open woodland
	E globoidea/A costata/C gummifera very tall open woodland
	E globoidea very tall open woodland
	E globoidea/A costata very tall woodland
Plectranthus suaveolens	*E globoidea* very tall open forest
	E microcorys/Co maculata very tall open forest
	Co maculata very tall open forest
	Co maculata/E propinqua very tall open forest
Prostanthera densa	The shrubland and dry forest communities all potentially provide suitable habitat for this species.
Syzygium paniculatum	*Eucalyptus* spp very tall closed forest
	E microcorys/E propinqua very tall closed forest

Table 3.5 SPECIES OF CONSERVATION SIGNIFICANCE AND VEGETATION COMMUNITIES IN WHICH THEY ARE KNOWN TO OR POTENTIALLY OCCUR IN THE STUDY AREA

Species	Vegetation Community
	E microcorys/E propinqua/Co maculata very tall closed forest
	E microcorys very tall closed forest
	E pilularis/E robusta extremely tall closed forest
	E propinqua/A costata/E resinifera/Co maculata extremely tall closed forest
Tetratheca juncea	*Co gummifera/E capitellata/A costata* very tall open forest
	E umbra/Co gummifera/A costata very tall open forest#
	A costata/E fibrosa/E capitellata/Co gummifera very tall open forest#

Note: # denotes communities in which the species are known to occur

i. Asperula asthenes

This species grows in damp locations, often along river banks (Harden 1992). Therefore, it is likely that suitable habitat exists for this species surrounding the creeklines within the study area. The species has been recorded within the locality approximately three kilometres to the southwest of the township of Bulahdelah (NPWS Wildlife Atlas 1997). *Table 3.5* lists those communities in which this species may occur.

ii. Callistemon acuminatus

This species predominantly occurs on exposed dry rocky slopes on sandstone. However, at least three near coastal occurrences are known, including a site at Tea Gardens. The communities in which the species are found are varied. When occurring on rocky slopes the species is found in woodlands and shrublands. The species has also been found growing amongst closed forest emergents such as *Ceratopetalum gummiferum* and *Schizomeria ovata*, amongst riparian vegetation (Sheringham and Westaway 1997) and also amongst coastal shrublands (N. Barkwill, ERM Mitchell McCotter, pers. obs.).

Areas of suitable habitat for the species (both coastal and rocky) exist within the study area. *Table 3.5* lists those communities in which this species may occur.

iii. Eucalyptus fergusonii ssp *fergusonii*

This species occurs in wet sclerophyll forest or woodland on sandy soils (Harden 1991).

Known habitat for the species exists at numerous sites within the locality. It has been observed at Burdekin's Gap, within Nerong State Forest, at Fame Cove and on Mount Karuah (N. Barkwill, ERM Mitchell McCotter, pers obs). The species generally occurs on skeletal soil derived from sandstone parent material. It has also been observed occurring at Fame Cove by Scotts *et al.* (1997). At the Mount Karuah and Fame Cove sites, the species has been recorded as a co-dominant, frequently in association with spotted gums and other iron barks (N. Barkwill, ERM Mitchell McCotter, pers obs; Scotts *et al* 1997). *Table 3.5* lists those communities in which this species are known to or may occur.

iv. Eucalyptus glaucina

The habitat for this species is grassy woodland on moderately fertile and well watered soil (Harden 1992).

Extensive areas of suitable habitat for this species exist, particularly in the central, low lying portions of the study area where the communities are dominated by forest red gum (*Eucalyptus tereticornis*) and where cabbage gum (*Eucalyptus amplifolia*) frequently occurs as a sub or co-dominant. *Table 3.5* lists those communities in which this species may occur.

v. Goodenia fordiana

The habitat for the species is sclerophyll forest on the lower escarpment ranges (Harden 1992). *Table 3.5* lists those communities in which this species may occur.

vi. Grevillea guthrieana

This species grows on sandstone derived loam on creek lines in moist eucalypt forest (Olde and Marriott 1994). The species is only known from two locations in NSW. The first is at a site approximately three kilometres east of Booral (along Booral Creek) beyond the northern limit of the proposed Upgrade (Olde and Marriott 1994; 1995).

The species therefore potentially occurs at various locations throughout the study area, particularly at the northern and southern ends of the proposed Upgrade where

the soils have been derived from sandstone parent material. *Table 3.5* lists those communities in which this species may occur.

vii. Macrozamia pauli-guilielmi ssp *flexuosa*

This species grows in sclerophyll forests on the coast and coastal ranges (Harden 1990). Within the locality, the species has been recorded at Fame Cove where the species was rare, being observed in only dry spotted gum-ironbark forests (Scotts *et al.* 1997). *Table 3.5* above those communities in which this species may occur.

viii. Melaleuca groveana

This species grows in heath, often in exposed sites restricted to higher areas (Harden 1991). Although habitat for the species exists throughout the locality, optimal habitat suitable for the species is rare throughout the study area. Sub-optimal habitat in the form of woodland or open forest communities with a heathy understorey occur commonly. *Table 3.5* lists those communities in which this species may occur.

ix. Plectranthus suaveolens

Hunter (1998a) and Harden (1992) document the habitat of the species being rocky and shallow soils sites in exposed situations. It frequently occurs in habitats that have an altitudinal range of 900 to 1300 m.

Within the locality, the species has been recorded at the Fame trig station (Scotts *et al.* 1997). *Table 3.5* lists those communities in which this species may occur.

x. Prostanthera densa

The habitat for this species is sclerophyll forest and shrubland, on coastal headlands and near coastal ranges, chiefly on sandstone. *Table 3.5* lists those communities in which this species may occur.

xi. Syzygium paniculatum

This species grows in subtropical and warm temperate rainforest (Harden 1991).

There is no rainforest within the study area, therefore, the extent of suitable habitat for this species is minimal. It has however been recorded within the subregion and *Table 3.5* lists those communities in which this species may occur.

xii. Tetratheca juncea

This species grows in sandy, occasionally swampy heath and in dry sclerophyll forest, chiefly in the coastal districts from Bulahdelah to Lake Macquarie (Harden 1992). Payne (1993) states that the species is known from a variety of landscapes with vast differences in vegetation community structure. It has previously been recorded in *Angophora costata/Eucalyptus haemastoma* open forest, *Angophora costata* woodland with a mid-storey of *Allocasuarina* as well as *Banksia aemula* heathland on sand dunes (Payne 1993). More frequently the species occurs in *Angophora costata/Eucalyptus haemastoma/Corymbia gummifera* forests.

Payne (1993) states that the species is frequently located where the understorey/groundcover is dominated by *Acacia myrtifolia, Lomandra obliqua, Dodonaeae triquetra, Pimelea linifolia, Pultenaea villosa* and *Lambertia formosa*. Also, the grass *Themeda australis* is nearly always a dominant groundcover species.

Winning (cited in Payne 1993) found that generally, populations of *Tetratheca juncea* are present on ridges or upper slopes and favour a southernly or easterly aspect.

Table 3.5 lists those communities in which this species is known or may occur.

3.3.7 Threatened, Rare and Regionally Significant Species Recorded During this Survey

One threatened species, *Tetratheca juncea* (listed on Schedule 2 (Vulnerable) of the TSC Act) was recorded during this survey. Additionally, one species listed by Briggs and Leigh (1996) as a rare or threatened Australian plant (rated as poorly known) was recorded, this being species *Eucalyptus fergusonii* ssp. *fergusonii*. The location of the distribution and the extent of the *Tetratheca juncea* populations are illustrated in *Figure 3.2*, with the location of *Eucalyptus fergusonii* ssp *fergusonii* illustrated in *Figure 4.1*.

Due to the direct threat of plant destruction resulting from the proposed Upgrade, base-line data were gathered to enable effective long-term monitoring of the remaining population of *Tetratheca juncea*. Unlike *Tetratheca juncea, Eucalyptus fergusonii* was not sampled extensively as part of the preparation of this SIS. It is considered that the proposed Upgrade would not impact on this species to the extent that a viable local population would be placed at risk of extinction due to the low number of individual plants in close proximity to the proposed Upgrade. Where individuals do occur, they grow on moderately steep slopes which are unsuitable for the construction of the proposed Upgrade.

Of primary interest during the *Tetratheca juncea* survey was the extent of the population, the number of plants comprising the population, the composition of the plant community in which the population occurs and a variety of abiotic factors, including topography, aspect, slope and drainage characteristics. These were noted in the field and are documented in *Table 3.6*. The estimated extent of the *T. Juncea* population on the southern side of the Pacific Highway is approximately 10.3 hectares (12,215 individuals), while the estimated extent of the population on the northern side is approximately 5.7 hectares (2770 individuals).

Table 3.6 *TETRATHECA JUNCEA* SURVEY RESULTS

Site	Easting/Northing	Overstorey Composition	Overstorey Foliage Cover (%)	Mid-storey Composition	Understorey Composition	Groundcover Composition	Groundcover Foliage Cover (%)	*Tetratheca juncea* plants per quadrat
Southern Side of Highway								
E1	407300/6488600	*Angophora costata, Corymbia gummifera, Eucalyptus propinqua, E. globoidea*	45	*Allocasuarina littoralis*, juvenile *A. costata*	*Doryanthes excelsa*	*Dianella caerulea, Themeda australis, Imperata cylindrica*	100	92
E2	407316/6388551	*A. costata*	40	*Al. littoralis*	*Leptospermum polygalifolium*	*X. resinosa, Gahnia* sp., *Adiantum aethiopicum*	100	28
E3	407107/6388390	*E. piperita, E. microcorys, C. gummifera, A. costata*	65	juvenile *A. costata* & *C. gummifera, Al. littoralis*	*D. excelsa*	*Pteridium esculentum, Hakea* sp., *I. cylindrica*	100	13
E4	407370/6388545	*A. costata, E. eugenioides, C. gummifera*	40	juvenile *A. costata, A. littoralis*	*Pultenaea* sp.	*P. esculentum* and other grasses	95	1
E5	407507/6388513	*A. costata, E. piperita, C. gummifera, E. eugenioides*	55	juvenile *A. costata* and other juvenile *Eucaltypus* sp.	absent	*Lomandra longifolia, Gahnia* sp., *P. esculentum*	100	20

Table 3.6 *TETRATHECA JUNCEA* SURVEY RESULTS *(Contd)*

Site	Easting/Northing	Overstorey Composition	Overstorey Foliage Cover (%)	Mid-storey Composition	Understorey Composition	Groundcover Composition	Groundcover Foliage Cover (%)	*Tetratheca juncea* plants per quadrat
E6	407570/6388528	*E. piperita*	<5	*Al. littoralis*	*L. polygalifolium*	*X. resinosa*, *Gahnia* sp., *Ad. aethiopicum*	100	9
E7	407584/6388499	*A. costata*, *C. gummifera*, *E. piperita*, *E. globoidea*	15	absent	*L. polygalifolium*	variety of grasses	80	3
							Average population size per hectare[1,2]	1186
Northern Side of Highway								
W1	407900/6388432	*E. piperita*, *A. costata*, *C. gummifera*	25	juvenile *A. costata*, *Al. littoralis*	*Banksia spinulosa*, juvenile *Al. littoralis*, *Xanthorrhoea resinosa*, *L. polygalifolium*	*P. esculentum*, *Hakea* sp., *I. cylindrica*	100	12
W2	408015/6388471	*A. costata*, *C. gummifera*	40	*Al. littoralis*	*Hakea* sp., *L. polygalifolium*,	variety of grasses	100	12
W3	408028/6388485	*C. gummifera*, *E.*	50	*Al. littoralis*,	*X. resinosa*, *Hakea*	*P. esculentum*,	90	7

		eugenioides, A. costata		juvenile *Eucalyptus* spp.	sp.	variety of grasses		
W4	407857/6388495	*A. costata, E. piperita, C. gummifera*	10	juvenile *A. costata, E. piperita, C. gummifera*	juvenile *Al. littoralis*	*X. resinosa, L. polygalifolium*	75	8
							Average population size per hectare [1,3]	486

Notes:

1. *Calculated by determining average number of plants per 200m² (40m x 5m quadrat) multiplied by 50 to obtain an estimation of population size per 10,000m² (one hectare).*
2. *Calculated for eastern side of the road*
3. *Calculated for western side of the road*

3.3.8 *Protected Flora Species*

Protected flora species are those that are listed on Schedule 13 (Protected Native Plants) of the NPW Act 1974. *Table 3.7* lists the protected species that were sampled within the study area during the vegetation surveys.

Table 3.7 PROTECTED SPECIES RECORDED DURING THE SURVEY

Scientific Name	Common Name	Map Code of Communities where Observed
Boronia polygalifolium	Milkwort Boronia	4, 29, 7, 8, 13, 15, 28, 33,
Boronia spp.		29, 3, 15, 28, 33, 17, 34
Dendrobium spp.		26
Doryanthes excelsa	Gymea Lily	34, 33, 8,
Livistona australis	Cabbage Tree Palm	36, 26, 10
Lomatia silaifolia	Crinkle Bush	Most dry forest community types
Adiantum aethiopicum	Maidenhair Fern	36, 26,10, 20, 22, 5, 35
Adiantum sp		36
Platycerium sp	Elkhorn	18

3.3.9 *Restrictions to the Flora Survey*

A number of restrictions to the flora survey were experienced. These are discussed below.

The detection and identification of some flora species was restricted due to seasonality of surveys and a consequent lack of suitable flowering or fruiting material for some species.

The study area encompasses approximately 3675 hectares along 36.75 km of Pacific Highway between Bulahdelah and Karuah. This area is made up of a wide variety of habitats and micro-habitats, not all of which could be adequately sampled in the limited time available for field sampling. Therefore, only portions of those habitats deemed suitable for threatened flora species, as identified from topographic maps, API and ground truthing, were sampled during the current survey.

The CRA habitat models (contained in *Appendix E*) have been found to be inaccurate. The broad nature of the stratification means that some vegetation communities have been included in the wrong strata. For example, ground truthing during the current surveys revealed that forest red gum (*Eucalyptus tereticornis*) is the dominant canopy

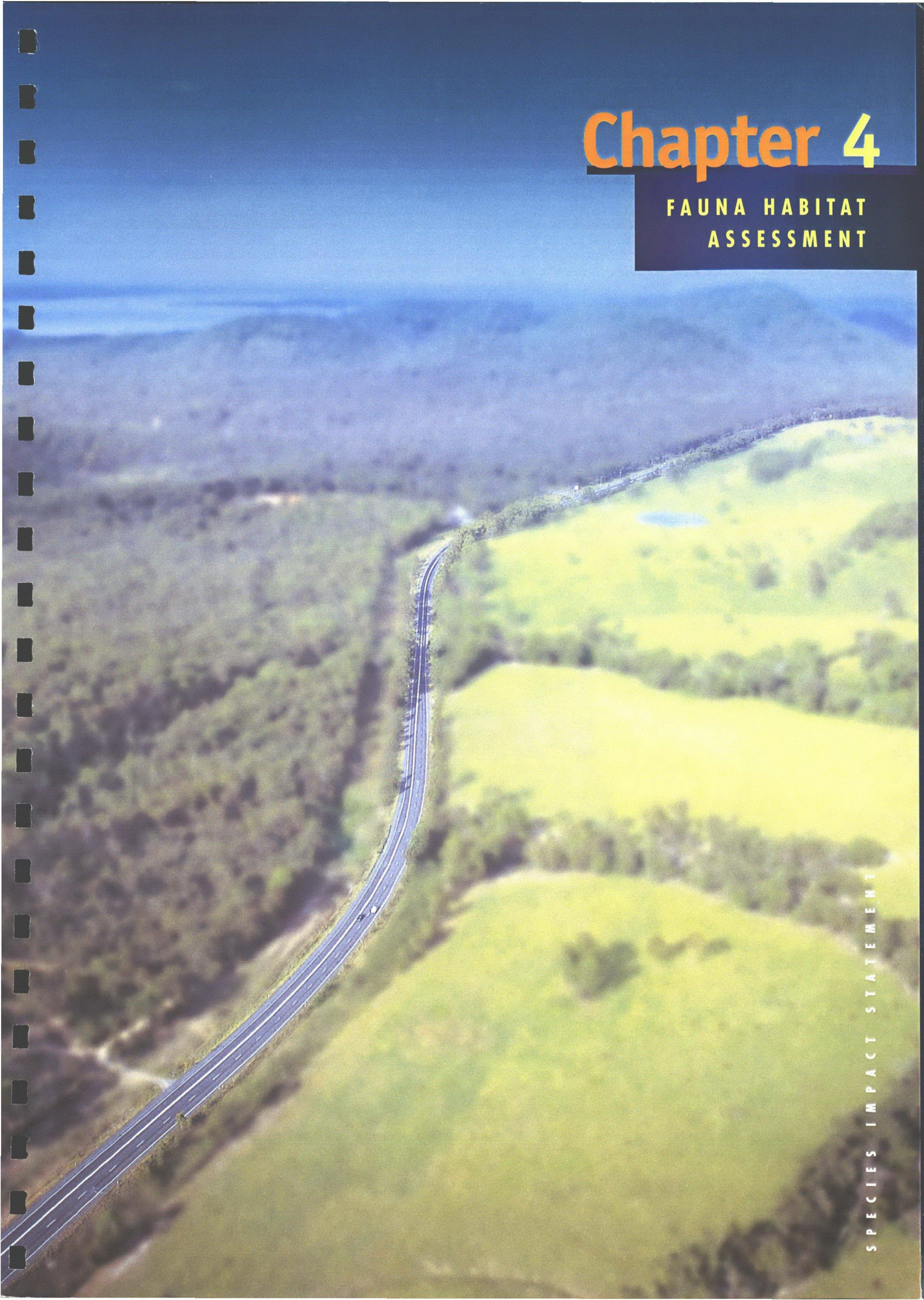
species west of the existing highway between Waterholes Gap and Nerong Waterholes. However, CRA mapped the dominant species in this area as spotted gum (*Corymbia maculata*) and grey gum (*E. propinqua*). CRA mapping identified extensive areas of grey gum (*E. propinqua*) dominant forest along the study corridor, however, ground truthing revealed relatively few areas of forest where grey gum was a dominant canopy species. Furthermore, ground truthing during the current survey revealed that smooth-barked apple (*Angophora costata*) was a commonly occurring species throughout the study area, and a dominant canopy species in the Mount Karuah area. However the CRA mapping failed to indicate the proliferation of this species within the study area, and indicated that spotted gum (*C. maculata*) and grey gum (*E. propinqua*) were the dominant species at Mount Karuah.

It is difficult to accurately determine the conservation (reservation) status of vegetation communities since a large number of nature reserves and National Parks have recently been or are about to be gazetted and unfortunately, no data regarding the type and extent of vegetation communities in these areas are available.

A difficulty in identifying all stringybark species due to morphological similarities and the potential of hybridisation was experienced. Misidentification of these species may have led to the incorrect determination of a community's reservation/conservation status.

Chapter 4

FAUNA HABITAT ASSESSMENT



Chapter 4

FAUNA HABITAT ASSESSMENT

This chapter describes the methodology for fauna habitat assessment of the study area. It details the habitat types and determines the potential habitats for threatened species known or likely to occur in the study area.

4.1 HABITAT ASSESSMENT METHODOLOGY

Vegetation communities reflect differences in community structure and plant species composition. The majority of fauna species select habitat based primarily on structural characteristics of vegetation communities rather than their composition of plant species (ERM Mitchell McCotter 1996). One notable exception is the koala (*Phascolarctos cinereus*), which selects habitat based on the presence of particular plant species. Structural characteristics of vegetation communities include the height of the dominant layer, the number of distinctive layers and the density of vegetation.

Many specialised faunal groups may also rely upon the availability of water or specific micro-climatic characteristics (for example. leaf litter, caves, rocks, logs, tree hollows) in order to survive. Human activities, particularly those that alter the structure or cover of vegetation, have the potential to change faunal habitat characteristics, which, in turn, may result in modifications to the composition of fauna within an area.

Investigations for the SIS sought to identify and assess the type and quality of fauna habitats occurring along the proposed Upgrade. Assessment of fauna habitat types and quality was derived from a qualitative assessment of various habitat characteristics adjacent to the length of the existing alignment. The existing highway was traversed for a maximum distance of 200 m on both the eastern and western sides, and the following characteristics recorded:

- dominant vegetation type;
- structural vegetation characteristics;
- presence of potential threatened flora and/or fauna habitat;
- level and type of disturbance (ie. fire history, rubbish dumping, logging, grazing activity);

- density of ground litter (ie. logs, leaf litter); and
- presence/absence of standing or flowing water (modified from SWC Wetlands and Ecological Management Consultancy 1994).

The results of these investigations are presented in the following sections.

4.2 RESULTS OF HABITAT ASSESSMENT

4.2.1 Habitat Types

Based on the structural characteristics of the vegetation communities identified in *Chapter 3*, a total of six fauna habitats have been identified within the study area. These habitat types are:

- Dry Open Forest;
- Swamp Forest;
- Closed Forest;
- Woodland;
- Shrubland; and
- Grassland.

Each habitat type is discussed below. *Figure 4.1* illustrates the extent and distribution of each habitat type within the study area.

i. Dry Open Forest

This is one of the most common habitat types occurring throughout the study area. Extensive areas of dry open forest occur within Nerong State Forest, Waterholes Gap, west of Nerong Waterholes and both sides of the existing Pacific Highway at Mount Karuah.

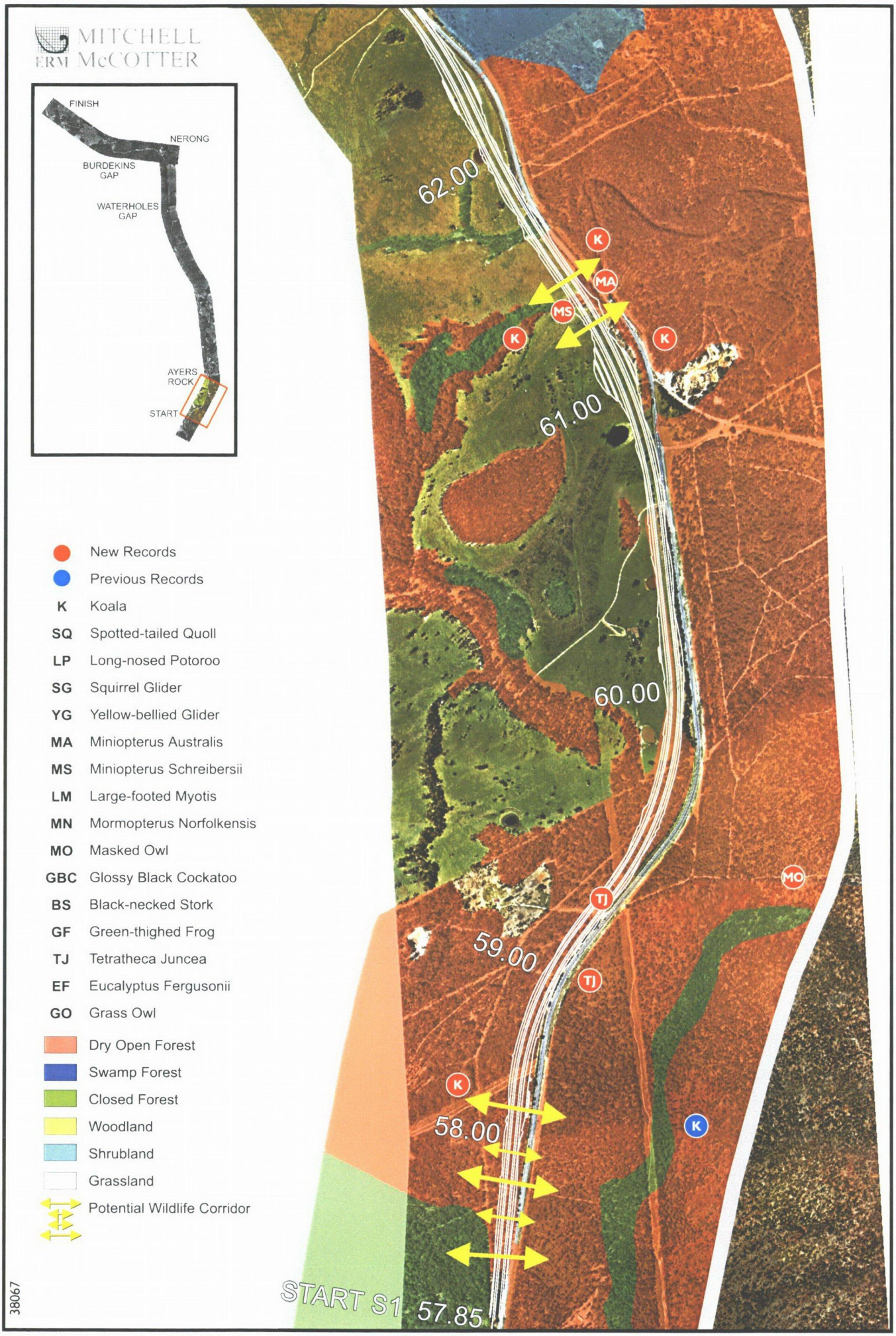


Figure 4.1a DISTRIBUTION AND EXTENT OF HABITAT TYPES, THREATENED SPECIES RECORDS AND POTENTIAL WILDLIFE CORRIDORS IN THE STUDY AREA

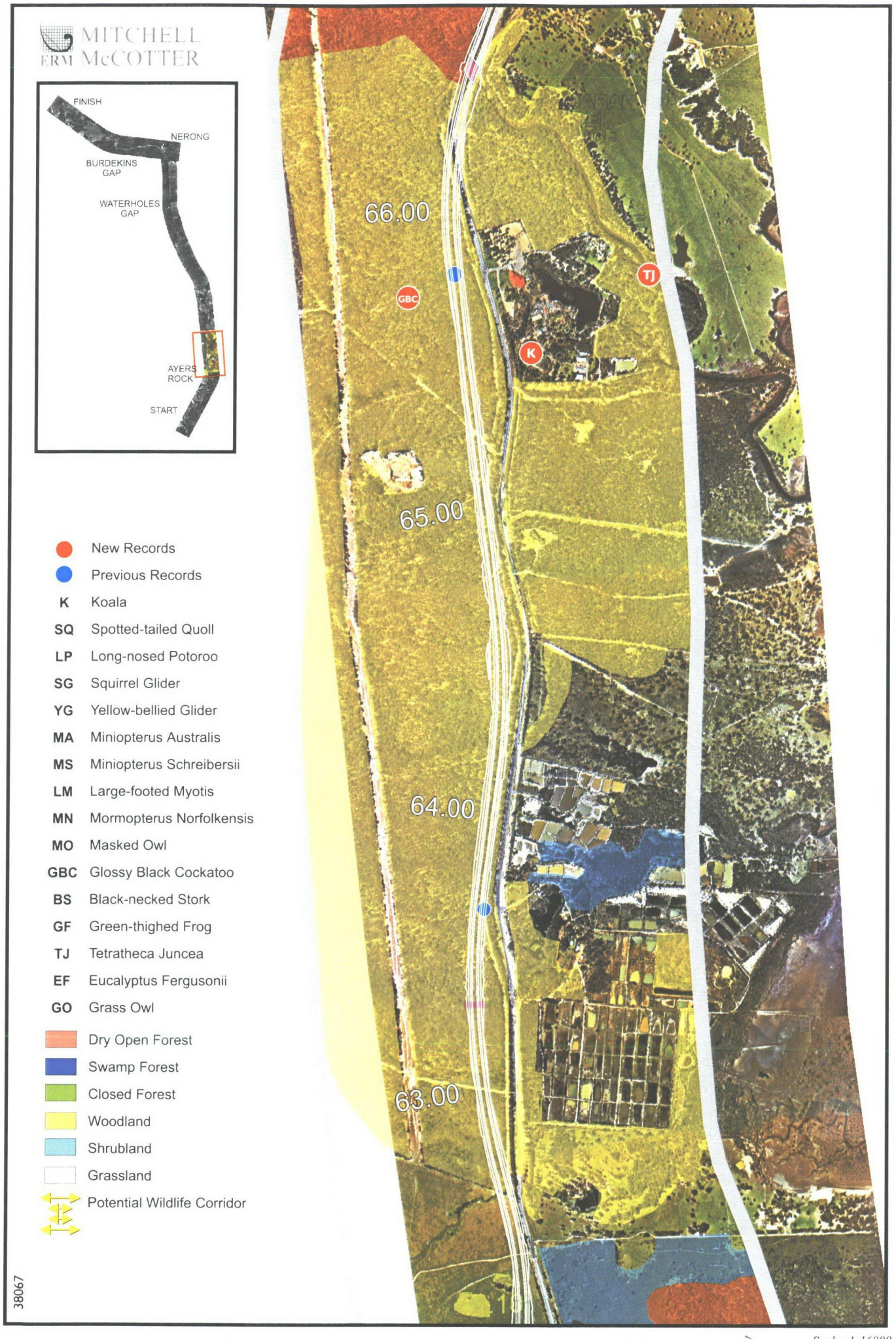


Figure 4.1b DISTRIBUTION AND EXTENT OF HABITAT TYPES, THREATENED SPECIES RECORDS AND POTENTIAL WILDLIFE CORRIDORS IN THE STUDY AREA

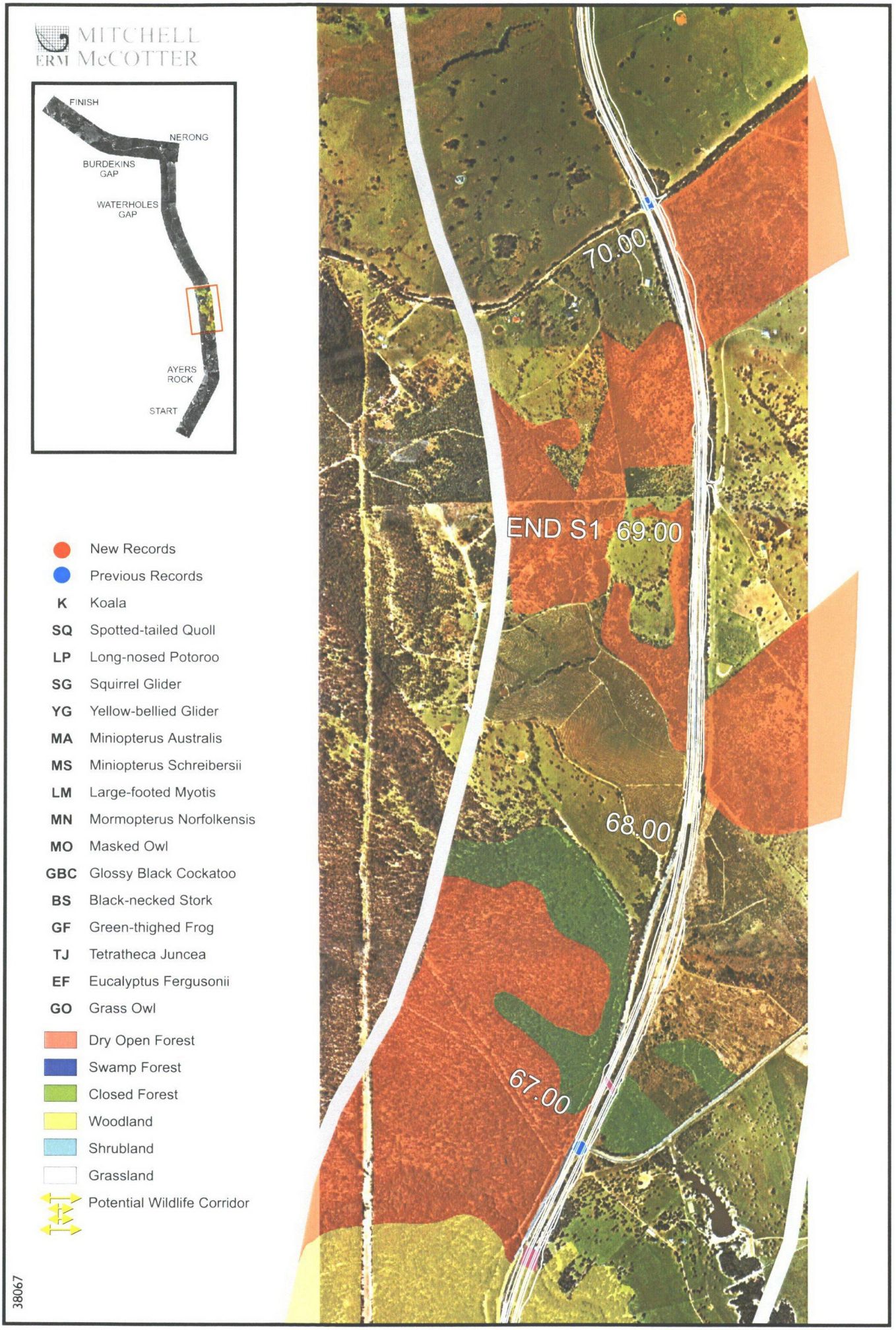


Figure 4.1c DISTRIBUTION AND EXTENT OF HABITAT TYPES, THREATENED SPECIES RECORDS AND POTENTIAL WILDLIFE CORRIDORS IN THE STUDY AREA

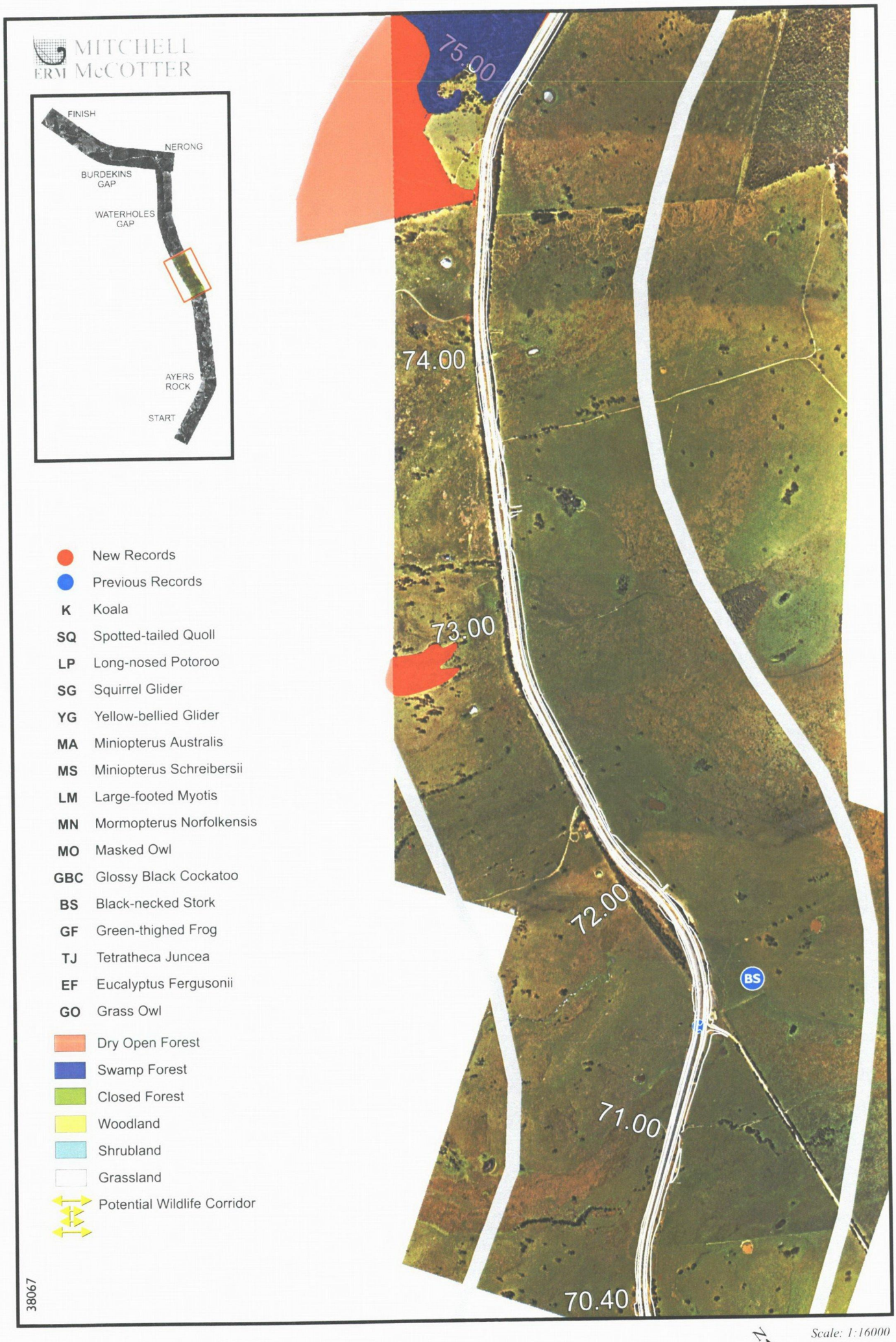


Figure 4.1d DISTRIBUTION AND EXTENT OF HABITAT TYPES, THREATENED SPECIES RECORDS AND POTENTIAL WILDLIFE CORRIDORS IN THE STUDY AREA

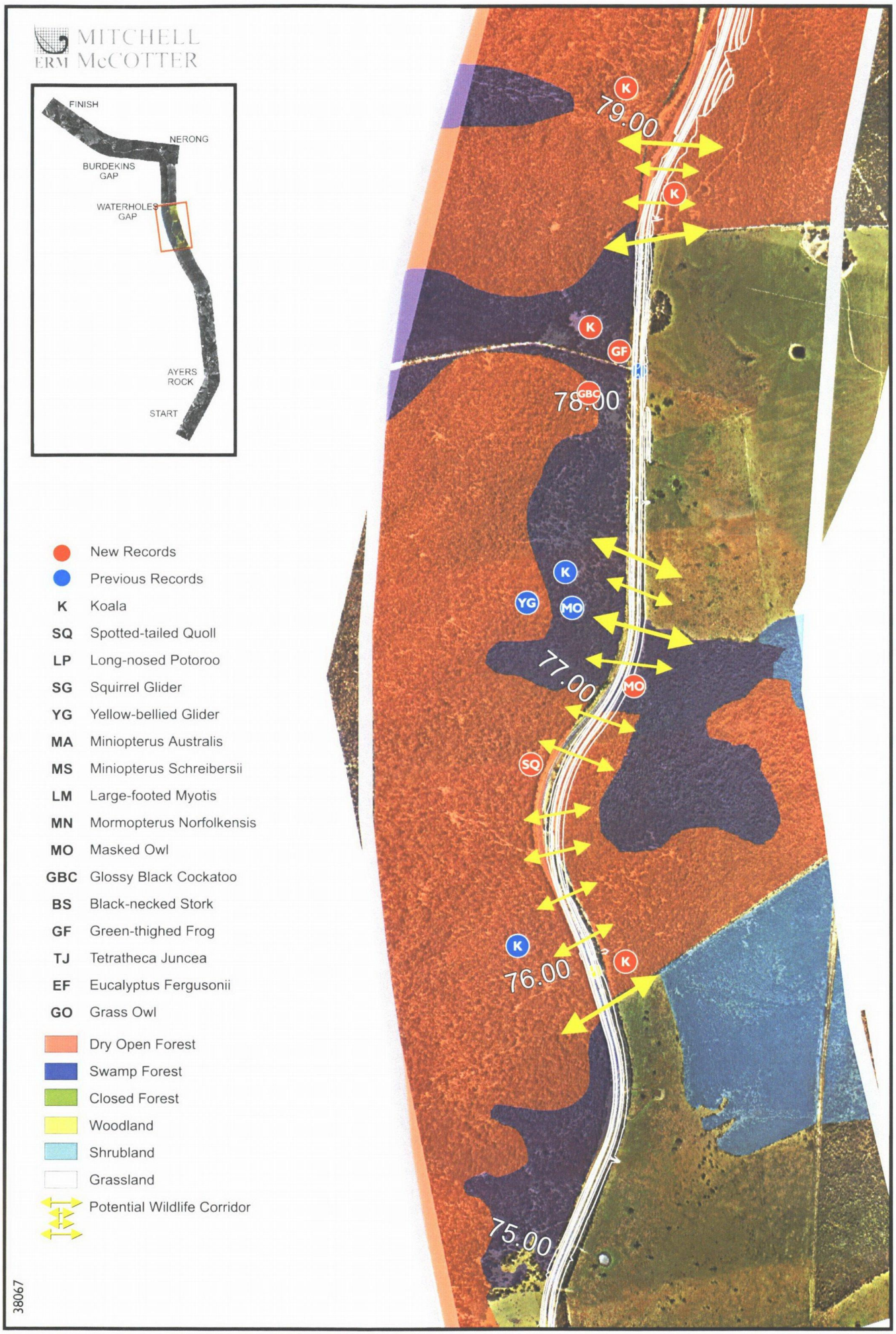


Figure 4.1e DISTRIBUTION AND EXTENT OF HABITAT TYPES, THREATENED SPECIES RECORDS AND POTENTIAL WILDLIFE CORRIDORS IN THE STUDY AREA

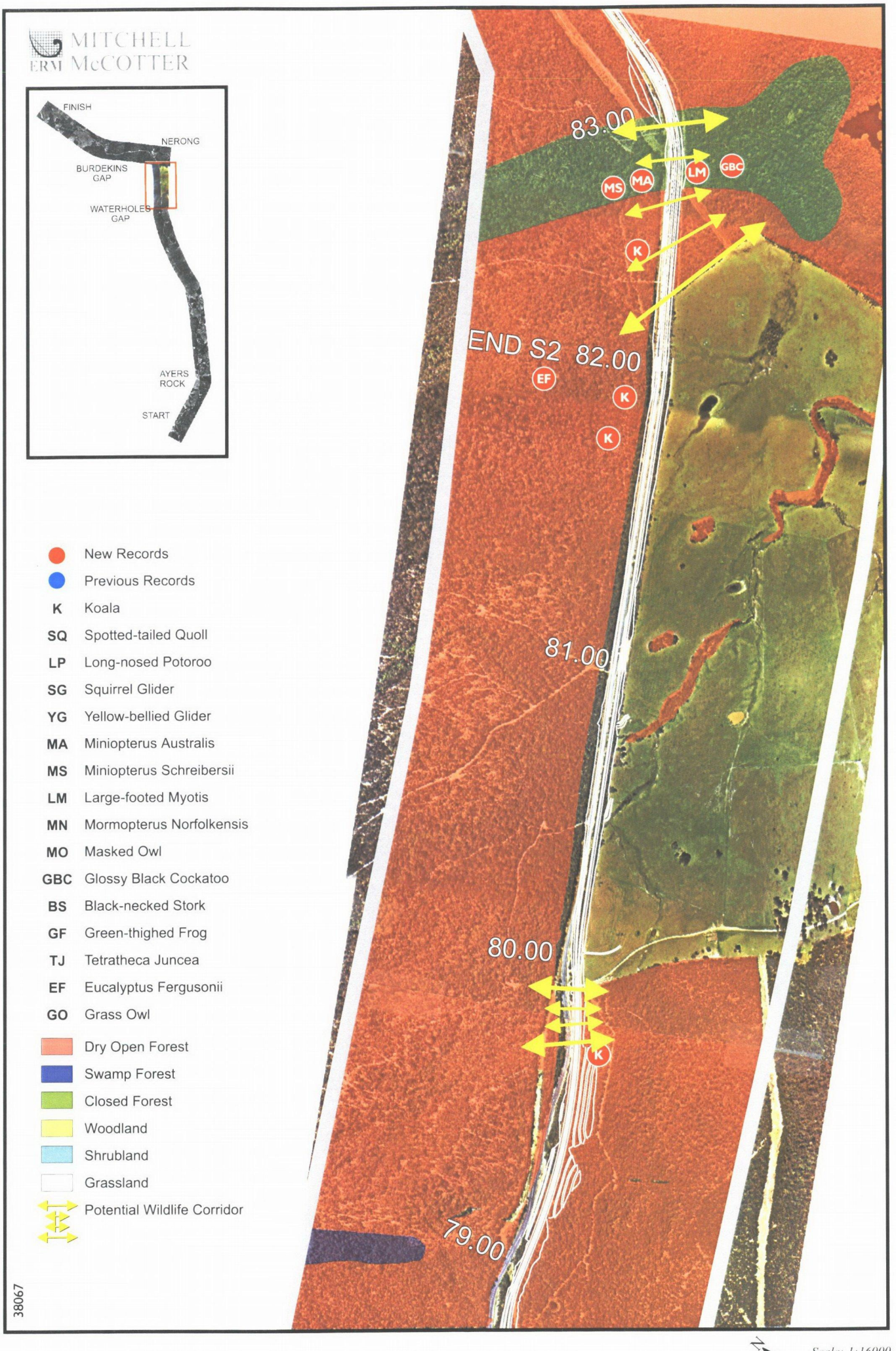


Figure 4.1f DISTRIBUTION AND EXTENT OF HABITAT TYPES, THREATENED SPECIES RECORDS AND POTENTIAL WILDLIFE CORRIDORS IN THE STUDY AREA

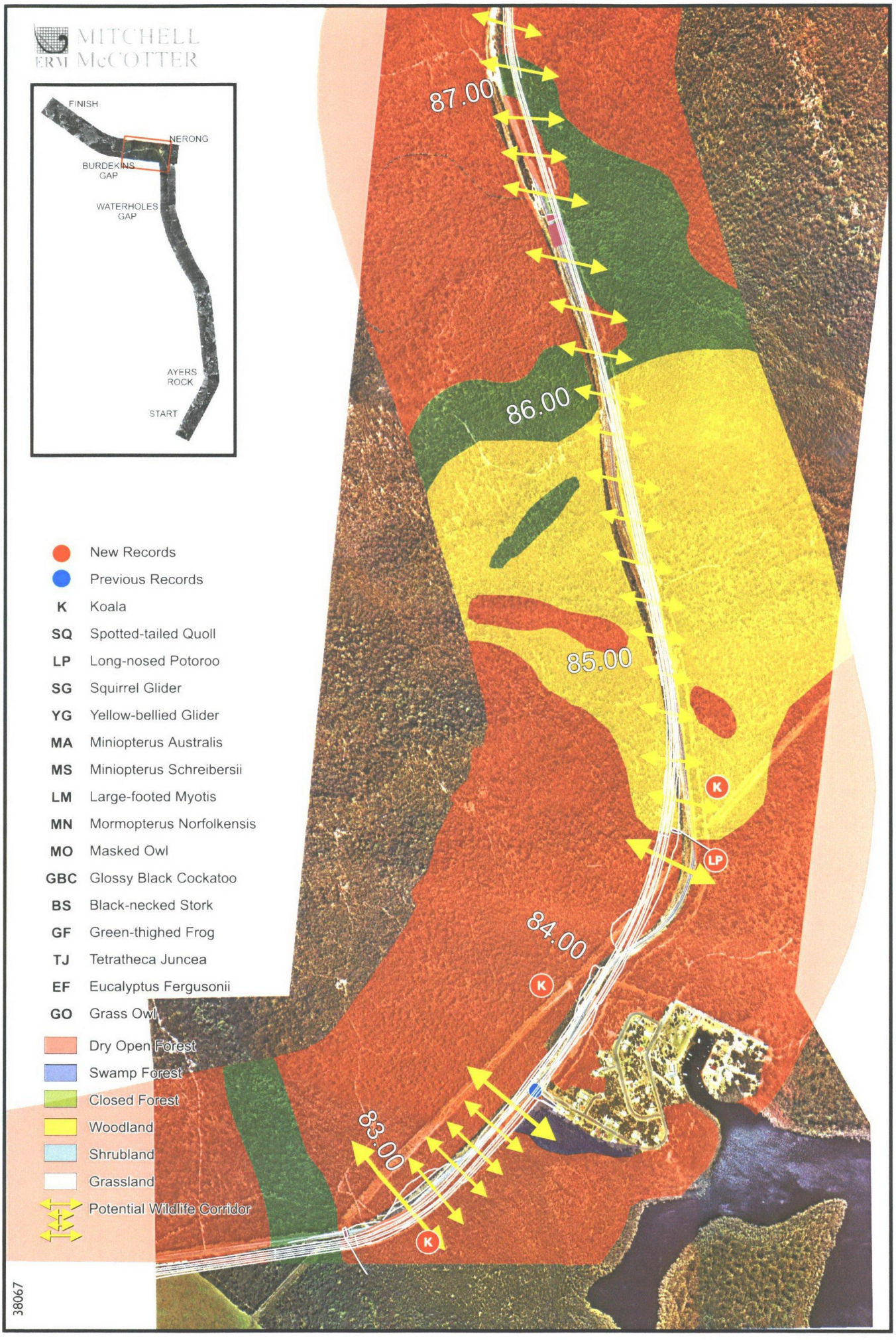


Figure 4.1g DISTRIBUTION AND EXTENT OF HABITAT TYPES, THREATENED SPECIES RECORDS AND POTENTIAL WILDLIFE CORRIDORS IN THE STUDY AREA

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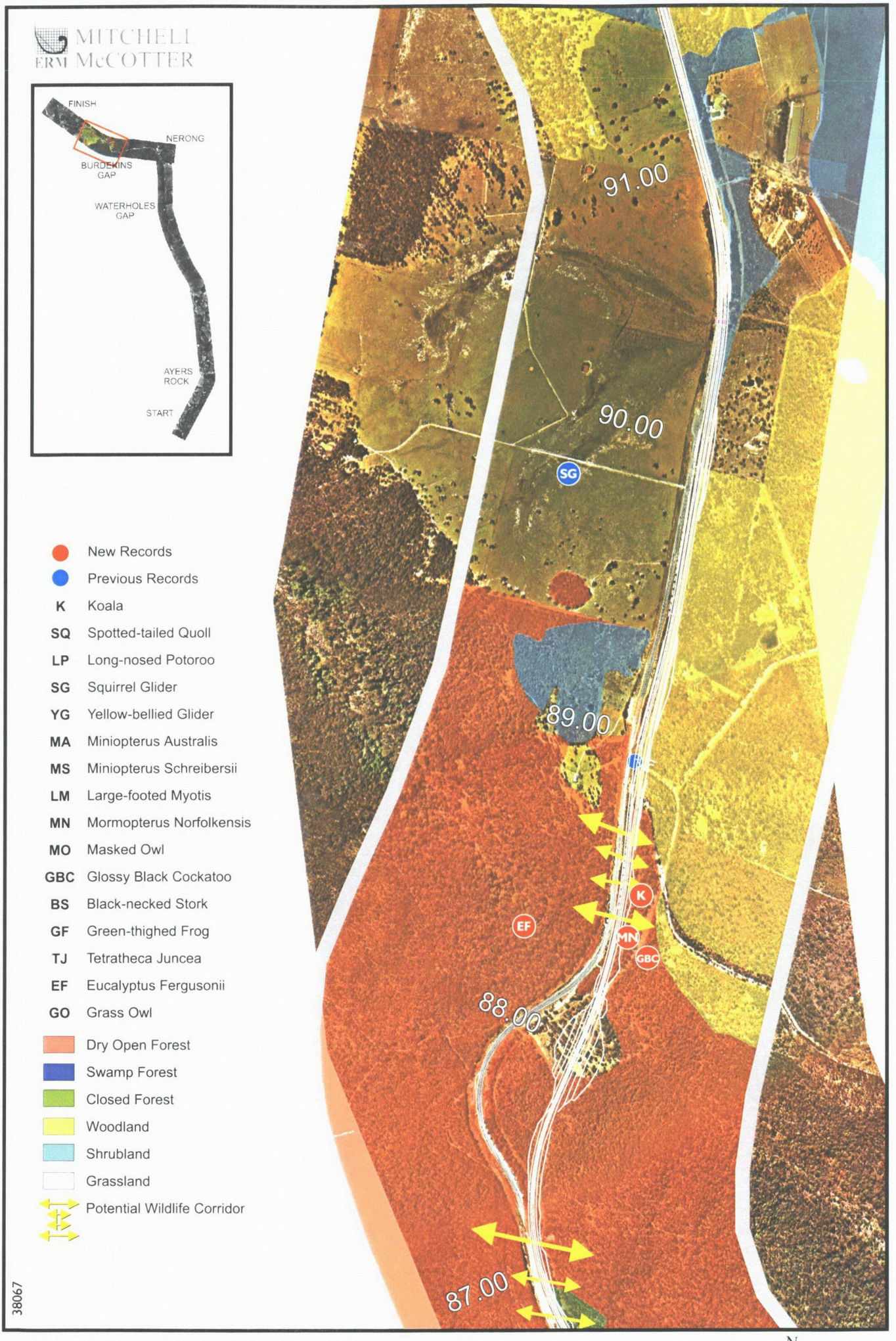

Figure 4.1h DISTRIBUTION AND EXTENT OF HABITAT TYPES, THREATENED SPECIES RECORDS AND POTENTIAL WILDLIFE CORRIDORS IN THE STUDY AREA

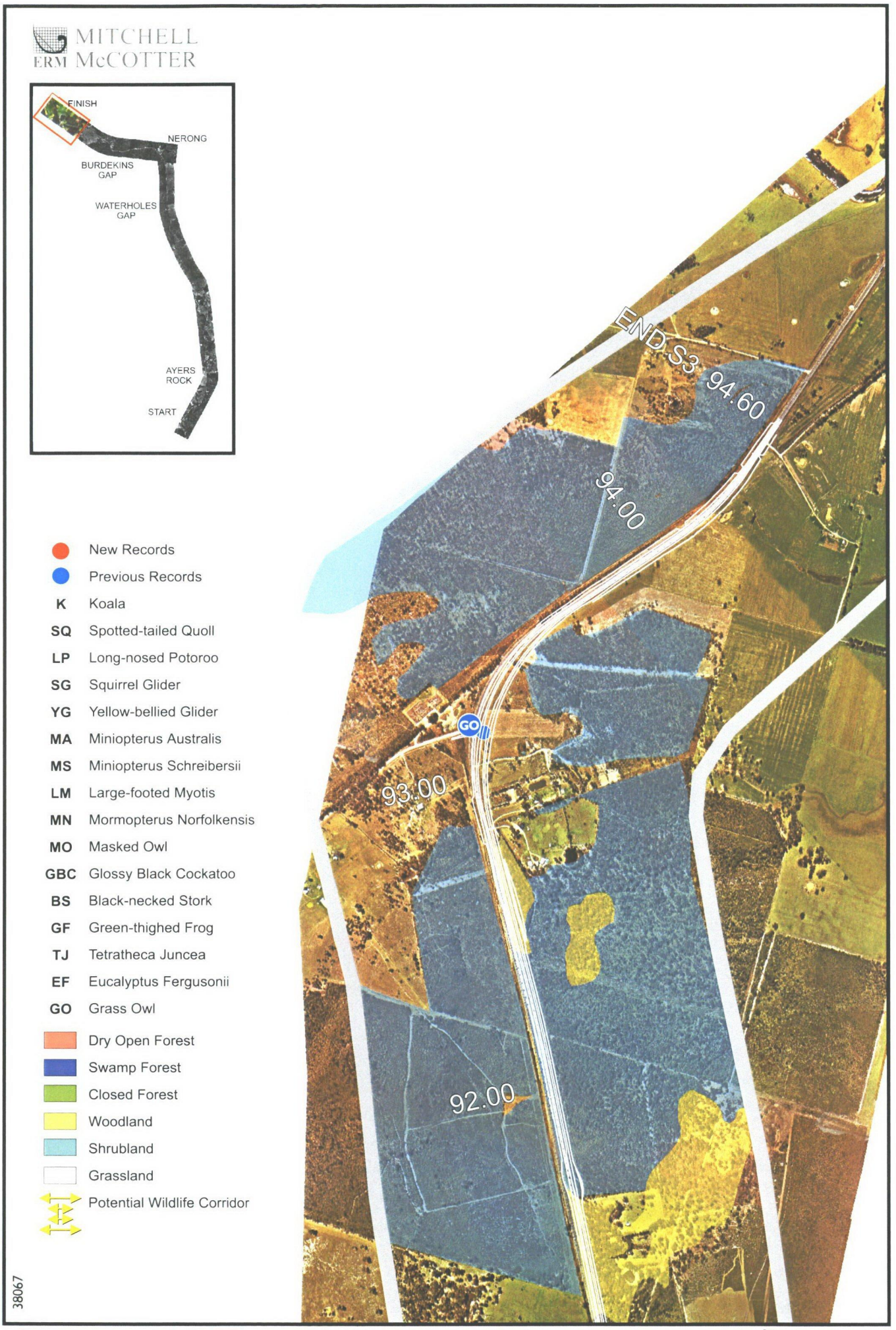

Figure 4.1i DISTRIBUTION AND EXTENT OF HABITAT TYPES, THREATENED SPECIES RECORDS AND POTENTIAL WILDLIFE CORRIDORS IN THE STUDY AREA

a. Dominant vegetation types

- *Eucalyptus globoidea/Angophora costata* very tall open forest;
- *E. microcorys/Corymbia maculata* very tall open forest;
- *C. gummifera/E. capitellata/A. costata* very tall open forest;
- *C. maculata/E. propinqua* very tall open forest;
- *E. pilularis/E. microcorys* very tall open forest;
- *E. microcorys/E. capitellata/A. costata* very tall open forest;
- *C. maculata* very tall open forest;
- *E. pilularis/A. costata/E. globoidea* very tall open forest;
- *E. propinqua/A. costata/E. microcorys* very tall open forest;
- *A. costata/Eucalypt* spp very tall open forest;
- *A. costata/M. quinquenervia/E. resinifera* very tall open forest;
- *E. umbra/C. gummifera/A. costata* very tall open forest;
- *E. microcorys/E. propinqua/M. quinquenervia* very tall open forest;
- *C. gummifera/C. maculata/E. capitellata* very tall open forest;
- *A. costata/E. microcorys/E. globoidea* very tall open forest;
- *A. costata/E. microcorys* very tall open forest;
- *C. maculata/E. fibrosa* very tall open forest;
- *A. costata/E. fibrosa/E. capitellata/C. gummifera* very tall open forest;
- *E. globoidea* very tall open forest; and
- *Pinus radiata/E. microcorys/C. maculata* mid-high open forest

b. Structural vegetation characteristics

The overstorey vegetation is generally between 25 to 30 m high with a foliage cover of between 40 and 50%. The midstorey vegetation is usually between five and 15 m high with a foliage cover of between 10 and 30%. The understorey vegetation is usually between 1.5 and 2.5 metres high. The foliage cover of the understorey is generally sparse to moderate in density. However, the density of the understorey vegetation in this habitat type often increases substantially in the vicinity of ephemeral drainage channels. The groundcover vegetation is generally less than one metre high with a moderate density of between 30 and 80% foliage cover.

c. Level and type of disturbance

Dry open forest communities are in a relatively natural state in that they are dominated by native plants and have very few weeds. However, they have been disturbed by forestry activities and low to moderate intensity fires. Consequently, the trees are relatively small and lack large tree hollows required by larger arboreal fauna. Previous clearing for agricultural activities is the major cause of habitat fragmentation in the study area. The existing Pacific Highway represents another major form of fragmentation of this habitat type in the study area. The powerline easement has also caused significant fragmentation of this habitat type near the Nerong township, through Waterholes Gap and Nerong Waterholes and in the southern portion of the study area from Viney Creek Road to Mount Karuah.

d. Density of ground litter

This habitat type generally has a moderate cover of ground litter. There are relatively few areas within this habitat type that have either sparse or dense groundcover of litter.

e. Presence/absence of water

There are only two permanently flowing watercourses within the study area (Bundabah and Bulga Creeks), both of these occur within this habitat type. All other watercourses in this habitat type have intermittent flow. However, most of the named watercourses contain semi-permanent ponds. Furthermore, this habitat type contains large areas of poorly drained soils that enable small pools to remain on the surface for up to several weeks depending on prevailing weather conditions.

ii. Closed Forest

This habitat type is restricted to moist sheltered areas in protected gullies and riparian zones of the ephemeral watercourses throughout the study area.

a. Dominant vegetation types

- *Eucalyptus* spp. very tall closed forest;
- *E. microcorys/E. propinqua* very tall closed forest;
- *E. microcorys/E. propinqua/Corymbia. maculata* very tall closed forest;
- *E. microcorys* very tall closed forest;

- *E. pilularis/E. robusta* extremely tall closed forest; and
- *E. propinqua/A. costata/E. resinifera/C. maculata* extremely tall closed forest.

b. Structural vegetation characteristics

The overstorey vegetation varies in height between 25 and 40 m with a foliage cover of between 65 and 75%. The midstorey vegetation is usually between 10 and 20 m high with a foliage cover of 30 to 35%. The understorey vegetation is approximately five metres high with a sparse to moderate foliage cover. The groundcover vegetation is generally 40 to 50 cm high with a moderate density of between 30 and 80% foliage cover.

c. Level and type of disturbance

Closed forest communities are in a relatively natural state in that they are dominated by native plants and have very few weeds. However, they have been disturbed by forestry activities and infrequent low to moderate intensity fires. Consequently, the trees are relatively small and lack large tree hollows required by larger arboreal fauna. Previous land clearing for agricultural activities represents the major cause of fragmentation in this habitat type. The existing Pacific Highway also represents one of the major forms of fragmentation of this habitat type in the study area. Other causes of fragmentation include the formation of cattle tracks by grazing activity and the formation of fire trails within State Forest areas. The powerline easement has also caused fragmentation of this habitat type along several of the watercourses including Grey Gum Creek, Jacks Creek, Bundabah Creek and Bulga Creek.

d. Density of ground litter

This habitat type generally has a moderate to dense cover of ground litter. There are relatively few areas within this habitat type that have a sparse cover of ground litter.

e. Presence/absence of water

This habitat type is generally associated with riparian vegetation communities within the study area. However, only ephemeral watercourses occur within this habitat type, although many of these contain semi-permanent ponds. Furthermore, this habitat type contains large areas of poorly drained soils that enable small pools to remain on the surface for up to several weeks depending on prevailing weather conditions.

iii. Swamp Forest

This habitat type is restricted to low lying areas with poorly drained soils within the study area. An extensive area of swamp forest occurs west of the existing highway between Waterholes Gap and Nerong Waterholes, and extends east along the northern fringe of Nerong Waterholes. A small area also occurs immediately south of the Nerong township.

a. Dominant vegetation types

- *Casuarina glauca* tall open forest;
- *E. tereticornis* very tall open forest; and
- *E. tereticornis / E. propinqua* very tall open forest.

b. Structural vegetation characteristics

The overstorey vegetation is generally between 20 and 30 m high with a foliage cover of between 40 and 50 %. The midstorey vegetation is usually absent or sparse with a height of eight to ten metres. The sparse understorey vegetation is usually between 1.5 and 2.5 cm high. The groundcover vegetation is generally less than one metre high with a moderate density of between 30 and 60 % foliage cover.

c. Level and type of disturbance

With the exception of the *E. tereticornis* very tall open forest, swamp forest communities are in a relatively natural state in that they are dominated by native plants and have very few weeds. However, the Eucalypt dominated communities have been disturbed by forestry activities and occasional low intensity fires. Consequently, the trees are relatively small and lack large tree hollows required by larger arboreal fauna. Previous land clearing for agricultural activities represents the major cause of fragmentation in this habitat type. Other major causes of habitat fragmentation appear to be the construction of the Pacific Highway and powerline easement. The remaining areas of this habitat type occur immediately south of the Nerong township and west of the highway between Waterholes Gap and Nerong Waterholes. The latter area has been further fragmented by the formation of forestry trails.

The grazing of livestock still takes place on the heavy moist soils of this habitat type in the vicinity of Nerong Road. This appears to have caused noticeable disturbance to the soil surface and litter layer.

d. Density of ground litter

This habitat type generally has a sparse cover of ground litter. There are relatively few areas within this habitat type with a moderate or dense cover of ground litter.

e. Presence/absence of water

Several small ephemeral drainage lines occur within this habitat type. These watercourses appear to contain semi-permanent ponds that dry up only during extended dry periods. This habitat type occurs on flat poorly drained soils within the study area. During periods of high rainfall large expanses of this habitat type become inundated. Pools of water may be retained in soil depressions for up to several weeks depending on prevailing weather conditions.

iv. Woodland

An extensive area of this habitat type occurs west of the existing highway between Bundabah Creek and the Crayhaven aquaculture farm.

a. Dominant vegetation types

- *Eucalyptus globoidea/Angophora costata/Corymbia gummifera* very tall open woodland;
- *E. globoidea* very tall open woodland;
- *E. globoidea/A. costata* very tall open woodland; and
- *E. globoidea/A. costata* very tall woodland.

b. Structural vegetation characteristics

The overstorey vegetation varies between 25 and 35 m high with a sparse foliage cover. The midstorey vegetation is usually between 15 and 20 m high with a sparse foliage cover. The understorey vegetation is approximately three to five metres high with a sparse to moderate foliage cover. The groundcover vegetation is generally 50 to 70 cm high with a moderate density of between 30 and 80% foliage cover.

c. Level and type of disturbance

Woodland communities are in a relatively unnatural state due to extensive thinning of canopy vegetation and the abundance of weed species. They have been disturbed by forestry activities and occasional moderate intensity fires. Consequently, the trees are relatively small and lack large tree hollows required by larger arboreal fauna. Previous land clearing for agricultural activities represents the major cause of fragmentation in this habitat type. The existing Pacific Highway also represents one of the major forms of fragmentation of this habitat type in the study area. Other causes of fragmentation include the formation of vehicle access tracks along property boundaries, the rock quarry, powerline easement and clearing for commercial activities such as the Crayhaven Aquaculture Farm and Ayers Rock roadhouse.

d. Density of ground litter

This habitat type generally has a sparse cover of ground litter. There are relatively few areas within this habitat type with a moderate or dense cover of ground litter.

e. Presence/absence of water

Permanent waterbodies within this habitat type are mainly restricted to occasional artificial dams. Small ephemeral drainage lines within this habitat type contain small ephemeral or semi-permanent pools. The poorly drained soils that underlie the study area may also enable small pools to remain on the surface for up to several weeks depending on prevailing weather conditions.

v. Shrubland

This habitat type is primarily restricted to flat poorly drained land north of Burdekin's Gap. A smaller area also occurs south of Nerong Waterholes approximately 500 m from the existing highway.

a. Dominant vegetation types

- *Melaleuca nodosa* tall shrubland;
- *M. linariifolia/M. quinquenervia/M. styphelioides/Casuarina glauca* very tall shrubland; and
- *M. nodosa* very tall shrubland.

b. Structural vegetation characteristics

The overstorey vegetation varies from three to six metres high with a foliage cover of between 60 and 80%. The midstorey and understorey strata are usually absent. The groundcover vegetation is generally 50 to 70 cm high with a moderate to dense foliage cover of between 30 and 80%.

c. Level and type of disturbance

The shrubland communities are in a relatively unnatural state. They are predominantly regrowth vegetation with an abundance of weed species present. Occasional moderate-intensity fires occur in most parts of this habitat type. Previous land clearing for agricultural activities represents the major cause of fragmentation in this habitat type. The existing Pacific Highway also represents one of the major forms of fragmentation of this habitat type in the north of the study area. Other major causes of fragmentation include the formation of vehicle access tracks along property boundaries and clearing of vegetation for grazing and rural activities. The powerline easement represents a major cause of fragmentation in this habitat type near Nerong Waterholes.

d. Density of ground litter

This habitat type generally has a sparse cover of ground litter. There are relatively few areas within this habitat type with a moderate or dense cover of ground litter.

e. Presence/absence of water

This habitat type occurs on flat poorly drained soils within the study area. During periods of high rainfall large expanses of this habitat type become inundated and may remain in a waterlogged state for up to several weeks depending on prevailing weather conditions.

vi. Grassland

Grassland is the most common habitat type in the study area. Extensive areas of grassland occur east of the existing highway between Jack's Creek, Waterholes Gap, Nerong Waterholes south to Viney Creek Road. Further large areas occur on the western side of the existing highway south of Nerong Waterholes to Viney Creek Road and in the vicinity of Bulga Creek.

a. Dominant vegetation types

Predominantly introduced pasture grass species and native grass species.

b. Structural vegetation characteristics

Overstorey, midstorey and understorey stratas are usually absent. Occasional individual trees and small wood lots have been retained presumably to provide shade for livestock. The groundcover vegetation is generally 20 to 100 cm high with a moderate to dense foliage cover of between 50 and 100%.

c. Level and type of disturbance

This is a highly disturbed habitat type that has been predominantly cleared of native vegetation for rural activities.

d. Density of ground litter

This habitat type generally has a sparse cover of ground litter. There are relatively few areas within this habitat type with a moderate cover of ground litter.

e. Presence/absence of water

Artificial dams are common within this habitat type. Some dams contain dense stands of aquatic emergent vegetation such as typha that provide good potential habitat for amphibians and waterbirds. Small ephemeral drainage lines contain small temporary pools. Surface water from rainfall events would either drain into dams or evaporate within a few days due to the lack of substantial shading vegetation.

4.3 HABITAT OF THREATENED FAUNA SPECIES KNOWN OR LIKELY TO OCCUR

In order to determine the relationships between habitats and the occurrence of threatened species it is necessary to identify the habitat requirements for each threatened species to enable a comparison with known habitat characteristics. The following discussion identifies the habitat requirements for each threatened species known or likely to occur within the study area and relates these requirements to the habitat components of each main habitat type within the study area.

For the purposes of this SIS, each habitat type within the study area that represents potential habitat for a threatened species is classified as either "primary habitat" or "secondary habitat". The term "primary habitat" indicates that a particular habitat type contains the essential habitat components to satisfy the needs of a threatened species. The term "secondary habitat" indicates that a particular habitat type contains some resources that may be utilised by a threatened species but are not

recognised as essential habitat components. *Table 4.1* summarises the potential habitats within the study area for each threatened species known or likely to occur.

Table 4.1 POTENTIAL HABITATS FOR THREATENED FAUNA SPECIES KNOWN OR LIKELY TO OCCUR WITHIN THE STUDY AREA.

Class	Scientific Name	Common Name	Primary Habitat	Secondary Habitat	Likelihood of Occurrence
Amphibians	*Litoria brevipalmata*	Green-thighed frog	3	1; 2	known to occur
	Litoria aurea	Green and golden bell frog	nil	6	low
	Mixophyes balbus	Stuttering frog	nil	nil	low
	Mixophyes iteratus	Giant barred frog	nil	nil	low
	Crinia tinnula	Wallum froglet	nil	5	low
Reptiles	*Hoplocephalus stephensii*	Stephen's banded snake	1; 2; 3	4	high
	Hoplocephalus bitorquatus	Pale-headed snake	1; 2; 3	4	high
Mammals	*Phascogale tapoatafa*	Brush-tailed phascogale	2	1; 3; 4	moderate
	Phascolarctos cinereus	Koala	1; 2; 3	4	known to occur
	Dasyurus maculatus	Spotted-tailed quoll	1; 2; 3	4; 5	known to occur
	Petaurus norfolcensis	Squirrel glider	1; 2	3; 4	known to occur
	Petaurus australis	Yellow-bellied glider	nil	1, 2, 3; 4	known to occur
	Pseudomys gracilicaudatus	Eastern chestnut mouse	nil	2; 3; 5	low
	Potorous tridactylus	Long-nosed potoroo	1; 2	3; 4; 5	known to occur
	Aepyprymnus rufescens	Rufous bettong	2	3; 4	moderate
	Thylogale stigmatica	Red-legged pademelon	nil	1	low
	Planigale maculata	Common planigale	1; 2; 5	3; 4	high
	Kerivoula papuensis	Golden tipped bat	nil	1; 2	low

Table 4.1 POTENTIAL HABITATS FOR THREATENED FAUNA SPECIES KNOWN OR LIKELY TO OCCUR WITHIN THE STUDY AREA.

Class	Scientific Name	Common Name	Primary Habitat	Secondary Habitat	Likelihood of Occurrence
	Mormopterus norfolkensis	Eastern freetail bat	1; 2; 3; 4	5; 6	known to occur
	Miniopterus australis	Little bent-wing bat	nil	1; 2; 3; 4; 5; 6	known to occur
	Miniopterus schreibersii	Large bent-wing bat	nil	1; 2; 3; 4; 5; 6	known to occur
	Myotis adversus	Large-footed myotis	1; 2; 3; 4	6	known to occur
	Vombatus ursinus **	Common wombat **	nil	2; 4	low
Aves	*Burhinus grallarius*	Bush stone-curlew	nil	2; 4; 6	low - moderate
	Calyptorhynchus lathami	Glossy black-cockatoo	nil	1, 2; 3	known to occur
	Pandion haliaetus	Osprey	nil	2	low
	Lophoictinia isura	Square-tailed kite	1; 2; 4	3; 5; 6	high
	Tyto novaehollandiae	Masked owl	nil	2; 3; 4	known to occur
	Tyto tenebricosa	Sooty owl	nil	1; 2; 3	low
	Ninox strenua	Powerful owl	nil	1; 2; 3; 4	high
	Ninox connivens	Barking owl	nil	1; 2; 3; 4	high
	Tyto capensis	Eastern grass owl	nil	5; 6	known to occur
	Neophema pulchella	Turquoise parrot	nil	2; 4; 6	moderate - high
	Lathamus discolor	Swift parrot	nil	2; 3	moderate - high
	Xanthomyza phrygia	Regent honeyeater	2; 3	1; 4	moderate
	Ixobrychus flavicollis	Black bittern	2	1	high
	Epippiorhynchus asiaticus	Black-necked stork	nil	1; 6	known

Table 4.1 POTENTIAL HABITATS FOR THREATENED FAUNA SPECIES KNOWN OR LIKELY TO OCCUR WITHIN THE STUDY AREA.

Class	Scientific Name	Common Name	Primary Habitat	Secondary Habitat	Likelihood of Occurrence
	Irediparra gallinacea	Comb-crested jacana	nil	1; 2; 6	low
	Ptilinopus superbus	Superb fruit-dove	nil	1	low - moderate
	Ptilinopus regina	Rose-crowned fruit-dove	nil	1	low - moderate
	Ptilinopus magnificus	Wompoo fruit-dove	nil	1	low - moderate

Key: ** Not listed on NSW TSC Act, however is a species of conservation concern.

Habitat Type:

1 Closed Forest
2 Dry Open Forest
3 Swamp Forest
4 Woodland
5 Shrubland
6 Grassland

4.3.1 *Green-thighed Frog*

Litoria brevipalmata is known to inhabit primarily rainforest and wet sclerophyll forest. However, it has also been recorded in dry open forest and coastal swamp forest. Breeding aggregations of this species utilise grassy margined, semi-permanent and permanent ponds in late spring and summer usually after heavy rainfall.

The primary habitat components for this species are:

- stands of lowland temperate forest;
- small permanent streams with well established fringing vegetation that are subject to periodic flooding; and
- ephemeral overflow or ponding areas beside these creeks.

This species has been recorded within the swamp forest habitat despite there being no permanently flowing watercourse present. All other primary habitat components are contained within this habitat type. Sheltering habitat is likely to exist within the dry open forest and closed forest habitats. However, suitable breeding habitat, in the form of large flooded grassy areas is unlikely to exist.

4.3.2 *Green and Golden Bell Frog*

The preferred habitat of *Litoria aurea* has been described as vegetation beside permanent water such as streams, swamps, lagoons, farm dams and ornamental ponds (Goldingay 1996). In NSW the species tends to use disturbed sites and breeds mostly in ephemeral ponds (Pyke and White 1996). The species is rarely found within forested lands (Lemckert 1996). Ephemeral ponds free of predatory fish appear essential for successful breeding because fish are significant predators on the eggs and tadpoles of *L. aurea* (Pyke and White 1996). Conversely recent studies suggest that bell frogs can breed in water that contains high densities of predatory fish if the waterbodies have adequate submergent vegetation and benthic detritus to provide protection (Goldingay 1996; van de Mortel and Goldingay 1998).

The primary habitat components for this species are:

- large unshaded permanent or ephemeral swamps and ponds with emergent vegetation;
- sandy or rocky substrates;

- absence of predatory fish species such as *Gambusia holbrooki*, or the presence of adequate submergent vegetation and benthic detritus to provide cover for eggs and tadpoles.

Some unshaded waterbodies with emergent vegetation exist within the cleared areas of the study area. Although relatively small, these ponds could provide potential foraging and sheltering habitat for adult bell frogs. However, mosquito fish (*Gambusia holbrooki*) occur in the majority of waterbodies, and there does not appear to be suitable substrate or adequate submergent vegetation to provide protection for tadpoles or morphlings. Therefore, suitable breeding habitat for this species is unlikely to occur in the study area.

4.3.3 Stuttering Frog and Giant Barred Frog

Mixophyes balbus and *M. iteratus* have similar habitat requirements. They both occur near flowing streams in rainforest, wet sclerophyll forest and Antarctic Beech forest throughout their ranges (Cogger 1996). Both species are almost always found in association with permanent watercourses in riverine rainforest habitat (Cogger 1996). However, these species may forage in areas well away from the stream breeding sites (State Forests of NSW 1995).

The primary habitat components for these *Mixophyes* species are:

- clean flowing streams;
- densely vegetated riparian zones
- tree overstorey and shrub understorey layers;
- undisturbed leaf litter; and
- insects and smaller frog prey base.

There is unlikely to be any suitable habitat for these *Mixophyes* species in the study area due to a lack of permanently flowing freshwater streams or riverine rainforest vegetation.

4.3.4 Wallum Froglet

Cogger (1996) states that *Crinia tinnula* is confined to acid, paperbark swamps of the 'wallum' country. However, studies by White (1995) recorded the species predominantly in heath/sedge sites with no paperbark swamps in the local area.

The species utilises the vegetated muddy edges of pools in preference to open bodies of water (State Forests of NSW 1995).

The primary habitat components for this species are:

- a dense cover of ground vegetation, with interspersed canopy cover for refuge;
- ephemeral sites such as larger puddles in heath or puddles in watercourses and creeklines for breeding purposes.

There is unlikely to be any suitable habitat for *Crinia tinnula* in the study area due to a lack of "wallum" or heath/sedge vegetation. Secondary habitat for the species could potentially occur along watercourses extending from the existing road to SEPP 14 Wetland No. 698 on the Bulahdelah Plain.

4.3.5 Stephen's Banded Snake

H. stephensii inhabits dry rainforest, sub-tropical rainforest, wet sclerophyll forest, dry sclerophyll forest and rock outcrops, from near sea level up to 950 m (Gilmore and Parnaby 1994). The species utilises gaps underneath decorticating bark on trees, or in hollow trunks and limbs of dead trees (Gilmore and Parnaby 1994).

The primary habitat components of the species are:

- abundance of large trees with decorticating bark and hollows, or exfoliating rock outcrops which provide shelter; and
- abundance of tree frogs, lizards, birds and small mammals to provide a prey base.

The closed forest, dry open forest and swamp forest habitats are likely to provide primary habitat for this species. All of these habitat types have an abundance of prey species, and although these habitats lack large trees with large hollows, there is an abundance of small to medium sized trees with small hollows and decorticating bark to provide shelter. Suitable shelter also exists in the form of rocky scree slopes at Burdekin's Gap and west of Jack's Creek.

4.3.6 Pale-headed Snake

This species has been recorded from dry open forest and woodland to wet sclerophyll forest and rainforest within NSW (Cogger 1996). This nocturnal species is frequently found beneath decorticating bark on trees, or in hollow trunks and

limbs of dead trees, especially in the vicinity of watercourses (Gilmore and Parnaby 1994).

The primary habitat components of the species are:

- abundance of large trees with decorticating bark and hollows which provide shelter; and
- abundance of tree frogs, lizards and small mammals to provide a prey base.

The habitat requirements of this species are similar to those of the stephen's banded snake, hence closed forest, dry open forest and swamp forest habitats are likely to provide primary habitat for this species. All of these habitat types have an abundance of prey species, and although these habitats lack large trees with large hollows, there is an abundance of small to medium-sized trees with small hollows and decorticating bark to provide shelter. Suitable shelter also exists in the form of rocky scree slopes at Burdekin's Gap and west of Jack's Creek.

4.3.7 Brush-tailed Phascogale

The species occurs in dry sclerophyll forest types, with a sparse groundcover of herbaceous plants, grass, scleromorphic shrubs or leaf litter (Soderquist 1995). This species has also been recorded in cool temperate rainforest and wet sclerophyll forest (Gilmore and Parnaby 1994). *P. tapoatafa* is mainly nocturnal, sheltering in nests in tree hollows lined with leaves or shredded bark during the day, sometimes shared with others (Gilmore and Parnaby 1994).

Females forage over home ranges of 20 to 70 hectares that rarely overlap (Soderquist 1995). Home ranges of males overlap extensively with both females and other males, and may cover over 100 hectares (Gilmore and Parnaby 1994; Soderquist 1995).

The primary habitat components for this species are:

- relatively large tracts of dry open forest or woodland containing box, stringybark, ironbark, blackbutt, or red bloodwood;
- sparse groundcover vegetation; and
- trees with suitable hollows for nesting

Limited areas of primary habitat exist within the dry open forest communities of the study area due to a moderate density of groundcover vegetation. However, limited areas of suitable habitat with sparse groundcover vegetation do exist on steeper elevated land, particularly at Burdekin's Gap, Waterholes Gap and northerly facing

slopes at Mount Karuah. Secondary habitat also exists within areas of closed forest, swamp forest and woodland.

4.3.8 *Koala*

Phascolarctos cinereus occurs where suitable food trees exist, ranging from tall open forest to open woodland (State Forests of NSW 1995). The statewide distribution of the species is closely linked with tree species occurring on high nutrient soils along river flats and drainage lines (Smith *et al.* 1994). In the general vicinity of the study area this species appears to prefer high site quality mature and old growth forests (Smith *et al.* 1994). The primary habitat component for the species is the presence of recognised local food trees. The preferred food tree species in the study area include tallowwood (*E. microcorys*), grey gum (*E. propinqua and punctata*) and forest red gum (*E. tereticornis*).

Based on the existence of preferred food tree species, primary habitat for koalas occurs within the dry open forest, swamp forest and closed forest habitats. Secondary habitat potentially exists within areas of woodland habitat. *Figure 4.2* illustrates the distribution and extent of koala habitat within the study area.

4.3.9 *Common Wombat*

This species (*Vombatus ursinus*) is not currently listed on the NSW TSC Act (1995). However, it is considered by NPWS to be a species of conservation concern due to the presence of a disjunct population at Fame Cove east of the proposed Upgrade. Its main habitat is the forest-covered, often mountainous areas of south-eastern Australia (McIlroy 1995). At lower altitudes the species occurs in more open vegetation such as woodland, coastal scrub and heathland (McIlroy 1995).

The primary habitat components for the species are likely to be:

- temperate, humid microclimate;
- suitable burrowing conditions; and
- native grasses for food.

No primary habitat for this species is likely to occur in the study area due to a lack of forest/woodland vegetation types with extensive native grassy/heath understoreys. Secondary foraging habitat may occur in the woodland and dry open forest habitats south east of the Tea Gardens turnoff.

4.3.10 Spotted-tailed Quoll

D. maculatus inhabits a range of forest communities including wet and dry sclerophyll forest and rainforest, where it nests in rock caves, hollow logs or hollows in trees (State Forests of NSW 1995). The species has a mean home range of approximately 875 hectares, hence it requires large tracts of forest. The few forested environments in which the species has been recorded are characterised by high soil fertility and low disturbance from forestry operations and an absence or low abundance of foxes (State Forests of NSW 1995).

The primary habitat components for this species are:

- large tracts of relatively undisturbed forest to satisfy the species home range requirements;
- rock caves, hollow logs and trees with hollows to serve as a sheltering resource;
- forested areas with a low abundance of foxes (*Vulpes vulpes*), low rate of competition for food resources.

Primary habitat for this species in the study area is likely to occur in the closed forest, dry open forest and swamp forest habitats. Suitable sheltering resources are likely to be more abundant in areas of closed forest. The woodland and shrubland habitats are likely to represent secondary foraging habitat for the species.

4.3.11 Squirrel Glider

In NSW, *P. norfolcensis* has been recorded primarily in dry sclerophyll forest and woodland on dry upper slopes and ridges (State Forests of NSW 1995). The species seems to prefer mature or mixed aged stands of greater than one eucalypt species (State Forests of NSW 1995). The species nests in a bowl-shaped, leaf-lined nest in a tree hollow (Suckling 1995). In Central Victoria the species feeds on insects, eucalypt sap, acacia gum, nectar and pollen (Suckling 1995).

The primary habitat components for this species are:

- mature forests that provide a plentiful supply insects, nectar and pollen (Quin 1995; Suckling 1995); and
- large trees with hollows for diurnal roosting and shelter when breeding.

Areas of dry open forest and closed forest habitats containing a mixed stand of mature eucalypt species are likely to provide primary habitat components for this

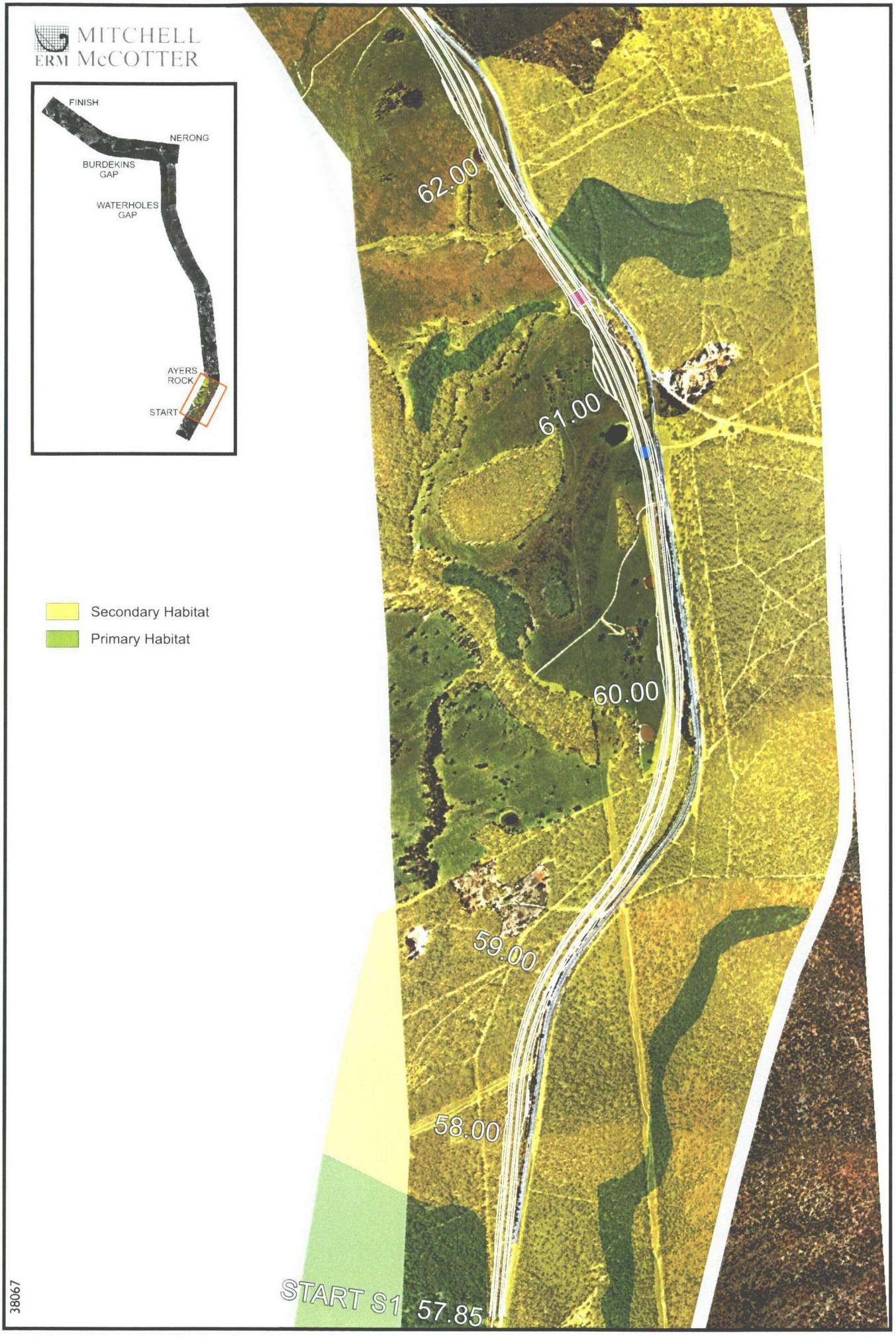

Figure 4.2a POTENTIAL KOALA HABITAT

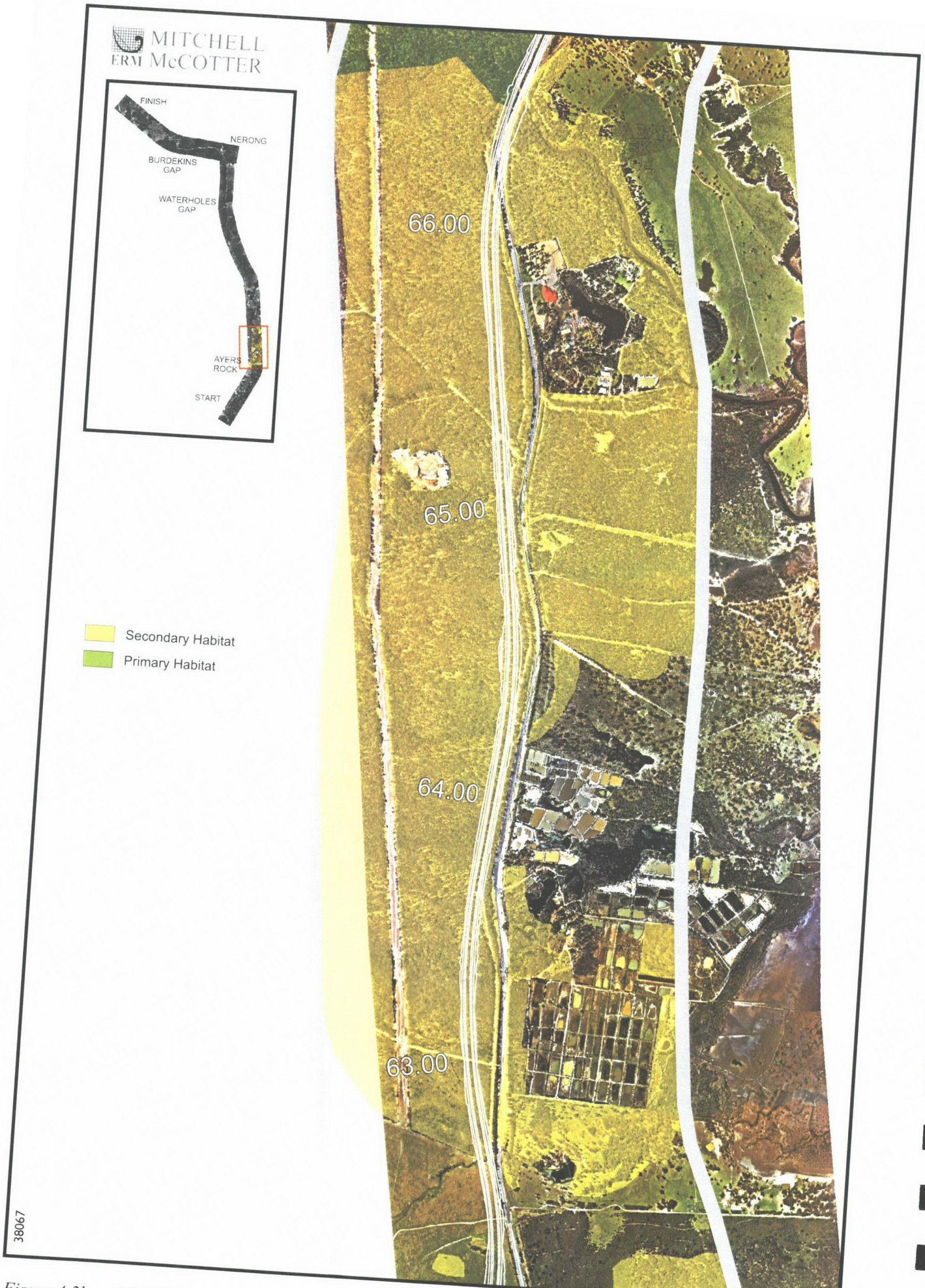

Figure 4.2b POTENTIAL KOALA HABITAT

Scale: 1:16000

Figure 4.2c POTENTIAL KOALA HABITAT

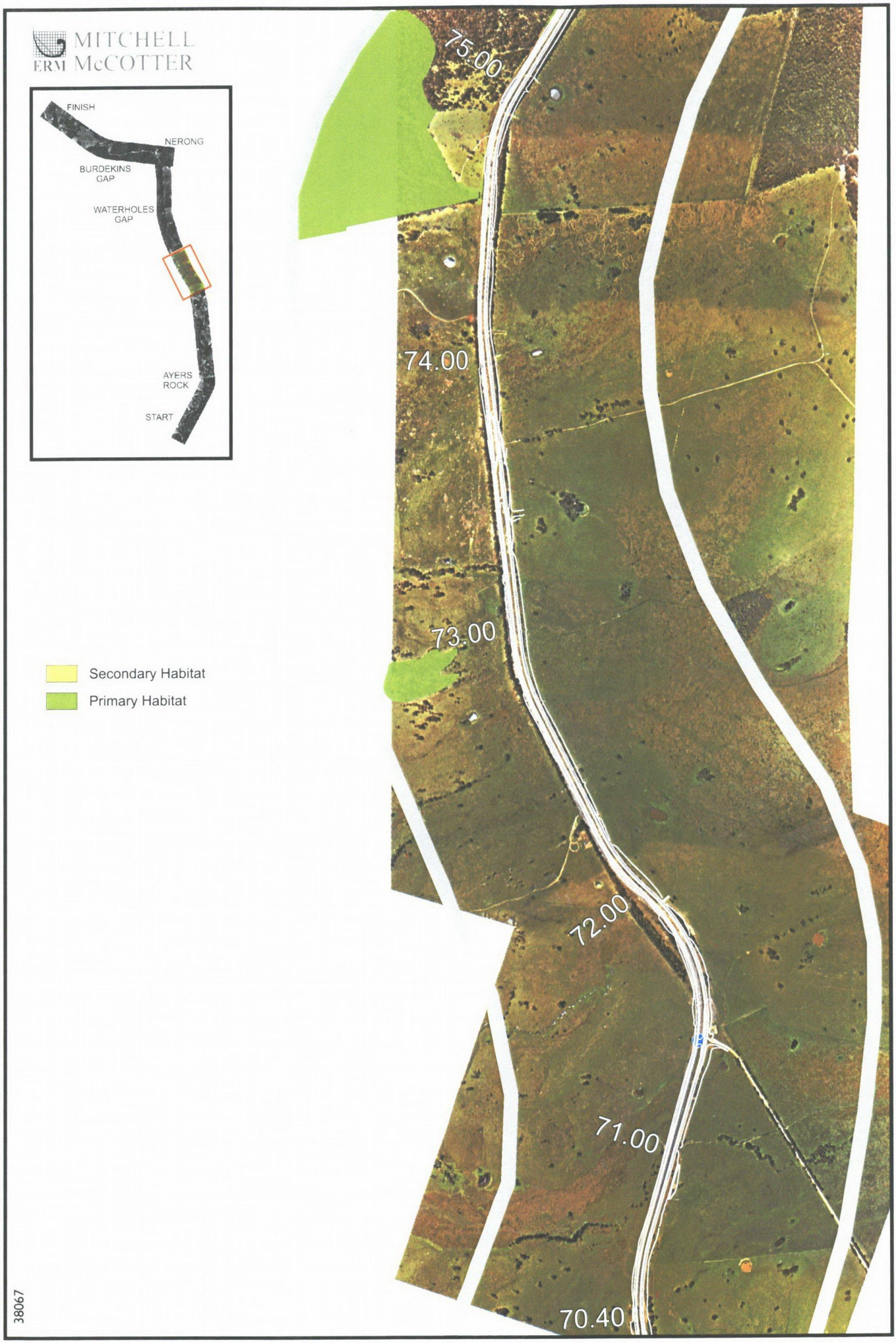

Figure 4.2d POTENTIAL KOALA HABITAT

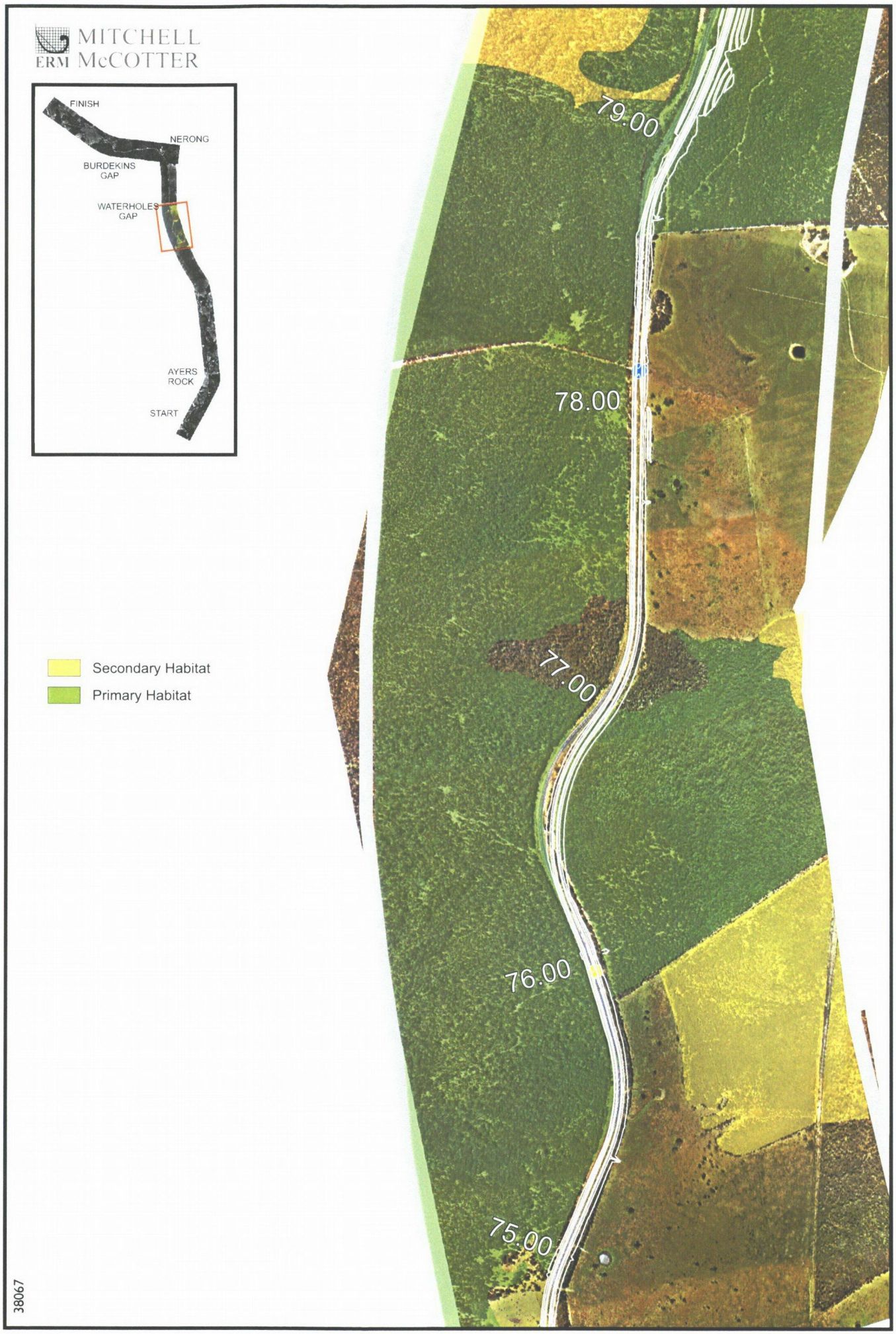

Figure 4.2e POTENTIAL KOALA HABITAT

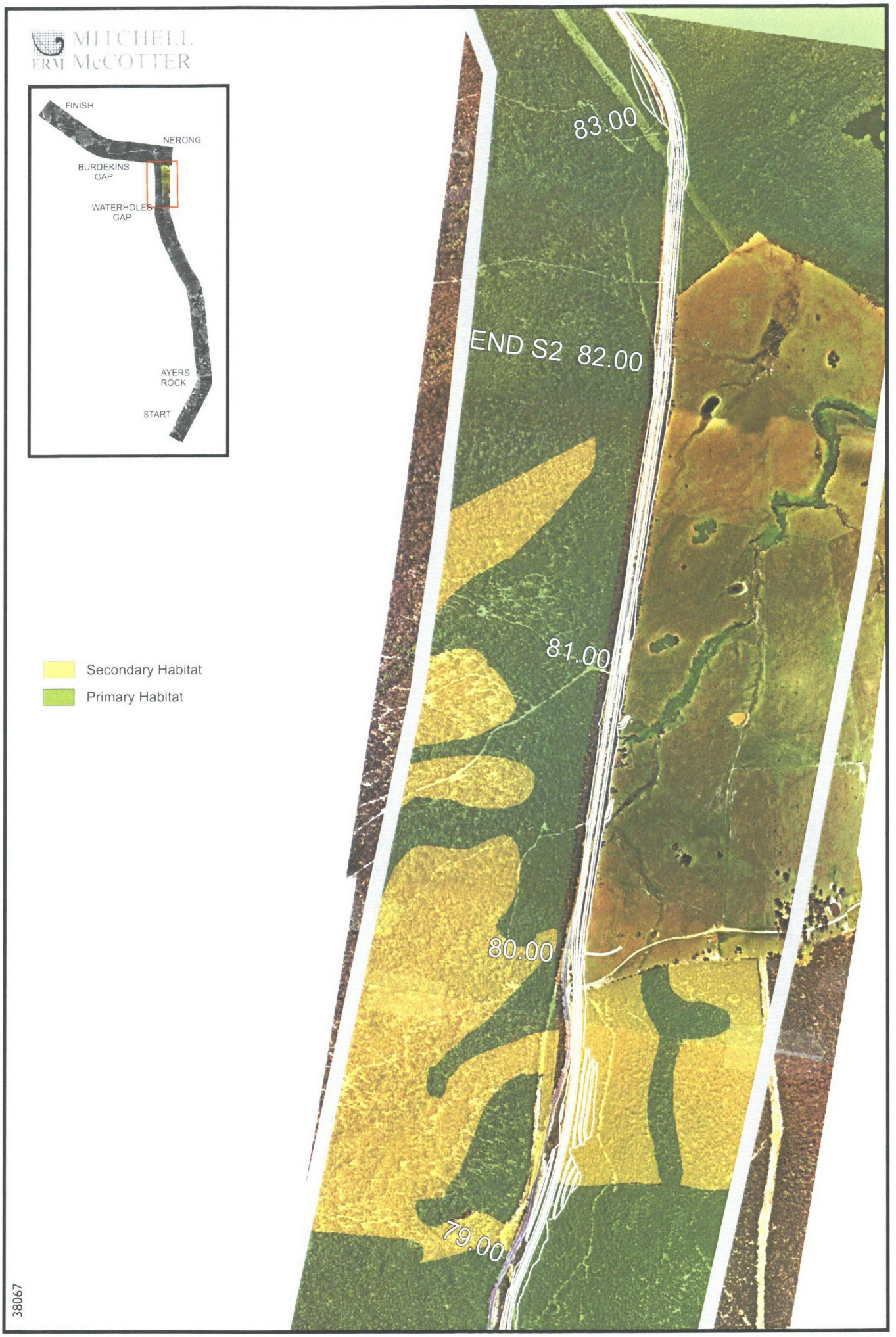

Figure 4.2f POTENTIAL KOALA HABITAT

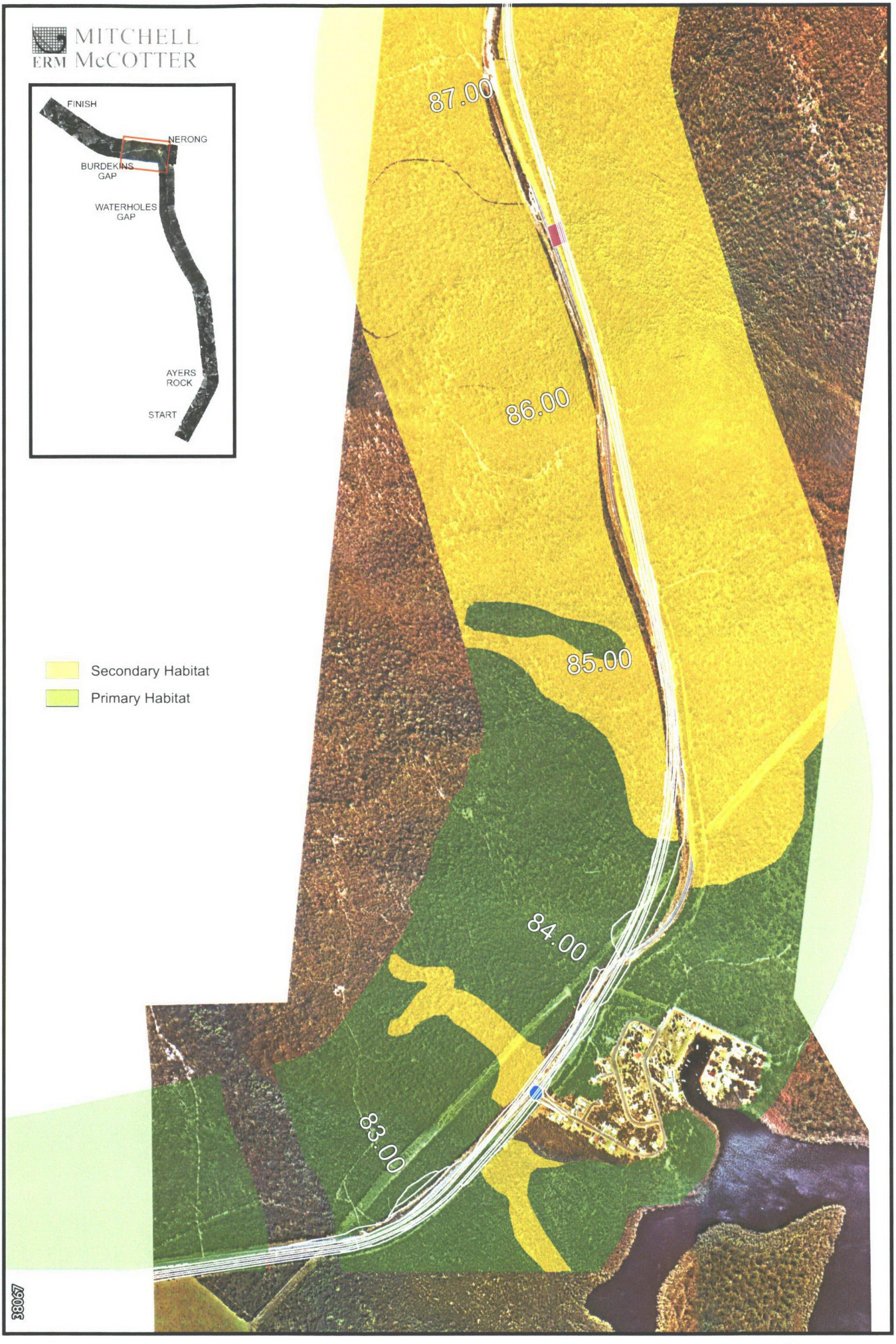

Figure 4.2g POTENTIAL KOALA HABITAT

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Scale: 1:16000

Figure 4.2h POTENTIAL KOALA HABITAT

N

Scale: 1:16000

Figure 4.2i POTENTIAL KOALA HABITAT

species. In particular, habitats containing swamp mahogany (*E. robusta*), tallowwood (*E. microcorys*) and bloodwood (*Corymbia gummifera*) are likely to represent primary habitat for this species (D. Sharp pers. comm.). Swamp forest and woodland areas are likely to provide secondary foraging habitat for the species due to the lack of mixed eucalypt species in the former, and mature trees in the latter.

4.3.12 Yellow-bellied Glider

Petaurus australis forages over a wide range of canopy heights, and in plant communities that have an open overstorey and understorey (Davey 1984). The foraging behaviour of the species is diverse and responsive to changes in tree phenology such as periods of flowering and bark shedding (Kavanagh 1984). Smooth-barked eucalypts are considered to be important to the species due to the diversity of foraging substrates they provide (Forestry Commission of NSW 1993).

The primary habitat components for this species are:

- a mosaic of tree species associations, including those that flower in winter and those with smooth bark that shed in long strips;
- mature forests that provide a large crown and trunk surface, hence providing a larger foraging resource (State Forests of NSW 1995); and
- large trees (preferably living) with large hollows (15 cm diameter; 130 cm deep) for shared diurnal roosting and shelter when breeding (Gibbons and Lindenmayer 1997).

No primary habitat is likely to exist in the study area due to a lack of mature forest and a general paucity of suitable roosting habitat. Secondary foraging habitat is likely to occur within the closed forest, dry open forest, swamp forest and woodland habitats.

4.3.13 Eastern Chestnut Mouse

P. gracilicaudatus occurs in thick sedges and grasses in moist and dry heathland, and blady grass and tussock grass in dry open forest (State Forests of NSW 1995). Optimal habitat for the species is heath vegetation in the early stages of regeneration after fire (State Forests of NSW 1995).

No primary habitat in the form of heathland or dense wet heath exists in the study area. Secondary habitat for the species could potentially occur in the swamp forest, shrubland and areas of dry open forest with dense xeric understorey/groundcover species.

4.3.14 Long-nosed Potoroo

In north-east NSW, high elevation rainforest and moist hardwood forest are favoured by this species (Seebeck *et al.* 1989). The rainforest areas are utilised as a sheltering resource, while the surrounding wet sclerophyll forests are utilised as a foraging resource (Seebeck *et al.* 1989). The species appears to avoid virgin rainforest in preference for the ecotone between rainforest and moist open forest (Seebeck *et al.* 1989). In southern NSW the species habitat consists of a mixed array of vegetation types ranging from woodland with dry heath understorey, to wet heaths, dense coastal scrubs and mixed species open-forest (Seebeck *et al.* 1989).

The primary habitat components for the species are:

- vegetation that provides dense cover preferred by the species when sheltering from predators; and
- relatively open vegetation favoured by the species when foraging.

The dry open forest and closed forest habitats are likely to provide both the shelter and foraging resources required by this species. The swamp forest, woodland and shrubland habitats may represent secondary foraging habitat.

4.3.15 Rufous Bettong

This species occurs mainly in dry open woodland with a sparse understorey, in areas dominated by spotted gum (*Corymbia maculata*), often with other *Eucalyptus*, *Casuarina* and *Angophora* species (Schlaeger 1981; Southwell 1987).

Aepyprymnus rufescens is primarily a rhizophagous species, grazing mostly on the roots of grasses with long tapering tap roots. The species also feeds on a variety of native and perennial herbs and epigeal fungi, insects, flower parts and grass seeds (Dennis and Johnson 1995). During the day *A. rufescens* shelters in a nest constructed of grass or bark, lining and covering a shallow excavation.

The primary habitat component for the species is well grassed open forest and woodland with a sparse shrub layer. Primary habitat for the species is likely to occur in areas of dry open forest with a sparse understorey, particularly those dominated by spotted gum (*Corymbia maculata*). Secondary habitat may exist in the swamp forest and woodland habitats.

4.3.16 *Red-legged Pademelon*

Thylogale stigmatica inhabits mid to high-elevation rainforest and associated moist hardwood forest (State Forests of NSW 1995). In the southern part of its range this species rarely leaves the forest and its diet consists of leaves and fruit from a variety of rainforest plants, particularly the moreton bay fig (*Ficus macrophylla*) (Johnson and Vernes 1995). Core breeding and sheltering habitat is provided by dense shrub layers in rainforest or the edges of moist forest (State Forests of NSW 1995).

The primary habitat components for the species are:

- rainforest or moist eucalypt forest with a dense understorey cover; and
- in NSW, rainforest vegetation containing moreton bay figs and other rainforest fig species.

There is no primary habitat for this species within the study area. Areas of closed forest could represent secondary foraging habitat.

4.3.17 *Common Planigale*

In NSW the species has been recorded from subtropical and dry rainforest, dry sclerophyll forest, heathland and grassland, from sea level up to 400 m ASL. Habitat selection is primarily influenced by the surface cover (Gilmore and Parnaby 1994). The species is predominantly a nocturnal species that shelters in a saucer-shaped nest lined with grass and shredded bark built in crevices, hollow logs, beneath bark or under rocks (Gilmore and Parnaby 1994).

Primary habitat is likely to occur in dry open forest, closed forest and shrubland habitats in areas with dense groundcover vegetation. The edges of adjacent swamp forest and woodland habitats may also represent secondary foraging habitat for the species.

4.3.18 *Golden Tipped Bat*

The distribution of preferred habitat for *Kerivoula papuensis* in the study area cannot be accurately determined at this stage due the current lack of knowledge regarding this species habitat requirements. However, the species has been recorded predominantly in rainforest and along rainforest gullies within wet sclerophyll forest (Churchill 1998). These bats have been found roosting in abandoned nests of gerygones and scrubwrens (Churchill 1998). Little is known of the species reproductive patterns (Churchill 1998).

There is unlikely to be any primary habitat for this species in the study area, however the dry open forest and closed forest habitats may contain secondary habitat.

4.3.19 Eastern Freetail Bat

The specific habitat requirements for this species are relatively unknown at present (Allison and Hoye 1995; State Forests of NSW 1995). It has been recorded in a variety of forest types ranging from rainforest to dry sclerophyll forest and woodland. The species roosts in tree hollows and under loose bark (State Forests of NSW 1995). Inferences from wing morphology and echolocation call design indicate that *Mormopterus norfolkensis* is probably adapted to foraging either within open forest types or above the canopy of dense forest types (State Forests of NSW 1995).

The primary habitat components for the species are likely to be:

- well-timbered forests to provide a foraging resource for the species; and
- tree hollows to provide suitable roosting resources for the species.

Primary habitat components for this species are likely to exist within the dry open forest, closed forest, swamp forest and woodland habitats. Secondary foraging habitat could also exist in the shrubland and grassland habitats.

4.3.20 Little Bent-wing Bat

Miniopteris australis generally occurs in forested areas, particularly in well timbered valleys, where it forages for insects below the canopy of well timbered habitats including rainforest (Dwyer 1995a). Roost sites for the species include caves, old mines, stormwater channels, tree hollows and buildings (State Forests of NSW 1995a). The species congregates in large nursing colonies numbering up to several thousand individuals (State Forests of NSW 1995). There are currently only five known nursery caves in Australia, with only one of these occurring in NSW (State Forests of NSW 1995).

The primary habitat components for the species are:

- well-timbered forests to provide a foraging resource for the species;
- suitable roosting resources such as caves, old mines, stormwater channels and tree hollows; and
- suitable cave systems large enough to support large nursing colonies.

There is unlikely to be any primary habitat for this species in the study area due to a lack of suitable cave roost and nursery sites. Suitable foraging resources are likely to exist throughout all main habitat types in the study area.

4.3.21 Large Bent-wing Bat

Miniopteris schreibersii generally occurs in forested areas, particularly in well timbered valleys, where it forages for insects above the tree canopy (Dwyer 1995b). Roost sites for the species include caves, old mines, stormwater channels and comparable structures (State Forests of NSW 1995). The species forms large nursing colonies numbering up to several thousand individuals (State Forests of NSW 1995).

The primary habitat components for the species are:

- well-timbered forests to provide a foraging resource for the species;
- suitable roosting resources such as caves, old mines, stormwater channels and tree hollows; and
- suitable cave systems large enough to support large nursing colonies. In the south of its range the species requires caves that retain high temperatures produced by the activity of thousands of bats to enable the early development of young (Dwyer 1995b).

There is unlikely to be any primary habitat for this species in the study area due to a lack of suitable cave roost and nursery sites. Suitable foraging resources are likely to exist throughout all main habitat types in the study area.

4.3.22 Large-footed Myotis

Myotis adversus has been recorded in a wide variety of habitat types including mangroves, paperbark swamps, rainforest, wet and dry sclerophyll forest and open woodland (Churchill 1998). The species always occurs near water primarily due to its foraging requirements, which consist of aquatic insects and small fish caught from the water surface (Richards 1995; Churchill 1998). *M. adversus* is commonly a cave dwelling bat, but is also known to roost in tree hollows, dense vegetation, under bridges, in mines tunnels and stormwater drains (Churchill 1998).

The primary habitat components for the species are:

- suitable roosting resources such as caves, old mines, stormwater channels and tree hollows in close proximity to waterbodies; and

- waterbodies containing aquatic insects and small fish.

Primary habitat components for this species are likely to exist within the dry open forest, closed forest, swamp forest and woodland habitats. Secondary foraging habitat could also exist in the grassland habitats.

4.3.23 Bush Stone-curlew

On the coast this species inhabits dry open forest and woodland with low sparse groundcover vegetation (Ferrier *et al.* 1994; Johnson and Baker-Gabb 1994). The species feeds nocturnally on invertebrates and small vertebrates and usually lies hidden during the day (Gilmore and Parnaby 1994).

The primary habitat component for this species is open forest/woodland with sparse understorey vegetation, yet with abundant fallen branches and logs to provide suitable diurnal shelter for roosting (Ferrier *et al.* 1994).

No areas of primary habitat for this species are likely to exist within the study area due to a paucity of habitats with sparse groundcover vegetation. Small areas of sub-optimal habitat could exist in the dry open forest, woodland and grassland habitats.

4.3.24 Glossy Black-Cockatoo

The distribution of this species generally corresponds with the distribution of its primary food source, the seeds of *Allocasuarina torulosa, A. verticillata* and *A. littoralis* (State Forests of NSW 1995). Lower rainfall dry sclerophyll forest on flat ground such as in the lower Clarence valley and the northern tablelands are this species optimum habitat. The species requires large hollows in tall mature trees for nesting (Gibbons and Lindenmayer 1997; Pizzey and Knight 1997).

The primary habitat components for this species are:

- stands of mature *Allocasuarina* trees, particularly *A. littoralis*; and
- tall mature nesting trees containing large hollows (0.3 to 3.1 metres deep with wide entrance hole).

No primary habitat for this species is likely to occur in the study area due to a paucity of suitable nesting resources. Suitable foraging resources for the species are known to occur within the dry open forest, closed forest and swamp forest habitats.

4.3.25 *Osprey*

The primary habitat components of this species are:

- a water body (estuary, river, lake or ocean) possessing a sufficient supply of food fish (Clancy 1991);
- a supply of food (mainly fish) of appropriate size (25-35 m) to support breeding birds and their offspring (Clancy 1991);
- feeding perches close to feeding grounds and nest site (Clancy 1991); and
- a suitable nesting substrate consisting of a tall dead tree (sometimes living), with nesting material available locally (Clancy 1991).

Nesting sites are usually located within two km of suitable feeding habitat (Clancy 1991). No primary habitat for the species exists within the study area due to a lack of foraging resources. However, suitable nesting habitat could potentially exist in the vicinity of Mount Karuah or the Nerong township.

4.3.26 *Square-tailed Kite*

Lophoictinia isura is regarded to be a migratory species to coastal and sub coastal open forests and woodlands in south-eastern NSW (Gilmore and Parnaby 1994). The species inhabits eucalypt forests and woodlands rich in passerines, particularly spotted gum (*Corymbia maculata*) (Debus *et al.* 1993), and is known to hunt over adjacent heaths and other low shrubby habitats (Gilmore and Parnaby 1994). There are no specific nesting requirements for the species.

The primary habitat components for this species are:

- large areas of undisturbed forest for breeding;
- extensive areas of woodland on fertile soils for hunting; and
- high abundance of nesting passerine birds (main prey item).

Primary habitat for this species in the study area could potentially occur within the dry open forest, closed forest and woodland habitat types. Secondary foraging habitat could exist within the swamp forest, shrubland and grassland habitats.

4.3.27 *Masked Owl*

Tyto novaehollandiae typically occurs in dry sclerophyll forests and woodlands with a low, sparse understorey layer (Kavanagh and Peake 1993; Hyem 1979). This species prefers to forage in open or partly cleared country, and preys upon a range of small arboreal and terrestrial mammals (Debus and Rose 1994). *Tyto novaehollandiae* appears to have a lesser dependence on arboreal mammal prey than that of *Ninox strenua* and *Tyto tenebricosa* (State Forests of NSW 1995). Although the species hunts in relatively open country, it prefers the dense cover of gullies or caves when roosting (Hyem 1979). This species favours large hollows for nesting, with depths varying from 0.4 to five metres (Hyem 1979). Large old trees with hollows are required for breeding, with the same tree cavity often used for several years in a row.

The primary habitat components for this species are:

- large old trees with large hollows (0.4 to 5 metres deep), in or near gullies and sheltered aspects for nesting and roosting;
- dry open forests with a low, sparse understorey layer for foraging; and
- terrestrial and arboreal mammal prey base.

No primary habitat for this species is likely to occur within the study area due to a paucity of suitably large tree hollows. Suitable foraging resources are known to occur within the dry open forest habitat, and are likely to exist within the woodland and swamp forest habitats.

4.3.28 *Sooty Owl*

This species has been associated with rainforests and tall, moist forest occurring at low elevations (<300 m) (Kavanagh and Peake 1993a; State Forests of NSW 1995b). It appears to have an association with sheltered east-south facing sites, with a tall (>four metres) dense understorey layer (Kavanagh and Peake 1993). Preferred prey species include the common ringtail possum and sugar glider (Debus 1994).

The primary habitat components for this species are:

- large trees with large hollows (40 to 50 cm deep, 40 to 60 cm diameter), in or near gullies and sheltered aspects;
- dense, sheltering foliage of rainforest and moist hardwood forest; and
- terrestrial and arboreal mammal prey base.

No primary habitat for this species is likely to occur within the study area due to a paucity of suitably large tree hollows and dense sheltering foliage. Suitable foraging habitat for the species is likely to exist within dry open forest, closed forest and swamp forest habitats. Both of the preferred prey species for *Tyto tenebricosa* were recorded in these habitat types during the current surveys.

4.3.29 Powerful Owl

Ninox strenua inhabits both wet and dry sclerophyll forests, however, the optimum habitat for the species appears to be tall, dense eucalypt forest with a dense understorey, on hills and mountains up to 1200 m altitude (Kavanagh and Peake 1993). The species is often recorded in densely forested gullies and on coastal slopes (Lindsey 1992). Dense rainforest areas are generally avoided.

The primary habitat components for this species are:

- an adequate and constant supply of arboreal mammals, particularly greater gliders in northern NSW (State Forests of NSW 1995), or common ringtail possums in coastal forests (Debus and Chafer 1994). This implies a need for productive forests with a mature structure (Smith *et al.* 1994); and

- large trees with large hollows (0.5 to three metres deep, 30 to 50 cm internal diameter) required for nesting;

No primary habitat for this species is likely to occur within the study area due to a paucity of suitably large tree hollows. Suitable foraging habitat for the species is likely to exist within dry open forest, closed forest, swamp forest and woodland habitats. Common ringtail possums were recorded in dry open forest habitat during the current surveys.

4.3.30 Barking Owl

Kavanagh and Peake (1993) regarded *Ninox connivens* to be predominantly a non-forest species that prefers open woodlands. However, the species is also frequently recorded in dry open forests (Davey 1993). *Ninox connivens* selects nesting hollows in the crown of mature trees. The species does not appear to be reliant on any particular prey species (Davey 1993).

The primary habitat components for this species are:

- an adequate and constant supply of arboreal and small ground mammals; and

- large trees with large hollows (0.5 to three metres deep, 30 to 50 cm internal diameter) required for nesting.

No primary habitat for this species is likely to occur within the study area due to a paucity of suitably large tree hollows. Suitable foraging habitat for the species is likely to exist within dry open forest, closed forest, swamp forest and woodland habitats.

4.3.31 Eastern Grass Owl

This species is a specialist of coastal and inland grassland (State Forests of NSW 1995). It also inhabits coastal heath, agricultural crops and swamp margins (Shields 1994; Maciejewski 1997). Core breeding habitat is dense, secluded grass tussock swards, sometimes not far from water (State Forests of NSW 1995). Rodents are the species main prey base, however, birds, insects, frogs and reptiles are also taken (Shields 1994).

The primary habitat components for the species are:

- dense grassland swards or coastal heathland bordering swamps or other waterbodies;

- reliable supply of rodents (main prey item);

Primary habitat for this species in the form of dense grassland or coastal heath does not exist in the study area. Dense grassland habitat does occur further to the east of the study area within the locality. The shrubland and grassland habitats are likely to provide suitable foraging resources for the species.

4.3.32 Turquoise Parrot

Neophema pulchella has been recorded from sea level to 1,200 m, occurring in woodlands and dry sclerophyll forests (Gilmore and Parnaby 1994). It feeds on the ground, typically in small groups, on the seeds of grasses and herbs (Gilmore and Parnaby 1994). This species is considered to be an edge specialist of eucalypt woodland adjoining clearings (State Forests of NSW 1995). It also inhabits timbered ridges and creeklines in farmland, usually with grassy understoreys. The preferred breeding habitat is open grassy woodland with a supply of available tree cavities and an abundant stock of seeding grasses (State Forests of NSW 1995). Drier inland districts are favoured but they will visit adjacent coastal areas to forage (State Forests of NSW 1995).

The primary habitat components for this species are:

- open woodland with grassy understorey near permanent water; and
- adequate supply of tree cavities.

Due to the proximity of the study area to the coast, this species is likely to utilise habitat within the study area for foraging purposes only. Suitable foraging habitat is likely to exist within the dry open forest, woodland and grassland habitats.

4.3.33 Swift Parrot

Lathamus discolor has been recorded from a variety of woodland and dry sclerophyll forest types, particularly where winter flowering eucalypts are present (Gilmore and Parnaby 1994). The species also utilises profusely flowering banksias in coastal forest and woodland (State Forests of NSW 1995). Its diet is primarily composed of eucalypt nectar although it will feed on lerps and the honeydew secretions of psyllids (Gilmore and Parnaby 1994). Spotted gum (*Corymbia maculata*) has been identified as a preferred feed tree (State Forests of NSW 1995). This species breeds only in eastern and northern Tasmania, and overwinters on the mainland (Blakers *et al.* 1984).

The primary habitat components for this species are:

- woodland and dry sclerophyll forest types containing winter flowering eucalypts and/or coastal banksias.

The swamp forest and dry open forest habitats contain some winter flowering eucalypt species, including spotted gum (*Corymbia maculata*), tallowwood (*Eucalyptus microcorys*), red ironbark (*E. fibrosa*), swamp mahogany (*E. robusta*) and forest red gum (*E. tereticornis*). These habitat types could provide suitable foraging habitat for this species.

4.3.34 Regent Honeyeater

This species is nomadic, occurring on the NSW coast primarily in the winter months (Ferrier *et al.* 1994) and during periods of drought (D. Geering, Co-ordinator of the Regent Honeyeater Recovery Program, Department of Natural Resources and Environment, Victoria pers. comm.). In inland areas the species prefers to forage on large-flowers of eucalypts such as *E. sideroxylon*, *E. melliodora*, *E. camaldulensis*, *E. albens*, and *E. leucoxylon* (Ferrier *et al.* 1994; Gilmore and Parnaby 1994; State Forests of NSW 1995). Known breeding sites of the species in NSW include the Capertee Valley (Geering & French 1998), near Armidale (Oliver *et al.* 1998) and Albury (S. Ambrose pers. comm.).

Preferred habitat for the species in coastal areas is lowland coastal forests dominated by swamp mahogany (*Eucalyptus robusta*) or spotted gum (*Corymbia maculata*). The species has also been recorded foraging on the flowers of *Banksia integrifolia* and mistletoe (Gilmore and Parnaby 1994). Geering (pers. comm.) suggests that coastal habitats may be important for the continued existence of regent honeyeaters in central NSW (where probably over 75% of the total population occurs).

The primary habitat components for this species are:

- habitat that provides reliable and ample supplies of nectar, containing preferred feed tree species as listed previously;
- areas with low competition from more aggressive honeyeaters such as noisy miners, wattlebirds and noisy friar birds.

Forested areas containing spotted gum are widespread throughout the study area. Conversly, only small stands of swamp mahogany (*E. robusta*) occur in the study area. Several other less preferred winter flowering eucalypt species also occur in the study area (listed in previous section). Although the study area is not near any of the known breeding locations, breeding attempts by the species have been recorded outside known breeding sites during periods of drought (S. Ambrose pers. comm.). Therefore, during the winter months or during periods of drought (ie. low nectar flows in breeding areas) areas of dry open forest containing spotted gum, and swamp forest containing swamp mahogany could potentially represent primary habitat for a limited number of breeding individuals. Closed forest and woodland habitats may also contain secondary foraging habitat for the species.

4.3.35 Black Bittern

Ixobrychus flavicollis occurs in thick vegetation at margins of watercourses, swamps, billabongs, mudflats and mangroves in tidal creeks and rivers. Critical breeding habitat is mangrove belts along coastal waterways and densely vegetated wetlands (State Forests of NSW 1995). Nests usually consist of an untidy platform of sticks on a sheltered horizontal branch overhanging water (Pizzey and Knight 1997). The species feeds on small fish and invertebrates.

The primary habitat components for this species are:

- dense stands of mangroves or other wetland vegetation for breeding purposes; and
- permanent creeks and waterbodies with adequate supply of small fish and invertebrates.

Primary habitat for this species is likely to occur within the riparian vegetation associated with Bulga and Bundabah Creeks. These are the only permanent creeks within the study area. Three SEPP 14 Wetlands occur in the locality, however none of these extend into the study area. The larger dam sites within the dry open forest and grassland habitats may also represent secondary foraging habitat for the species. Dense vegetation along ephemeral watercourses could also provide secondary foraging habitat for the species.

4.3.36 Black-necked Stork

The black-necked stork (*Ephippiorhynchus asiaticus*) inhabits riverine swamps, large permanent pools and coastal wetlands and estuaries (Blakers *et al.* 1984). Fresh, brackish and saline waters are utilised, including farm dams and sewage ponds (State Forests of NSW 1995). The bird forages in shallow waters, feeding primarily on fish and frogs (Blakers *et al.* 1984). The nest usually consists of a large flat pile of sticks, grass, rushes, high and exposed in a tall live or dead tree (Pizzey and Knight 1997). Breeding grounds for the species occur predominantly north from Coffs Harbour, NSW (Blakers *et al.* 1984).

The primary habitat components for this species are:

- abundant supply of fish and frogs;
- live and dead trees, preferably bordering swamps and rivers; and
- high water quality.

No primary habitat exists within the study area for this species due to a lack of swamps and associated dead trees. However, the permanent and ephemeral watercourses and dams within the study area may provide suitable foraging habitat for the species.

4.3.37 Comb-crested Jacana

The comb-crested jacana (*Irediparra gallinacea*) prefers deep, permanent freshwater lagoons with abundant aquatic vegetation and relatively stable water levels and food supplies (State Forests of NSW 1995; Pizzey and Knight 1997). The species feeds on invertebrates and aquatic plant material (Smith 1991). The nest consists of a small floating platform supported by aquatic vegetation (Smith 1991).

The primary habitat components for this species are:

- permanent fresh waterbodies with abundant floating aquatic vegetation.

No primary habitat exists within the study area for this species due to a lack of permanent fresh waterbodies with abundant floating aquatic vegetation. However, the permanent and ephemeral watercourses and dams within the study area may provide suitable foraging habitat for dispersing individuals.

4.3.38 Superb, Rose-crowned and Wompoo Fruit-doves

These three species inhabit sub-tropical, warm temperate and depauperate rainforests throughout their ranges (Gilmore and Parnaby 1994; State Forests of NSW 1995). These species may occasionally utilise moist open forest and riparian zones containing a rainforest understorey (Gilmore and Parnaby 1994).

The primary habitat component for these species is the existence of rainforest vegetation containing fruiting trees, particularly figs, native tamarind, myrtles, laurels, olive-berry and pigeonberry trees.

No primary habitat for these species is likely to exist within the study area due to a lack of rainforest vegetation with suitable fruiting trees. Sub-optimal foraging habitat may exist for these species in areas of closed forest.

4.4 HABITAT CORRIDORS

Habitat corridors consist of areas between vegetation communities that enable fauna to move safely. Depending upon their width and condition, corridors can provide movement opportunities to some or all fauna. Habitat corridors may consist of a well vegetated continuous link between various large areas of habitat, or small remnants of closely spaced vegetation that enable more mobile species to conduct their migratory movements.

Early land clearance for agriculture, and more recently for the Pacific Highway and other developments have resulted in fragmentation of habitats within a large proportion of the study area. The remaining habitat corridors that link the hinterland and coastal fauna populations are likely to be valuable for maintaining genetic flow between remaining areas of habitat (L. Baker, NPWS pers. comm.).

Examination of aerial photography and topographic maps indicate that the proposed Upgrade would intersect five potential habitat corridors including:

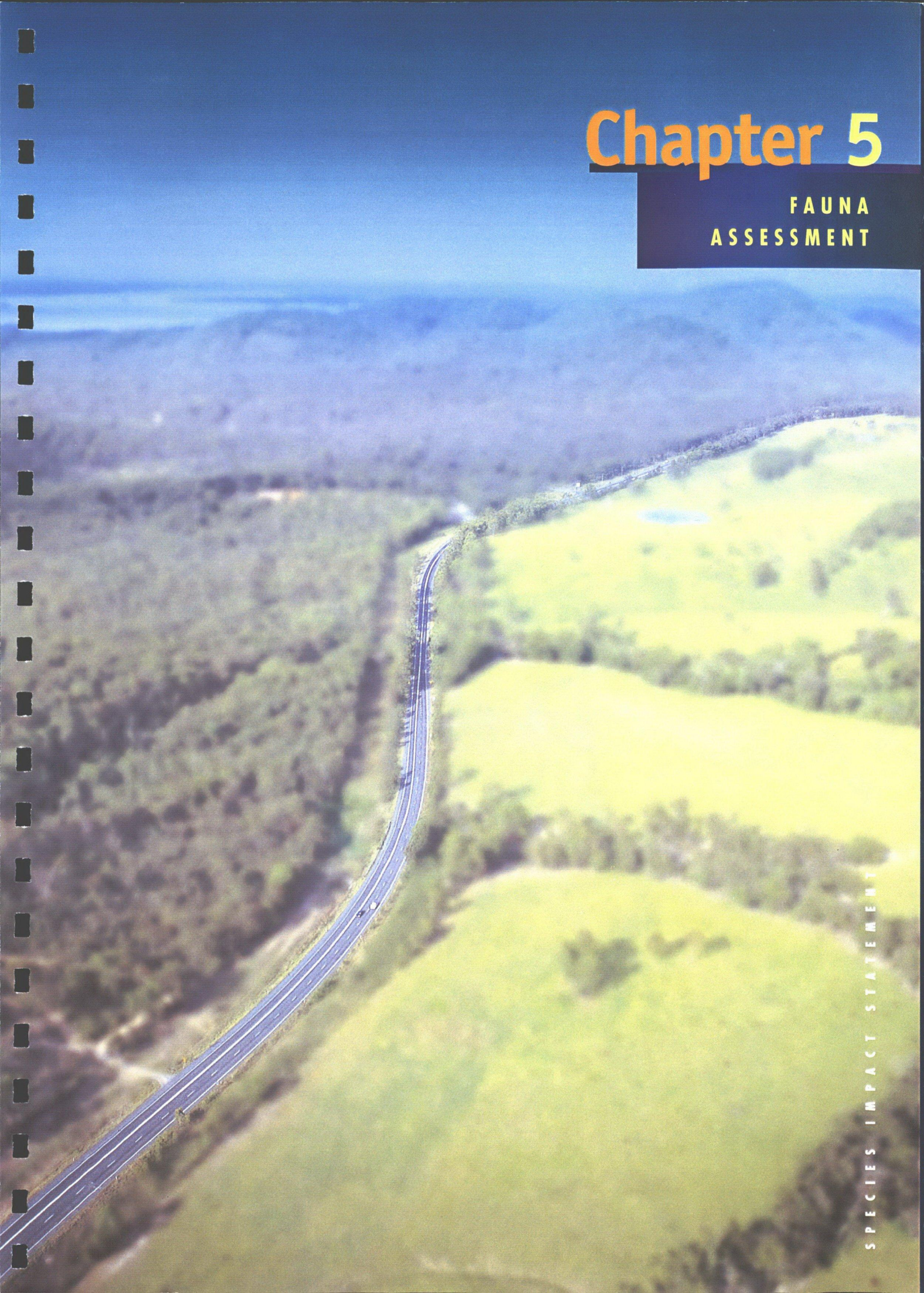
- vegetation linking hinterland and coastal vegetation within Myall Lakes National Park;

- vegetation linking hinterland habitats within Nerong State Forest via freehold forested land (Nerong Waterholes) to freehold coastal vegetation;
- vegetation linking habitats within Nerong State Forest to a large remnant of vegetation at Waterholes Gap;
- vegetation linking remnant riparian habitat along Bulga Creek to freehold forested habitats near North Arm Cove; and
- vegetation linking freehold forested habitats around Mount Karuah to those of forested areas north of the Pacific Highway.

The location and extent of remaining habitat corridors are illustrated in *Figure 4.1*.

The effectiveness of remaining habitat corridors has most likely been significantly reduced by the clearing for agriculture in the locality and the construction of the Pacific Highway and powerline easement in previous years. However, it is considered that the proposed Upgrade, without appropriate mitigation measures, is likely to reduce the effectiveness of these remaining habitat corridors even further.

Consequently, an extensive range of mitigation measures have been formulated to minimise potential impacts of the proposed Upgrade on the effectiveness of remaining habitat corridors in the study area. All proposed mitigation measures are discussed in *Chapter 7*.



Chapter 5

FAUNA ASSESSMENT

Chapter 5

FAUNA ASSESSMENT

This chapter describes the methodology for the fauna assessment of the study area and details the results of the fauna surveys undertaken. Threatened fauna species known or likely to occur in the study area are also identified.

5.1 INTRODUCTION

This chapter reports the methods and results of investigations of fauna within the study area that were undertaken for both the REF and SIS. SIS investigations were designed to build upon the earlier investigations of the REF. In part, the justification for the level of additional survey effort for the SIS was provided by a series of Comprehensive Regional Assessment (CRA) models supplied by NPWS. The CRA models indicate the potential habitat quality for threatened species within the sub-region.

The CRA habitat models indicate areas of potentially suitable habitat for threatened species. These models indicated that the proposed upgrading of the highway could potentially have a significant impact on a number of threatened species that were not surveyed in detail for the REF.

Overall, the fauna investigations were designed to:

- verify and build upon the list of threatened and regionally significant fauna known to utilise the study area;
- supply more accurate data about the distribution and abundance of threatened and regionally significant species and their habitats to be used for prediction of impacts of the proposed Upgrade; and
- develop mitigation measures to minimise the impacts of the proposed Upgrade.

5.2 ASSESSMENT METHODOLOGY

5.2.1 *Review of Existing Information*

The desktop study aimed to provide an inventory of threatened species known or likely to occur in the locality. It consisted of a literature review of previous surveys undertaken in the locality, consultation with public authorities, individuals and interest groups and database searches. The NPWS Wildlife Atlas (NPWS 1997 and 1998) and State Forests of NSW databases (State Forests of NSW 1999) were searched for flora and fauna records.

5.2.2 *Field Survey Methodology*

Comprehensive field surveys were conducted in areas identified by CRA habitat modelling and ground truthing as suitable habitat for threatened species. The surveys included a variety of detection techniques, both direct and indirect.

Initial survey tasks undertaken for the REF were conducted within areas of habitat likely to be removed or disturbed by the proposed Upgrade. Survey tasks conducted later for the SIS focussed on potentially suitable habitats for threatened species. Sampling sites were selected in areas identified by CRA mapping and ground truthing as offering suitable habitat for threatened species.

5.2.3 *Survey Effort*

A survey team of two people conducted the fauna survey for the REF, which consisted of 11 tasks carried out over six days (*Table 5.1*). For the SIS, a four person survey team carried out an initial 11 tasks over 14 days. This was followed by a two person survey team completing ten tasks over five days. Additional amphibian searches and tadpole sampling were conducted by a two person team over four days.

Table 5.1 SIZE OF SURVEY TEAM AND LIST OF TASKS PERFORMED DURING EACH SURVEY PERIOD

Survey Period	Number of Team Members	Survey Tasks Performed
August 18, 1997 (REF)	2	HT
January 12 to 16, 1998	2	GE; AE; BD; Spot; AS; CP; RS; DB; Pit; KH
October 19 to November 1, 1998	4	HT; GE; AE; BD; Spot; AS; CP; RS; KH; Harp; BCP
November 2 to 6, 1998	2	Rapt; CP; Spot; RS; BCP; Harp; AS; RS; WB; HT
November 18 to 19, 1998	2	AS
December 9 and 11, 1998	2	TS; RS

Survey Tasks:

HT	Hairtubes	DB	Diurnal Bird Surveys
GE	Ground-based Elliott Traps	Pit	Pitfall Traps
AE	Arboreal Elliott Traps	KH	Koala Habitat Assessment
BD	Bat Detection	Harp	Harp Trapping
Spot	Spotlighting	Rapt	Raptor Search
AS	Amphibian Survey	BCP	Bush Stone-curlew Call Playback
CP	Call Playback	WB	Waterbird Searches
RS	Reptile Search	TS	Tadpole Survey

The survey tasks particularly targeted those threatened species considered by NPWS as being likely to occur in the study area. The detection methods and survey effort allocated to each threatened species known or likely to occur in the study area are provided in *Table 5.2*.

Table 5.2 DETECTION METHODS USED AND SURVEY EFFORT ALLOCATED TO EACH THREATENED SPECIES KNOWN OR LIKELY TO OCCUR IN THE STUDY AREA

Scientific Name	Common Name	Sampling Techniques	Total Survey Effort	Locations	Habitat Types	Complied with DG's Requirements
Litoria brevipalmata	Green-thighed frog	Search; CP; Spot; TS	28 hrs	NR; BG; NW; Cray	SF; DOF; WL	yes
Litoria aurea	Green and Golden Bell frog	Search; CP; Spot; TS	11.5 hrs	SC; WG; Cray; NR; OR; BG	DOF; GL; SF; WL;	yes
Mixophyes balbus	Stuttering frog	Search; Spot; TS	20.5 hrs	JC; NR	CF; SF	no (see *Table 5.4*)
Mixophyes iteratus	Giant Barred frog	Search; CP; Spot; TS	20.5 hrs	JC; NR	CF; SF	exceeded
Crinia tinnula	Wallum froglet	Inc. Obs.; TS	n/a	n/a	n/a	no (see *Table 5.4*)
Hoplocephalus stephensii	Stephen's banded snake	Search; Spot	5 hrs	BG; JC; WG; NR; Cray	DOF; CF; WL; SF	no (see *Table 5.4*)
Hoplocephalus bitorquatus	Pale-headed snake	Search; Spot	5 hrs	BG; JC; WG; NR; Cray	DOF; CF; WL; SF	no (see *Table 5.4*)
Phascogale tapoatafa	Brush-tailed phascogale	Spot; AE; Scat	Spot=32 hrs; HT=848 tn; AE=240 tn	NSF; WG; MK	DOF	no (see *Table 5.4*)
Phascolarctos cinereus	Koala	Spot; Search; HA	Spot=25 hrs	NSF; JC; WG; NW; MK	SF; DOF; CF	yes

Table 5.2 DETECTION METHODS USED AND SURVEY EFFORT ALLOCATED TO EACH THREATENED SPECIES KNOWN OR LIKELY TO OCCUR IN THE STUDY AREA

Scientific Name	Common Name	Sampling Techniques	Total Survey Effort	Locations	Habitat Types	Complied with DG's Requirements
Dasyurus maculatus	Spotted-tailed quoll	HT; Scat	HT=848 tn	NSF; JC; MK;	DOF; CF	yes
Petaurus norfolcensis	Squirrel glider	Spot; AE; HT	Spot=24 hrs; HT=848 tn	NSF; JC; WG; NW; MK	DOF; CF; SF	no (see *Table 5.4*)
Petaurus australis	Yellow-bellied glider	Spot; AE; HT	Spot=24 hrs; HT=848 tn	NSF; JC; WG; NW; MK	DOF; CF; SF	no (see *Table 5.4*)
Pseudomys gracilicaudatus	Eastern chestnut mouse	GE; HT	GE= 440tn; HT=848 tn	NSF; MK; NW; GGG; WG	WL; DOF; SF; CF	no (see *Table 5.4*)
Potorous tridactylus	Long-nosed potoroo	HT; Spot; Scat	Spot=32 hrs; HT=848 tn	NSF; JC; WG; NW; MK	DOF; CF; SF	no (see *Table 5.4*)
Thylogale stigmatica	Red-legged pademelon	Spot; Scat	Spot=32 hrs	NSF; JC; WG; NW; MK	DOF; CF; SF	yes
Planigale maculata	Common planigale	GE; Pit; HT	GE=440 tn; Pit=40 tn; HT=848 tn	NSF; WG; NW; MK; SC	DOF; SF; CF	exceeded
Kerivoula papuensis	Golden tipped bat	Harp; Det; Trip	Harp=18 tn; Det=5.2 hrs; Trip=3	GGG; JC; MK; BC	CF; DOF	exceeded
Mormopterus norfolkensis	Eastern freetail bat	Harp; Det; Trip	Harp=18 tn; Det=5.2 hrs; Trip=3	GGG; JC; MK; BC	CF; DOF	exceeded

Table 5.2 DETECTION METHODS USED AND SURVEY EFFORT ALLOCATED TO EACH THREATENED SPECIES KNOWN OR LIKELY TO OCCUR IN THE STUDY AREA

Scientific Name	Common Name	Sampling Techniques	Total Survey Effort	Locations	Habitat Types	Complied with DG's Requirements
Miniopterus australis	Little Bentwing Bat	Harp; Det; Trip	Harp=18 tn; Det=5.2 hrs; Trip=3	GGG; JC; MK; BC	CF; DOF	exceeded
Miniopterus schreibersii	Large bentwing bat	Harp; Det; Trip	Harp=18 tn; Det=5.2 hrs; Trip=3	GGG; JC; MK; BC	CF; DOF	exceeded
Myotis adversus	Large-footed myotis	Harp; Det; Trip	Harp=18 tn; Det=5.2 hrs; Trip=3	JC; MK; BC	CF; DOF	exceeded
Burhinus grallarius	Bush stone-curlew	CP	3 hrs	VCR; NR; MK	DOF; SF; GL	no (see *Table 5.4*)
Calyptorhynchus lathami	Glossy black-cockatoo	Feed		n/a	all habitats except GL	yes
Pandion haliaetus	Osprey	Search	2 hrs	farmland	GL	yes
Lophoictinia isura	Square-tailed kite	Search	2 hrs	farmland	GL	yes
Tyto novaehollandiae	Masked owl	CP; Spot	CP=30 hrs; Spot=32 hrs	NSF; JC; WG; NW; MK; CFT;	DOF; CF; SF	no (see *Table 5.4*)
Tyto tenebricosa	Sooty owl	CP; Spot	CP=30 hrs; Spot=32 hrs	NSF; JC; WG; NW; MK; CFT;	DOF; CF; SF	no (see *Table 5.4*)
Ninox strenua	Powerful owl	CP; Spot	CP=30 hrs;	NSF; JC; WG;	DOF; CF; SF	no

Table 5.2 DETECTION METHODS USED AND SURVEY EFFORT ALLOCATED TO EACH THREATENED SPECIES KNOWN OR LIKELY TO OCCUR IN THE STUDY AREA

Scientific Name	Common Name	Sampling Techniques	Total Survey Effort	Locations	Habitat Types	Complied with DG's Requirements
			Spot=32 hrs	NW; MK; CFT;		(see *Table 5.4*)
Ninox connivens	Barking owl	CP; Spot	CP=25 hrs; Spot=32 hrs	NSF; JC; WG; NW; MK; CFT;	DOF; CF; SF	no (see *Table 5.4*)
Neophema pulchella	Turquoise parrot	Inc. Obs.	n/a	n/a	n/a	yes
Lathamus discolor	Swift parrot	Inc. Obs.	n/a	n/a	n/a	yes
Xanthomyza phrygia	Regent honeyeater	Inc. Obs.	n/a	n/a	n/a	yes
Ixobrychus flavicollis	Black bittern	Search	2 hrs	BC; BuC	DOF; CF	yes
Epippiorhynchus asiaticus	Black-necked stork	Search	2 hrs	BC; BuC	DOF; CF	yes
Jacana gallinacea	Comb-crested jacana	Inc Obs.	n/a	n/a	n/a	yes
Ptilinopus magnificus	Superb fruit-dove	Inc Obs.	n/a	n/a	n/a	yes
Ptilinopus regina	Rose-crowned fruit-dove	Inc Obs.	n/a	n/a	n/a	yes
Ptilinopus magnificus	Wompoo fruit-dove	Inc Obs.	n/a	n/a	n/a	yes

Note: Refer to *Table 5.4* for differences between DG's Requirements and survey methodology used.

Key:

Detection Method

Search	Targeted Search	Harp	Harp Trapping
AE	Arboreal Elliott Traps	Det	Bat Detection
GE	Ground Elliott Traps	Trip	Triplining
Spot	Spotlighting	Pit	Pitfall Traps
Scat	Scat Search	HT	Hairtubes
Feed	Feeding Signs Search	HA	Habitat Assessment
CP	Call Playback	Inc. Obs.	Incidental Observations
TS	Tadpole Sampling		

Location:

NR	Nerong Road		NSF	Nerong State Forest
BG	Burdekin's Gap		MK	Mount Karuah
NW	Nerong Waterholes		NW	Nerong Waterholes
Cray	Opposite Crayhaven fish farm	GGG	Grey Gum Gully	
SC	Splityard Creek		BC	Bulga Creek
WG	Waterholes Gap		VCR	Viney Creek Road
OR	Old Tea Gardens Road		CFT	Cox's Fence Trail
JC	Jack's Creek		BuC	Bundabah Creek

The majority of survey tasks conducted for the SIS were undertaken within 300 m of the proposed Upgrade in areas of habitat undisturbed by the existing Pacific Highway. Some spotlighting transects and call playback sites were located between 500 and 1000 m from the existing Pacific Highway in order to survey areas less affected by traffic noise.

The total survey effort allocated to each survey task during the survey period is provided in *Table 5.3*.

Table 5.3 TOTAL SURVEY EFFORT

Task	Location	Transect Length (km)	Dates Sampled	Survey Effort
Spotlighting				**Survey Effort (hrs)**
	NSF 1	0.5	21/10/98; 29/10/98; 2/11/98; 5/11/98	2
	NSF 2	1	21/10/98; 29/10/98; 2/11/98; 5/11/98	4
	NSF 3	0.5	21/10/98, 29/10/98, 2/11/98, 5/11/98	2
	JC	1	28/10/98; 1/11/98; 3/11/98; 5/11/98	4
	WG	0.5	22/10/98; 24/10/98; 27/10/98; 2/11/98	2
	NW	1	21/10/98; 24/10/98; 27/10/98	3
	CFT	0.5	28/10/98; 24/10/98; 27/10/98	3
	MK	1	29/10/98; 1/11/98; 3/11/98; 6/11/98	4
REF Surveys	BG; GGG; WG; NW; MK	n/a	12-16/1/98	8
Call Playback		**No. of calls played**		**Survey Effort (nights)**
	NSF 1	7	21/10/98, 27/10/98, 30/10/98, 2/11/98,	4
	NPE	7	20/10/98	1
	JC	7	20/10/98, 26/10/98, 28/10/98, 2/11/98	4
	WG	7	22/10/98, 24/10/98,	4

Table 5.3 TOTAL SURVEY EFFORT

Task	Location	Transect Length (km)	Dates Sampled	Survey Effort
			28/10/98, 2/11/98	
	NW	7	24/10/98, 27/10/98, 30/10/98	3
	MK 1	7	21/10/98, 27/10/98, 29/10/98	3
	MK 2	7	29/10/98, 1/11/98, 6/11/98	3
REF Surveys	MK; WG; NWG; GGG; BG		12-16/1/98	5
Bush Stone Curlew Call Playback				**Survey Effort (hours)**
	NR		30/10/98, 3/11/98, 5/11/98	1.5
	VCR		5/11/98, 6/11/98	1
	MK 1		2/11/98	0.5
Ground Elliotts				**Survey Effort (Trapnights)**
	NSF 1		20-23/10/98	40
	NSF 2		20-23/10/98	40
	WG		26-29/10/98	40
	NW		20-23/10/98	40
	MK		20-23/10/98	40
	GGG		26-29/10/98	40
REF Surveys	MK; WG; BG		12-16/1/98	200
Arboreal Elliotts				
	NSF 1		20-23/10/98	40
	NSF 2		20-23/10/98	36
	WG		26-29/10/98	40
	NW		20-23/10/98	40
	MK		20-23/10/98	40
REF Surveys	MK; WG; BG		12-16/1/98	40
Hairtubes				
	Hair Tube Line 1		21/10/98 to 2/11/98	72

Table 5.3 TOTAL SURVEY EFFORT

Task	Location	Transect Length (km)	Dates Sampled	Survey Effort
	(NSF)			
	Hair Tube Line 2 (NSF)		21/10/98 to 2/11/98	108
	Hair Tube Line 3 (NSF)		6-19/11/98	78
	Hair Tube Line 4 (MK)		6-19/11/98	130
REF Survey	BC; NR; JC; BR		12-16/1/98	450
Harp Trapping				
	NSF (chainage 86.00 west)	Forestry Trail	20-22/10/98	3
	GGG	Track through riparian vegetation	24-26/10/98	3
	JC 1	Across Creek	23-25/10/98	3
	JC 2	Across box culvert	20-23/10/98	4
	BC		3-5/11/98	3
	MK		4-5/11/98	2
Bat Detection				**Survey Effort (hrs)**
	NSF 1		21/10/98	1
	NSF 2		21/10/98; 29/10/98	1
	NSF 3		21/10/98; 29/10/98	1
			REF Surveys	2.25
Triplining				**Survey Effort (hrs)**
	BG		24-25/10/98	3
Frog/Reptiles				
	BG	pond inspection	19/11/98	1
	JC	100m transect	19/10/98, 26/10/98, 5/11/98, 18/11/98	4.5
	SC	typha bed inspection	5/11/98, 18/11/98	2.5

Table 5.3 TOTAL SURVEY EFFORT

Task	Location	Transect Length (km)	Dates Sampled	Survey Effort
	WG	pond inspection	26/10/98, 19/11/98	5.5
	NR	100m transect/pond inspection	19/10/98, 26/10/98, 30/10/98, 5/11/98, 18/11/98, 19/11/98	13.5
	NW	flooded paddock/100 m transect	19/11/98	1
	Cray	pond inspection	30/10/98, 5/11/98, 19/11/98	2.5
	OR	typha bed inspection	19/10/98, 30/10/98, 19/11/98	3.5
REF Surveys	NR; OR; NW; GGG; BR		12-16/1/98	6

NSF 1	Nerong State Forest Site 1	WG	Waterhole's Gap	NPE	Nerong Powerline East
NSF 2	Nerong State Forest Site 2	NW	Nerong Waterholes	OR	Old Tea Gardens Road
NSF 3	Nerong State Forest Site 3	CFT	Cox's Fence Trail	GGG	Grey Gum Gully
JC	Jack's Creek	MK	Mount Karuah	BR	Booral Road
BC	Bulga Creek	SC	Splityard Creek	BG	Burdekin's Gap
JC 1	Jack's Creek Site 1	MK 1	Mount Karuah Site 1	Cray	Crayhaven Fish Farm
JC 2	Jack's Creek Site 2	MK 2	Mount Karuah Site 2		

5.2.4 *Survey Timing*

Fauna surveys conducted for the REF were undertaken between January 12 and 16, 1998. Hairtube transects were also established for the REF during August and September, 1997. Additional fauna surveys conducted for the SIS were undertaken between October 19 and November 5, 1998. Further amphibian surveys were conducted between November 18 and 19, 1998. Tadpole surveys were conducted between December 9 and 11, 1998.

5.2.5 *Amphibian Searches*

Amphibian searches were conducted specifically to detect the green-thighed frog (*Litoria brevipalmata*), green and golden bell frog (*Litoria aurea*), stuttering frog (*Mixophyes balbus*) and the giant barred frog (*Mixophyes iteratus*). Targeted searches were undertaken at six sites within the study area. Site selection was based on the

presence of suitable habitat as determined through the use of NPWS habitat models, ground truthing and location of previous records in the study area. Two sites were located within the Nerong State Forest. Individual sites were located next to the intersection with Old Tea Gardens Road, Waterholes Gap, opposite Crayhaven crayfish farm and one site approximately 700 m north of Waterholes Gap on the eastern side of the existing highway alignment. Each site was surveyed at least twice on two non-consecutive nights after rain. Amphibian survey sites are illustrated on *Figure 5.1*.

Additional single visit surveys were undertaken at a dam site near Burdekin's Gap and in temporarily inundated open forest at Nerong Waterholes. These additional surveys were undertaken shortly after detecting the green-thighed frog (*Litoria brevipalmata*) at the Nerong Road site (refer to *Section 5.3.2*). The survey team considered the weather conditions to be ideal for detecting this species, hence they took the opportunity to search for the species in additional areas.

Each survey consisted of a 30 minute (minimum) visual search (using a spotlight) by two team members (occasionally up to four team members), and call playback survey broadcasting calls of amphibian species likely to occur. Each suitable call was played for five minutes, followed by a two minute listening period. Each call playback survey was preceded and followed by a ten minute listening period. The total survey effort conducted to detect each targeted amphibian species is provided in *Table 5.4*.

Target surveys were not conducted to detect the wallum froglet (*Crinia tinnula*) due to a lack of suitable habitat in the study area and the inappropriate season for detecting this species.

5.2.6 Tadpole Sampling

Dip netting for tadpoles was undertaken in 25 watercourses within the study area in conjunction with the aquatic fauna and habitat assessment conducted from 9 to 11 December, 1998 (Refer to *Working Paper 7* for sampling locations). A dip net with a 35 mm diameter and two mm mesh size was used. The netting technique consisted of scooping underneath overhanging vegetation, around snags and instream vegetation and along the creekbed. The duration of netting at each site varied depending on the abundance and size of pools, and the extent of instream and overhanging vegetation. Generally, a minimum of ten minutes netting was conducted at relatively degraded sites, while a maximum of 40 minutes was conducted at sites containing higher quality habitat.

5.2.7 *Reptile Searches*

Nocturnal reptile searches were conducted in conjunction with amphibian searches to detect the pale-headed snake (*Hoplocephalus bitorquatus*) and stephen's banded snake (*Hoplocephalus stephensii*). The searching technique included spotlight searching, and searching of fallen logs, decorticating and fallen bark, rock outcrops and other likely substrates. Two team members conducted each search for a minimum time period of 30 minutes. Nocturnal driving transects were also conducted along Nerong Road and the southern access road to Waterholes Gap to detect these species. Reptile survey sites are illustrated on *Figure 5.1*.

Diurnal searches were conducted for *Hoplocephalus* species at Mount Karuah, Burdekin's Gap and Jack's Creek (*Figure 5.1*). Each search was conducted by two team members for a minimum time period of 60 minutes.

5.2.8 *Ground-Based Elliott Trapping*

The initial ground-based Elliott survey conducted for the REF aimed primarily at determining the use of selected roadside vegetation by small ground mammals as wildlife corridors, and to identify the assemblage of small ground mammals within the study area. A total of five ground-based Elliott traplines were established in various habitats within the study area. A-type Elliott traps were set at 20 m intervals, in groups of ten, and left open for four nights (200 trap nights).

The surveys undertaken for the SIS used ground-based Elliott trapping primarily to detect the eastern chestnut mouse (*Pseudomys gracilicaudatus*). A total of six ground-based Elliott traplines were established in suitable habitat within the study area. The most suitable habitat within the study area for this species consisted of dry open forest with moderate to dense groundcover vegetation. A-type Elliott traps were set at 20 m intervals, in groups of ten, and left open for four nights (240 trap nights). All transects were located within 300 m of the existing highway. Three transects were placed east of the existing highway within Nerong State Forest (*Figure 5.2*). One transect was placed within suitable habitat at Waterholes Gap, Nerong Waterholes and Mount Karuah (*Figure 5.2*). The bait used consisted of a mixture of rolled oats, honey and peanut butter.

5.2.9 *Hairtube Sampling*

During the initial surveys conducted for the REF a total of 45 hairtubes were set within nine transects in areas identified as potential fauna movement corridors and areas containing potentially significant habitats. Each transect consisted of five hairtubes spaced 20 m apart. A total of 450 sampling nights were performed.

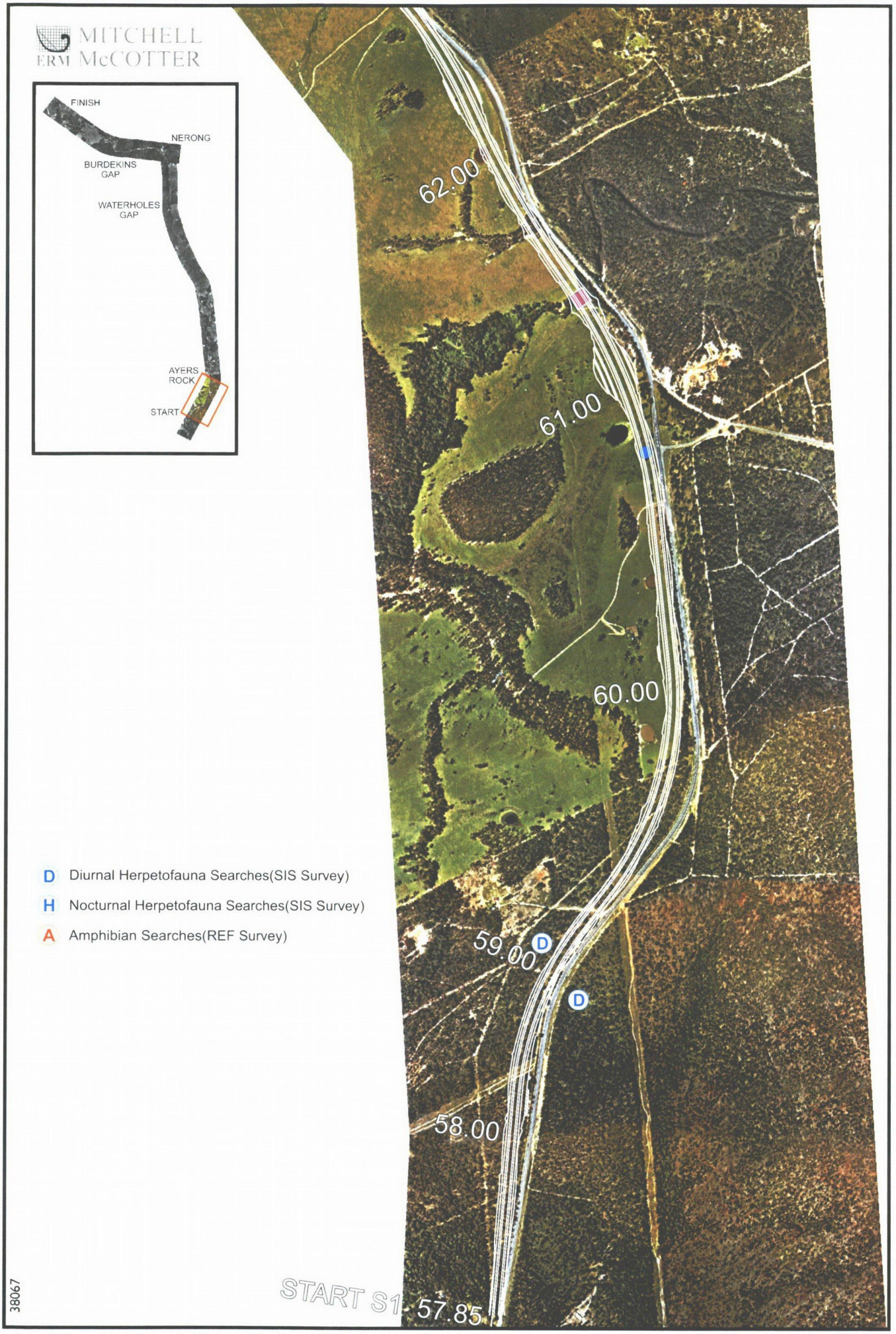


Figure 5.1a LOCATION OF HERPETOFAUNA SURVEY SITES WITHIN THE STUDY AREA

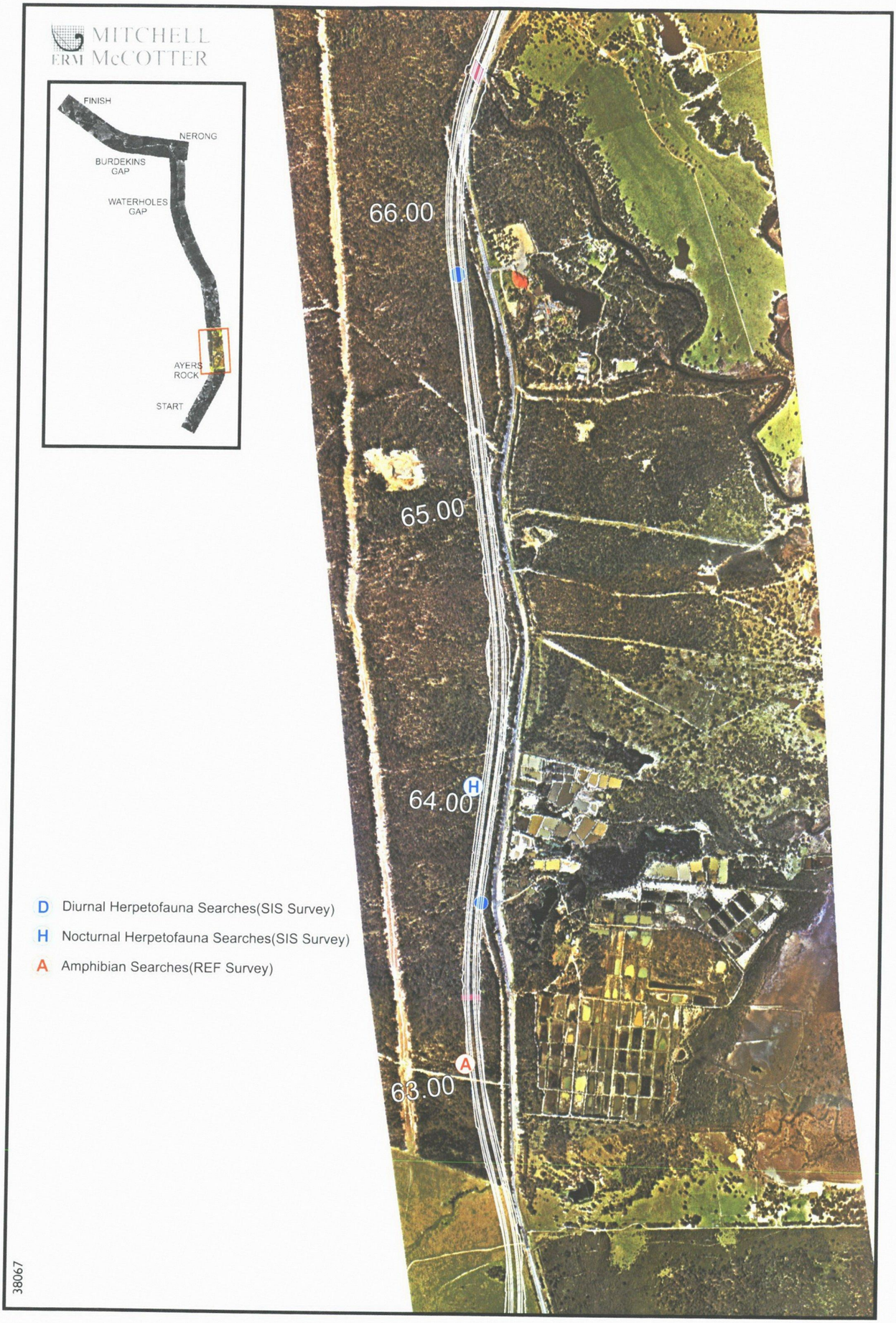


Figure 5.1b LOCATION OF HERPETOFAUNA SURVEY SITES WITHIN THE STUDY AREA

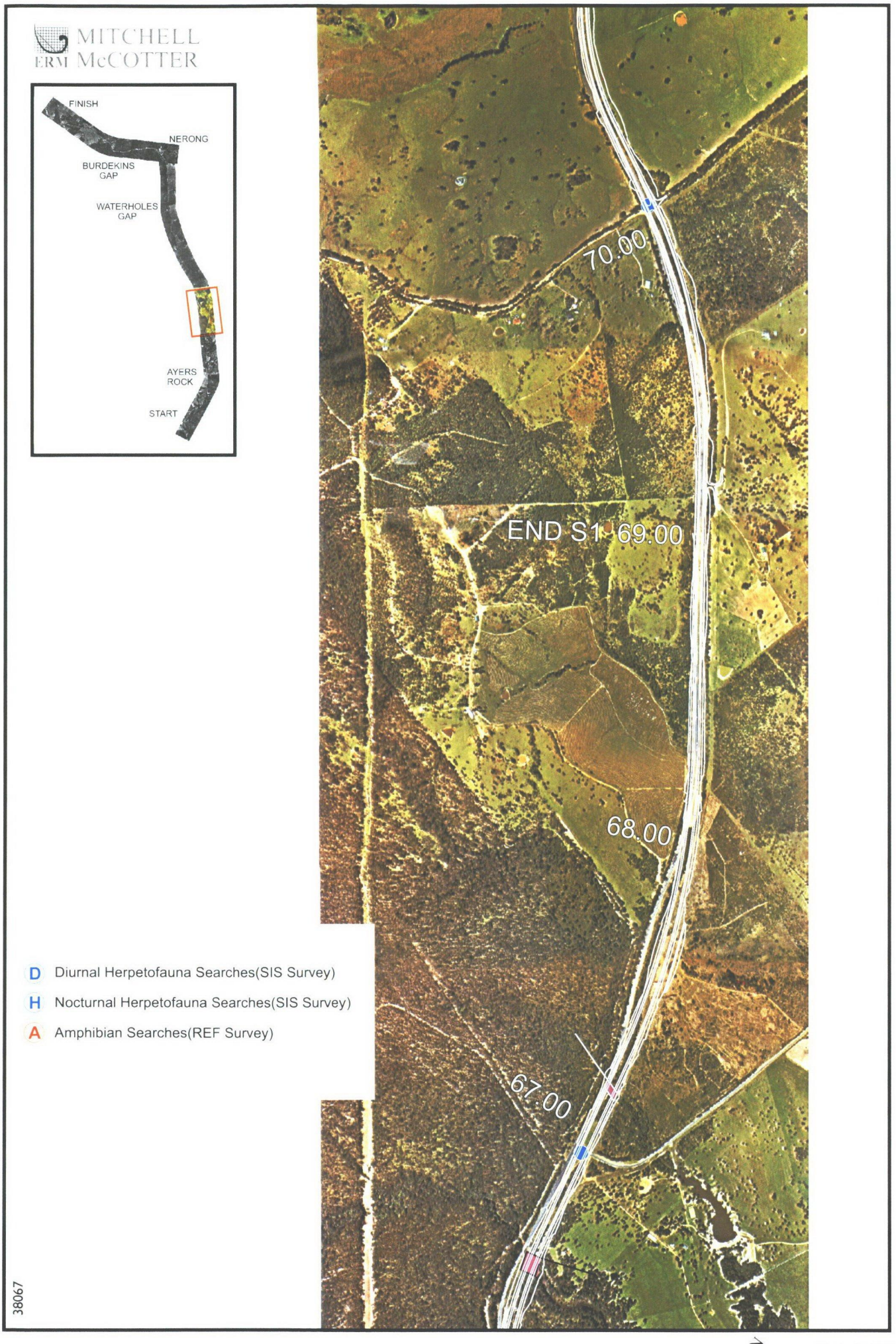


Figure 5.1c LOCATION OF HERPETOFAUNA SURVEY SITES WITHIN THE STUDY AREA

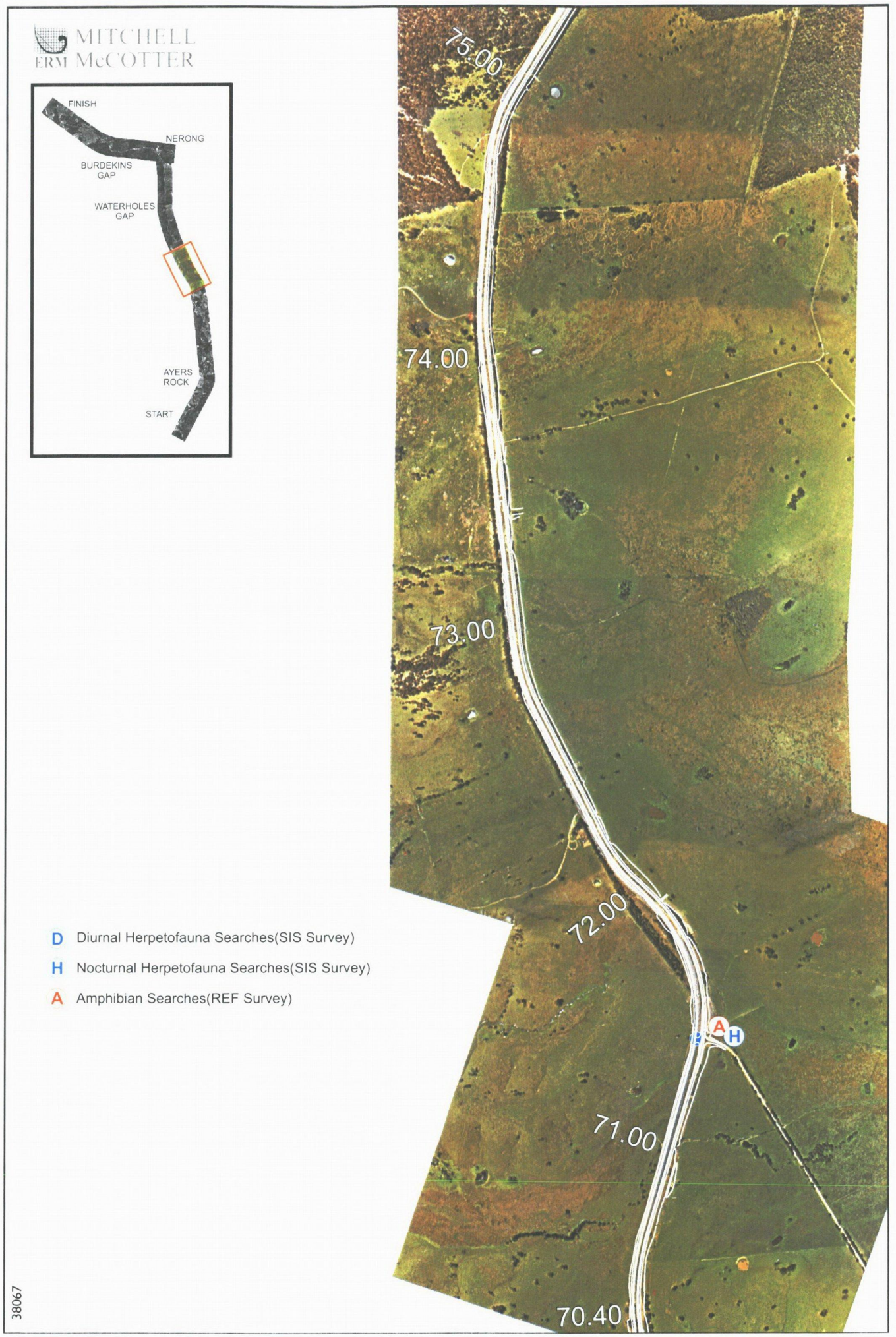


Figure 5.1d LOCATION OF HERPETOFAUNA SURVEY SITES WITHIN THE STUDY AREA

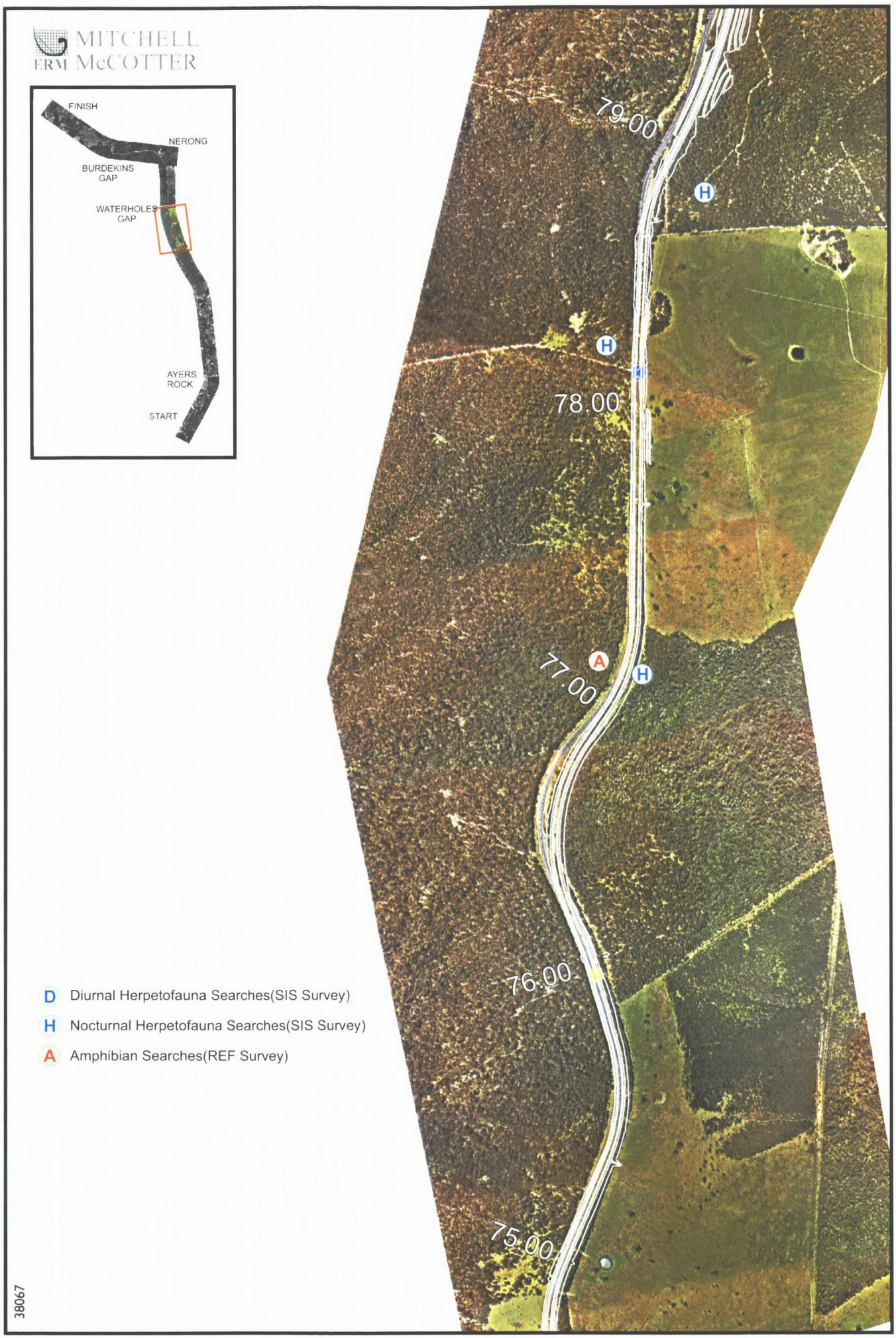


Figure 5.1e LOCATION OF HERPETOFAUNA SURVEY SITES WITHIN THE STUDY AREA

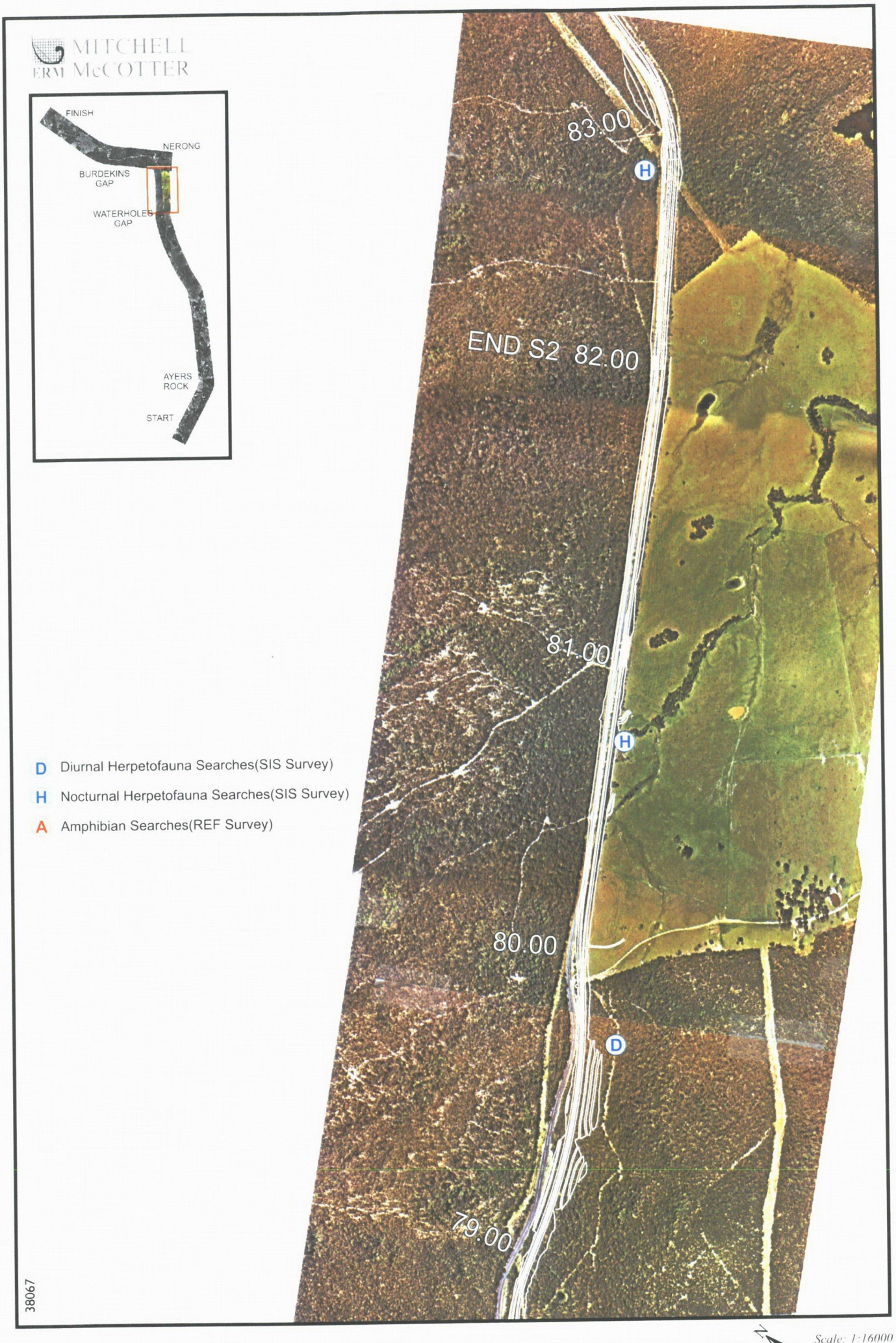


Figure 5.1f LOCATION OF HERPETOFAUNA SURVEY SITES WITHIN THE STUDY AREA

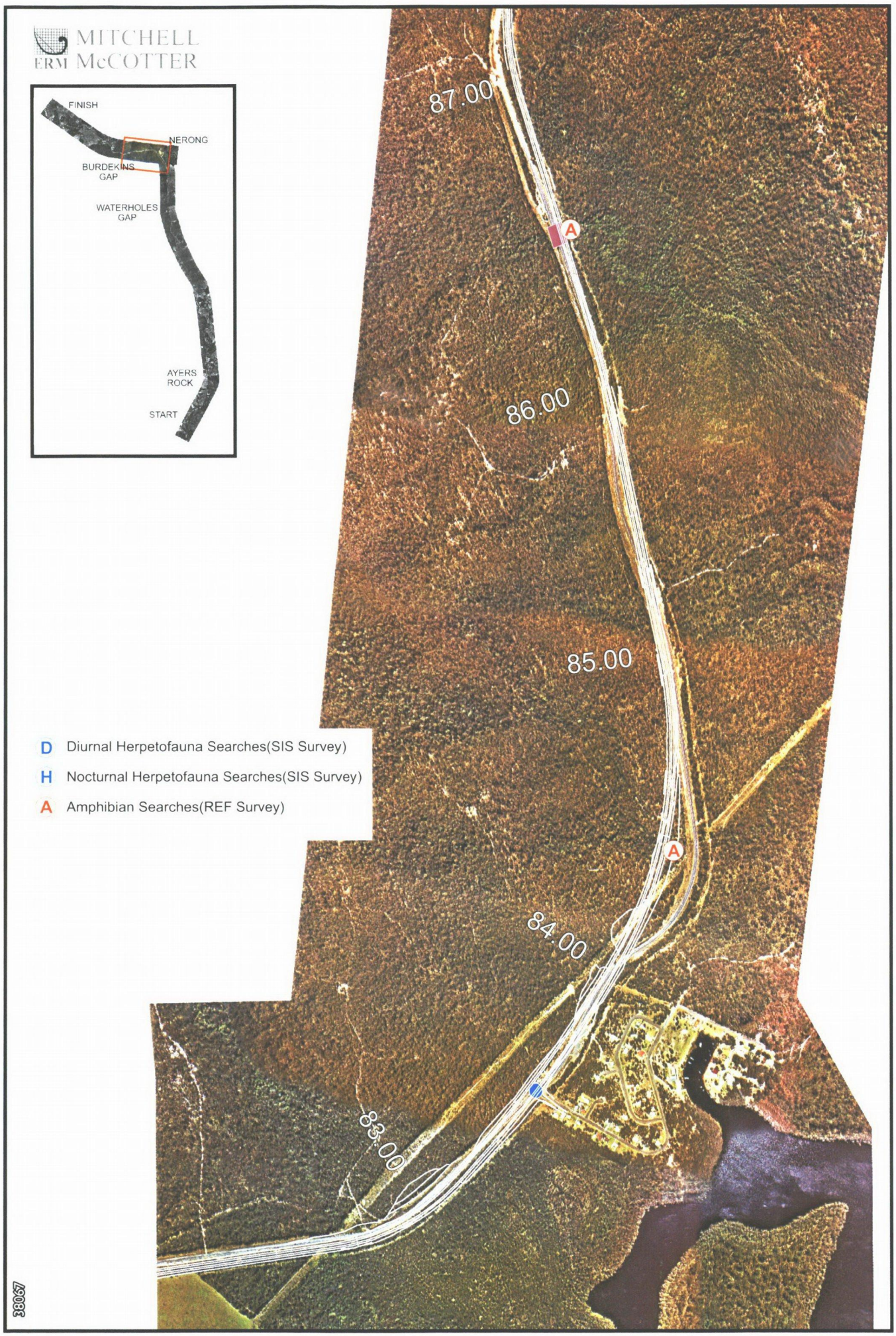


Figure 5.1g LOCATION OF HERPETOFAUNA SURVEY SITES WITHIN THE STUDY AREA

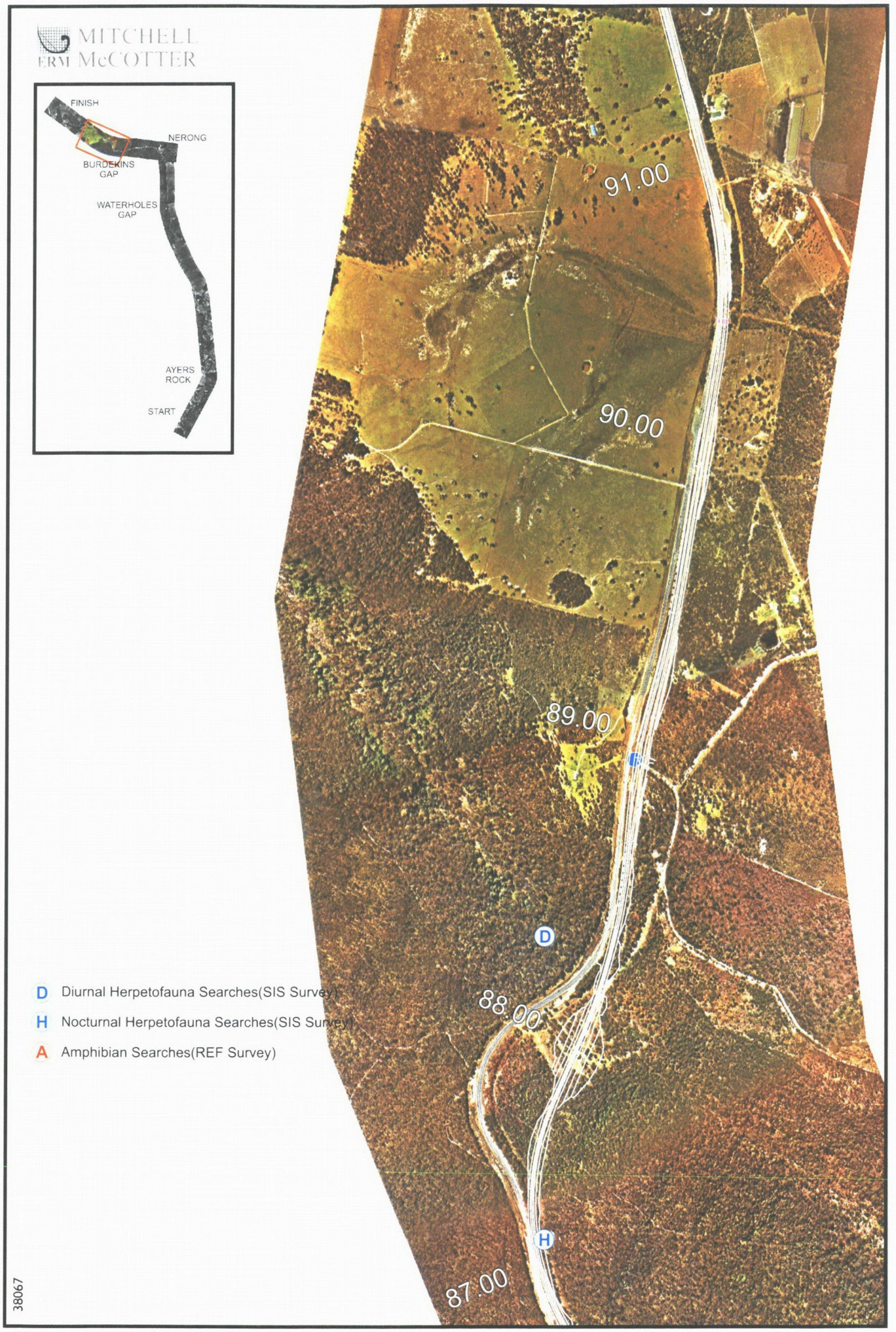


Figure 5.1h LOCATION OF HERPETOFAUNA SURVEY SITES WITHIN THE STUDY AREA

Figure 5.1i LOCATION OF HERPETOFAUNA SURVEY SITES WITHIN THE STUDY AREA

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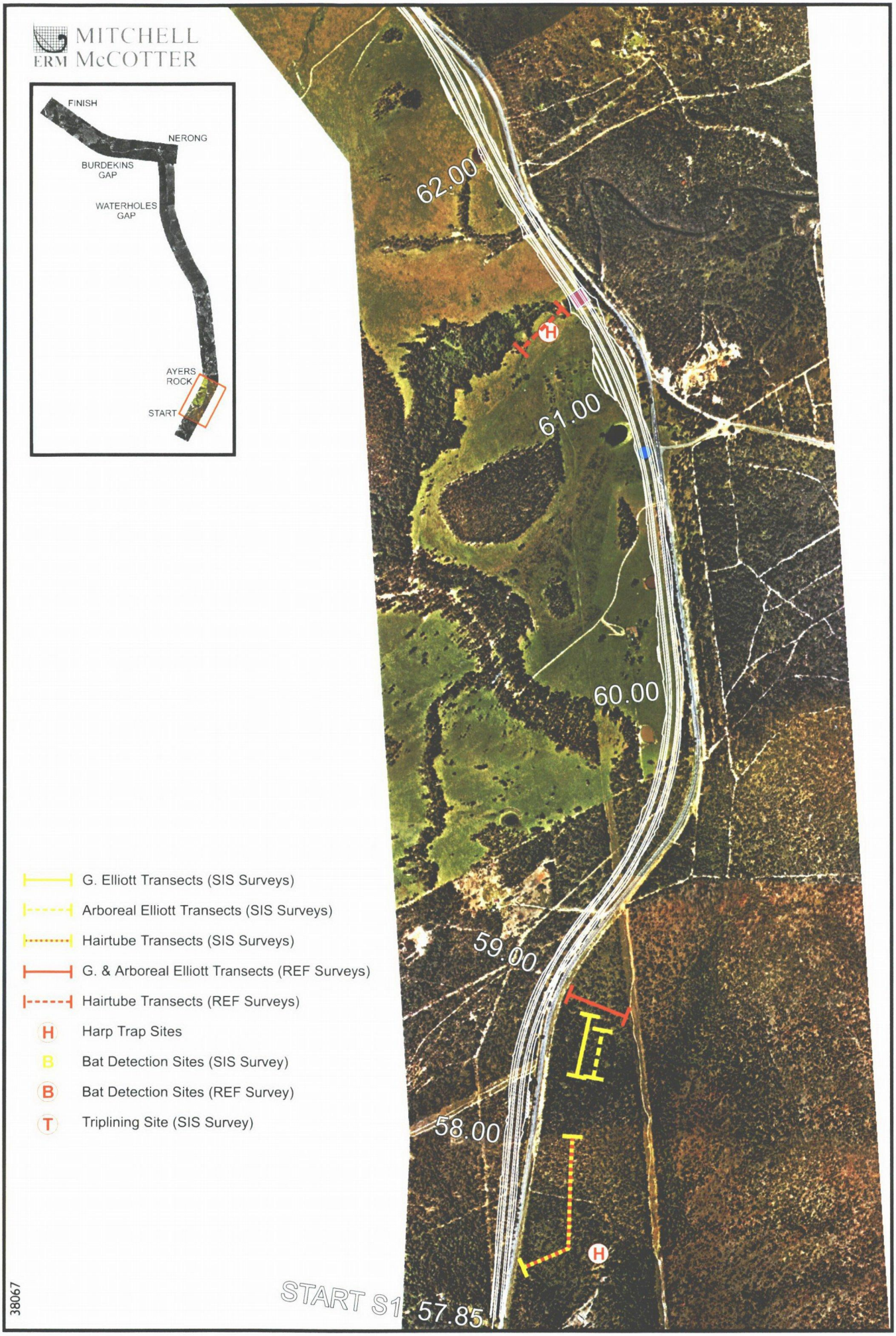

Figure 5.2a LOCATION OF HAIRTUBE TRANSECTS, GROUND - BASED AND ARBOREAL ELLIOTT TRANSECTS, BAT TRAPPING AND DETECTION SITES

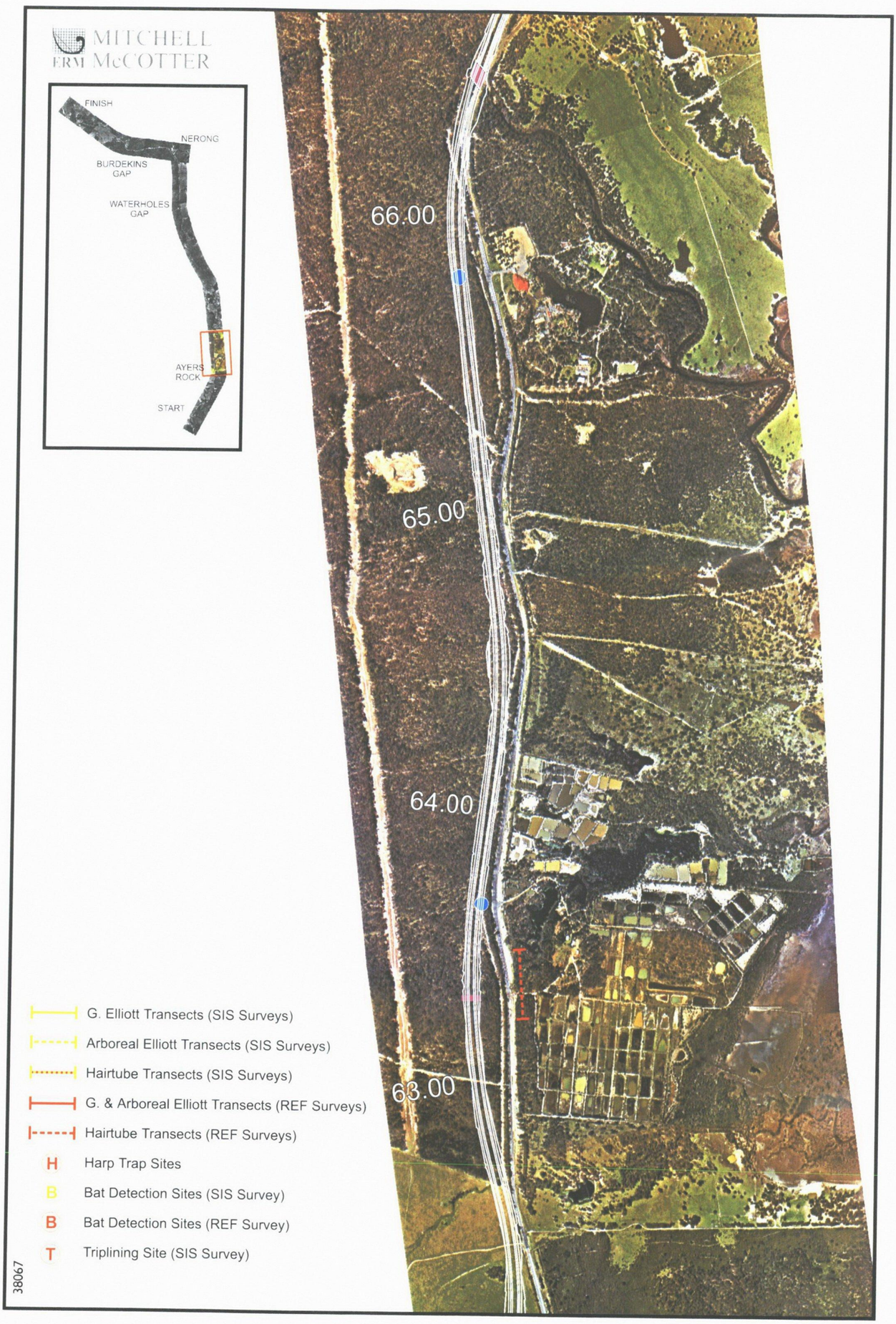

Figure 5.2b LOCATION OF HAIRTUBE TRANSECTS, GROUND - BASED AND ARBOREAL ELLIOTT TRANSECTS, BAT TRAPPING AND DETECTION SITES

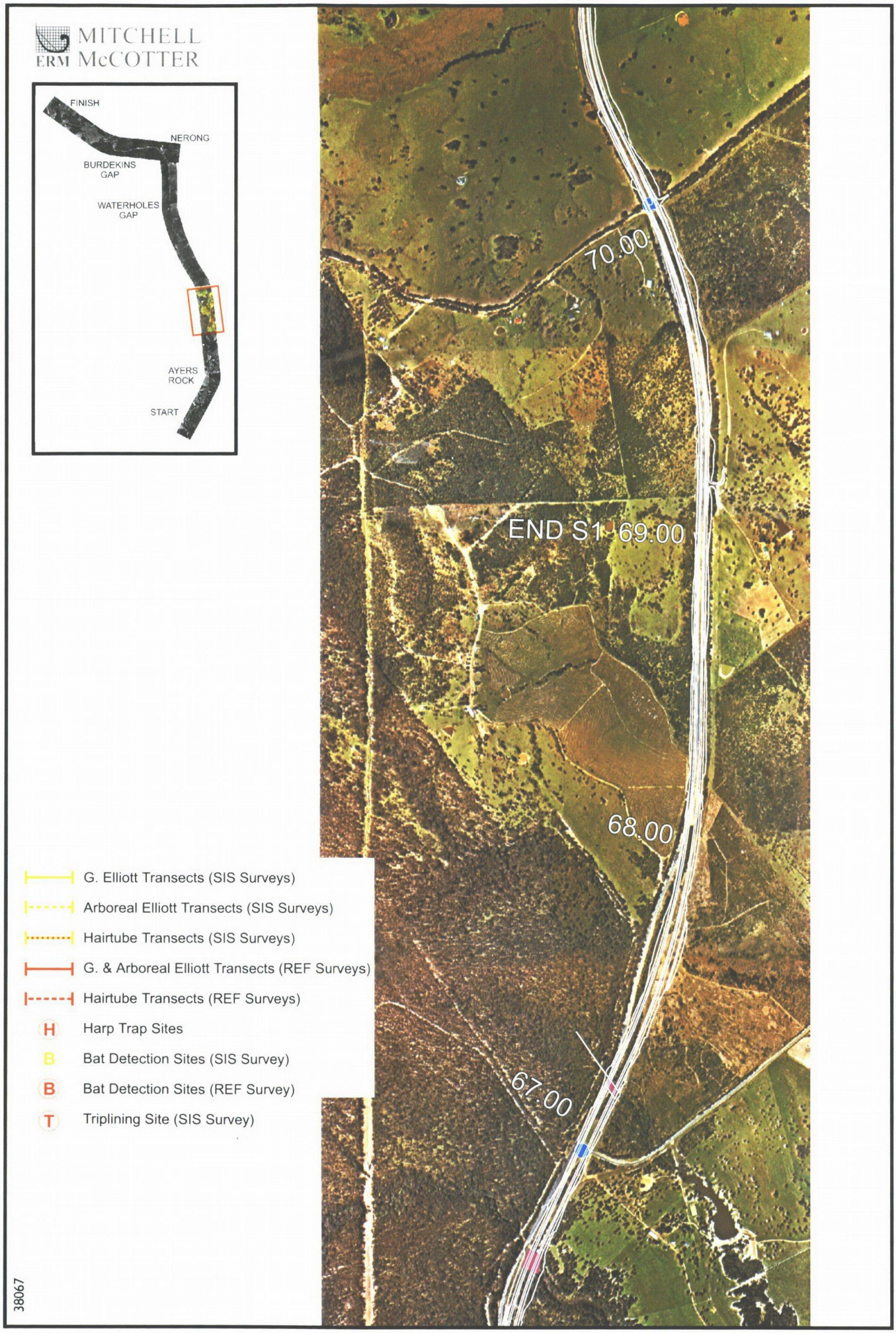

Figure 5.2c LOCATION OF HAIRTUBE TRANSECTS, GROUND - BASED AND ARBOREAL ELLIOTT TRANSECTS, BAT TRAPPING AND DETECTION SITES

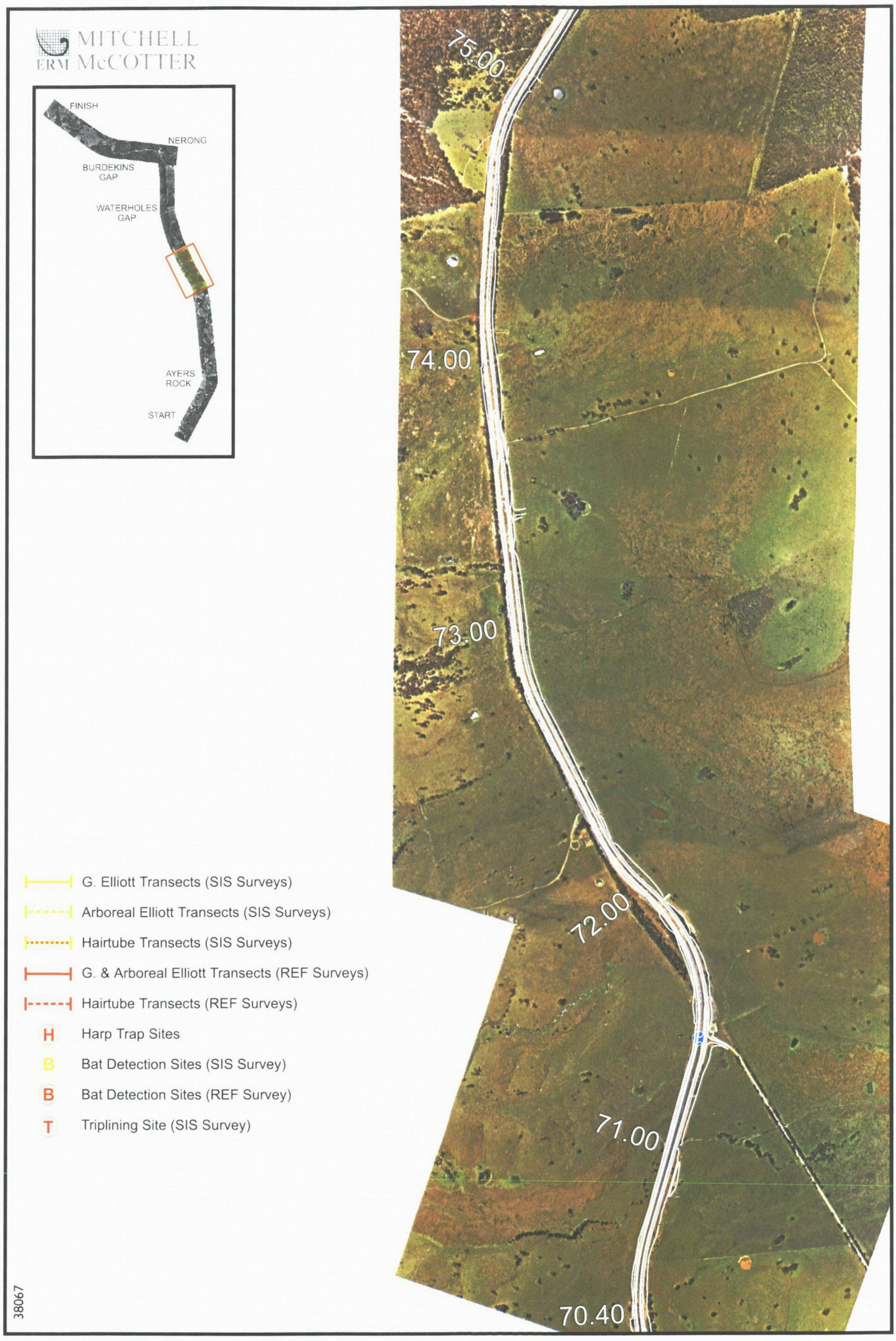

Figure 5.2d LOCATION OF HAIRTUBE TRANSECTS, GROUND - BASED AND ARBOREAL ELLIOTT TRANSECTS, BAT TRAPPING AND DETECTION SITES

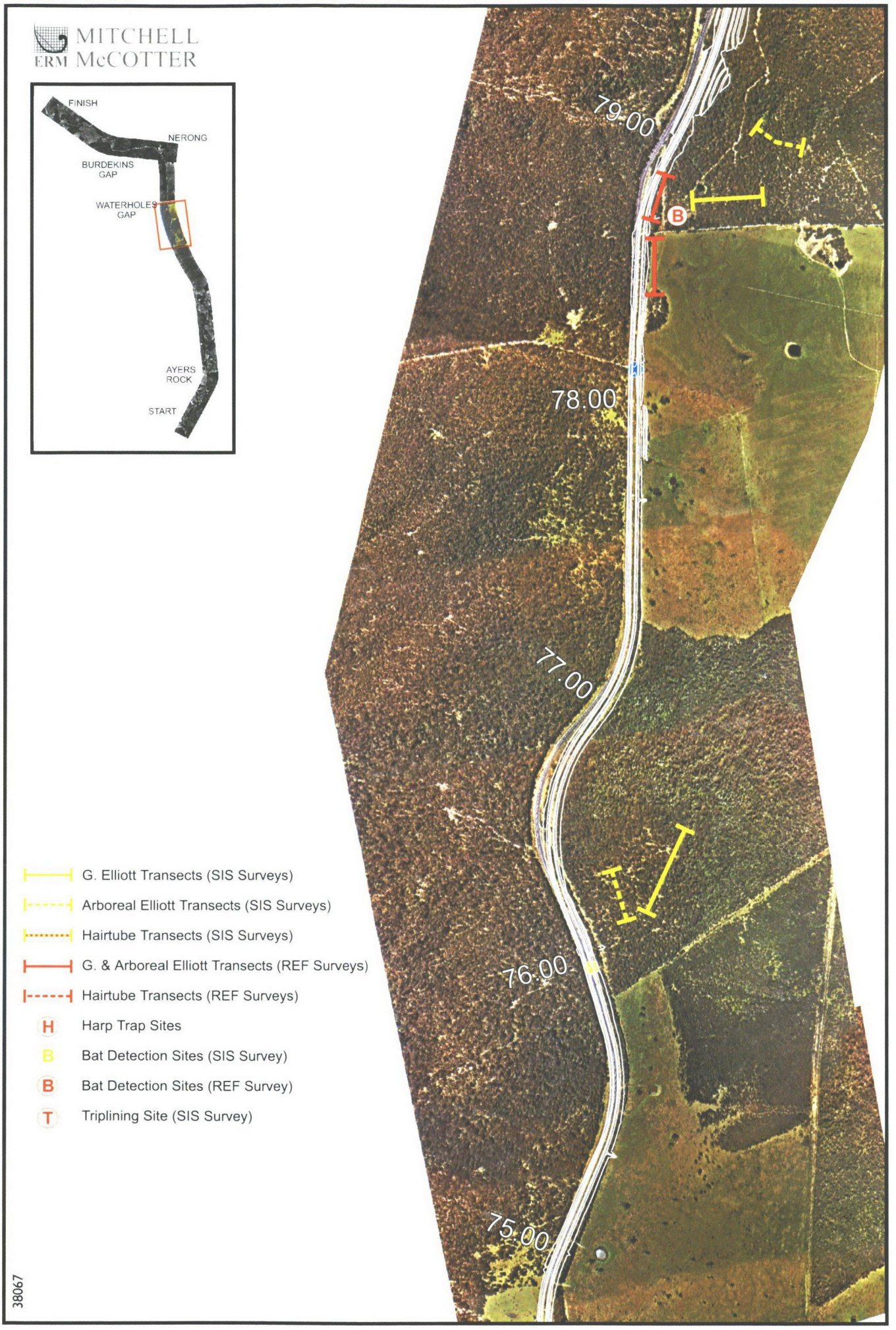

Figure 5.2e LOCATION OF HAIRTUBE TRANSECTS, GROUND - BASED AND ARBOREAL ELLIOTT TRANSECTS, BAT TRAPPING AND DETECTION SITES

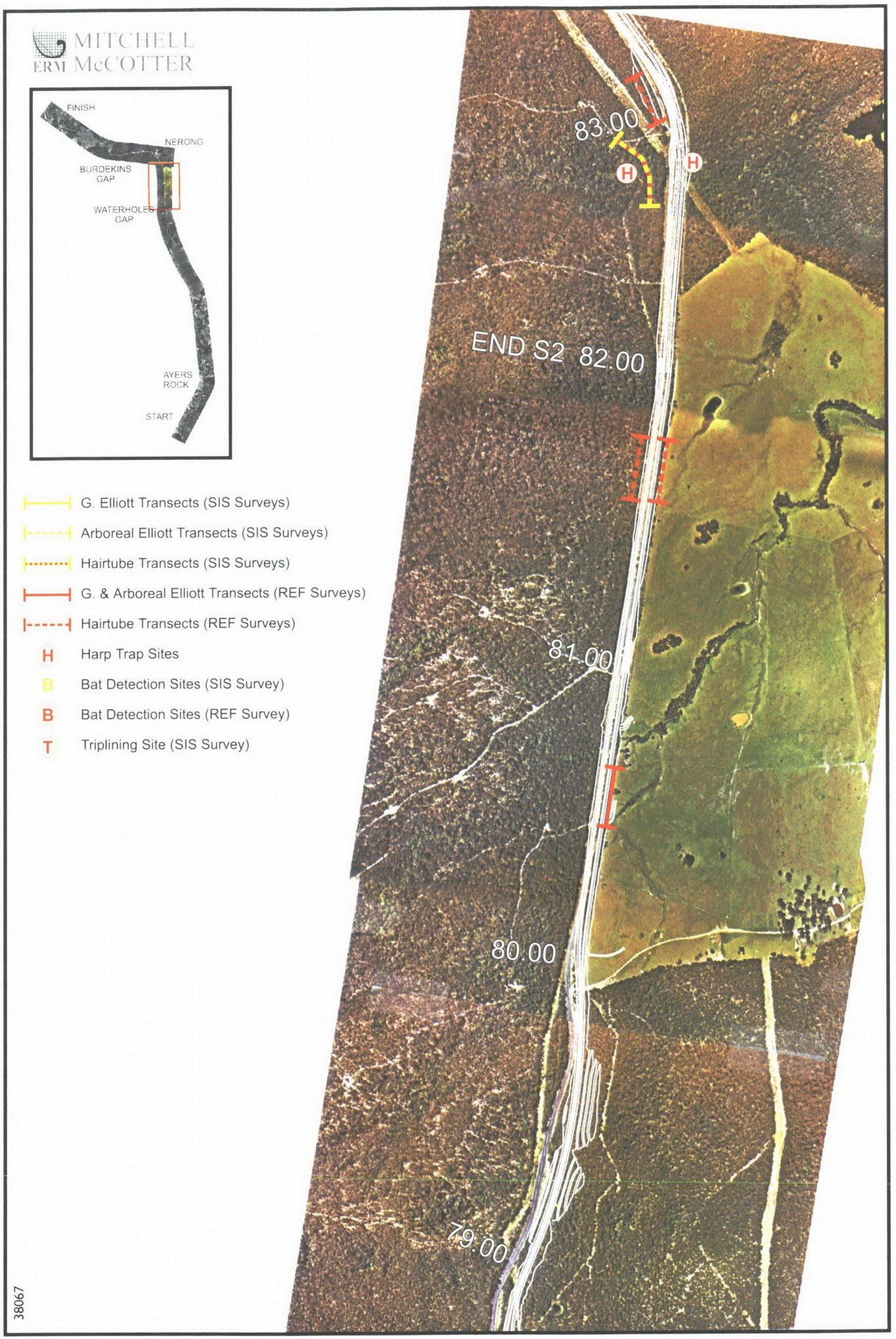

Figure 5.2f LOCATION OF HAIRTUBE TRANSECTS, GROUND - BASED AND ARBOREAL ELLIOTT TRANSECTS, BAT TRAPPING AND DETECTION SITES

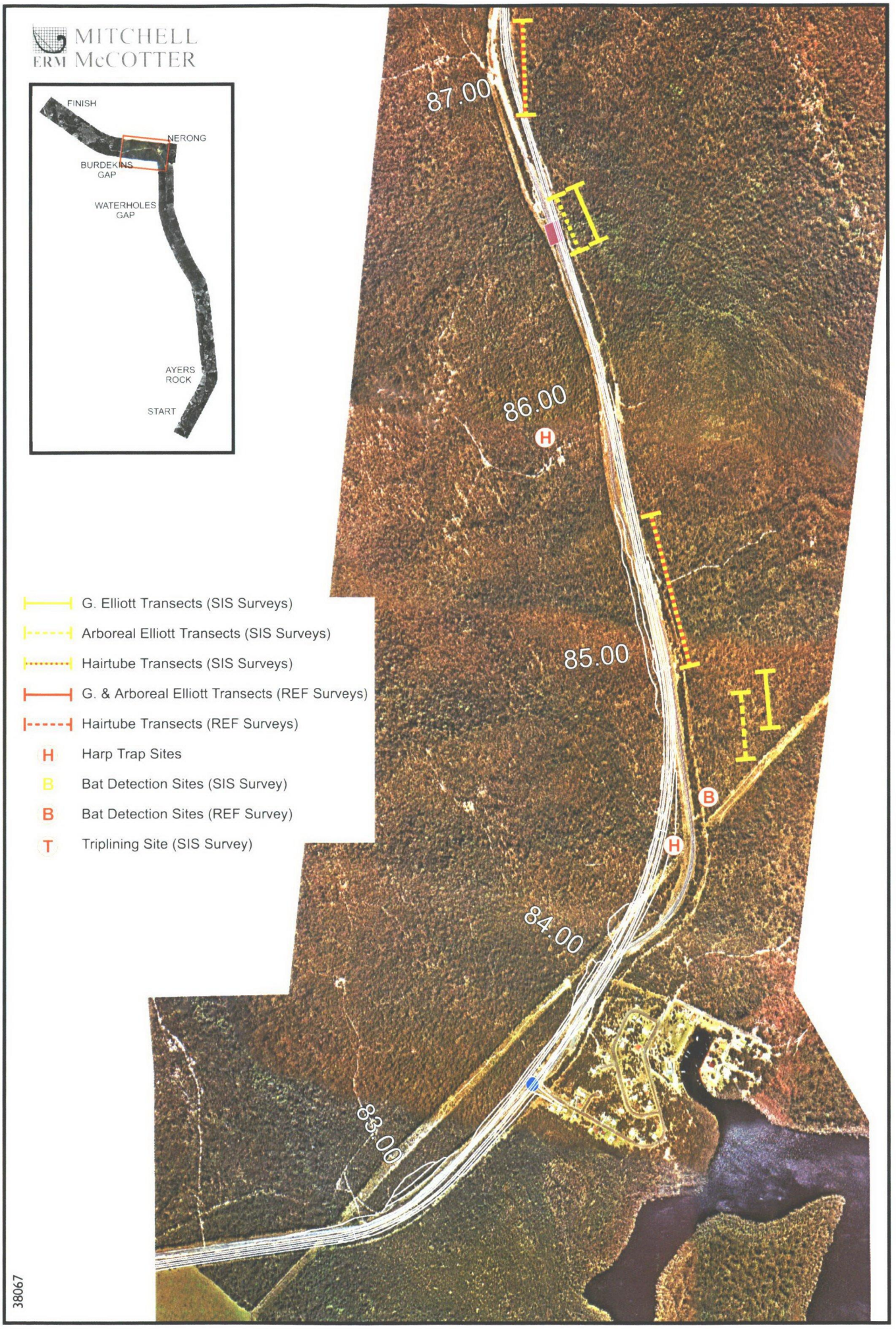

Figure 5.2g LOCATION OF HAIRTUBE TRANSECTS, GROUND - BASED AND ARBOREAL ELLIOTT TRANSECTS, BAT TRAPPING AND DETECTION SITES

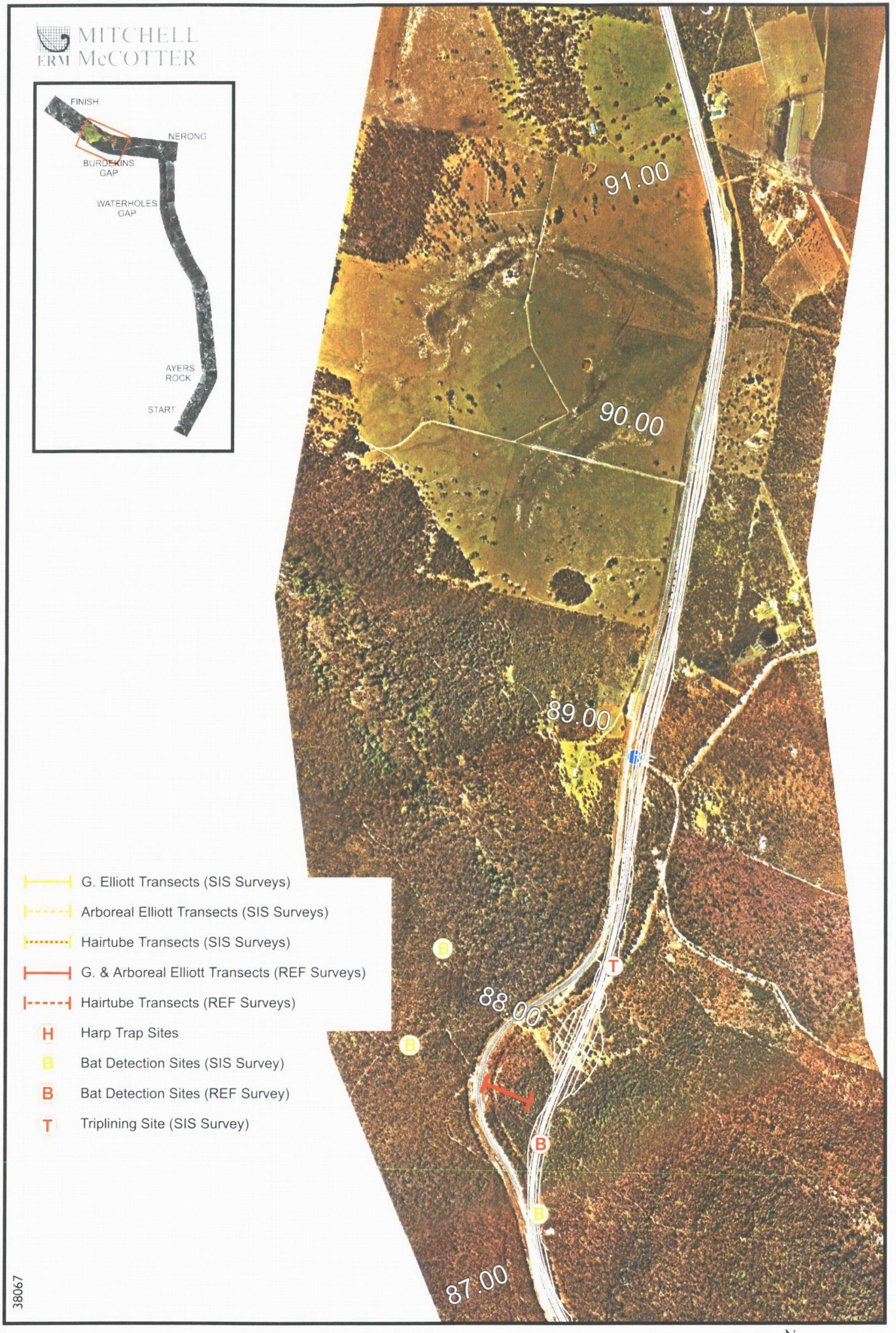

Figure 5.2h LOCATION OF HAIRTUBE TRANSECTS, GROUND - BASED AND ARBOREAL ELLIOTT TRANSECTS, BAT TRAPPING AND DETECTION SITES

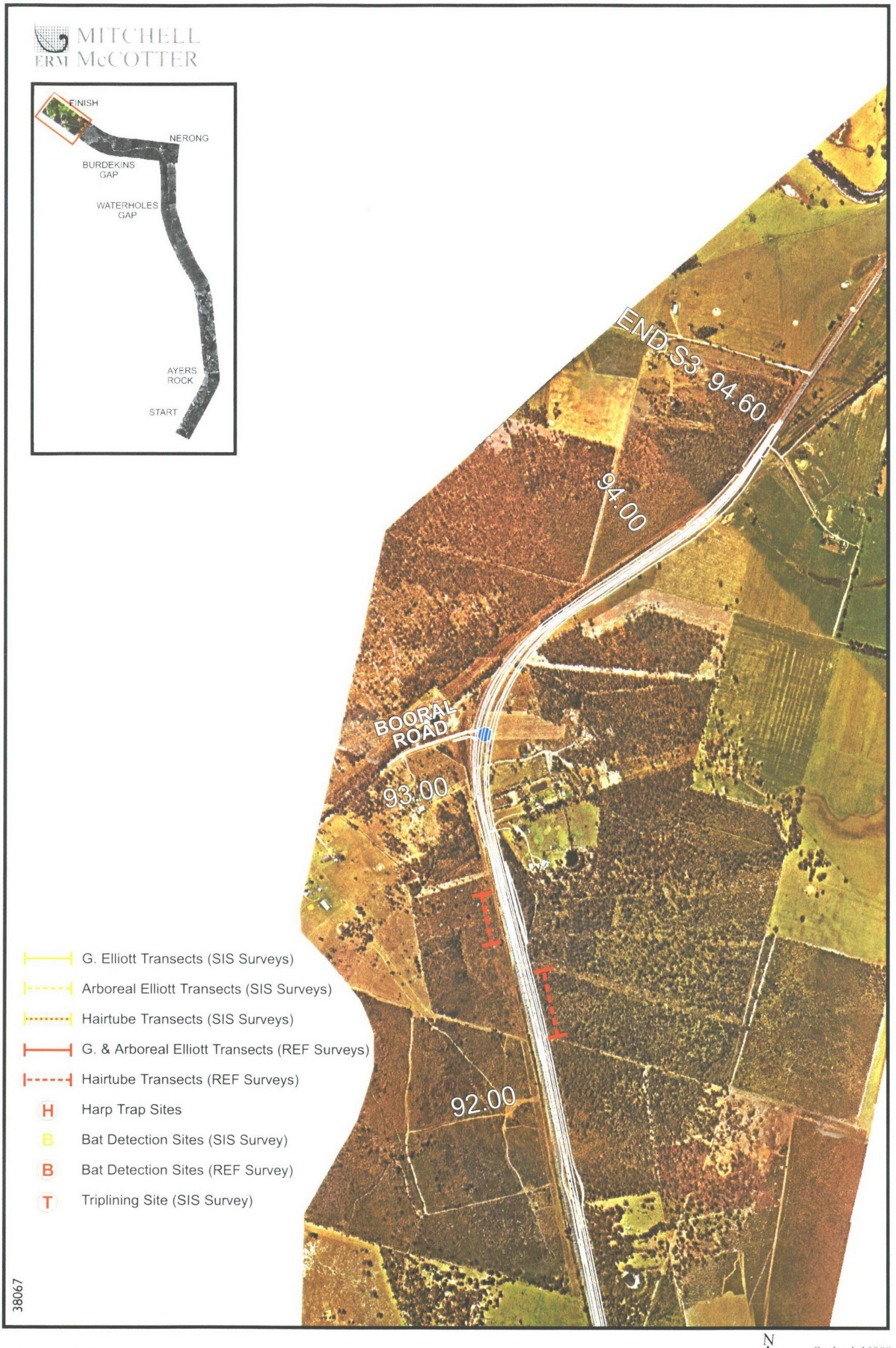

Figure 5.2i LOCATION OF HAIRTUBE TRANSECTS, GROUND - BASED AND ARBOREAL ELLIOTT TRANSECTS, BAT TRAPPING AND DETECTION SITES

The hairtube sampling for the SIS targeted the brushtailed phascogale (*Phascogale tapoatafa)*. The CRA habitat models indicated that a large area of intermediate habitat for this species in the form of dry open forest potentially existed on the eastern side of the Pacific Highway within Nerong State Forest. Ground truthing confirmed that sub-optimal habitat for the species did occur at this location and near Mount Karuah. Therefore, three transects were established in Nerong State Forest, and one transect was established near Mount Karuah. A total of 398 sampling nights were performed at four sampling locations. The numbers of hairtubes used on each transect varied due to several hairtubes being stolen during the sampling period. All transects remained in the field for a minimum of ten survey nights.

The location of all hairtube transects within the study area are illustrated in *Figure 5.2*.

5.2.10 Arboreal Elliott Trapping

The initial arboreal Elliott survey conducted for the REF aimed primarily at determining the use of selected roadside vegetation by arboreal mammals as wildlife corridors, and to identify the assemblage of arboreal mammals within the study area. Two arboreal B- type Elliott traps were placed on suitable trees in close vicinity to each ground-based Elliott transect (40 trap nights).

The surveys conducted for the SIS used Arboreal Elliott trapping to detect the squirrel glider (*Petaurus norfolkensis*), yellow-bellied glider (*Petaurus australis*) and brush-tailed phascogale (*Phascogale tapoatafa*). A total of five arboreal Elliott transects were established in suitable habitat within the study area. B-type Elliott traps were set at 50 metre intervals, in groups of ten, and left open for four nights (200 trap nights). Two transects were placed approximately 100 m east of the existing highway within Nerong State Forest (*Figure 5.2*). One transect was placed within suitable habitat at Waterholes Gap, Nerong Waterholes and Mount Karuah (*Figure 5.2*). The bait used consisted of a mixture of rolled oats, honey and peanut butter. Every second trap was baited with meat.

5.2.11 Spotlighting Surveys

The initial spotlighting surveys conducted for the REF aimed primarily at identifying the assemblage of arboreal mammals within 100 m of the existing Pacific Highway. Particular attention was paid to vegetation at Burdekin's Gap, Grey Gum Gully, Waterholes Gap, Nerong Waterholes and Mount Karuah. A total of two hours spotlighting was conducted by two team members per night for four nights (total eight hours).

The spotlighting surveys conducted for the SIS aimed primarily at detecting the squirrel glider (*Petaurus norfolkensis*), yellow-bellied glider (*Petaurus australis*) and brush-tailed phascogale (*Phascogale tapoatafa*). A total of 3.5 kilometres of transects were established within Nerong State Forest (2x1 kilometre transects, 3x0.5 kilometre transects). A 500 m transect was established at Waterholes Gap, and one kilometre transects were established at Nerong Waterholes and Mount Karuah. A total transect distance of six kilometres was covered during the spotlighting surveys. With the exception of Nerong Waterholes, all transects were completed four times over four non-consecutive nights in suitable weather conditions. With the exception of Mount Karuah, all transects were located within vegetation types containing preferred koala feed trees. Each transect was surveyed by two team members walking at approximately one kilometre per hour.

Driving transects were established along Nerong Road (three kilometres) and the southern access road to Waterholes Gap (two kilometres). The mean speed of the vehicle was maintained at approximately five kilometres per hour. Each driving transect was conducted twice over two non-consecutive nights.

Spotlighting was only undertaken during suitable weather conditions, characterised by mild temperatures, low wind and no rainfall. The location of all spotlighting transects within the study area are illustrated in *Figure 5.3*.

5.2.12 Call Playback Surveys

Call Playback was undertaken to detect the masked owl (*Tyto novaehollandiae*), sooty owl (*Tyto tenebricosa*), powerful owl (*Ninox strenua*), barking owl (*Ninox connivens*), squirrel glider (*Petaurus norfolkensis*), yellow-bellied glider (*Petaurus australis*) and the koala (*Phascolarctos cinereus*).

A total of two call playback sites were selected within Nerong State Forest, one site was established at Waterholes Gap and Nerong Waterholes, and two sites were established at Mount Karuah. The location of all call playback sites within the study area are illustrated in *Figure 5.3*.

A complete set of calls (seven in total) was played once at each site per night over four non-consecutive nights. Each call playback survey comprised of an initial 10 minute listening period, followed by five minutes call of a species followed by two minutes listening. A final 10 minute listening period was conducted after all calls were complete.

Two team members undertook each call playback survey. One team member was placed approximately 100 m from the megaphone, while the other team member remained within 20 m of the megaphone. Both team members used a spotlight

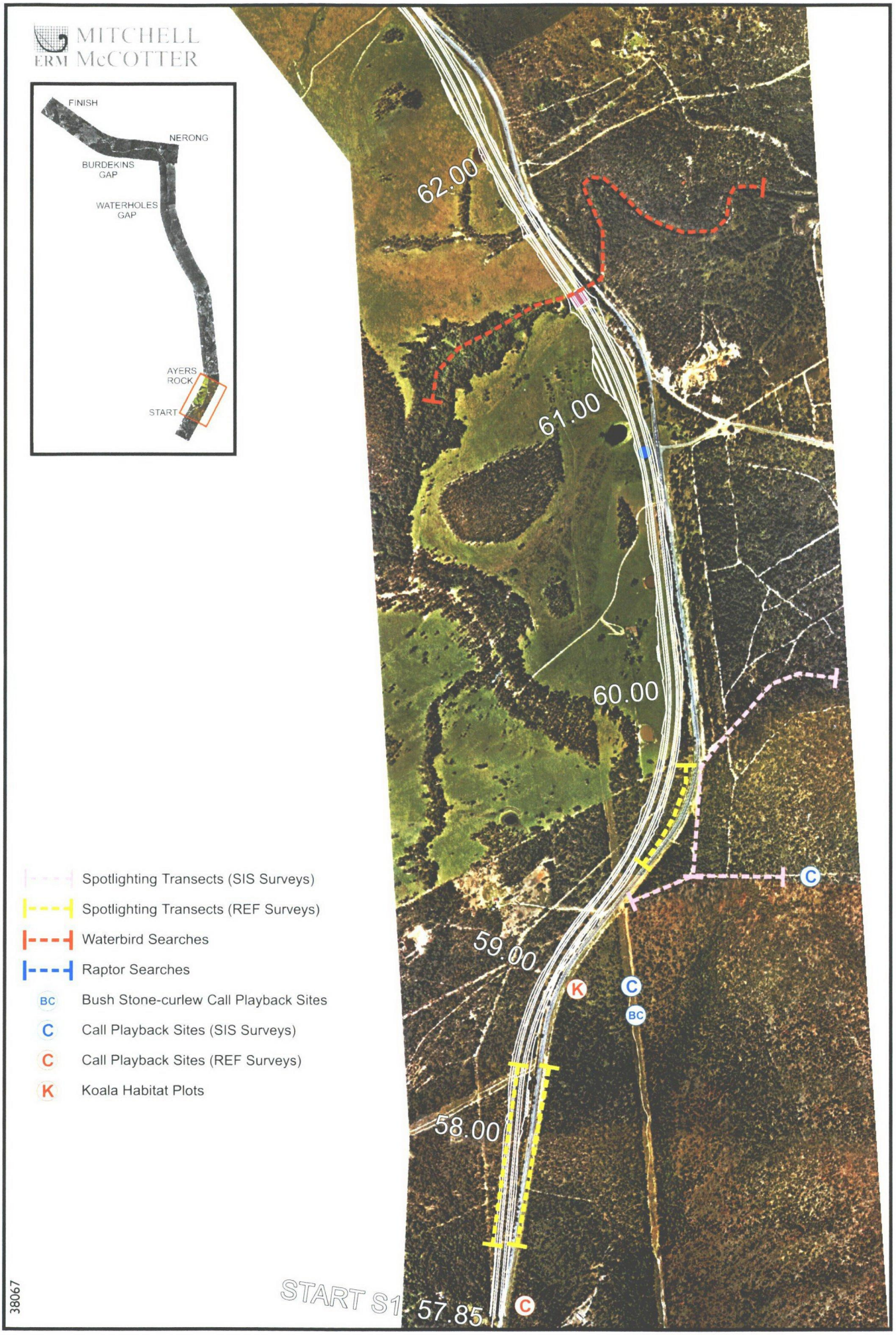

Figure 5.3a LOCATION OF SPOTLIGHTING TRANSECTS, CALL PLAYBACK SITES, WATERBIRD SEARCHES, RAPTOR SURVEYS AND KOALA HABITAT PLOTS

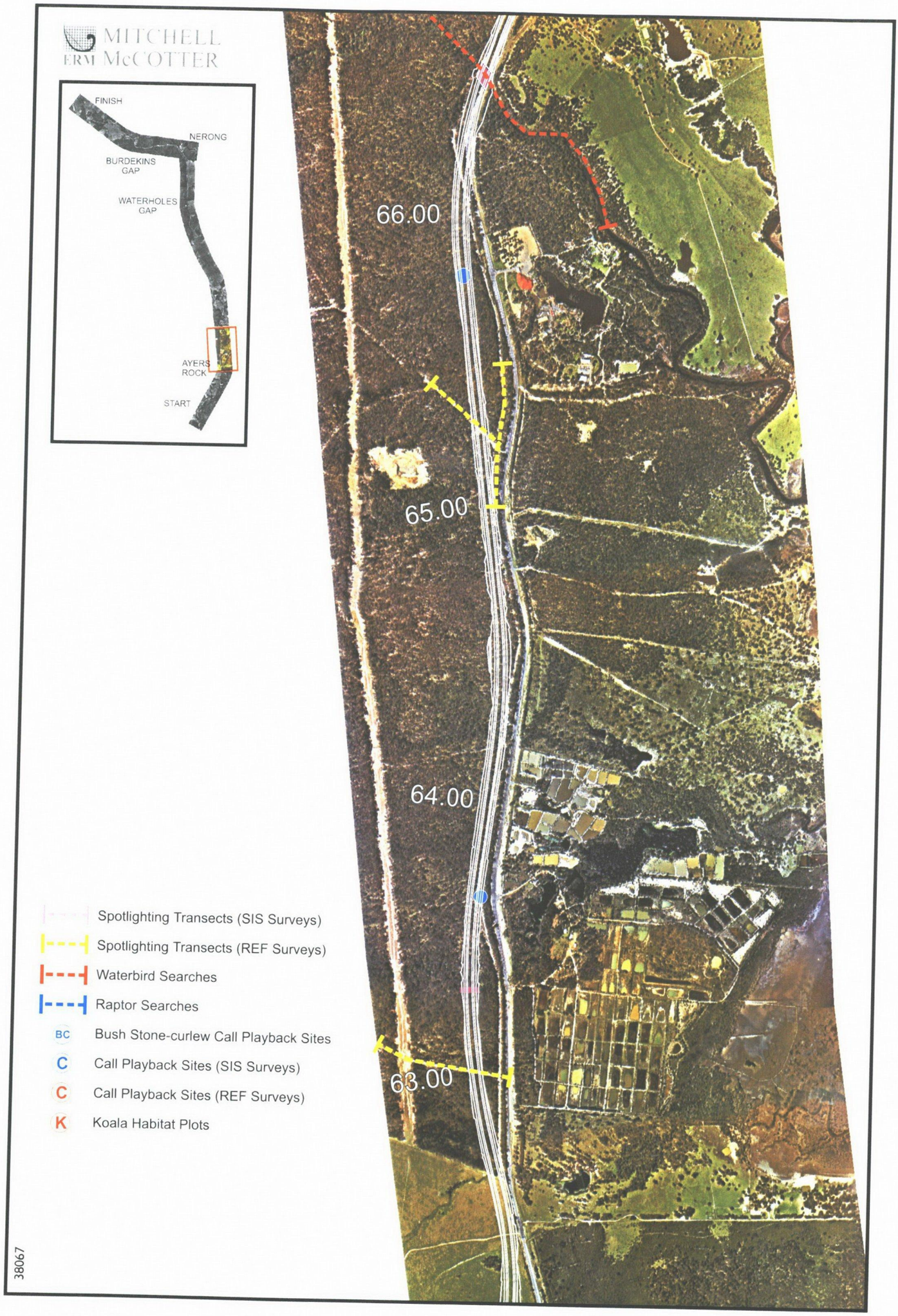

Figure 5.3b LOCATION OF SPOTLIGHTING TRANSECTS, CALL PLAYBACK SITES, WATERBIRD SEARCHES, RAPTOR SURVEYS AND KOALA HABITAT PLOTS

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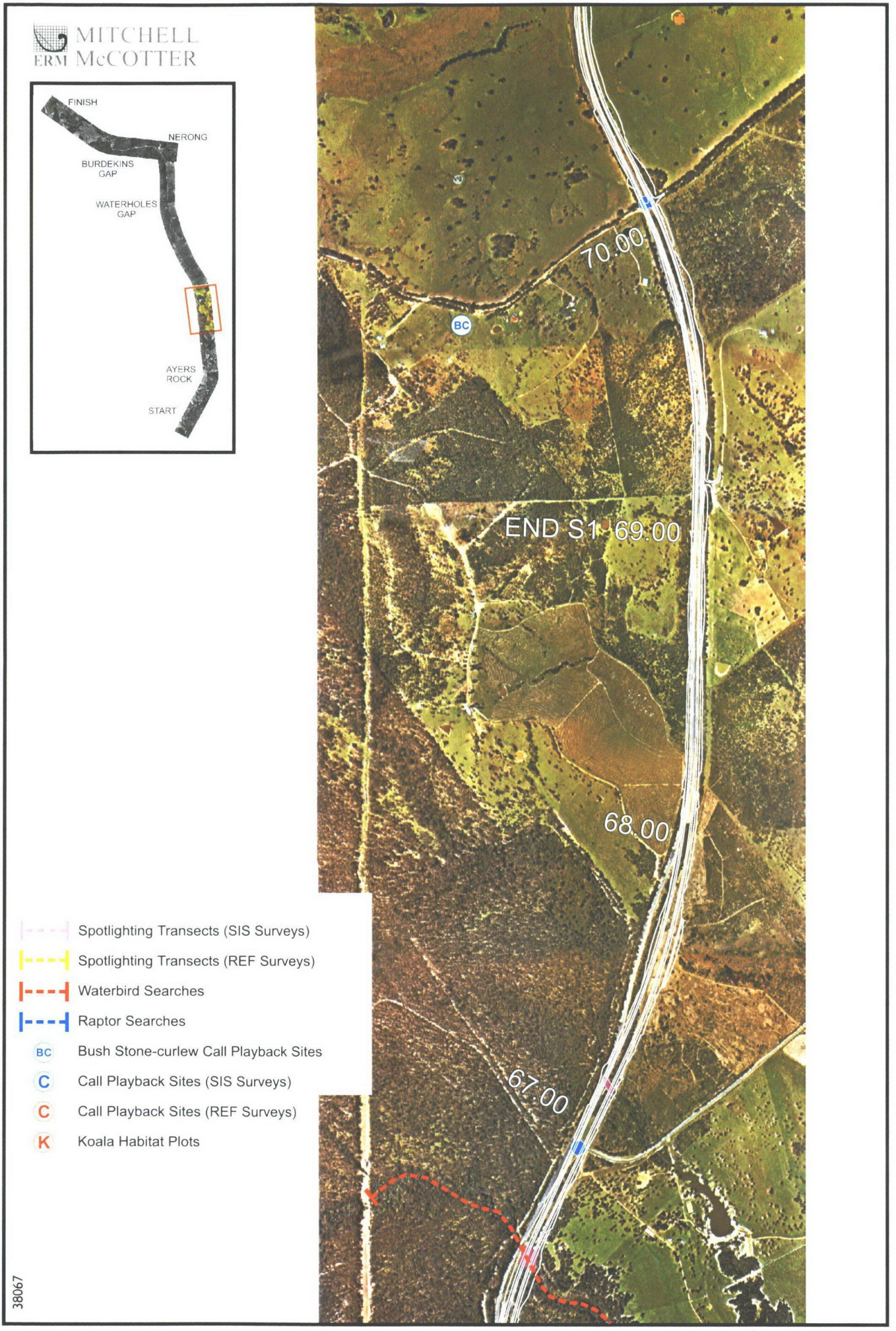

Figure 5.3c LOCATION OF SPOTLIGHTING TRANSECTS, CALL PLAYBACK SITES, WATERBIRD SEARCHES, RAPTOR SURVEYS AND KOALA HABITAT PLOTS

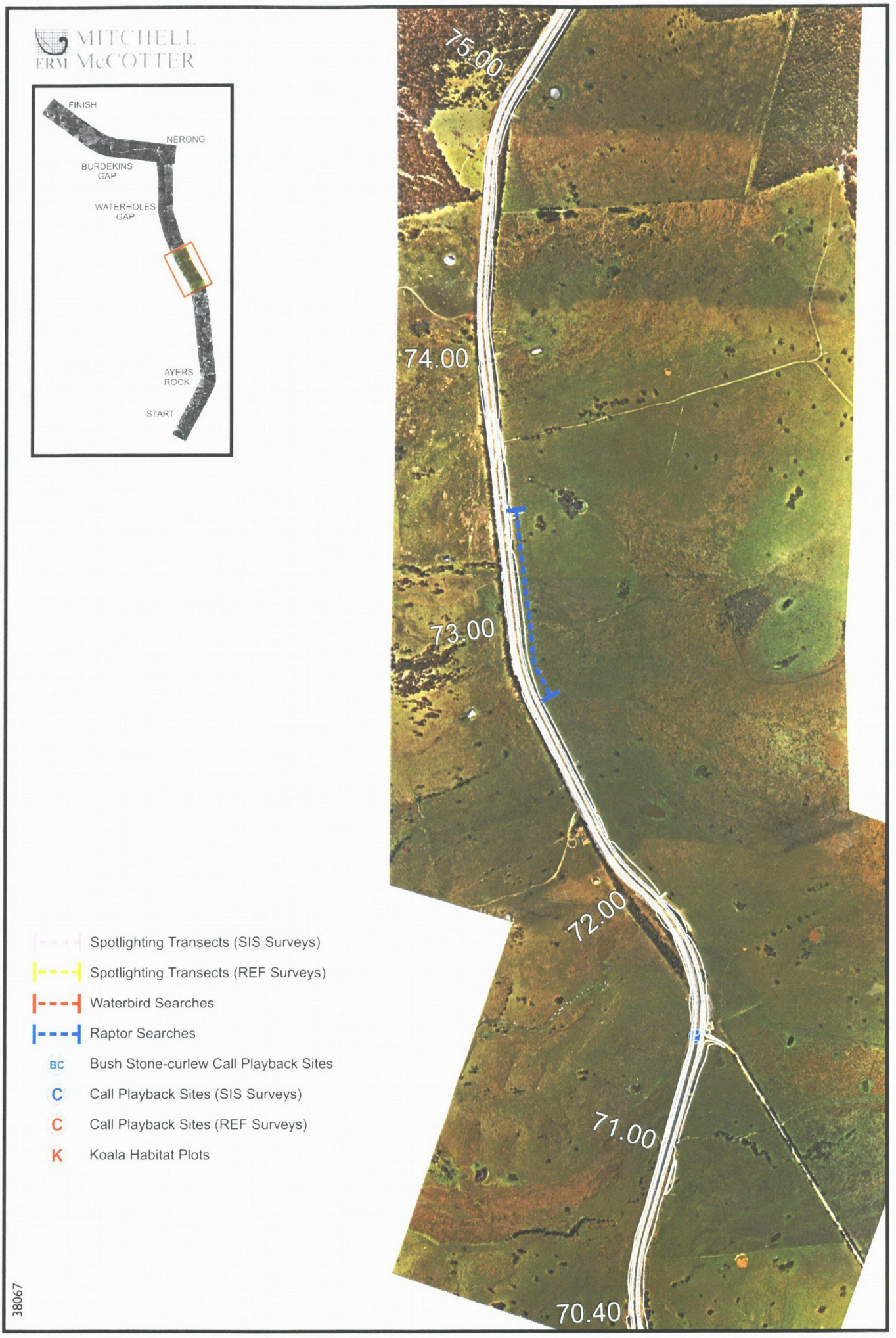

Figure 5.3d LOCATION OF SPOTLIGHTING TRANSECTS, CALL PLAYBACK SITES, WATERBIRD SEARCHES, RAPTOR SURVEYS AND KOALA HABITAT PLOTS

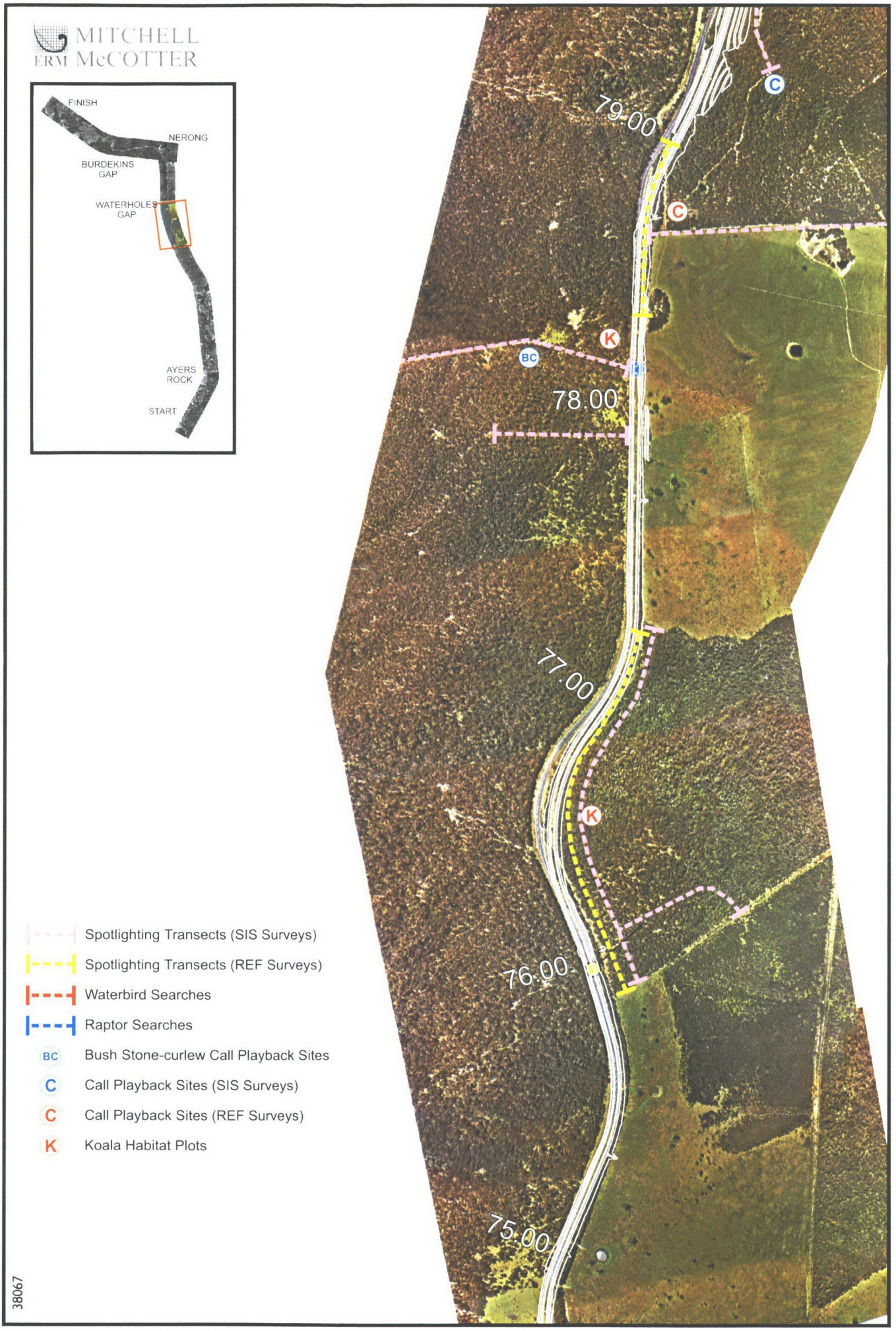

Figure 5.3e LOCATION OF SPOTLIGHTING TRANSECTS, CALL PLAYBACK SITES, WATERBIRD SEARCHES, RAPTOR SURVEYS AND KOALA HABITAT PLOTS

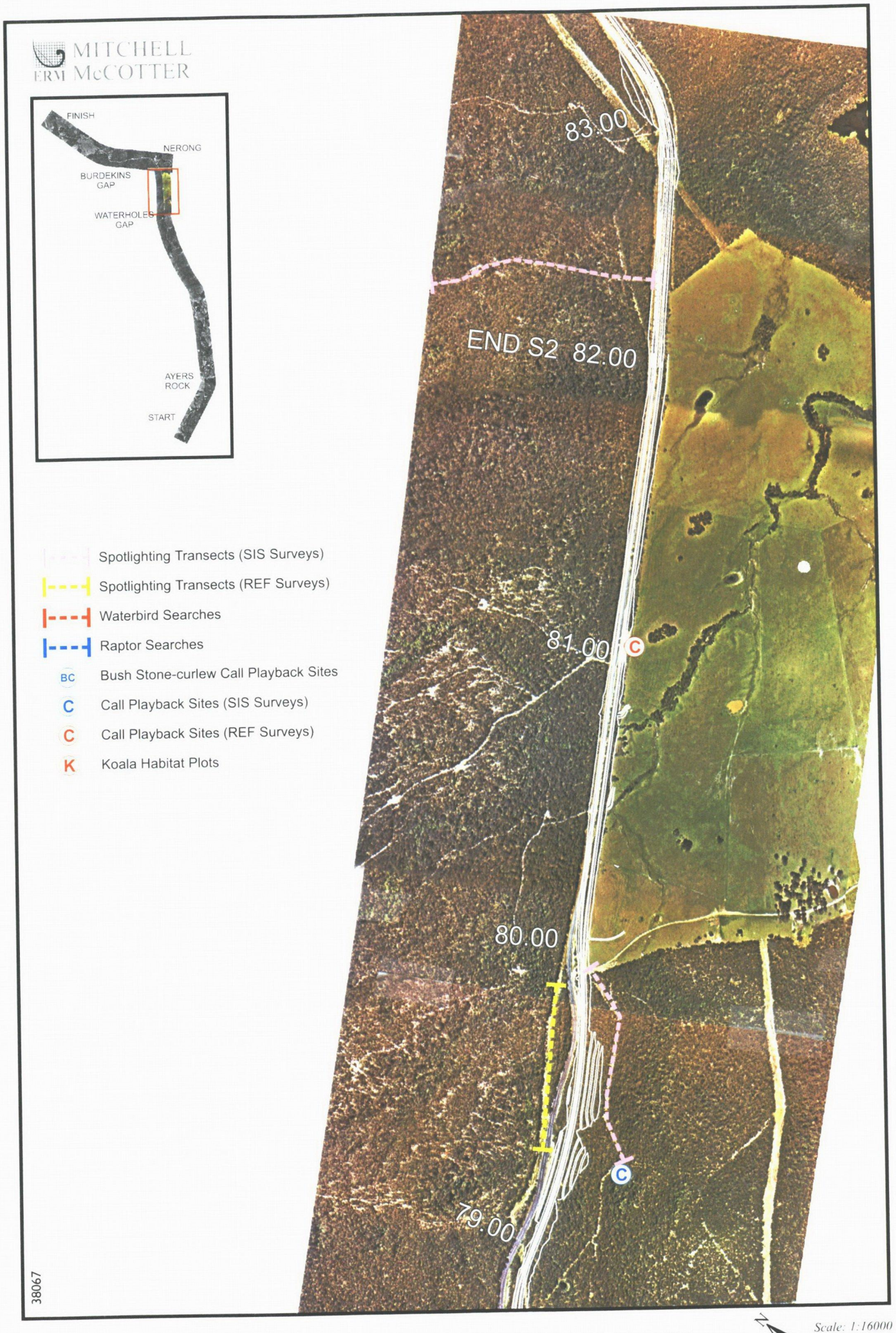

Figure 5.3f LOCATION OF SPOTLIGHTING TRANSECTS, CALL PLAYBACK SITES, WATERBIRD SEARCHES, RAPTOR SURVEYS AND KOALA HABITAT PLOTS

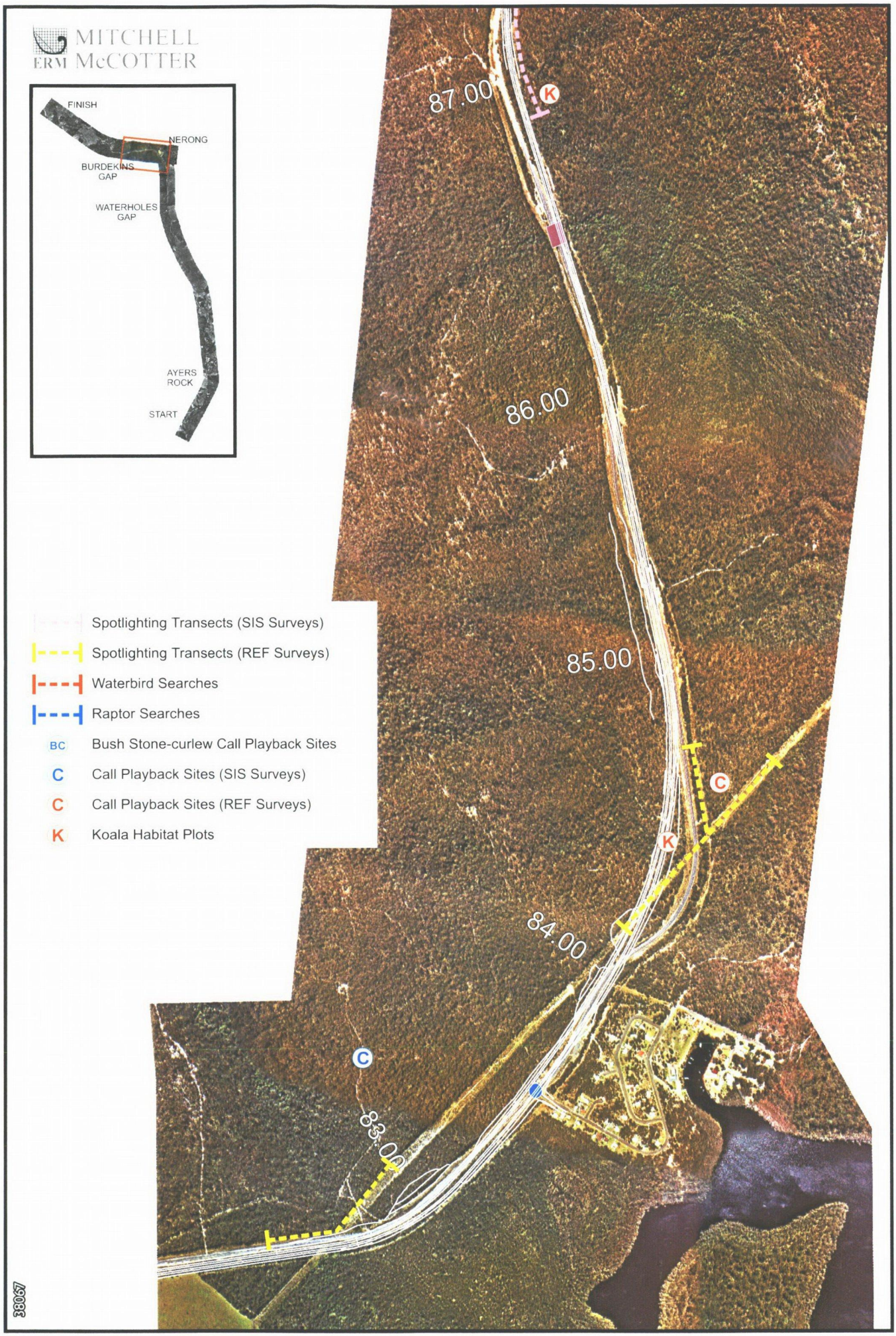

Figure 5.3g LOCATION OF SPOTLIGHTING TRANSECTS, CALL PLAYBACK SITES, WATERBIRD SEARCHES, RAPTOR SURVEYS AND KOALA HABITAT PLOTS

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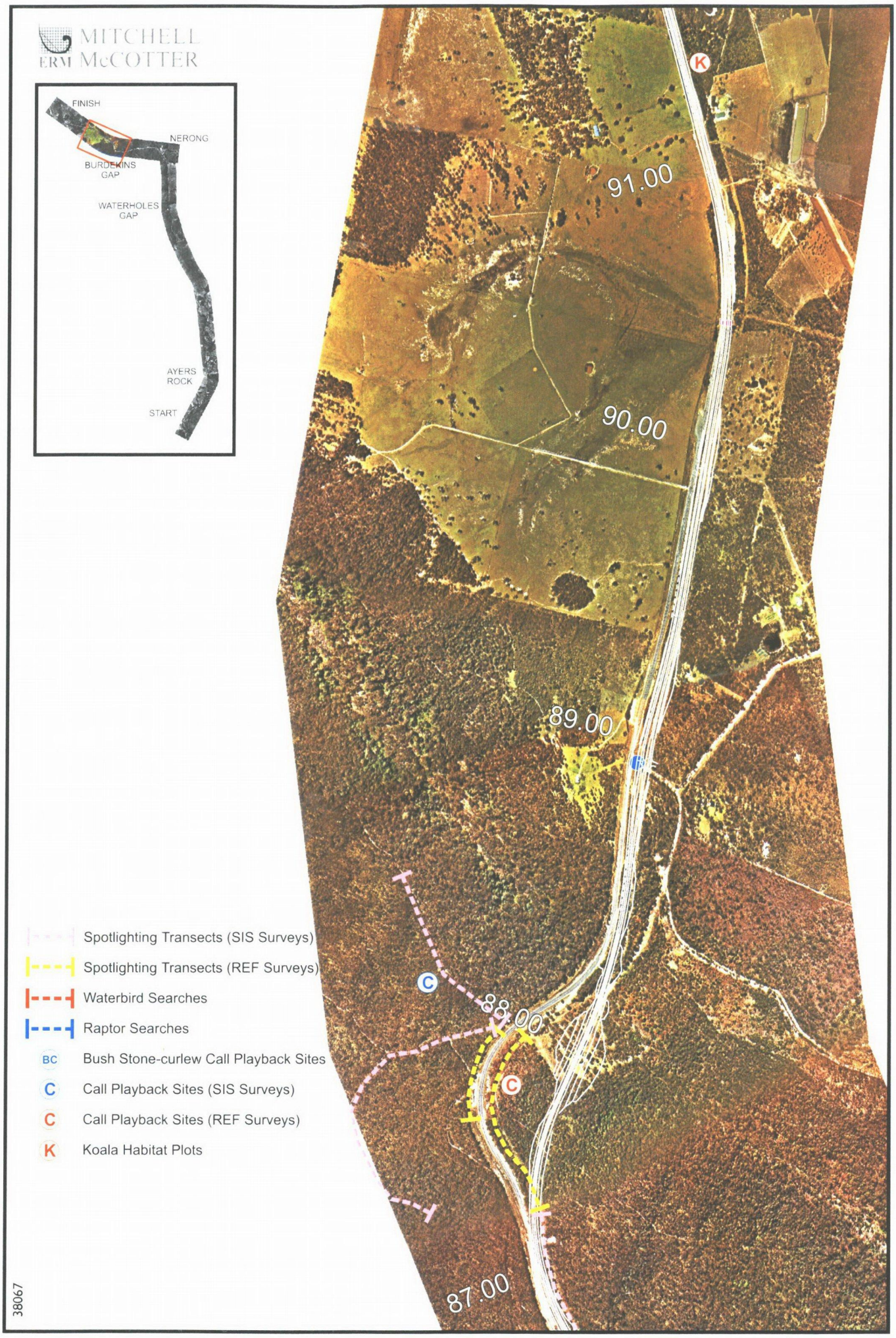


Figure 5.3h LOCATION OF SPOTLIGHTING TRANSECTS, CALL PLAYBACK SITES, WATERBIRD SEARCHES, RAPTOR SURVEYS AND KOALA HABITAT PLOTS

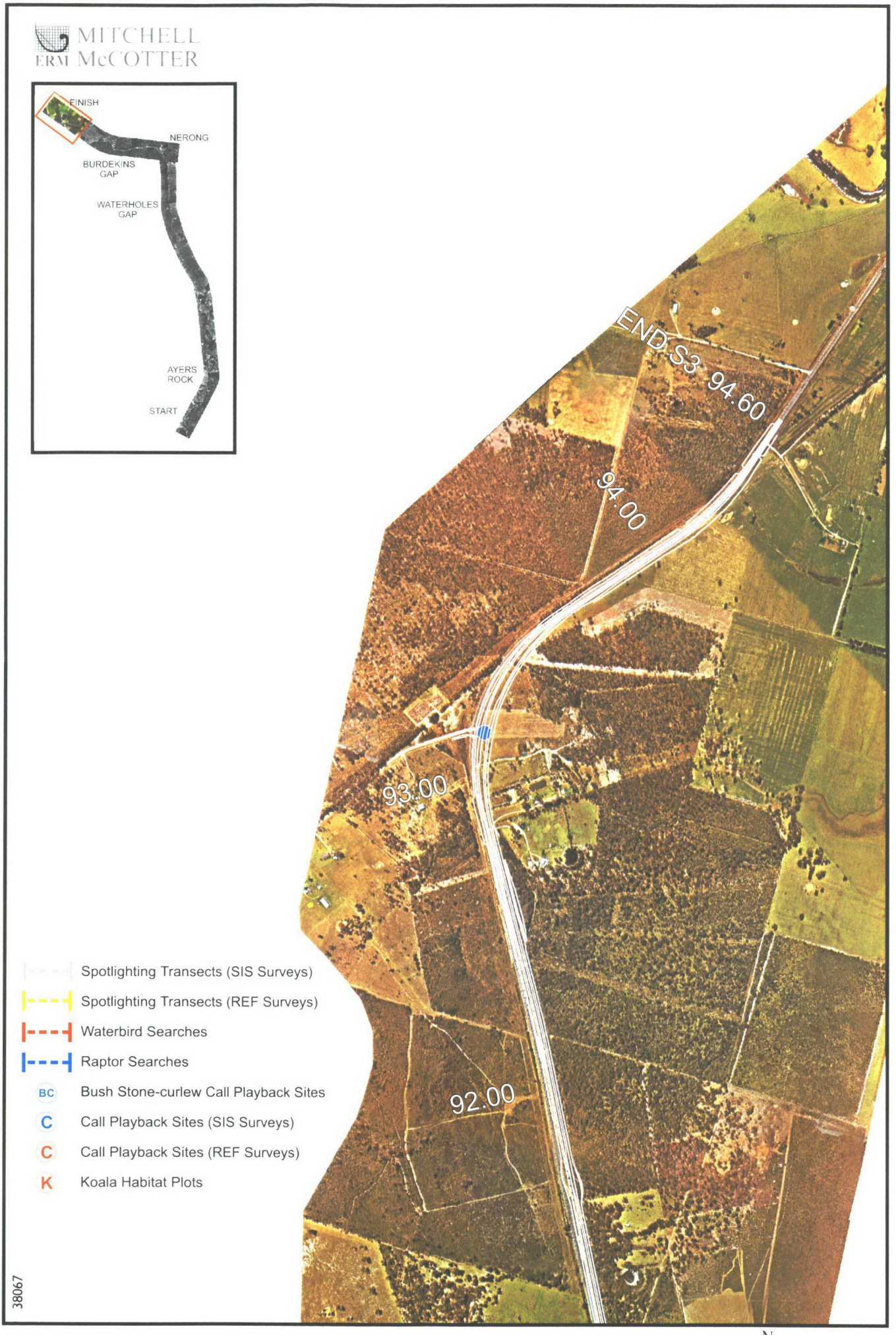


Figure 5.3i LOCATION OF SPOTLIGHTING TRANSECTS, CALL PLAYBACK SITES, WATERBIRD SEARCHES, RAPTOR SURVEYS AND KOALA HABITAT PLOTS

during and after the call playback survey to detect any threatened species responding to the calls.

Call playback was only undertaken during suitable weather conditions, characterised by mild temperatures, low wind and no rainfall.

5.2.13 Bush Stone-Curlew Call Playback Surveys

No optimum habitat for the bush stone-curlew (*Burhinus grallarius*) exists along the highway alignment. However, call playback was undertaken at three sites along the existing alignment where areas of sub-optimal habitat could be located. The sites were located at Mount Karuah, Viney Creek Road and Nerong Road (*Figure 5.3*).

The call playback surveys for this species were undertaken during the full moon phase. Furthermore, the species was heard calling on the northern bank of the Karuah River during the call playback survey period, thus indicating suitable weather conditions and moon phase for the species detection.

Each call playback survey comprised of an initial 10 minute listening period, followed by two call periods of five minutes duration. Each call period was followed by a two minute listening period. A final 10 minute listening period was conducted on completion of call playback.

5.2.14 Avifaunal Surveys

Diurnal waterbird surveys were conducted to detect the black bittern (*Ixobrychus flavicollis*) and black-necked stork (*Ephippiorhynchus asiaticus*). Targeted surveys were conducted over two consecutive days along the banks of Bundabah and Bulga Creeks for a distance of approximately 500 m east and north of the existing highway (*Figure 5.3*). Temporarily inundated paddocks and farm dams were opportunistically searched on numerous occasions from the highway whilst travelling to conduct other survey tasks.

Raptor surveys were conducted at appropriate sites to detect the presence of the osprey (*Pandion haliaetus*) and square-tailed kite (*Lophoictinia isura*). Surveys were conducted for a minimum of 30 minutes at two sites over two consecutive days.

5.2.15 Harp Trapping

Harp trapping was undertaken to detect microchiropteran bat species, particularly the little bent-wing bat (*Miniopterus australis*). Harp trapping was conducted at six sites within the study area (*Figure 5.2*). Three harp trap sites were located within

Nerong State Forest. Two of these sites were set up across creeklines (Jack's Creek and Grey Gum Creek), while the third site was set up within a fire trail. One harp trap site was located on the eastern side of a box culvert underneath the existing Pacific Highway on Jack's Creek. One site was established on both Bulga Creek and an unnamed creek east of the rest area near Mount Karuah.

A minimum of three nights trapping was undertaken at each trap location. At each site the harp trap was placed across potential bat flyways. Although harp trapping specifically requires the sampling of bat flyways, attempts were made to ensure that all habitat types were sampled. Tarpaulins were used to block the gaps around and under the trap, so as to funnel bats into the harp. The harp trap was erected one hour prior to dark, and left in place until 6.30am the following morning.

All bats captured were placed into separate calico bags for identification. Bats were identified using Parnaby (1992) and Strahan (1995). Bats were retained until the following night, at which time they were released in the vicinity of their place of capture.

5.2.16 Anabat Surveys

Anabat surveys were conducted to detect microchiropteran bat species, particularly the eastern freetail bat (*Mormopterus norfolkensis*) and little bent-wing bat (*Miniopterus australis*). Three hours of walking transects were conducted along spotlighting transects within Nerong State Forest, and two hours of stationary bat detection was undertaken at the triplining site (*Figure 5.2*).

Anabat surveys were also conducted at three sites during the initial surveys conducted for the REF. Stationary bat detection was conducted for 45 minutes at each site. Sites were located at Waterholes Gap, Burdekin's Gap and Grey Gum Gully (*Figure 5.2*).

5.2.17 Triplining

Triplining was conducted to identify microchiropteran bat species, particularly the eastern freetail bat (*Mormopterus norfolkensis*), large-footed myotis (*Myotis adversus*) and the greater broad-nosed bat (*Scotorepens rueppellii*). Triplining was conducted for 1.5 hours per night over two nights at a dam located on the eastern side of the existing highway at Burdekins Gap (*Figure 5.2*).

5.2.18 *Koala Survey*

i. Information Review

A NPWS Wildlife Atlas database search was conducted in order to review the known distribution of koalas in the locality. State Forests of NSW were contacted in regards to previous records of koalas in the locality, particularly in Nerong State Forest. No other relevant studies for the locality were available at the time of report production. No wildlife carer group exists for the particular stretch of road within the study area. Local residents were contacted in regards to previous koala sightings and road kills.

ii. Habitat Assessment

The vegetation types within the study area were mapped, and habitat types with a potential to support koalas were identified (*Figure 4.2*).

iii. Field Survey

As part of the threatened fauna features search vegetation on both sides of the existing road were searched for the entire length of the study area for koala scats, scratches and sightings. In every 100 m of suitable habitat at least five suitable trees were inspected for indicators of koala activity. Where scats were located all potential koala habitat trees within a 100 m radius were searched for additional scats in order to track the extent and movement of koalas in the area.

All spotlighting transects (except the site at Mount Karuah) were located within vegetation types containing preferred koala feed trees, hence spotlighting surveys targeted the species (*Figure 5.3*). The call of the male koala was played at all call playback sites over four non-consecutive nights (*Figure 5.3*).

During the surveys undertaken for the REF six koala habitat plots, based on the AKF methodology, were conducted in areas of suitable koala habitat along the existing highway alignment (*Figure 5.3*).

5.2.19 *Opportunistic Observations*

All vertebrate species observed or heard outside survey sites during general fieldwork activities were recorded as opportunistic records. Driving between sampling sites during the day and at night (particularly during and after rainfall events) was utilised as a survey method for detecting vertebrate fauna, particularly

reptiles and amphibians. Moist areas occurring along spotlighting transects were visually checked for herpetofauna, and amphibian calls identified.

5.2.20 Road Strike Identification

All vertebrate species killed by road strike were identified, and the location recorded so as to identify potential road strike blackspots.

5.2.21 Comparison of NPWS Recommended Fauna Survey Methodology with Surveys Actually Undertaken

The following *Table 5.4* compares NPWS' recommended fauna survey methodology with the surveys actually undertaken.

Table 5.4 COMPARISON OF NPWS FAUNA SURVEY RECOMMENDATIONS TO SURVEYS ACTUALLY UNDERTAKEN.

NPWS Recommended Methodology	ERM Methodology	Justification
Spotlighting on foot - up to 1 km from the road corridor, covering 1 km per hour, 30 minutes per site, utilising random meander searching or transects	Complied to DG's requirements, except without random meander searching	Transects used in preference to random meander searches to enable replication of survey effort over four non-consecutive sampling nights.
Call playback - located 1km apart, 10 minutes listening, followed by five minutes call of a species followed by two minute listening period and spotlighting. 10 minutes listening period after calling ceases. Playback to be undertaken at least twice at each of the sites over a minimum of two non-consecutive nights.	Sites were located approx. 2km apart in suitable habitat. However, playback was undertaken four times at each site over four non-consecutive nights. Other aspects of methodology complied to DG's requirements.	Sites were spaced further apart than recommended due to size of study area and uniformity of habitats.
Dusk census - listening for calls at least 30 minutes prior to sunset and 60 minutes after sunset.	Dusk censuses were undertaken opportunistically while undertaking other survey tasks (ie. setting up harp traps, commuting to call playback sites.	Very few appropriately discrete areas for dusk census (ie. gullies, patches of rainforest and old growth forest) within the study area. Traffic noise levels were very high even at 500 m from the road, restricting transmission of calls.
Stagwatching - watching hollows starting 30 minutes prior to sunset until 60 minutes after sunset.	Stag watching was not undertaken during the current survey.	Proliferation of small hollow bearing trees in study area, hence deemed that more time actively spotlighting would be more beneficial than stag watching. Very few suitable stags for roosting owls in study area (ie. large hollows).
Macropod surveys - spotlighting from a slow	Complied with DG's Requirements	

Table 5.4 COMPARISON OF NPWS FAUNA SURVEY RECOMMENDATIONS TO SURVEYS ACTUALLY UNDERTAKEN.

NPWS Recommended Methodology	ERM Methodology	Justification
moving vehicle, collection and identification of macropod scats, late evening and dusk watches		
Ultrasonic bat detection - slowly walking along a transect for 30 minutes on at least three nights, pausing to record calls, or placing the unit at the entrance of likely roosts	Exceeded DG's requirements	Triplining was also conducted. All bridges and culverts along the existing road were searched for evidence of bats.
Harp trap - undertaken for a minimum of three nights at each site	Complied with DG's Requirements	
Frog surveys - tadpole surveys to be carried out in all suitable waterbodies	Complied with DG's Requirements	
Crinia tinnula - surveys in suitable habitat over three non-consecutive nights diurnally and nocturnally, call identification, spotlighting, specimen capture and identification, minimum of 30 minutes per hectare, call playback	No targeted surveys were undertaken for this species	No suitable habitat for the species exists in the study area.
Litoria aurea - diurnal and nocturnal pond surveys for one hour if area exceeds 1 hectare or 30 minutes if less than 1 hectare. Night surveys to be conducted for a minimum of three nights at each site. Survey to be undertaken following heavy rain.	Complied with DG's Requirements	
Litoria brevipalmata - minimum of 1 hour night survey for every one hectare surface area of temporarily flooded areas or ponds, minimum of 30	Complied with DG's Requirements	

Table 5.4 COMPARISON OF NPWS FAUNA SURVEY RECOMMENDATIONS TO SURVEYS ACTUALLY UNDERTAKEN.

NPWS Recommended Methodology	ERM Methodology	Justification
minutes survey for each swamp less than one ha surface area, over a minimum of three nights, spotlighting and call playback.		
Mixophyes spp. - survey within 50 m of watercourses in rainforest and moist eucalypt forest, spotlighting and listening for calls, call playback, minimum three nights of survey per site	Complied with DG's Requirements	
Reptiles - *Hoplocephalus* spp. - 2 hour foot based searching per 10 ha of suitable habitat, vehicle searches, roadkill search and identification	Foot based searching conducted opportunistically along entire alignment as part of fauna features search. Vehicle searches, roadkill search and identification were also conducted.	Unrealistic survey technique considering the size of the study area and extent of potential habitat for this species in the study area (although marginal quality habitat).
Threatened Fauna Features - searches for features indicative of the presence of threatened fauna species or populations.	Complied with DG's Requirements	
Koala Survey -information review, habitat assessment, mapping of habitat types, scat identification, spotlighting, transect searches of potential habitat	Complied with DG's Requirements	
Brush-tailed Phascogale - hair tube analysis, linear or grid layout of hair tubes, 10 tubes per 2 km of transect, 10 nights, one transect per 50 hectares, up to 500 m from the route, tree mounted and ground based, baited with a meat based product	Complied with DG's Requirements, except for length of transects.	Transects limited to 500m length due to limited suitable habitat for the species in the study area.

Table 5.4 COMPARISON OF NPWS FAUNA SURVEY RECOMMENDATIONS TO SURVEYS ACTUALLY UNDERTAKEN.

NPWS Recommended Methodology	ERM Methodology	Justification
Arboreal Elliott Trapping - brush-tailed phascogale and squirrel glider - minimum of four nights per sight, min 400 trap nights for the entire survey, baited with rolled oats, peanut butter and honey, honey and water mix to be sprayed on tree boles	Complied with DG's Requirements, except only 240 trap nights were performed for the entire survey.	Limited suitable habitat for brushtailed phascogale in study area. Additional spotlighting was performed to supplement the shortage of trapnights. Spotlighting deemed to be a more effective technique for detecting these species.
Terrestrial Elliott Trapping - Eastern Chestnut Mouse - minimum of four nights per site, minimum effort of 400 trap nights in suitable habitat,	Complied with DG's Requirements	
Scat and tracks survey - dedicated and opportunistic surveys in suitable habitat, scats to be identified by a reputable analyst.	Complied with DG's Requirements	
Diurnal Birds - wetland surveys - diurnal searches, call playback, raptor nests - searches along the road corridor.	Complied with DG's Requirements	

5.2.22 *Weather Conditions*

Survey tasks were conducted over three seasons; Winter (August 1997) Summer (January 1998) and Spring (October/November 1998). Weather conditions experienced during the survey period are documented in *Table 5.5*. Weather conditions were rated as only fair for the January 1998 surveys, with high wind conditions and threatening storm clouds prevailing for a number of days. Conversely, weather conditions were ideal for the duration of the October/November 1998 surveys. The weather information was obtained from the Bureau of Meteorology for the Williamtown RAAF Airbase, which is the nearest weather data recording location (*Table 5.5*). Temperatures experienced during survey tasks are provided on the recording sheets in *Appendix H*.

Table 5.5 WEATHER CONDITIONS DURING THE SURVEY PERIOD

Date	Daily Maximum (°C)	Daily Minimum (°C)	Rainfall in 24 hours to 9am (mm)	Cloud Cover 9am	Cloud Cover 3pm	Wind (km/h) 9am	Wind (km/h) 3pm
18/8/97	20.8	8.6	0	1	1	WNW 17	W 26
9/12/97	29.2	19.9	0	7	7	NNW 15	WNW 8
10/12/97	26.2	18.3	0.2	7	5	S 33	S 39
12/1/98	29.8	17.6	0	2	2	NE 15	E 39
13/1/98	32.1	18.7	0	2	4	N 21	ENE 24
14/1/98	32.2	22.8	0	7	8	N 4	WNW 13
15/1/98	35.8	21.2	n/a	1	3	WNW 30	NW 22
16/1/98	25	19.1	1.8	7	7	SSE 15	SE 15
19/10/98	17	24	0	8	7	SSE 8	ESE 11
20/10/98	20	13	30.4	2	2	W 30	SSE 26
21/10/98	21	8	0	0	1	WNW 15	SE 21
22/10/98	22	12	0	5	n/a	WNW 8	n/a
23/10/98	22	13	4	4	6	Calm	ESE 18
24/10/98	27	11	0	6	5	NW 8	WNW 11
25/10/98	25	15	0	8	4	W 4	E 15
26/10/98	28	17	0.2	3	3	WNW 26	WNW 26
27/10/98	21	16	5	3	4	WNW 8	W 41
28/10/98	19	7	1.6	1	2	SW 22	SSE 26
29/10/98	21	7	0	8	4	Calm	E 18
30/10/98	18	15	0	8	8	NNW 4	Calm

Table 5.5 WEATHER CONDITIONS DURING THE SURVEY PERIOD

Date	Daily Maximum (°C)	Daily Minimum (°C)	Rainfall in 24 hours to 9am (mm)	Cloud Cover 9am	Cloud Cover 3pm	Wind (km/h) 9am	Wind (km/h) 3pm
31/10/98	n/a	13	1	3	3	WNW 15	S 31
1/11/98	19	n/a	n/a	n/a	4	n/a	S 44
2/11/98	18	9	1	7	n/a	SSW 21	n/a
3/11/98	20	12	4	6	4	SSE 18	SSE 26
4/11/98	23	10	0	7	6	WNW 8	E 18
5/11/98	29	11	0	6	6	NW 2	W 4
6/11/98	22	13	0	8	6	S 26	S 26

Source: Bureau of Meteorology (1998)

5.2.23 Limitations to the Fauna Surveys

The study area encompasses approximately 3675 hectares along 36.75 km of Pacific Highway. This area is made up of a wide variety of habitats and micro-habitats, not all of which could be adequately sampled in the limited time available for field sampling. Therefore, only portions of those habitats deemed suitable for threatened species, as identified from CRA models, topographic maps, API and ground truthing, were sampled during the current survey. This approach was endorsed by NPWS.

Some threatened species that were expected to occur in the study area were not detected during the current surveys. However, all threatened species known or likely to occur in the study area have been considered during the formulation of mitigation measures for the proposed Upgrade. Specific limitations to the survey are discussed below.

Inaccuracies in the CRA vegetation mapping as mentioned in *Section 3.3.9* have most likely attributed to the significant inaccuracies in the CRA threatened species habitat modelling discovered during the current survey. For example, extensive areas of intermediate habitat for the bush stone-curlew were mapped on the CRA habitat models, however, ground truthing revealed almost no intermediate or high quality habitat for this species in the study area. The CRA habitat models also indicated an area of intermediate to high quality habitat for *Mixophyes balbus* near Nerong Waterholes. However, this species is usually associated with permanently flowing freshwater streams at relatively high altitudes. Neither of these components occur in the study area. However, where possible, habitat suitability for target species was checked in the field prior to sampling.

i. Mapping of Potential Habitat Trees

General mapping of potential habitat trees within the study area was deemed to be unfeasible due to the proliferation of trees considered by the survey team to represent potential habitat. For example, there were many trees with hollow entrances the size of a golf ball. Such hollows could potentially represent a roosting hollow large enough to be used by several species of vertebrate fauna including snakes, microchiropteran bats, birds and small to medium sized gliders. Conversely, such a hole could just as easily have been blind (as did appear to be the case for many such holes), and represent no suitable roosting resources for any vertebrate fauna.

ii. Amphibians and Reptiles

Many amphibians and several species of reptile (ie. Stephen's banded snake and pale-headed snake) are nocturnal and reside in often inaccessible refuges whilst not active or are particularly cryptic when not active. Furthermore, amphibian and reptile activity is influenced by climatic factors such as temperature and humidity. Therefore, the effectiveness of herpetological surveys is strongly influenced by such factors as the time of day, season and prevailing weather conditions.

The recommended time for conducting herpetological surveys is between September and January. All surveys undertaken for this report were conducted during this recommended time period. However, the initial surveys undertaken for the REF were conducted during a prolonged dry period, which appears to have affected the detectability of amphibian species.

The surveys undertaken for the SIS were conducted under optimum survey conditions characterised by higher than average rainfall for the season, rainfall immediately prior to or during sampling, low wind and mild to warm temperatures.

iii. Avifauna

Appropriate survey techniques were utilised for conducting targeted surveys for threatened avifauna likely to occur within the study area. However, some waterbirds are secretive species such as the black bittern (*Ixobrychus flavicollis*), or highly mobile and nomadic such as the black-necked stork (*Ephippiorhynchus asiaticus*). The sporadic occurrence of some resources (e.g. nectar availability) may result in some threatened species only utilising the study area occassionally, and potentially outside the survey periods. Such characteristics can often make detection of these species difficult.

The high density of traffic using the existing Pacific Highway, particularly trucks, throughout most nights produces significant and almost continual noise. When conducting call playback surveys anywhere within one kilometre of the existing highway such loud noise inhibited the ability of team members to detect the calls of responding nocturnal birds. Traffic noise may also cause diurnal birds to retreat from the road edges when large or noisy vehicles pass, hence making it harder for observers to detect.

iv. Terrestrial Mammals

Survey results are often biased by variations in vegetation structure, due to greater visibility in open forests as opposed to dense forests. This may have affected the detectability of some species that inhabit dense vegetation types such as the long-nosed potoroo (*Potorous tridactylus*) and spotted-tailed quoll (*Dasyurus maculatus*).

v. Arboreal Mammals

The low detectability of arboreal mammals, particularly gliders, during the surveys may be due to a lack of flowering eucalypts in the study area during the survey period. The lack of detectability may also be due to very low densities of gliders in the region due to such species having relatively large home ranges (ie. 20 to 30 hectares) (Ross Goldingay pers. comm.). Nevertheless, the survey intensity was high and the weather conditions during the survey period were suitable.

vi. Microchiropteran Bats

The detectability of microchiropteran bats is influenced by the time day, temperature, rainfall and wind conditions. The optimum time for conducting surveys is within the first two hours after dusk when bats leave their roosts to search for food and water. Warm temperatures are preferable due to higher insect activity levels. Surveying during heavy rainfall or windy conditions should be avoided.

The current surveys were conducted under suitable weather conditions (*Table 5.3*), and during the preferred time of day. Air temperatures during the surveys were adequate, however, higher temperatures would have been preferred.

The effectiveness of harp trapping is influenced by the density of vegetation and the existence of suitable bat flyways within each habitat type. Bat detection is limited in its applicability due to difficulties associated with identifying all Australian bat species by their calls. Therefore, to minimise these shortcomings a combination of three survey techniques were used during the current surveys. Nevertheless, the bat

detection recording of the eastern freetail bat (*Mormopterus norfolkensis*) was only tentative due to the difficulty in identifying it from *Mormopterus* species 1.

5.3 RESULTS OF THE FIELD SURVEY PROGRAM

A total of 167 vertebrate fauna species were recorded during the surveys undertaken for the SIS. These species consisted of 18 amphibians, 16 reptiles, 102 birds and 38 mammals. Of these, nine species are currently listed as threatened on the NSW TSC Act (1995) (*Table 5.6*). Recording sheets for each survey task are provided in *Appendix H*.

Several areas within the study area were identified for containing relatively high species diversity of particular vertebrate classes. The swamp forest habitat between Waterholes Gap and Nerong Waterholes contained the highest amphibian species diversity (*Table 5.7*). The dry open forest at Mount Karuah contained the highest arboreal mammal species diversity (*Table 5.10*). The riparian vegetation along Jack's Creek contained the highest number of microchiropteran bat species (*Table 5.13*). Although no structured diurnal avifaunal surveys were conducted the extensive incidental records indicate that dry open forest habitat at Waterholes Gap and Nerong Waterholes contain the highest species diversity of avifauna (*Appendix H*).

5.3.1 Threatened Species Known or Likely to Occur in the Study Area

At the completion of the current surveys 14 threatened species are known to occur within the study area (*Table 5.6*). Five of these species were not known to occur prior to the current surveys. The location of all previous and new threatened species records within the study area and locality are illustrated in *Figure 4.1*. The assessment of habitat types within the study area indicates that an additional 15 threatened species not previously recorded in the study area are also likely to utilise these habitat types.

Table 5.6 THREATENED FAUNA SPECIES FAUNA KNOWN OR LIKELY TO OCCUR IN THE STUDY AREA.

Class	Scientific Name	Common Name	Record Status	Likelihood of Occurrence
Amphibians	*Litoria brevipalmata*	Green-thighed frog	P; C	known to occur
Reptiles	*Hoplocephalus stephensii*	Stephen's banded snake	none	high
	Hoplocephalus bitorquatus	Pale-headed snake	none	high
Mammals	*Phascogale tapoatafa*	Brush-tailed phascogale	none	moderate

Table 5.6 THREATENED FAUNA SPECIES FAUNA KNOWN OR LIKELY TO OCCUR IN THE STUDY AREA.

Class	Scientific Name	Common Name	Record Status	Likelihood of Occurrence
	Phascolarctos cinereus	Koala	P; C	known to occur
	Dasyurus maculatus	Spotted-tailed quoll	C	known to occur
	Petaurus norfolcensis	Squirrel glider	P	known to occur
	Petaurus australis	Yellow-bellied glider	P	known to occur
	Potorous tridactylus	Long-nosed potoroo	C	known to occur
	Planigale maculata	Common planigale	none	high
	Mormopterus norfolkensis	Eastern freetail bat	P; C	known to occur
	Miniopterus australis	Little bent-wing bat	C	known to occur
	Miniopterus schreibersii	Large bent-wing bat	C	known to occur
	Myotis adversus	Large-footed myotis	C	known to occur
Aves	*Burhinus grallarius*	Bush stone-curlew	none	low - moderate
	Calyptorhynchus lathami	Glossy black-cockatoo	P; C	known to occur
	Lophoictinia isura	Square-tailed kite	none	high
	Tyto novaehollandiae	Masked owl	P; C	known to occur
	Ninox strenua	Powerful owl	none	moderate-high
	Ninox connivens	Barking owl	none	high
	Tyto capensis	Grass owl	P	known to occur
	Neophema pulchella	Turquoise parrot	none	moderate - high
	Lathamus discolor	Swift parrot	none	moderate - high
	Xanthomyza phrygia	Regent honeyeater	none	moderate
	Ixobrychus flavicollis	Black bittern	none	high
	Epippiorhynchus asiaticus	Black-necked stork	P	known to occur
	Ptilinopus magnificus	Superb fruit-dove	none	low - moderate
	Ptilinopus regina	Rose-crowned fruit-dove	none	low - moderate
	Ptilinopus magnificus	Wompoo fruit-dove	none	low - moderate

Key: P Previous record C Recorded during surveys

5.3.2 *Amphibians*

i. Previous Surveys

Previous surveys in the locality have been undertaken by Lemckert *et al.* (1997). Other records for the study area were obtained from the NPWS Wildlife. No other formal surveys were available for inclusion in this report.

The NPWS Wildlife Atlas indicated that a total of 34 amphibian species have been previously recorded in the sub-region. Four of these species are currently listed as threatened on the NSW TSC Act (1995). These species include the wallum froglet (*Crinia tinnula*), green-thighed frog (*Litoria brevipalmata*), stuttering frog (*Mixophyes balbus*) and the green and golden bell frog (*Litoria aurea*).

ii. Results of the Study Surveys

Results of the study surveys indicate that the amphibian community in the study area consists of at least 17 species of frogs from two families and seven genera, including one species (*Litoria brevipalmata*) currently listed as threatened on the NSW TSC Act (1995) (*Table 5.7*).

The highest species diversity of amphibians within the study area was recorded in swamp forest habitat adjacent to Nerong Road. Amphibian species diversity was generally higher at sampling sites between Waterholes Gap and Nerong Waterholes. *Table 5.7* provides a list of all amphibian species recorded during the study survey.

Table 5.7 AMPHIBIAN SPECIES RECORDED IN THE STUDY AREA DURING THE STUDY SURVEYS

Family	Common Name	Scientific Name	Status	Location
Myobatrachidae	Tusked frog	*Adelotus brevis*	common	NR
	Common eastern froglet	*Crinia signifera*	abundant	BG; NSF2 (i); JC (i); SC; WG; NR; NW; Cray
	Striped marsh frog	*Limnodynastes peronii*	abundant	JC; SC; WG; NR; VC; Cray
	Spotted marsh frog	*Limnodynastes tasmaniensis*	common	VC (i); NR
	Great barred frog	*Mixophyes fasciolatus*	common	NR
	Brown toadlet	*Pseudophryne bibroni*	uncommon	NR

Table 5.7 AMPHIBIAN SPECIES RECORDED IN THE STUDY AREA DURING THE STUDY SURVEYS

Family	Common Name	Scientific Name	Status	Location
	Red-backed toadlet	*Pseudophryne coriacea*	common	NSF2 (i); BG; JC; WG; NR; NW; Cray
		Uperoleia fusca	common	JC (i); NR; NW (i); Cray
		Uperoleia laevigata	common	SC; WG; NR; Cray
Hylidae	**Green-thighed frog**	***Litoria brevipalmata***	**vulnerable**	**NR**
	Bleating tree frog	*Litoria dentata*	common	NR; NW
	Eastern dwarf Tree frog	*Litoria fallax*	abundant	NSF2 (i); JC; SC; WG; NR; NW (i); VC; Cray; MK (i)
	Freycinet's frog	*Litoria freycineti*	uncommon	NSF2 (i)
	Dainty green tree frog	*Litoria gracilenta*	common	NR; NW
		Litoria latopalmata	abundant	NSF2 (i); SC; WG; MK (i)
	Peron's tree frog	*Litoria peronii*	common	NSF2 (i); SC, WG; NR; NW; VC
		Litoria tyleri	common	NR

Key: (i) incidental observation **bold text** species listed on TSC Act

Location:

BG	Burdekin's Gap	NR	Nerong Road
NSF2	Nerong State Forest Spotlight Transect	NW	Nerong Waterholes
JC	Jack's Creek	VC	Viney Creek Road
SC	Splityard Creek	Cray	opposite Crayhaven Crayfish Farm
WG	Waterholes Gap	MK	Mount Karuah

The majority of these species are common to abundant (Stewart 1995), and considered to be habitat generalists which are unlikely to be affected by most forms of habitat modification. However, although not listed on the NSW TSC Act (1995), species such as the brown toadlet (*Pseudophryne bibroni*) and freycinet's frog (*Litoria*

freycineti) are considered to be uncommon and potentially at risk (Stewart 1995). Declines have been reported in some populations of brown toadlet (*Pseudophryne bibroni*) and bleating tree frog (*Litoria dentata*) (Mahony 1996).

The green-thighed frog (*Litoria brevipalmata*) was recorded near Nerong Road during the current survey after heavy rainfall (*Figure 5.4*). The species was utilising flooded grassy understorey within forest red gum (*Eucalyptus tereticornis*) open forest.

The majority of waterbodies in the study area are unlikely to represent suitable habitat for the green and golden bell frog (*Litoria aurea*). This is due to the abundance of mosquito fish (*Gambusia holbrooki*), presence of predominantly clay substrates rather than sand or rock substrates and a lack of non emergent aquatic plants in waterbodies of the study area (Goldingay 1996; Pyke and White 1996).

There is unlikely to be suitable habitat within the study area for *Mixophyes* species due primarily to the lack of permanently flowing clean freshwater watercourses or densely vegetated riparian zones with associated undisturbed leaf litter.

The study area contains limited suitable habitat for the wallum froglet (*Crinia tinnula*) due to a lack of wallum vegetation in the study area.

5.3.3 Reptiles

i. Previous Surveys

The NPWS Wildlife Atlas records indicate that at least 53 species of reptile inhabit the sub-region. Two of these species, stephen's banded snake (*Hoplocephalus stephensii*) and pale-headed snake (*Hoplocephalus bitorquatus*), are currently listed as threatened on the NSW TSC Act (1995).

ii. Results of the Study Surveys

A total of 16 species of reptile were recorded during the study surveys from six families and 15 genera (*Table 5.8*). An additional two species were identified to genus level only. None of the species recorded are currently listed as threatened on the NSW TSC Act (1995). All of the species recorded in the study surveys have been previously recorded in the sub-region and are considered to be common in the area.

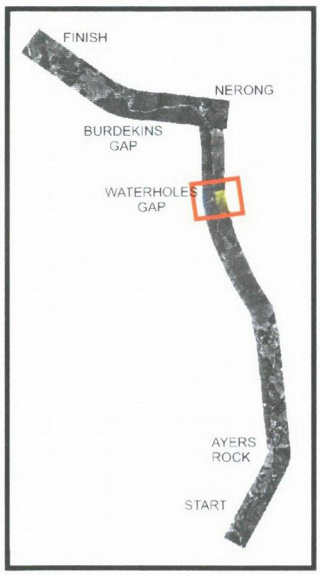
Suitable habitat does exist in the study area for the stephen's banded snake (*Hoplocephalus stephensii*) and pale-headed snake (*Hoplocephalus bitorquatus*). Both species have been previously recorded in the locality (ie. within 10 km of study area).

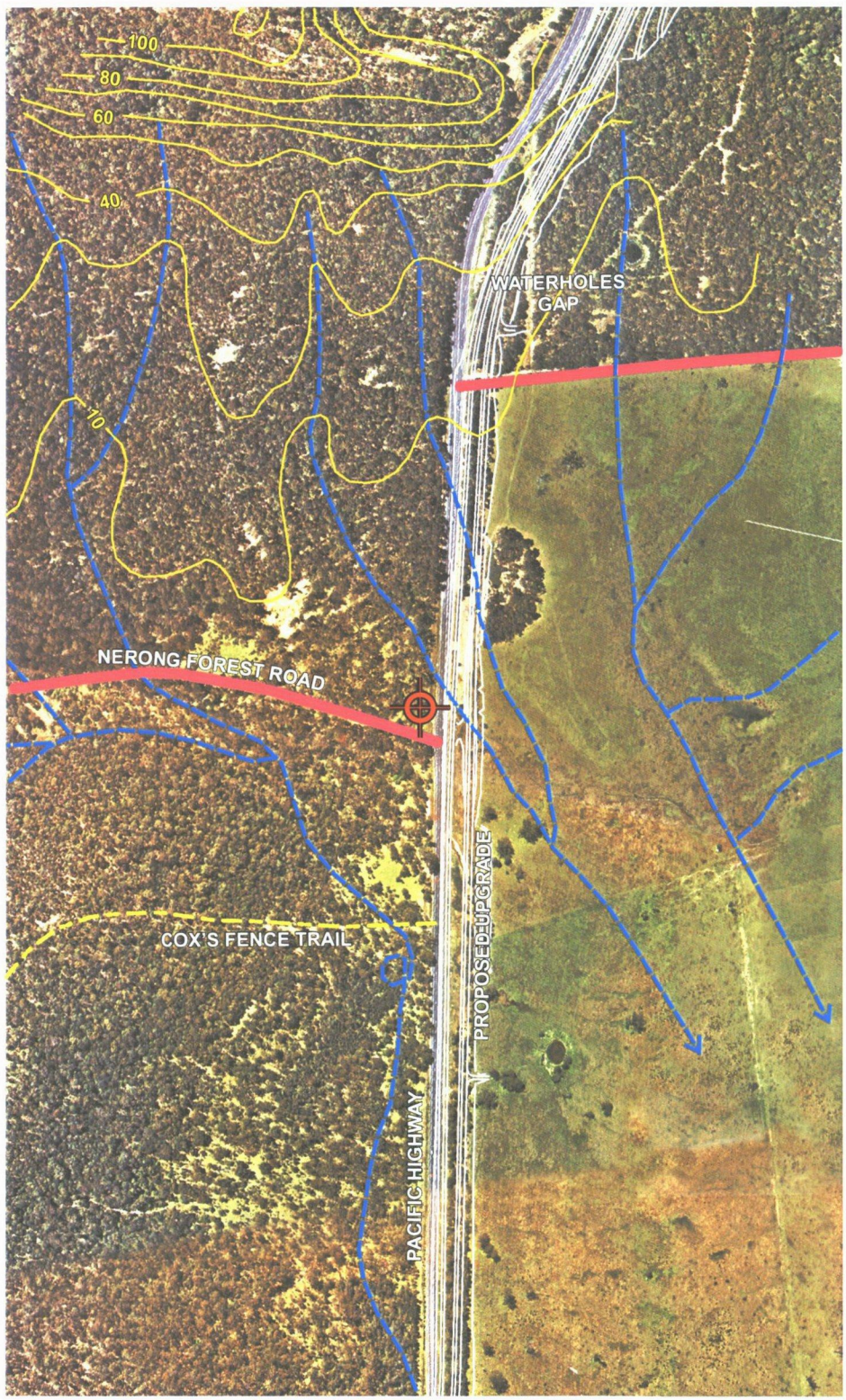
Table 5.8 REPTILE SPECIES RECORDED IN THE STUDY AREA DURING THE STUDY SURVEYS

Family	Common Name	Scientific Name	Location
Agamidae	Eastern water dragon	*Physignathus lesueurii*	throughout
	Jacky lizard	*Amphibolurus muricatus*	BG
	Bearded dragon	*Pogona barbata*	throughout
Varanidae	Lace monitor	*Varanus varius*	throughout
Colubridae	Brown tree snake	*Boiga irregularis*	BG
Elapidae	Eastern brown snake	*Pseudonaja textilis*	JC; OR
	Yellow-faced whip snake	*Demansia psammophis*	BC
	Red-bellied black snake	*Pseudechis porphyriacus*	The Rock roadhouse; OR
	Black-bellied swamp snake	*Hemiaspis signata*	GGG
	Common skink	*Lampropholis delicata*	throughout
Scincidae		*Egernia* sp.	NW
	Eastern water skink	*Eulamprus quoyii*	throughout
		Eulamprus sp.	NW
		Ctenotus robustus	OR
		Calyptotis ruficauda	BG
	Eastern blue-tongued Lizard	*Tiliqua scincoides*	throughout
Boidae	Diamond python	*Morelia spilota*	GGG; BC

Location:

throughout	commonly observed at numerous locations throughout study area
BG	Burdekin's Gap
JC	Jack's Creek
OR	Old Tea Gardens Road
BC	Bulga Creek
GGG	Grey Gum Gully
NW	Nerong Waterholes





Elevation Contours

Watercourses

Local Roads

Track

Location of Green - thighed Frog Record

Scale: 1:8000

Figure 5.4 LOCATION OF THE GREEN - THIGHED FROG DETECTED DURING THE CURRENT SURVEYS

5.3.4 *Avifauna*

i. Previous Surveys

The NPWS Wildlife Atlas records indicate that at least 310 bird species inhabit the sub-region. Of these, 20 species are currently listed as threatened on the NSW TSC Act (1995). Ecotone Consultants also recently found an eastern grass owl (*Tyto capensis*) road kill at the extreme northern end of the study area (B. Wilson pers. com.).

ii. Results of the Study Surveys

A total of 102 species of birds were recorded during the surveys (*Appendix I*). The glossy black-cockatoo (*Calyptorhynchus lathami*) and masked owl (*Ninox connivens*) were recorded in the study area during the current survey. Both of these species are currently listed as threatened on the NSW TSC Act (1995). All of the species recorded in the study surveys have been previously recorded in the sub-region, and the majority of them are considered to be common in forest types within the area.

5.3.5 *Mammals*

i. Previous Surveys

The NPWS Wildlife Atlas records indicate that at least 69 mammal species inhabit the sub-region. These records consist of 13 small terrestrial species, 22 medium to large terrestrial species, 11 arboreal species, two megachiropteran bat species and 21 microchiropteran bat species. Of these, 19 species are currently listed as threatened on the NSW TSC Act (1995), including two small terrestrial species, five medium to large terrestrial species, four arboreal species and eight microchiropteran bat species.

ii. Results of the Study Surveys

a. Introduced Mammals

A total of five introduced mammals were recorded in the study area during the current surveys (*Table 5.9*). These include two predatory medium to large terrestrial species (*Vulpes vulpes* and *Canis familiaris*), one small to medium terrestrial species (*Oryctolagus cuniculus*) and two small terrestrial species (*Rattus rattus* and *Mus musculus*).

The introduced rodents were rarely detected and never captured despite extensive Elliott trapping throughout the study area. Therefore, these species are considered to be relatively uncommon in the study area.

Table 5.9 INTRODUCED SPECIES RECORDED IN THE STUDY AREA DURING THE STUDY SURVEYS

Common Name	Scientific Name	Location	Detection Method
Fox	*Vulpes vulpes*	JC; WG; Cray; NSF2; Rock	roadkill; scat
Dog	*Canis familiaris*	BuC; WG; NW; BG; NSF2; Rock; VCR	roadkill; scat
Rabbit	*Oryctolagus cuniculus*	Rock	predator scat
Black rat	*Rattus rattus*	JC	dead individual
House mouse	*Mus Musculus*	WG	Hair

Location:

Cray	Crayhaven crayfish farm
NSF2	Nerong State Forest spotlight transect 2
Rock	"The Rock" petrol station
NW	Nerong Waterholes
JC	Jack's Creek
BuC	Bundabah Creek
NW	Nerong Waterholes
VCR	Viney Creek Road
WG	Waterholes Gap
BG	Burdekin's Gap

Detection Method:

Spot	Spotlight
Hair	Hair Analysis
Scat	Scat Analysis

b. Arboreal Mammals

A total of five arboreal species were recorded in the study area during the study surveys (*Table 5.10*). The common brushtail possum (*Trichosurus vulpecula*) was the most frequently recorded species during the spotlighting surveys. Koala scats were one of the most frequently identified scats during the study surveys due most likely to the high intensity of survey effort allocated to this species.

Despite a general lack of mature forest within the study area suitable habitat exists for the squirrel glider (*Petaurus norfolcensis*). The study area has very few large hollows suitable for the yellow-bellied glider (*Petaurus australis*), however, foraging resources for the species do exist. Suitable habitat for the brush-tailed phascogale (*Phascogale tapoatafa*) is restricted in the study area to dry open forests with sparse understories.

Table 5.10 ARBOREAL MAMMAL SPECIES RECORDED IN THE STUDY AREA DURING THE STUDY SURVEYS

Common Name	Scientific Name	Location	Detection Method
Koala	*Phascolarctos cinereus*	WG; NW (?); JC; NW; Rock; BC; FCT; NV; NR; MK	Spot; CP; Scat
Eastern pygmy-possum	*Cercartetus nanus*	NSF3 (?)	Spot
Sugar glider	*Petaurus breviceps*	JC; NW	Spot; CP
Common ringtail possum	*Pseudocheirus peregrinus*	NSF1; MK; MK1	Spot
Feathertail glider	*Acrobates pygmaeus*	NSF1	Spot
Common Brushtail possum	*Trichosurus vulpecula*	NSF1; NSF2; NP; JC; WG; CFT; NW; MK; MK1; scats throughout	Spot
	Trichosurus sp.	MK	Hair

Key: (?) unconfirmed sighting

Location:

NSF1	Nerong State Forest spotlight transect 1
NSF2	Nerong State Forest spotlight transect 2
NSF3	Nerong State Forest spotlight transect 3
NP	Nerong Powerline call playback site
JC	Jack's Creek
MK1	Mount Karuah call playback site 1
MK	Mount Karuah
Rock	'The Rock' Petrol Station
NW	Nerong Waterholes
CFT	Cox's Fence Trail
NV	Nerong Village
FCT	Fame Cove Turnoff
NR	Nerong Road
BC	Bulga Creek
WG	Waterholes Gap

Detection Method:

Spot	Spotlight
Hair	Hair Analysis
CP	Call Playback

c. Small Terrestrial Mammals

The bush rat (*Rattus fuscipes*), swamp rat (*Rattus lutreolus*) and brown antechinus (*Antechinus stuartii*) were the only native small terrestrial mammals recorded in the study area during the study surveys (*Table 5.11*).

Suitable habitat exists within the study area for the common planigale (*Planigale maculata*). Sub-optimal habitat also exists for the eastern chestnut mouse (*Pseudomys gracilicaudatus*).

Table 5.11 SMALL TERRESTRIAL M AMMALS RECORDED IN THE STUDY AREA DURING THE STUDY SURVEYS

Common Name	Scientific Name	Location	Detection Method
Bush rat	*Rattus fuscipes*	NP; GGG; NSFn; NSFs; JC	AE; GE; Hair
Brown antechinus	*Antechinus stuartii*	WG; NW; MK; NSFn; NSFs	AE; GE
Swamp rat	*Rattus lutreolus*	NW; MK; NSFs	GE
Black rat	*Rattus rattus*	JC (i)	dead individual
House mouse	*Mus musculus*		Hair

Key: (i) incidental observation

Location:

NSFn	Nerong State Forest - northern transect
NSFs	Nerong State Forest - southern transect
JC	Jack's Creek
WG	Waterholes Gap
NP	Nerong Powerline (east of highway)
NW	Nerong Waterholes
GGG	Grey Gum Gully
MK	Mount Karuah

Detection Method:

AE	Arboreal Elliott
GE	Ground Elliott
Hair	Hair Analysis

d. Medium-Large Terrestrial Mammals

A total of nine medium to large terrestrial native species were recorded in the study area during the study surveys (*Table 5.12*). The eastern grey kangaroo (*Macropus giganteus*) and red-necked wallaby (*Macropus rufogriseus*) were the most commonly recorded species. A total of two species recorded are currently listed as threatened on the NSW TSC Act (1995). These species include the spotted tailed quoll (*Dasyurus maculatus*) and the long-nosed potoroo (*Potorous tridactylus*).

Although not detected during the study surveys, primary habitat for the rufous bettong (*Aepyprymnus rufescens*) is likely to occur within the study area. Secondary foraging resources may also occur within areas of closed forest for the red-legged pademelon (*Thylogale stigmatica*).

Table 5.12 MEDIUM TO LARGE TERRESTRIAL MAMMALS RECORDED IN THE STUDY AREA DURING THE STUDY SURVEYS

Common Name	Scientific Name	Location	Detection Method
Short-beaked Echidna	*Tachyglossus aculeatus*	WG-NW; BuC	predator scat; roadkill
Spotted Tailed Quoll	***Dasyurus maculatus***	**NW**	**Scat**
Northern Brown Bandicoot	*Isoodon macrourus*	MK	Hair
Long-nosed Bandicoot	*Perameles nasuta*	NSF1; NW	Spot; Inc.
Long-nosed Potoroo	***Potorous tridactylus***	**GGG**	**Scat**
Eastern Grey Kangaroo	*Macropus giganteus*	throughout study area	Spot; Inc.; Scat
Whiptail Wallaby	*Macropus parryi*	BC	roadkill
Red-necked Wallaby	*Macropus rufogriseus*	throughout study area	Inc.; Scat
Swamp Wallaby	*Wallabia bicolor*	BG	Scat

Key:

Location:		Detection Method	
NSF1	Nerong State Forest spotlight transect 1	Scat	Scat Analysis
GGG	Grey Gum Gully	Spot	Spotlighting
BC	Bulga Creek	Inc.	Incidental Observation
MK	Mount Karuah	Hair	Hair Analysis
BuC	Bundabah Creek		
NW	Nerong Waterholes		

e. Microchiropteran Bats

A total of 12 microchiropteran bat species were recorded during the study surveys (*Table 5.13*). A total of four species recorded are currently listed as threatened on the NSW TSC Act (1995). These species include the little bent-wing bat (*Miniopterus australis*), common bent-wing bat (*Miniopterus schreibersii*), eastern freetail-bat (*Mormopterus norfolkensis*) and the large-footed myotis (*Myotis adversus*). The recording of *Mormopterus norfolkensis* is only a tentative identification due to difficulties in distinguishing its call from other similar species.

There is unlikely to be any primary habitat for the golden tipped bat (*Kerivoula papuensis*) within the study area due to a lack of rainforest vegetation. However, some areas of sub-optimal foraging resources may occur within open and closed forest habitats.

Table 5.13 MICROCHIROPTERAN BAT SPECIES RECORDED DURING THE STUDY SURVEYS

Common Name	Scientific Name	Location	Detection Technique
Little bent-wing-bat	***Miniopterus australis***	**BC; JC2**	**Harp**
Common bent-wing-bat	***Miniopterus schreibersii***	**BC; JC1**	**Harp**
Lesser Long-eared bat	*Nyctophilus geoffroyi*	JC2	Harp
Gould's Long-eared bat	*Nyctophilus gouldi*	JC1; JC2; GGG; BG	Harp/Anabat
	Nyctophilus spp.	JC1; JC2; GGG	Harp
Chocolate wattled bat	*Chalinolobus morio*	BC; BG	Harp/Anabat
Large-footed myotis	***Myotis adversus***	**JC1**	**Harp**
Eastern broad-nosed Bat	*Scotorepens orion*	JC2; BG	Harp/Trip
Eastern forest bat	*Vespadelus pumilus*	BC; JC2	Harp
	Vespadelus spp.	BC; JC2; GGG; BG	Harp/Trip/Anabat
Eastern freetail-bat ?	***Mormopterus norfolkensis ?***	**BG**	**Anabat**
	Mormopterus sp. 1	BG	Trip

Key: **bold text** species listed on TSC Act

? tentative identification

Location:

BG	Burdekin's Gap (Triplining Site)
GGG	Grey Gum Gully
JC1	Jack's Creek Site 1
JC2	Jack's Creek Site 2
BC	Bulga Creek

Detection Technique

Harp	Harp Trap
Trip	Tripline
Anabat	Bat Detector