Upgrading the Pacific Highway

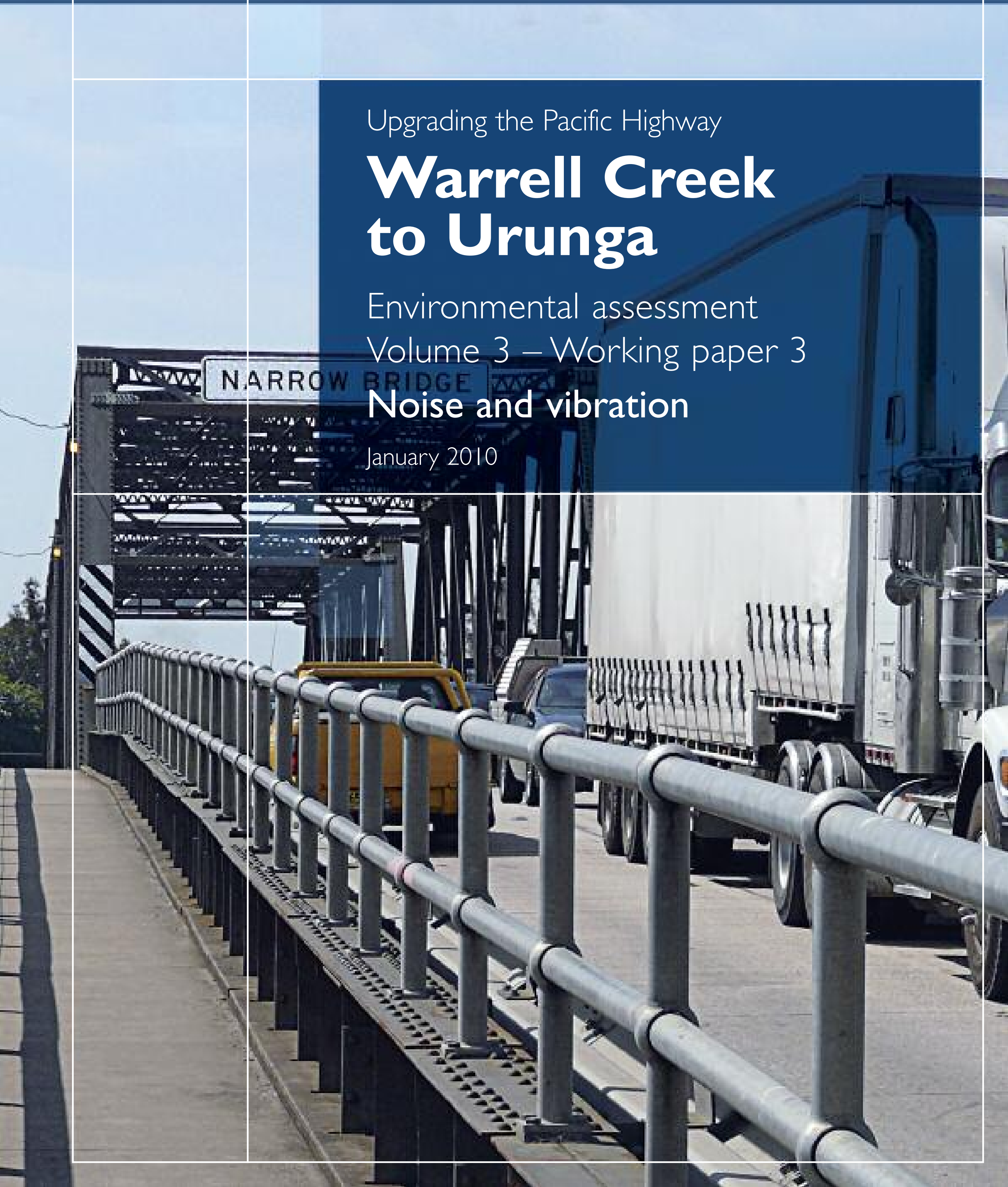
Warrell Creek to Urunga

Environmental assessment

Volume 3 – Working paper 3

Noise and vibration

January 2010



Warrell Creek to Urunga
Upgrading the Pacific Highway

WORKING PAPER 3 – NOISE AND VIBRATION IMPACT ASSESSMENT

V07

- 8 January 2010

Warrell Creek to Urunga Upgrading the Pacific Highway

WORKING PAPER 3 – NOISE AND VIBRATION IMPACT ASSESSMENT

V07

- 8 January 2010

Sinclair Knight Merz
ABN 37 001 024 095
100 Christie Street
PO Box 164
St Leonards NSW
Australia 1590
Tel: +61 2 9928 2100
Fax: +61 2 9928 2500
Web: www.skmconsulting.com

Contents

1. Introduction

Sinclair Knight Merz (SKM) has been commissioned by the NSW Roads and Traffic Authority (RTA) to conduct an environmental assessment (EA) of the Proposal for the Pacific Highway upgrade between Warrell Creek and Urunga, which forms part of the RTA's Pacific Highway Upgrading (PHU) Program. The Proposal corridor is located in the Mid-North Coast region of NSW and extends for approximately 42 km from the northern end of the existing Allgomera deviation, south of Warrell Creek, to the existing Waterfall Way interchange at Raleigh, as shown in **Figure 1-1**.

Noise and vibration is identified as a key issue in the Department of Planning (DoP) (now part of the Department of Planning & Local Government) Director-General's requirements. A detailed noise and vibration assessment for the Proposal was undertaken and is presented in this Working Paper.

1.1. Assessment requirements

The environmental assessment requirements in relation to noise and vibration were:

- Construction noise and vibration including construction traffic noise and blasting impacts.
- Operational road traffic noise impacts including consideration of local meteorological conditions (as relevant) and any secondary noise impacts from proposed noise mitigation measures.
- Consideration of the following guidelines as relevant: *Environmental Criteria for Road Traffic Noise* (EPA 1999), *Environmental Noise Management Manual* (RTA, 2001), *Environmental Noise Control Manual* (EPA, 1994), *Assessing Vibration: A Technical Guideline* (DEC, 2006).

1.2. Objectives

The purpose of this report is to assess the noise impacts that may occur as the result of the Proposal.

The assessment of road traffic noise has been undertaken in accordance with the Department of Environment, Climate Change and Water (DECCW) *Environmental Criteria for Road Traffic Noise* (EPA 1999) guideline and the RTA *Environmental Noise Management Manual* (RTA 2001). In particular, the DoP and the DECCW require an assessment of potential noise impacts with respect to key locations along the alignment of the Proposal.

FIGURE 1-1 | THE PROPOSAL

Warrell Creek to Urunga - Upgrading the Pacific Highway

As part of the investigation of noise impacts the tasks undertaken include:

- Identification of existing sensitive receivers.
- Determination of appropriate noise criteria for sensitive receivers.
- Determination of existing road traffic noise levels by conducting noise modelling and noise monitoring surveys.
- Prediction of the road traffic noise levels (operational noise) expected to result from the proposal and compare these to the relevant noise criteria.
- Recommendation of appropriate controls for any operational noise impacts.
- The assessment of potential construction noise impacts.

1.3. Investigation area

The proposed upgrade alignment is to be located on the mid north coast of NSW. The alignment comprises approximately 42 km of dual carriageway highway from the northern end of the existing Allgomera deviation, south of Warrell Creek and the existing Waterfall Way interchange at Raleigh. The alignment traverses two key rivers, the Nambucca in the south and the Kalang in the north.

A 1 km impact zone has been defined for the assessment of noise impacts. The investigation area has been split into four sections, as shown on **Figure 1-2** and described as follows.

Allgomera deviation to Nambucca River

The Warrell Creek to Nambucca River section commences at the northern end of the existing Allgomera Deviation north of Kempsey. North of the Allgomera Deviation the Proposal deviates to the east of the village of Warrell Creek to run generally parallel to and to the west of Rosewood Road. After passing under Albert Drive, the Proposal runs parallel to and on the eastern side of the existing highway to the crossing of Warrell Creek. North of Warrell Creek, the Proposal diverts to the east of the existing highway in the vicinity of Bald Hill Road to pass close to the Gumma Swamp wetland (SEPP14 wetland No.388) downstream of the township of Macksville. The Proposal then crosses the Nambucca River immediately downstream of the confluence with Newee Creek.

Nambucca River to North Coast Railway overbridge

This section of the Proposal commences on the northern bank of the Nambucca River. From there the Proposal generally follows the ridgeline in the vicinity of Old Coast Road before crossing the North Coast Railway Line to rejoin the existing highway west of Nambucca Heads. The Proposal avoids direct impact on the Newee Creek wetland (SEPP 14 wetland No. 383) and has been located to allow Old Coast Road to be reconstructed as an access road for adjoining properties.

Nambucca Heads to Ballards Road

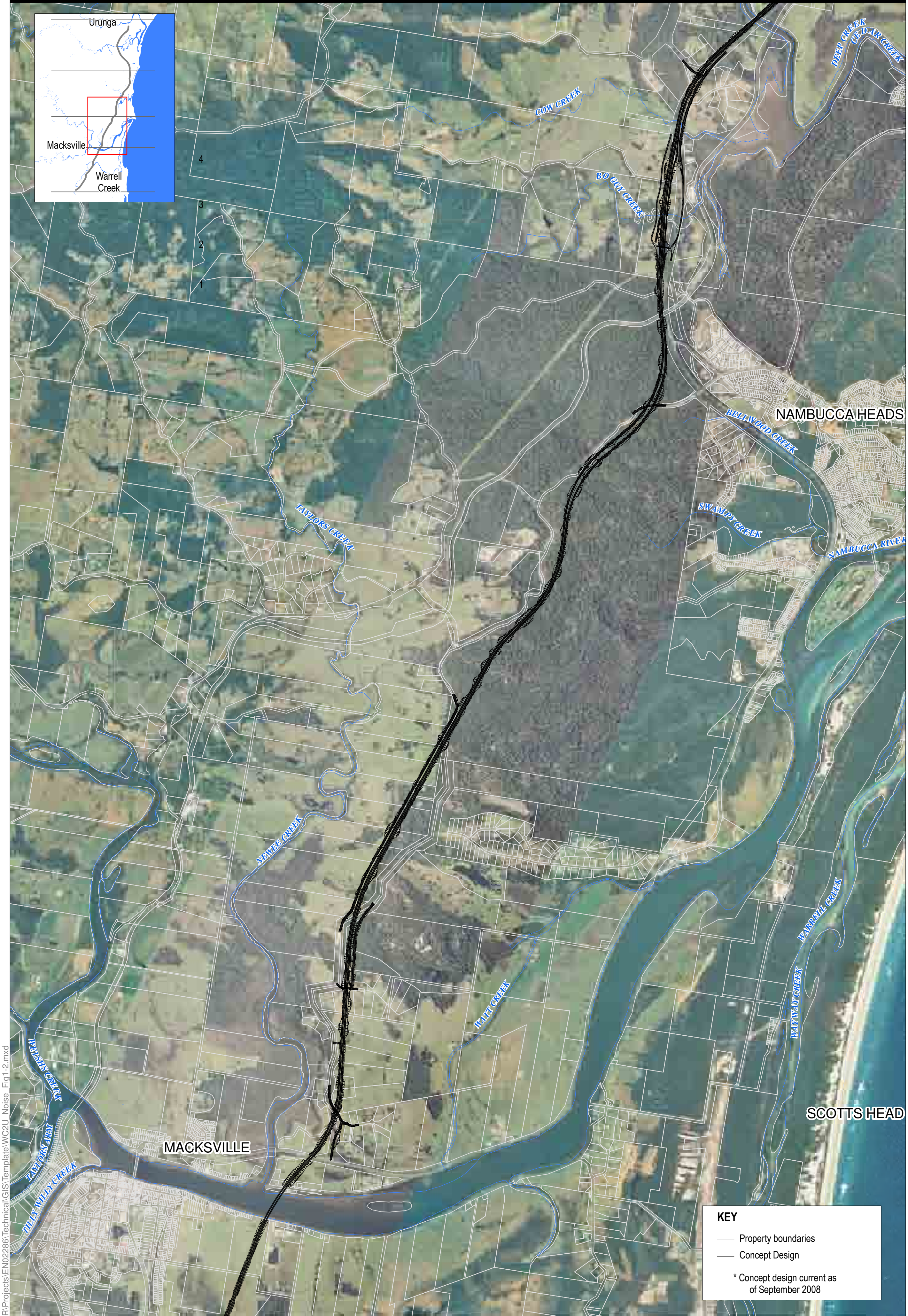
This area is highly constrained by the North Coast Railway Line and wetlands to the east and topographical constraints and proposed future urban areas to the west of the existing highway. Between Nambucca Heads and Ballards Road south of Urunga, the Proposal would be located on the western side of the existing highway which would be utilised as a local access road.

Ballards Road interchange to existing Waterfall Way interchange

North of Ballards Road the Proposal diverts to the west of the existing highway to traverse through Newry State Forest and cross the Kalang River in the vicinity of South Arm Road. The Proposal then passes to the west of SEPP 14 wetland No. 351 before passing to the east of Ridgewood Drive and the Raleigh Industrial area to rejoin the existing highway at Raleigh

FIGURE 1-2 | CONCEPT DESIGN

I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_Fig1-2.mxd



I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_Fig1-2.mxd

0 250 500 Metres

I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_Fig1-2.mxd


Urunga
Macksville
Warrell Creek
4
3
2
1
BURDETT PARK CREEK
RALEIGH
BOGGY CREEK
BACK CREEK
MANARM CREEK
BELLINGER RIVER
NEWRY ISLAND
URUNGA
KALANG RIVER
PICKETT HILL CREEK
DALHOUSIE CREEK
MCGRATHS CREEK
KEY
Property boundaries
Concept Design
* Concept design current as of September 2008
0 250 500 Metres

2. Existing noise environment

2.1. Noise sensitive receivers

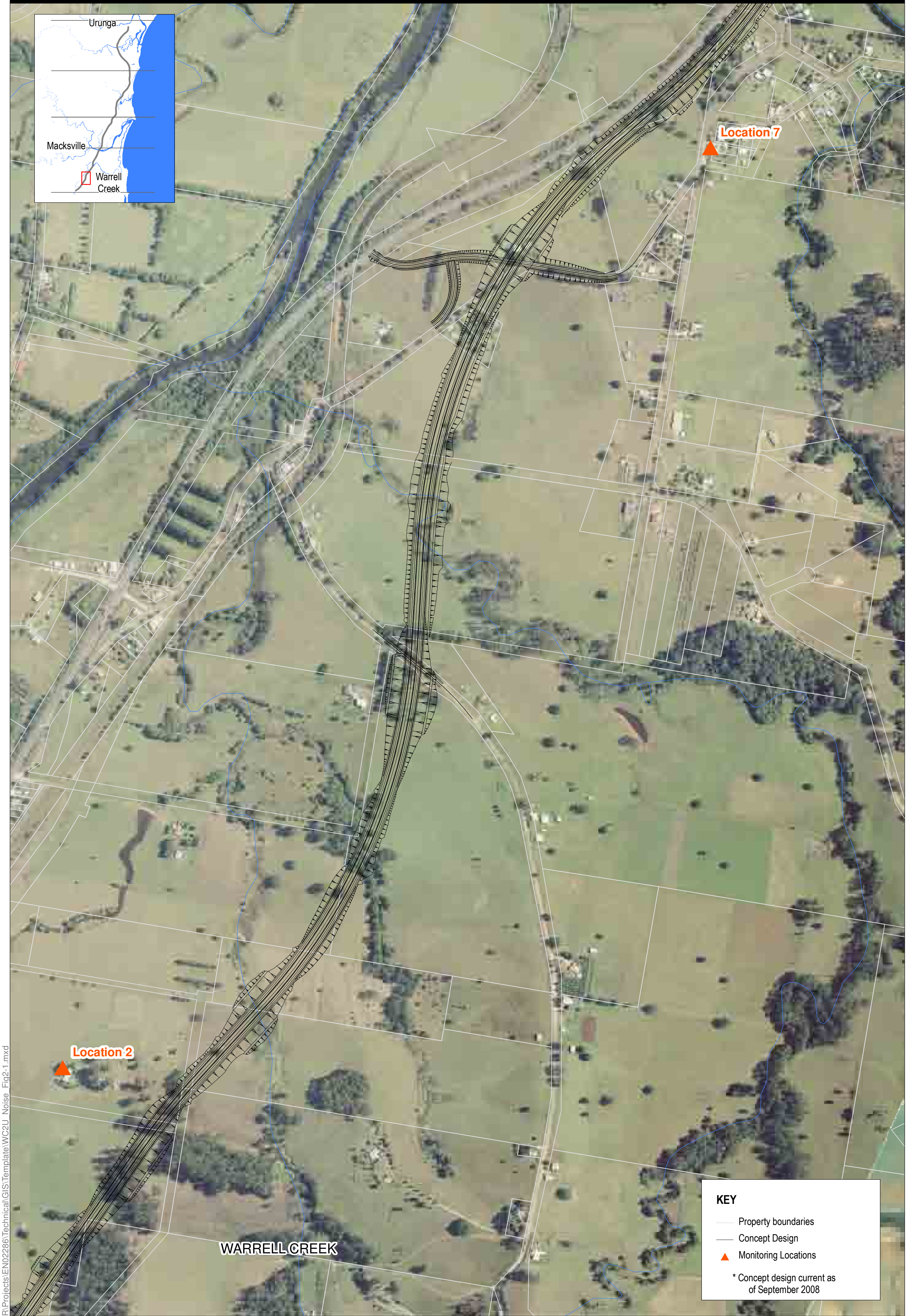
The investigation area includes a mix of rural and forestry uses, with urban settlements and villages forming the basis of residential communities. Residential development is generally located on the major rivers or on the coast. Agricultural uses in the investigation area include dairying and grazing, vegetable cropping and orchards, which often have isolated residential dwellings associated with the property. Forestry areas include the Newry, Little Newry and Nambucca State Forests, which provide visual and acoustic screening to some residential areas along the existing highway.

The investigation area continues to experience population growth and is expected to do so for the foreseeable future. Major residential population growth areas have been identified in and around Nambucca Heads, Valla Beach and Urunga. However rural residential development is also significant and is scattered throughout the investigation area. These communities include areas such as Warrell Creek and Donnellyville, Bald Hill, Letitia Close and Old Coast Road, and residential areas along Short Cut Road and Ridgewood Drive.

This assessment for the Proposal has identified and included each individual dwelling in the investigation area, which enables a detailed presentation of potential noise impacts. While all the identified receivers within the investigation were included in the initial modelling scenarios, only those receivers that were predicted to be inside the 50 dB(A) contour (i.e. predicted to experience noise levels greater than 50 dB(A)) were identified for additional assessment of potential noise impacts. From the 2863 residences in the investigation area, approximately 770 were predicted to be within this contour and these receivers formed the basis of the noise assessment for the Proposal. All 2863 receivers identified within the investigation area are shown on aerial photography and are presented in **Appendix A**.

2.2. Existing noise levels

Ambient noise levels were measured at key locations along the existing highway to provide information on the current noise environment prior to any road works (refer to **Figure 2–1**). Although these measurements provide information on the level of the existing traffic noise, their purpose is primarily to gather data that is used to validate the predictive accuracy of the road traffic noise model and to provide input to the construction noise impact assessment. The project specific noise criteria for operational noise levels for the Proposal are set independently of the existing noise levels (refer to **Section 3**).

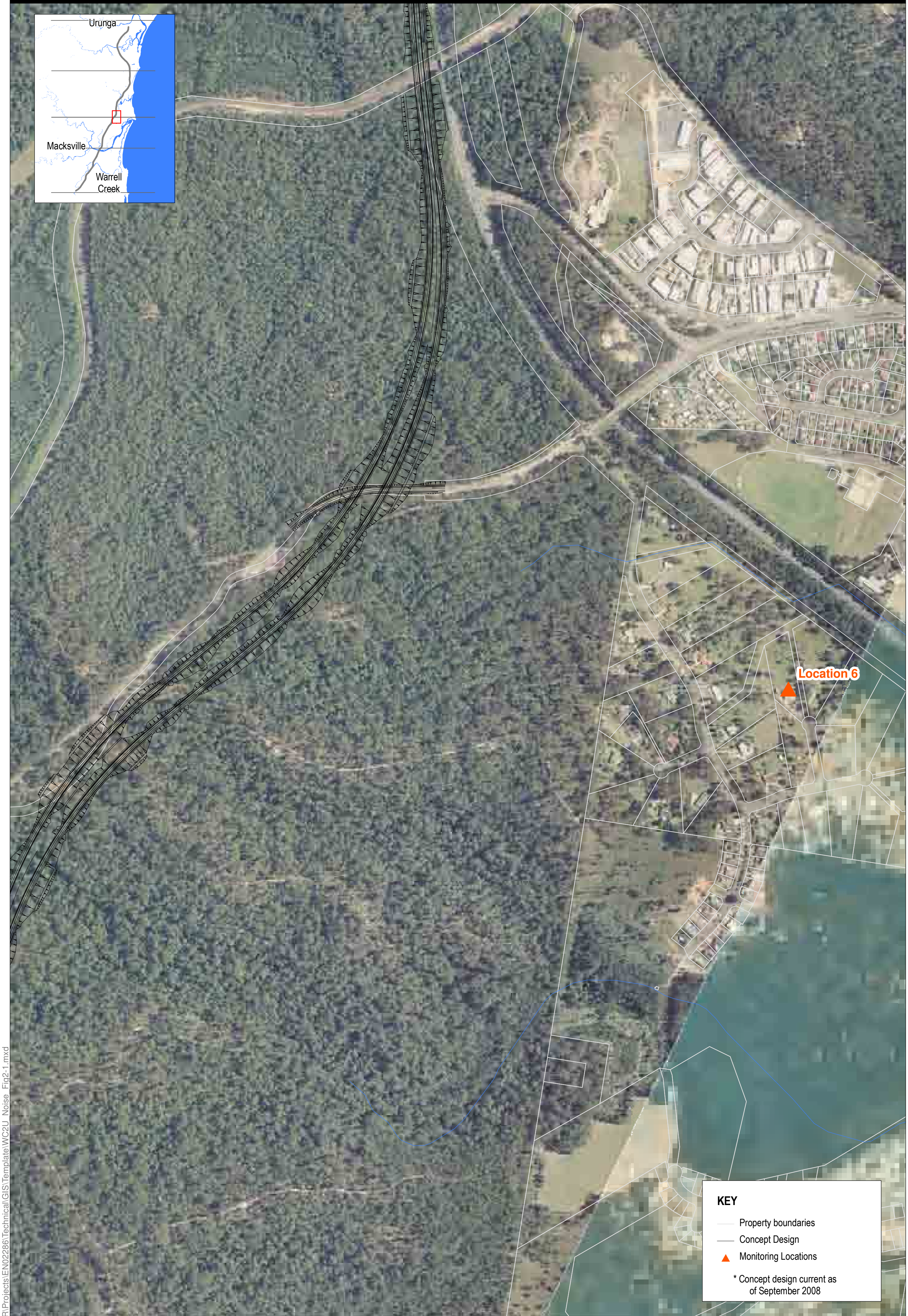


I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_Fig2-1.mxd


Urunga
Macksville
Warrell Creek
Location 4
KEY
Property boundaries
Concept Design
Monitoring Locations
* Concept design current as of September 2008
0
125
250 Metres

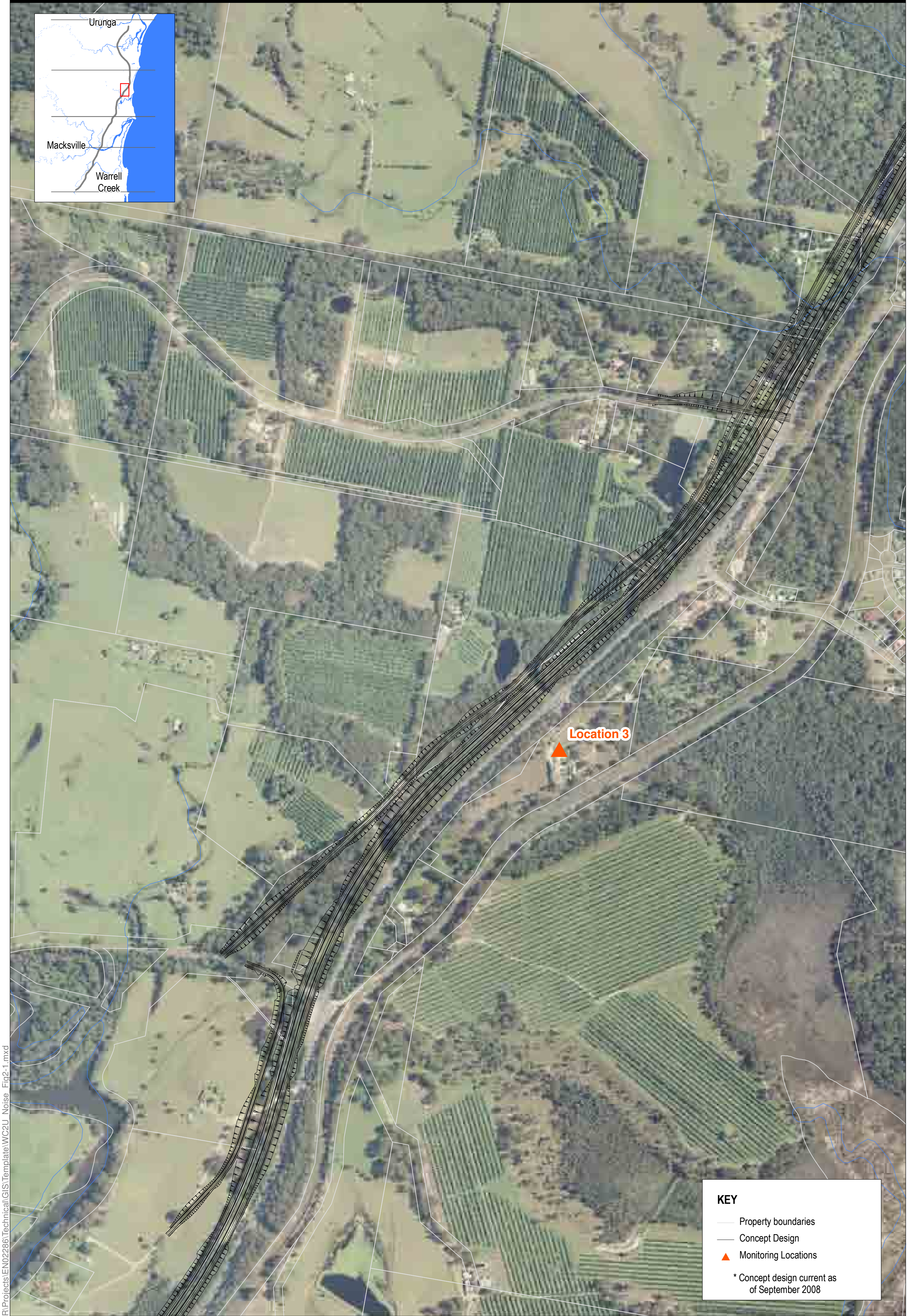
Urunga
Macksville
Warrell Creek
Location 5
KEY
Property boundaries
Concept Design
Monitoring Locations
* Concept design current as of September 2008
0
125
250 Metres

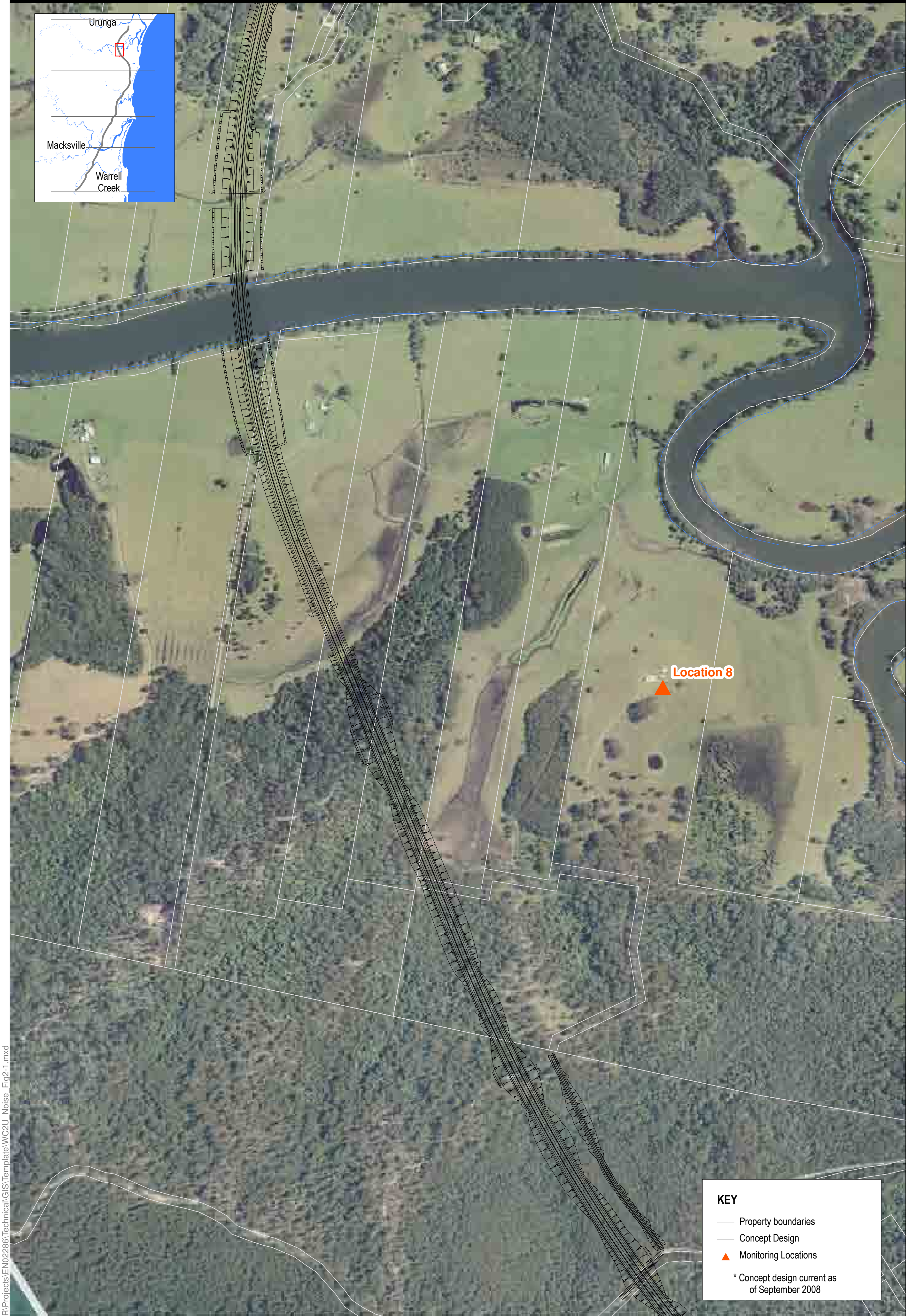
FIGURE 2-1 | NOISE MONITORING LOCATIONS

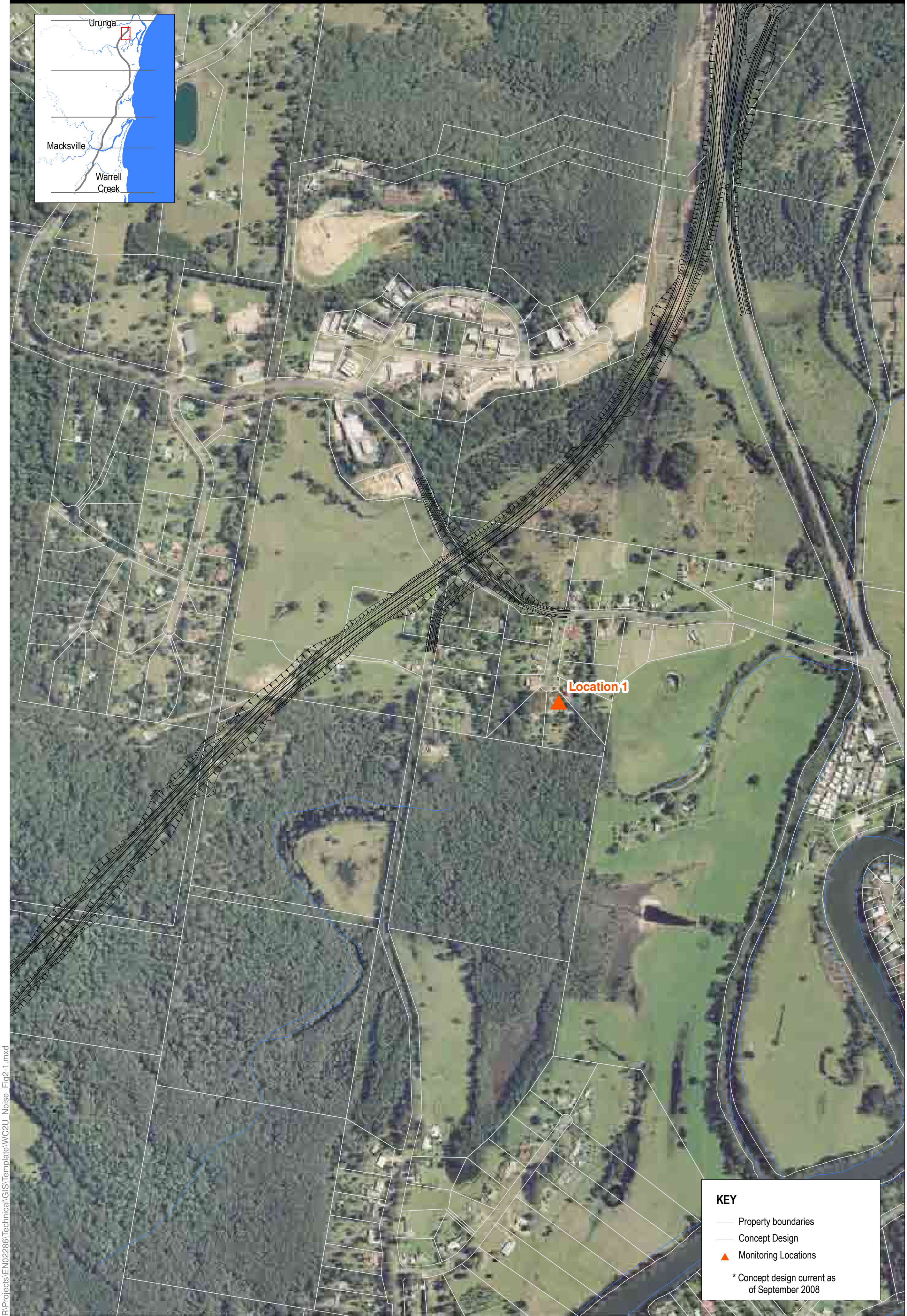


I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_Fig2-1.mxd

FIGURE 2-1 | NOISE MONITORING LOCATIONS




Urunga
Macksville
Warrell
Creek
Location 8
KEY
Property boundaries
Concept Design
Monitoring Locations
* Concept design current as
of September 2008
0
125
250 Metres



I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_Fig2-1.mxd

0 125 250 Metres

2.3. Monitoring methodology and results

Preliminary noise monitoring was undertaken in November 2007 over a nominal one week period. The monitoring provided information on the existing noise environment that was then used in the initial calibration of the noise model. Additional monitoring sites were later added in August 2008 to provide more detail of existing noise influences across the investigation area. The location of the noise monitoring equipment used to measure the existing ambient noise is shown in **Figure 2–1**. The monitoring locations range in distance from the existing highway and have been selected to be representative of receivers that would experience a noise impact from the existing or proposed alignments.

When measuring noise levels, the use of statistical descriptors is necessary to understand and describe how variations in the noise environment occur over any given period. For road traffic noise these descriptors are further classified for daytime (7:00 am – 10:00pm) and night time (10:00pm – 7:00am) periods. For environmental noise, the assessment period for night time is the same, however, day time is further split into day and evening as follows day time (7:00 am – 6:00pm) and evening (6:00pm – 10:00pm). Common descriptors used in this noise assessment are defined as follows:

- L_{A10} – the noise level exceeded for 10% of the measurement interval, this is commonly referred to as the average-maximum level;
- L_{A90} – the noise level exceeded for 90 percent of the measurement interval. This is commonly referred to as the background noise level.
- L_{Aeq} – the noise level having the same energy as the time varying noise level over the 15 minute interval. For traffic noise this descriptor is classified as $L_{Aeq\ 15\ Hr}$ and $L_{Aeq\ 9\ Hr}$ for the day and night time noise levels respectively. This is commonly referred to as the ambient noise level.
- L_{Amax} – the maximum noise level measured at a given location over the measurement interval.
- RBL – The Rating Background Level (RBL) is the overall single-figure background level, which is the 10th percentile of the L_{A90} values for each of the day evening and night time periods over the whole monitoring period.

The statistical noise indices were calculated from the monitored data for both road traffic noise and environmental noise parameters. The environmental noise statistics are used for the setting of construction noise criteria in **Section 6**. The $L_{A10,18\ hour}$ and $L_{Aeq,15\ hour}$ and $L_{Aeq,9\ hour}$ road traffic noise indices and the L_{Amax} descriptors were calculated on a daily basis for these monitoring locations and are summarised as the median of the combined daily results. Because the L_{A10} and L_{Aeq} indices are not directly interchangeable, a correction factor is required to convert the modelled L_{A10} values to the L_{Aeq}

criterion base. The difference between the $L_{A10,18\ hour}$ and $L_{Aeq,15\ hour}$ results is used to determine the correction factor applied to the results of the Calculation of Road Traffic Noise (CoRTN) noise modelling for the model validation for each location.

The daily traffic noise measurement profile for each of the locations is shown graphically in **Appendix B** and summarised in **Table 2-1**. The weather conditions throughout the monitoring period were obtained from the Bureau of Meteorology. The meteorological data has been incorporated into the analysis of the measured noise levels and any data that is considered to be invalid due to adverse weather has been removed from the results. Adverse weather includes occasions where wind speeds exceed 7 metres per second or where rain affects any 15 minute monitoring period.

Table 2-1 Summary of traffic noise monitoring descriptors

Location	Monitoring Date	$L_{A10\ 18\ hour}$	L_{Aeq} 15 hour	L_{Aeq} 9 hour	L_{Amax} Day	L_{Amax} Night	9 hour L_{A10} - L_{Aeq}
Location 1	21-Nov-07 to 06 Dec-07	53	55	48	66	61	1
Location 2	21-Nov-07 to 06 Dec-07	58	59	51	68	62	3
Location 3	21-Nov-07 to 06 Dec-07	61	58	56	68	69	4
Location 4	7 Aug to 08 to 19 Aug 08	57	53	53	65	65	4
Location 5	7 Aug to 08 to 19 Aug 08	55	52	53	65	65	3
Location 6	7 Aug to 08 to 19 Aug 08	58	55	57	68	70	3
Location 7	19 Aug 08 to 9 Sept 08	55	53	54	69	68	4
Location 8	19 Aug 08 to 9 Sept 08	47	46	46	59	54	0

Observations during the site surveys at locations 2, 3, 4, 5, 6 and 7 confirmed that the monitored noise levels were dominated by road traffic noise on the Pacific Highway during the day time periods. It follows that these locations are also likely to have an ambient noise environment dominated by traffic noise during the night time when other non-traffic noise sources are not present. At locations 1 and 8, the day time traffic noise was audible but did not provide a significant contribution to the noise environment. At these locations, traffic noise levels would tend to become more dominant during the evening and night time as other non-traffic noise sources diminished in level.

Selected environmental noise parameters for each monitoring location are presented in **Table 2-2**. The maximum noise levels recorded at each site are noted as the L_{Amax} as well as the ambient L_{Aeq} noise level and the rating background level (RBL).

- **Table 2-2 Summary of unattended environmental noise monitoring descriptors**

Location	Day			Evening			Night		
	L_{Amax*}	L_{Aeq*}	RBL†	L_{Amax*}	L_{Aeq*}	RBL†	L_{Amax*}	L_{Aeq*}	RBL†
Location 1	67	52	39	65	49	42	57	46	41
Location 2	69	58	42	65	52	41	61	51	40
Location 3	68	58	49	69	58	47	69	56	44
Location 4	64	53	48	65	54	45	65	53	40
Location 5	65	51	41	65	53	38	65	52	34
Location 6	68	53	43	67	56	39	71	56	32
Location 7	70	51	39	68	54	41	68	54	37
Location 8	61	44	37	55	44	41	54	44	40

Note * L_{AMax} and L_{Aeq} – 50th Percentile; † L_{A90} 10th Percentile

3. Project noise criteria

The project noise criteria in this section of the report refer to operational noise impacts. Construction activities have also been assessed as part of this report. For details of construction noise criteria and an assessment of construction noise and vibration impacts see **Section 6**.

3.1. Road traffic noise criteria

The noise criteria for the Proposal are in accordance with the *Environmental Road Traffic Noise Criteria* (ECRTN) guideline. The appropriate noise goals for the upgrade of the highway are listed in **Table 3-1**. The assessment methodology and application of the noise criteria are taken from the *Environmental Noise Management Manual* (ENMM).

- **Table 3-1: Road traffic noise base criteria**

Road category	Daytime Levels	Night-time levels
New Freeway	$L_{Aeq\ (15hour)}$ 55 dB(A)	$L_{Aeq\ (9hour)}$ 50 dB(A)
Redevelopment of an existing freeway	$L_{Aeq\ (15hour)}$ 60 dB(A)	$L_{Aeq\ (9hour)}$ 55 dB(A)

The road category that is applicable for the majority of the Proposal is that of a New Freeway defined by the ECRTN as:

> *"**New freeway/arterial** refers to a freeway, arterial or sub-arterial road that is proposed on a 'corridor' that has not previously been a freeway, arterial or sub-arterial road; or an existing freeway, arterial or sub-arterial that is being substantially realigned."*

Due to the influence of the existing highway the section between the rail crossing of the North Coast Railway Line at Nambucca Heads and Mines Road (Section 3) would have a road category for redevelopment of an existing freeway. This is defined in the ECRTN as:

> *"**Redevelop existing freeway/arterial** refers to an existing freeway, arterial or sub-arterial corridor where it is proposed to increase traffic-carrying capacity, change the traffic mix or change the road alignment through design or engineering changes. Redevelopment does not cover minor road works designed to improve safety, such as straightening curves, installing traffic control devices or making minor road alignments."*

The determination of which criterion is appropriate for a noise sensitive receiver is, for the most part, straight forward. However, some locations, due the influence of existing traffic noise, require further assessment to determine the applicable base criteria. Where this is necessary, the ENMM Practice

Note (i) assists in identifying which noise level criteria should apply for new roads and road upgrades. The practice note takes into account the following points:

– Road traffic noise exposure from existing routes.
– Significant contribution to noise exposure from a road development or upgrade.
– New road traffic noise sources.
– The location of the existing route corridor alignments relative to proposed works.

For the Proposal a scenario based on projected traffic volumes for both the day (ie. 7am-10pm) and night time period (i.e. 10pm-7am), was established. From the noise modelling results the operational noise impacts of the Proposal are expected to be greater during the night and therefore the night time criteria is the governing criteria for the Proposal. The ECRTN also requires that the noise levels are predicted for the year of opening and a future scenario for 10 years after opening.

3.1.1. Allowance criteria

Depending on the extent of impact of the current traffic noise environment at a receiver location, the base criteria may be modified for either a new road or a redeveloped road. These modifying values are known as the allowance criteria. At a location where there is an existing road traffic noise impact the allowance criteria is used in assessing the appropriate forms of noise mitigation. However, for the majority of the Proposal the base criteria in Table 3-1 would be applicable. According to the ECRTN, the allowance criteria for a new freeway or arterial road corridor are as follows:

> *"The new road should be designed so as not to increase existing noise levels by more than 0.5 dB."*

This statement refers to "existing noise levels" where base criteria are already exceeded, which are the direct result of road traffic. For a road redevelopment the following allowance criteria is noted in the ECRTN where base criteria are already exceeded:

> *"In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dB."*

In both cases the ECRTN states:

> *"Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In some instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land use developments; reduced vehicle emission levels through new vehicle*

standards and regulation of in-service vehicles; greater use of public transport; and alternative methods of freight haulage."

This last statement initially refers to the implementation of noise barriers, architectural treatments and other traffic noise reducing strategies. The RTA ENMM provides further detail on which strategies would be most appropriate taking into account the factors affecting each sensitive receiver location.

Other sensitive receivers not covered under the residential criteria, such as schools, hospitals and churches, have separate internal noise level criteria and these are listed in **Table 3-2**, which has been summarised from Table 2 of the ECRTN.

- **Table 3-2: Road traffic noise criteria for sensitive land uses**

SENSITIVE LAND USE	CRITERIA		
	DAY (7 am–10 pm) dB(A)	NIGHT (10 pm–7 am) dB(A)	NOISE MITIGATION MEASURES
1. Proposed school classrooms For existing school classrooms	L Aeq(1h) 40 (internal) – L Aeq(1h) 45 (internal) -	- -	To achieve internal noise criteria in the short term, the most practicable mitigation measures are often related to building or facade treatments. In the medium to longer term, strategies such as regulation of exhaust noise from in-service vehicles, limitations on exhaust brake use, and restricting access for sensitive areas or during sensitive times to low noise vehicles can be applied to mitigate noise impacts across the road system. Other measures include improved planning, design and for sensitive areas or during sensitive times to low noise vehicles can be applied to mitigate noise impacts across the road system. Other measures include improved planning, design and construction of sensitive land use developments; reduced new vehicle emission standards; greater use of public transport; and alternative methods of freight haulage. These medium- to long-term strategies apply equally to mitigating internal and external noise levels. Where existing levels of traffic noise exceed the criteria, all feasible and reasonable noise control measures should be evaluated and applied. Where this has been done and the internal or external criteria (as appropriate) cannot be achieved, the proposed road or land use development should be designed so as not to increase existing road traffic noise levels by more than 0.5 dB(A) for new roads and 2 dB(A) for redeveloped roads or land use development with potential to create additional traffic.
2. Hospital wards	L Aeq(1h) 35 (internal)	L Aeq(1h) 35 (internal)	
3. Places of worship	L Aeq(1h) 40 (internal)	L Aeq(1h) 40 (internal)	
4. Active recreation (for example, golf courses)	Collector and local roads: L Aeq(1h) 60 Freeway/ arterial roads: L Aeq(15h) 60		
5. Passive recreation and school playgrounds -	Collector and local roads: $L_{Aeq(1h)}$ 55 Freeway/ arterial roads: $L_{Aeq(15h)}$ 55		

Extracted from the *Environmental Criteria for Road Traffic Noise*

The non residential sensitive receivers currently identified for the Proposal include schools in the townships of Macksville and Nambucca Heads and Urunga as well as a hospital in Macksville. **Table 3-3** presents the identified non residential receivers in or around the investigation area.

- **Table 3-3: Road traffic noise criteria for sensitive land uses**

Designation	Description	Comments
School	Nambucca Heads High School Centenary Parade, Nambucca Heads	250 metres from the existing highway, but outside the Proposal investigation area
School	Hibiscus Christian School Dudley Street, Macksville	Within 550 metres of the Proposal
School	Macksville Public School Wallace Street, Macksville	Outside investigation area
School	Urunga Public School Bowra Street, Urunga	Outside investigation area
School	St Patrick's Primary School Wallace Street Macksville	Outside investigation area
School	Macksville High School Boundary St, Macksville	Outside investigation area
Hospital	Macksville District Hospital Boundary St, Macksville	120 metres from the existing highway, inside the investigation area.

Of the locations listed in **Table 3-3**, the Hibiscus Christian School may be potentially affected by the Proposal. All other locations are currently near the existing highway and would experience a reduction in noise from the highway as the result of the Proposal. The expected daytime noise levels at the Hibiscus Christian School should be assessed against the internal noise level criterion of LAeq(1h) 45dB(A) however, the prediction of internal noise levels is highly dependent on the construction of the building in question. For assessment purposes in this report, the predicted external noise level less 10 dB(A) has been used to estimate the internal noise level with windows open as per AS 3671 *Acoustics - Road traffic noise intrusion - Building siting and construction*. The predicted noise level at the school has been included in **Table 5-5**.

3.1.2. Maximum noise level assessment – sleep disturbance

The ECRTN provides guidance in assessing the likelihood of sleep arousal due to traffic noise impacts. The cause of sleep disturbance varies between studies however it is largely recognised that the maximum noise level of an event, the number of occurrences, the duration of the event, and the emergence above background or ambient noise levels are key factors. Not all people are affected to the same degree or by the same noise exposure and findings from studies of sleep disturbance measured by an awakening, change in sleep state or after-effects reflect the considerable variation in the population's response to noise. For assessment purposes, at locations where the traffic noise is continuous rather than intermittent, the ENMM employs a methodology to assess these impacts based on the emergence of the L_{Amax} over the $L_{Aeq\,(1hr)}$ noise level. A maximum noise pass-by event is defined as the emergence of the L_{Amax} level above the $L_{Aeq\,(1hr)}$ noise level, by 15 dB(A) or more, i.e.:

`

$$L_{Amax} \geq L_{Aeq\,(1hr)} + 15\ dB(A)$$

The assessment of sleep disturbance impacts is not always relevant for situations where mitigation is already recommended for a project. However, an assessment of maximum noise levels may be required when noise predictions indicate that the effects of a road project fall below the L_{Aeq} project specific noise criteria at a sensitive receiver and therefore would not be eligible for consideration of noise mitigation.

3.1.3. Nambucca Heads Rest area

The character of noise from rest areas differs from general traffic noise and therefore requires a different approach to assessment and management. The DECCW *NSW Industrial Noise Policy* (EPA 2000) (INP) is a document that provides guidelines for the assessment of noise emissions from premises that are scheduled under the *Protection of the Environment and Operations Act, 1997*. The INP is designed to determine an acceptable level of impact expected at a community level from industrial type noise sources and where the INP criteria are met no adverse noise impacts would be reasonably expected at a sensitive receiver location.

While the INP is not strictly used for the assessment of non industry based noise emissions, the application of the criteria may be implemented where guidance on appropriate noise levels is required. The INP requires that the noise from a development under assessment comply with the lower of the amenity or intrusive noise criteria. The intrusive criterion is determined by the difference between the noise under assessment being no more than 5 dB(A) above the Rating Background Level (RBL), while the amenity criterion is based on the zoning and general land use near the residences likely to be affected by noise emissions.

In general the amenity levels are more suited to planning of noise levels rather than the assessment of project specific impacts. The intrusive noise criteria are designed to account for shorter duration noise impacts and are often the most appropriate tool for assessing the effects of noise at a residential location. According to the INP a noise source is considered to be non-intrusive if:

- The $L_{Aeq, 15}$ minute level does not exceed the RBL by more than 5 dB(A) for each of the day, evening and night-time periods.
- The subject noise does not contain tonal, impulsive, or other modifying factors as detailed in Chapter 4 of the INP.

Background noise levels measured at Location 3, (see **Table 2-2**) are representative of the nearest sensitive receiver to the proposed rest area, which has been estimated to have a similar daily noise profile based on the distance from the road and its location in Section 3 of the Proposal. The RBL during the quietest period (night) at Location 3 is 49 dB(A). Based in the definition of a non intrusive noise impact, the noise goal for the operation of the rest area at the nearest receiver would be an $L_{Aeq\ 15\ min}$ 54 dB(A). An assessment of noise emissions from the rest area would indicate the potential for intrusive noise impacts to affect the nearest receiver and highlight the need for any mitigation requirements to meet the intrusive noise goals.

4. Assessment of traffic noise impacts

The assessment of noise impacts requires that the predicted noise levels from the modelling scenarios are compared to the criteria at a noise sensitive receiver location. The operational criteria for each location is taken from the ECRTN and is covered in **Section 3.1**, however, the selection of the appropriate criteria for each receiver is taken from the ENMM.

4.1. Definition of new and upgrade sensitive receivers

Where there is the potential for an existing traffic noise exposure to have an impact on sensitive receivers, an assessment of this situation is required. The RTA ENMM defines an existing road traffic noise exposure in Practice Note (i) as follows:

> *"A site is defined as having an "existing road traffic noise exposure" if the prevailing noise level from the existing road alignment(s) under consideration is equal to or greater than 55 dB(A) LAeq (15hr) (day) or 50 dB(A) LAeq (9hr) (night). The noise level contours corresponding to these day and night noise levels define the "noise catchment" for an existing road. In areas outside these contours, road traffic is unlikely to be a significant noise source."*

Where the assignment of the road upgrade category at a receiver is not straightforward, the ENMM provides additional information for the redeveloped criteria application in Practice Note (i). Specifically, the redeveloped road criteria in the ECRTN apply at the exposed facades of a noise sensitive receiver for a road redevelopment that occurs outside an existing road corridor for the same road category if:

> *"The existing traffic noise level is equal to or greater than the criteria applying to "redeveloped roads" (when allowances are taken into account, these are effectively 58 dB(A) day and 53 dB(A) night, and the upgrading does not involve a new road traffic noise source"*

Here a "new road traffic noise source" means an exposure from road traffic noise on a new facade of the building. The existing noise exposure at residential locations in the investigation area resulting from the current highway was initially determined by the 53 dB(A) night time noise contour. Where a new noise exposure is apparent for these receivers, the affected dwellings were further investigated to confirm the appropriate road criteria category. As a result of this process, the 1600 identified receivers for the Proposal were separated into new and upgrade road criteria categories for assessment purposes.

4.2. Development of the Proposal alignment and noise

During the route options assessment process and the later design of the Proposal the impacts of noise on receivers have been considered along with many other constraints. In the broader scheme, noise is one of many social and economic impacts that require assessment for the Proposal to gain approval from the Minister of Planning.

For the environmental assessment, and during the design of the Proposal, the potential for mitigation of noise impacts was included in the development process. The residential receivers in the investigation area are, for the most part, in small communities or on rural acreages making effective mitigation more difficult than a typical urban environment. The design of highway has therefore been used to reduce impacts to the noise environment where possible. In particular, where the general road alignment could be moved away from dwellings or lowered by a cutting to provide additional shielding, the noise factors were a consideration. The outcome of this process is an alignment that has provided the greatest benefit from topographic shielding available while fulfilling other constructability criteria at the concept design stage. After this process, the residual noise impacts above the criterion are the focus of the noise assessment and recommendation for noise mitigation for residential dwellings.

4.3. Assessment parameters

The parameters considered for a traffic noise assessment, when predicting noise impacts at a receiver, remain the same from project to project. The value of these parameters will however, vary between projects. The types of influences that can be considered for a noise assessment are based on emissions that can be quantified by the traffic data or design of the road. Other noise sources that occur randomly or in different locations depending on the driver (e.g. use of exhaust brakes, horns etc), cannot be considered when modelling traffic noise. A list of factors that have known impacts have been incorporated into the noise model and are discussed below.

4.4. Factors affecting road traffic noise

The level of road traffic noise may be influenced by many factors, which tend to increase or reduce the noise impacts at a receiver in differing proportions. The design of the road has a significant effect on the noise level at a receiver. **Table 4-1** lists the variables that are used as inputs to the noise model and the effect on noise emissions.

- **Table 4-1: Factors affecting road traffic noise**

Variable	Description
Traffic volumes and mix	The number of vehicles using the road as well as the proportion of heavy to light vehicles. A higher ratio of heavy vehicles increases the noise levels proportionally.
Traffic speed	An increase in traffic speed generally causes an increase in tyre noise.
Road surface types	Can be asphaltic concrete, low noise pavement or other types as applicable. Each surface type generates different levels of tyre noise.
Gradient of roadway	Noise level change as a result of traffic climbing or descending hills compared with traffic travelling along flat gradients.
Ground topography	Natural topographic features such as hills and valleys can shield residences from traffic noise.
Height of receivers	May be single or multiple storey residential dwellings. The height of the receiver would influence the exposure to traffic noise and the ability to mitigate adverse impacts.
Air and ground absorption	Noise levels reduce with increasing distance and ground vegetation.
Attenuation due to building structures	Existing buildings and structures may provide shielding of traffic noise to varying degrees.

Parameters that were used in the noise modelling for the assessment of noise impacts are shown in **Table 4–2**.

- **Table 4–2 Summary of modelling inputs**

Input Variable	2007 ONMR Data
Traffic numbers and mix	Traffic numbers forecast for the years 2012 and 2022 see Section 4.6.
Ground topography	Obtained from aerial photogrammetry, 2 m increments
Gradient of roadway	Taken from a 3D model of the design alignment
Air and ground absorption	Ground absorption as per SoundPLAN implementation of the CoRTN Algorithm
Height of receivers	1.5 m above ground terrain
The acoustic properties of the road pavement surfaces	Tyned asphaltic concrete assumed for the whole alignment having a relative correction of +2.5 dB(A) compared to Dense Grade Asphalt
Traffic Speed	110 km/h throughout the Proposal
Attenuation due to building structures	Building structures have not been included in the noise model due to the rural residential nature of the investigation area
Facade Reflection	+2.5 dB (A)
LA10 to LAeq conversion	Generally a reduction of 3 dB (A) from LA10 to LAeq but can be site specific. (See Table 2-1)

Vehicle counts on the existing highway were undertaken between 21 and 29 November 2007 at strategic locations along the highway (see **Table 4-3**). These counts were combined with noise monitoring at 4 locations where road traffic noise was the primary influence on the noise environment, which were then used as the basis for the validation of the noise model.

4.5. Modelling of traffic noise impacts

Traffic noise at each identified receiver has been predicted for the Proposal using the Calculation of Road Traffic Noise (CoRTN) method applied through a SoundPLAN noise modelling program. The CoRTN method predicts the $L_{A10,\ 18\ hour}$ and the $L_{A10,\ 1\ hour}$ noise levels at a receiver location based on the parameters listed in **Table 4–2**.

Table 2-1 presents the difference between the $L_{A10\ (9hr)}$ and the $L_{Aeq\ (9hr)}$ measured noise levels at each monitoring location and is used to convert the output from the CoRTN method to the same parameters as the criteria outlined in the ECRTN (i.e. L_{A10} to L_{Aeq}). The RTA and DECCW recommend a general conversion factor between these parameters of 3 dB(A) where site specific information is not available. For the monitoring locations within the investigation area where traffic noise is the dominant source, the difference is between 3-4 dB(A).

A project specific conversion factor of 3 dB(A) has been adopted, which represents a conservative conversion value for the measured sites. The results of the CoRTN predictions from the SoundPLAN model are then modified by the relationship, $L_{A10,\ period} = L_{Aeq,\ period}$ + 3 dB(A), to predict the $L_{Aeq,15hour}$ and $L_{Aeq,9hour}$ noise levels. A further correction of +2.5 dB(A) has been added to the $L_{Aeq,\ period}$ results to correct for facade reflections in accordance with the ENMM guidelines.

The CoRTN model sets the height of the traffic stream at 0.5 metres above pavement height, irrespective of the heavy vehicle content within the traffic stream. To account for the large proportion of heavy vehicles in the traffic stream the CoRTN assessment has been modified to incorporate three different source heights. These three heights are 0.5 metres for truck tyres and cars, 1.5 metres for truck engines and 3.6 metres for truck exhaust. Each of these emission sources have then been adjusted to account for the relative differences in the sound levels.

4.6. Modelled traffic values

The assessment of noise impacts considers three different scenarios of traffic flows. These are known as:

- The current year (2007), which considers the current road network and traffic conditions in assessing the level of existing impact at noise sensitive receiver locations. This scenario is also used to validate the noise model to provide an indication of the level of accuracy of the noise model based on known parameters.
- The future existing year, which considers traffic flows for a year equivalent to the year of opening of the Proposal, but with no change to the existing road infrastructure (the “do nothing” option). For the Warrell Creek to Urunga highway upgrade, the year of opening for the purposes of noise modelling is 2012; and
- The design year, which considers the proposed new road design and future traffic flows incorporating normal growth expected over a period of 10 years after the nominal year of opening of the road. The design year for the Warrell Creek to Urunga highway upgrade is expected to be in 2022.

Table 4-3 to **Table 4-6** present the traffic numbers used in each of the above modelling scenarios showing the total traffic numbers for day and night time and the percentage of heavy vehicles included in the traffic mix.

These data are used in the modelling of traffic noise impacts and are based on the average flows over the whole year. The traffic numbers used in the modelling represent the Annual Average Daily Traffic (AADT) flows and are calculated from SCATS data, RTA permanent counting stations and actual site measurements from tube counts. In practice the estimated vehicle movements would vary on a daily or weekly basis depending on seasonal traffic flows and other factors.

The assessment of the operational noise impacts from the Proposal includes the prediction of traffic noise levels for the future existing year (2012), the design year (2022) as well as sleep disturbance impacts caused by maximum noise levels and the noise related impacts from the proposed truck stop and rest area.

Table 4-3: Road traffic data input to noise model – existing highway, current year (2007)

Section Number and Description	Measured Traffic Flows							
	Daytime (15hour)				Night-time (9hour)			
	Light	Heavy	Total	% Heavy	Light	Heavy	Total	% Heavy
South of Bald Hill Road	7505	1059	8,564	12%	1077	763	1,840	41%
South of Florence Wilmot Drive	9582	1016	10,598	10%	1054	717	1,771	41%
South of Valla Beach Road	8094	1026	9,120	11%	1100	745	1,845	40%
North of Waterfall Way Interchange	7908	994	8,902	11%	890	736	1,627	45%

Table 4-4: Road traffic data input to noise model – existing highway, future existing year (2012)

Section Number and Description	Predicted Traffic Flows							
	Daytime (15hour)				Night-time (9hour)			
	Light	Heavy	Total	% Heavy	Light	Heavy	Total	% Heavy
South of Bald Hill Road	8177	1220	9,397	13%	1174	878	2,052	43%
South of Florence Wilmot Drive	10386	1223	11,608	11%	1142	863	2,005	43%
South of Valla Beach Road	8803	1215	10,018	12%	1197	882	2,078	42%
North of Waterfall Way Interchange	8610	1157	9,768	12%	969	857	1,826	47%

Table 4-5: Road traffic data input to noise model – new highway, design year (2022)

Section Number and Description	Predicted Traffic Flows							
	Daytime (15hour)				Night-time (9hour)			
	Light	Heavy	Total	% Heavy	Light	Heavy	Total	% Heavy
South of Warrell Creek	7808	1499	9,307	16%	1201	1006	2,207	46%
Warrell Creek to Bald Hill Interchange	6581	1217	7,799	16%	945	877	1,821	48%
Bald Hill Interchange to Nambucca Interchange	6769	1353	8,122	17%	744	955	1,700	56%
Nambucca Interchange to Ballard's Road Interchange	7982	1449	9,431	15%	1085	1052	2,137	49%
Ballard's Road Interchange to Waterfall Way Interchange	7639	1336	8,975	15%	860	990	1,850	54%
North of Waterfall Way Interchange	12732	1444	14,176	10%	1663	994	2,656	37%

Table 4-6: Road traffic data input to noise model – existing highway, design year (2022)

Section Number and Description	Predicted Traffic Flows							
	Daytime (15hour)				Night-time (9hour)			
	Light	Heavy	Total	% Heavy	Light	Heavy	Total	% Heavy
South of Bald Hill Road	2716	341	3,057	11%	390	246	636	39%
South of Florence Wilmot Drive	4712	166	4,877	3%	518	117	635	18%
South of Valla Beach Road	2503	209	2,712	8%	340	152	492	31%
North of Waterfall Way Interchange	2142	166	2,307	7%	241	123	364	34%

The operational noise impact assessment uses the results of the noise model predictions for the design year to provide details on the level of noise impact that is likely to result from the Proposal. These predictions are based on the modelling data outlined in **Table 4–2** for the various operational scenarios. In order to determine the predictive accuracy of the noise model it needs to be calibrated to a known operational scenario namely the current year of operations. This calibration process is known as the model validation, and is a process that is required by the DECCW and RTA to be undertaken for each unique road Proposal.

4.7. Validation of the noise model

In order to ensure the validity of the design year predictions a noise model for the existing road traffic flows shown in **Table 4-3** was developed. The modelled output was compared to the measured noise levels that were recorded during the noise surveys along the existing road alignment (refer **Section 2.3**). Only the monitoring locations that have an existing traffic noise exposure are suitable for use in the validation of existing traffic noise influences and therefore only the receivers within 250m of the existing alignment were used for the comparison of existing and predicted noise levels.

Table 4-7 Presents the predicted noise levels from validation model scenario and the measured noise levels from the unattended monitoring. Where appropriate the modelled results are facade corrected and include a conversion from L_{A10} to L_{Aeq} based on the relationship determined from the measured road traffic noise levels.

- **Table 4-7 Comparison of measured and modelled road traffic noise levels**

Receiver Location	Noise Levels – Year 2007 Traffic Counts					
	Daytime (15hour)			Night-time (9hour)		
	Measured	Modelled	Difference	Measured	Modelled	Difference
Location 3	58	59	+1	56	57	+1
Location 4	53	52	-1	53	52	-1
Location 6	55	55	0	57	53	+4
Location 7	53	54	+1	54	53	+1

The predicted road traffic noise levels for the current year from the validation model indicate a typical variation of within 2 dB(A) of the measured values, with the exception of one location during the night. Other than Location 6, these results are within the tolerance of predictive accuracy that is required by the RTA for a model validation.

At Location 6, the carriageway is a long flat straight section of the highway. The end of this straight section of road crosses a hill which may explain the discrepancies between the measured and modelled results for this location. It is expected that, due to the increase in truck activity during the night time, and being located near a hill, the use of exhaust brakes which are not accounted for in the traffic noise modelling, would lead to an under prediction of noise impacts. This issue and the associated impacts are expected to be addressed in the new alignment through the improved design. The new alignment reduces the grade of hills by smoothing out the overall height differences in the carriageway and therefore discrepancies with the noise model due to exhaust brake noise are expected to be minimised or even eliminated.

The results of the monitoring and modelling demonstrate that that the noise levels for the day time and the night time are similar for both periods. The ECRTN recognises the different needs for acoustic amenity during these times and provides for these differences by implementing a lower night time noise criteria. As noise levels from traffic on the highway approach the project noise criterion, the lower night time levels would be the first of the criteria to be met and/or exceeded. As a result, the $L_{Aeq\ 9hr}$ night time noise levels have been identified as being the critical assessment period and will be referred to as the assessment criterion from this point forward.

4.8. Noise impact assessment for the Proposal

The assessment of noise impacts from the Proposal were calculated for the identified receivers for the year 2022 design scenario and compared to the relevant noise criteria at each location. Assessment of the year 2022 traffic data provides the expected future noise levels so that mitigation measures designed for this scenario are still valid for at least 10 years into the future. The initial predictions were made without the inclusion of any noise mitigation measures and were based on the parameters for the modelling inputs in **Table 4–2** and the traffic data in **Table 4-5**.

All identified receivers in the study area (2863 dwellings) were incorporated into the modelling of noise impacts for the new highway. For the modelling scenario, contributions from the existing highway were not included in the prediction of noise emissions. The results of the modelling indicated that the majority of the identified receivers fall below the project noise criteria, however, they were initially included to ensure a thorough assessment of any potential impacts was made at all locations.

Where the night time criterion is expected to be exceeded, the receiver locations have been identified for further assessment. These receivers are detailed in **Table 4-8** (for redeveloped road categories) and **Table 4-9** (for new road categories), which presents the receiver location, the predicted daytime and night time noise level from the 2022 year of operations, the ECRTN criterion for night time and the difference between the predicted levels and the $L_{Aeq\ 9hr}$ criterion.

Of the 2,863 potential receivers modelled, 374 are predicted to experience an exceedance of the noise criterion for the Proposal in the absence of mitigation and management measures. These receivers, therefore, required further assessment for mitigation and management measures in accordance with ECRTN and ENMM guidelines. **Table 4-10** presents a summary of the number of receivers categorised by the range of predicted exceedances.

- **Table 4-8 Modelled road traffic noise levels for redeveloped road receivers- design year 2022**

Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)	Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)
5	68	67	55	12	1655	64	63	55	8
8	67	66	55	11	1656	56	56	55	1
11	60	59	55	4	1659	59	58	55	3
114	57	56	55	1	1663	59	58	55	3
115	58	57	55	2	1666	60	59	55	4
116	61	60	55	5	1669	62	61	55	6
120	58	58	55	3	1677	63	62	55	7
122	58	57	55	2	1682	61	60	55	5
124	62	61	55	6	1686	57	56	55	1
125	58	58	55	3	1697	57	56	55	1
127	57	56	55	1	1714	60	59	55	4
128	61	60	55	5	1718	57	57	55	2
130	66	65	55	10	1722	60	59	55	4
132	63	63	55	8	1734	62	61	55	6
138	56	56	55	1	1755	60	59	55	4
139	63	62	55	7	1762	59	58	55	3
140	58	57	55	2	1766	60	59	55	4
141	57	56	55	1	1770	59	58	55	3
146	58	57	55	2	1771	59	59	55	4
149	57	57	55	2	1782	59	58	55	3
151	58	57	55	2	1785	57	56	55	1
152	58	57	55	2	1788	60	59	55	4
153	59	58	55	3	1790	57	56	55	1

Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)	Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)
155	59	58	55	3	1791	64	63	55	8
157	60	59	55	4	1794	64	63	55	8
162	61	60	55	5	1795	63	62	55	7
1629	62	61	55	6	1798	57	57	55	2
1630	60	59	55	4	1799	58	57	55	2
1632	60	60	55	5	1800	64	64	55	9
1634	62	61	55	6	1805	57	56	55	1
1635	60	59	55	4	1809	62	61	55	6
1636	64	64	55	9	1810	57	57	55	2
1637	57	56	55	1	1816	60	59	55	4
1639	60	59	55	4	2827	56	56	55	1
1640	61	60	55	5	2835	56	56	55	1
1642	62	61	55	6	2837	59	58	55	3
1643	61	61	55	6	2838	57	56	55	1
1644	57	57	55	2	2839	57	56	55	1
1647	62	61	55	6	2841	57	56	55	1
1649	57	57	55	2	2844	57	56	55	1
1650	65	65	55	10	2845	58	57	55	2
1651	60	59	55	4	2851	59	58	55	3
1652	62	61	55	6	2855	58	57	55	2
1653	58	57	55	2	2856	57	56	55	1
1654	64	63	55	8	2862	58	57	55	2
					2864	58	57	55	2

- **Table 4-9 Modelled road traffic noise levels for new road receivers- design year 2022**

Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)	Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)
6	61	60	50	10	384	52	51	50	1
10	63	62	50	12	385	57	56	50	6
15	60	59	50	9	388	59	58	50	8
16	56	55	50	5	389	58	57	50	7
20	53	52	50	2	390	52	51	50	1
24	51	51	50	1	393	61	60	50	10
28	52	51	50	1	394	52	51	50	1
29	55	54	50	4	415	64	63	50	13
31	56	55	50	5	416	63	62	50	12
34	51	51	50	1	417	63	62	50	12
35	51	51	50	1	419	62	61	50	11
46	54	53	50	3	422	62	61	50	11
48	55	54	50	4	423	61	60	50	10
56	58	57	50	7	424	60	59	50	9
57	59	58	50	8	425	60	59	50	9
58	52	51	50	1	426	59	58	50	8
62	52	52	50	2	428	59	58	50	8
63	53	52	50	2	430	59	58	50	8
65	53	52	50	2	431	56	55	50	5
66	52	51	50	1	434	58	57	50	7
69	53	52	50	2	436	58	57	50	7
71	53	53	50	3	437	57	56	50	6
75	53	52	50	2	439	57	56	50	6

Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)	Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)
77	59	58	50	8	441	57	56	50	6
80	52	51	50	1	445	56	55	50	5
82	53	52	50	2	446	56	55	50	5
83	55	54	50	4	447	56	55	50	5
84	54	53	50	3	449	55	54	50	4
86	54	53	50	3	452	55	54	50	4
88	55	54	50	4	461	54	53	50	3
89	56	55	50	5	472	54	52	50	2
92	53	52	50	2	476	53	52	50	2
94	54	53	50	3	481	53	52	50	2
96	55	54	50	4	487	53	52	50	2
98	59	58	50	8	493	52	51	50	1
103	56	55	50	5	497	52	51	50	1
106	53	52	50	2	503	52	51	50	1
107	53	52	50	2	507	52	51	50	1
110	53	52	50	2	510	52	51	50	1
111	60	59	50	9	581	64	63	50	13
147	54	53	50	3	597	55	54	50	4
148	52	51	50	1	600	55	54	50	4
154	55	54	50	4	601	56	55	50	5
156	58	57	50	7	604	56	55	50	5
163	52	51	50	1	605	56	55	50	5
164	52	51	50	1	608	56	55	50	5
168	52	51	50	1	609	57	56	50	6
170	53	52	50	2	610	55	54	50	4

Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)	Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)
172	57	56	50	6	612	55	54	50	4
184	56	55	50	5	613	57	56	50	6
191	56	55	50	5	616	54	53	50	3
192	58	57	50	7	617	57	56	50	6
194	57	56	50	6	618	57	56	50	6
197	59	58	50	8	624	59	58	50	8
198	59	58	50	8	639	56	55	50	5
199	54	53	50	3	666	62	61	50	11
201	59	58	50	8	701	56	55	50	5
203	55	54	50	4	711	59	58	50	8
204	54	53	50	3	729	56	55	50	5
205	60	59	50	9	745	55	54	50	4
207	52	51	50	1	758	54	53	50	3
245	53	52	50	2	775	57	56	50	6
246	53	52	50	2	780	55	54	50	4
247	53	52	50	2	783	54	53	50	3
248	52	51	50	1	785	60	59	50	9
249	53	52	50	2	786	59	58	50	8
250	52	51	50	1	788	57	56	50	6
251	53	52	50	2	790	59	58	50	8
252	52	51	50	1	798	56	55	50	5
253	53	52	50	2	801	54	53	50	3
254	52	51	50	1	802	53	52	50	2
255	53	52	50	2	805	53	52	50	2
256	52	51	50	1	806	57	56	50	6

Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)	Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)
257	53	52	50	2	807	52	51	50	1
258	52	51	50	1	808	55	54	50	4
259	53	52	50	2	809	57	56	50	6
260	52	51	50	1	810	59	58	50	8
261	53	52	50	2	811	61	60	50	10
262	52	51	50	1	812	63	62	50	12
263	53	51	50	1	813	55	54	50	4
264	52	51	50	1	815	56	55	50	5
265	52	51	50	1	822	58	57	50	7
266	52	51	50	1	825	61	60	50	10
267	52	51	50	1	964	64	63	50	13
268	52	51	50	1	966	55	54	50	4
269	52	51	50	1	974	53	51	50	1
270	52	51	50	1	1007	54	53	50	3
271	53	52	50	2	1107	53	52	50	2
272	52	51	50	1	1825	58	57	50	7
274	52	51	50	1	1841	58	57	50	7
275	52	51	50	1	1859	52	51	50	1
276	52	51	50	1	1860	54	53	50	3
277	52	51	50	1	1922	56	55	50	5
278	52	51	50	1	1958	57	56	50	6
280	52	51	50	1	2117	52	51	50	1
281	52	51	50	1	2137	53	52	50	2
282	52	51	50	1	2200	56	55	50	5
283	52	51	50	1	2221	55	54	50	4

Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)	Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)
285	53	51	50	1	2260	58	57	50	7
286	52	51	50	1	2267	57	56	50	6
287	52	51	50	1	2268	60	59	50	9
289	52	51	50	1	2294	56	55	50	5
290	52	51	50	1	2318	63	62	50	12
292	52	51	50	1	2736	56	55	50	5
293	52	51	50	1	2741	62	61	50	11
294	52	51	50	1	2744	56	55	50	5
295	52	51	50	1	2748	52	51	50	1
296	52	51	50	1	2750	52	51	50	1
300	53	52	50	2	2751	55	54	50	4
301	52	51	50	1	2752	62	61	50	11
302	52	51	50	1	2754	54	53	50	3
303	52	51	50	1	2757	52	51	50	1
305	52	51	50	1	2759	61	60	50	10
306	52	51	50	1	2762	57	56	50	6
307	52	51	50	1	2763	54	53	50	3
308	52	51	50	1	2764	61	60	50	10
309	52	51	50	1	2766	59	58	50	8
310	52	51	50	1	2768	57	56	50	6
313	52	51	50	1	2769	52	51	50	1
314	52	51	50	1	2771	55	54	50	4
317	52	51	50	1	2772	59	58	50	8
318	52	51	50	1	2775	60	59	50	9
320	52	51	50	1	2776	57	56	50	6

Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)	Receiver Number	L_{Aeq} 15hr dB(A)	L_{Aeq} 9hr dB(A)	9hr Criterion dB(A)	Base Criteria Exceedance dB(A)
323	52	51	50	1	2778	57	56	50	6
324	52	51	50	1	2779	58	57	50	7
326	52	51	50	1	2782	58	57	50	7
336	52	51	50	1	2783	60	59	50	9
338	52	51	50	1	2785	54	53	50	3
342	52	51	50	1	2786	54	53	50	3
345	52	51	50	1	2787	52	51	50	1
348	52	51	50	1	2788	57	56	50	6
349	52	51	50	1	2789	59	58	50	8
350	52	51	50	1	2795	52	51	50	1
354	52	51	50	1	2797	52	51	50	1
355	52	51	50	1	2799	54	53	50	3
359	52	51	50	1	2803	53	52	50	2
361	52	51	50	1	2804	53	52	50	2
362	52	51	50	1	2804	53	52	50	2
368	52	51	50	1	2804	53	52	50	2
371	52	51	50	1	2795	52	51	50	1
373	54	53	50	3	2797	52	51	50	1
375	54	53	50	3	2799	54	53	50	3
376	52	51	50	1	2803	53	52	50	2
379	56	55	50	5	2804	53	52	50	2
380	52	51	50	1	2799	54	53	50	3
381	56	55	50	5	2803	53	52	50	2
					2804	53	52	50	2

- **Table 4-10 Predicted number of exceedances – no mitigation**

Exceedance Range dB(A)	Number of Receivers
1-2	170
3-5	100
6-10	89
Greater than 10	15
Total	374

Based on the need for the attenuation of noise impacts for the Proposal a discussion on the implementation and type of mitigation available to ameliorate the predicted exceedances is presented in **Section 5**. The information on mitigation measures provided in this report includes the location, type and effective parameters of any recommendations for each individual receiver. The details of these forms of mitigation would be refined during the detail design phase.

4.8.1. Meteorological impact assessment

The Director General's requirements include consideration of local meteorological conditions (as relevant). It is important to note that when undertaking an assessment of traffic noise impacts, that the incorporation of meteorological data into the CoRTN modelling algorithm is not possible. Furthermore, the results of modelling (if possible) cannot be compared to any valid criteria, as the assessment of adverse weather conditions are not supported by the ECRTN.

To respond to the Director General's requirements, the assessment team endeavoured to establish the significance of temperature inversions and wind patterns for the study area, in order to quantify the potential for noise impacts from these effects. An investigation of local meteorology was undertaken, however, meteorological stations in the area could not provide the appropriate data for this form of assessment. Nearby weather stations were also reviewed, but either could not supply appropriate data or were not representative of the area being investigated.

Without the relevant historical meteorological data for an area, it is impossible to ascertain the frequency and strength of temperature inversions. In general, inversions may increase noise levels by between 3-5 dB(A) depending on conditions. Although an estimate of impacts may be made to account for potential increases in noise levels, these estimates have no valid basis and may ultimately be an under or over estimate of noise impacts from these weather conditions. Temperature inversions (increase in temperature with height) arise from the cooling of the land surface which, in turn, cools the near surface air faster than the layers aloft. Temperature inversions can occur any time of the year, but usually at night when the sky is clear and winds are light. Since sound waves travel faster through warmer air, the sound "rays" from a ground based noise source can effectively be reflected back towards the ground thereby adding to the noise levels received directly from the source.

It is expected that where temperature inversions are experienced in an area it would affect residences at distances greater than approximately 100 metres from the road. Due to the nature of the weather conditions during an inversion, it is likely that residences would have windows and doors closed to assist in heat retention during the cooler months, and therefore the effects of the increase in noise levels from an inversion would be negated by the additional attenuation provided to the building by the closed windows and doors.

4.9. Benefit to existing receivers

There is expected to be a benefit to some existing receivers, which would result primarily from the reduction in traffic currently using the existing highway. The reduction in traffic noise expected for the residents adjacent to the existing highway has been based on the change in the amount of traffic numbers. This reduction is estimated to be approximately 7 dB(A) for both the daytime and night time periods. A reduction of this magnitude is considered to be significant and would therefore provide a noticeable change in noise levels at residential locations.

4.10. Maximum noise level assessment

According to Practice Note iii of the ENMM, a maximum noise level assessment is to be undertaken for potential sleep disturbance impacts from road traffic noise. The ENMM identifies the purpose of the maximum noise assessment as a method to prioritise and rank mitigation strategies, but states that it should not be applied as a decisive criterion in itself. Maximum noise levels have been compared to the ECRTN guidelines and used to determine where additional noise mitigation may be required. These locations have been identified in **Table 5-4** and **Table 5-5** in this report and should be reviewed at the detailed design stage to confirm the applicability of noise mitigation.

The ECRTN recommends the assessment of maximum noise levels by comparing the exceedances of the individual vehicle pass-by maximums with the L_{Aeq} for each hour of the night time period. The following guidelines taken from the ECRTN summarises the findings from international research on the topic:

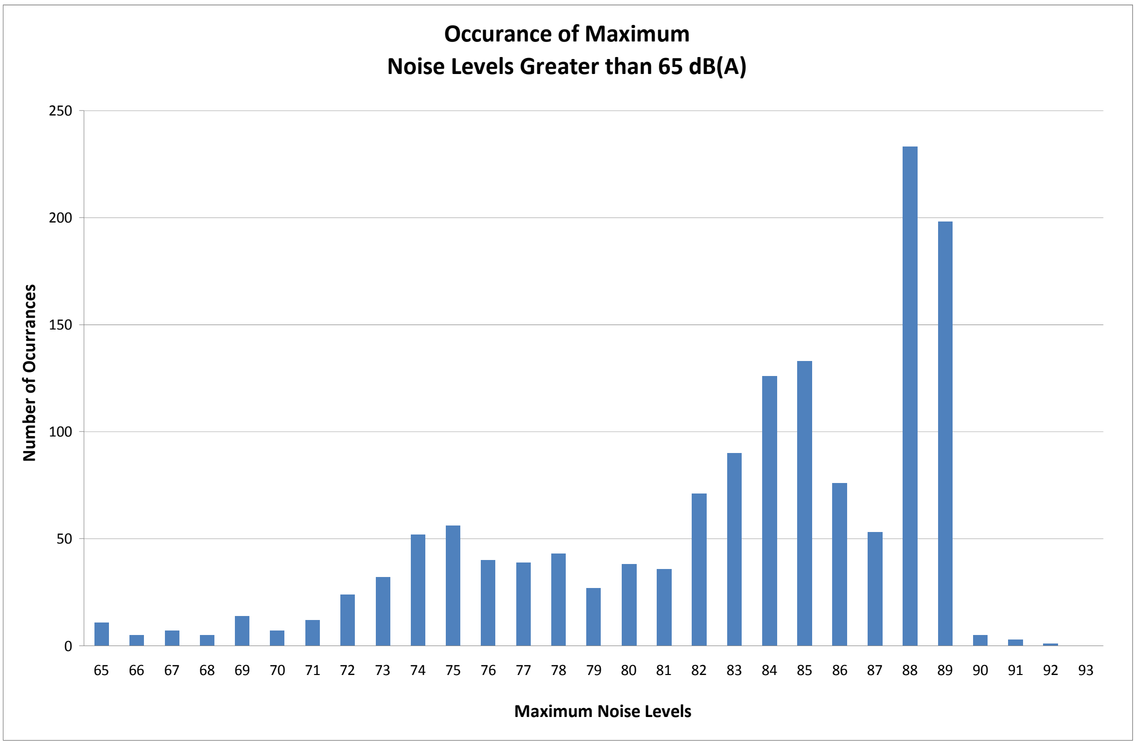
- Maximum internal levels below 50-55 dB(A) are unlikely to cause awakening reactions.
- One or two noise events per night with maximum internal noise levels of 65-70 dB(A) are not likely to significantly affect health and well being.

Predicted noise levels inside a dwelling with the windows open for ventilation have been assumed to be 10 dB(A) lower than the external noise level. Where windows are closed, a greater degree of attenuation would be expected. For assessment purposes the minimum transmission loss has been assumed.

The assessment of maximum noise impacts for the Proposal was undertaken by sampling night time traffic noise at a representative site along the Pacific Highway. The night time noise environment was recorded and later analysed to determine the maximum noise level events for the existing traffic flows. The methodology adopted for this measurement was based on the examination of existing levels at a location that would be similar in design to the Proposal. The measurements made at the existing Waterfall Way interchange, north of Urunga are expected to be representative of the Proposal having the same traffic profile, pavement surface, a dual lane carriageway in each direction and flat terrain with no hills or bends.

The measurements were made at a distance of 10 metres from the edge of the closest carriageway with 180 degree view of the road and because of the monitoring location in a cutting, measurement included the effects of a facade reflection. While the data includes all measured levels greater than 65 dB(A) recorded at the roadside location, these levels would be naturally attenuated as the distance away from the road side increases. **Figure 4-1** presents a graph of the raw data.

- **Figure 4-1 Maximum noise levels – raw data**



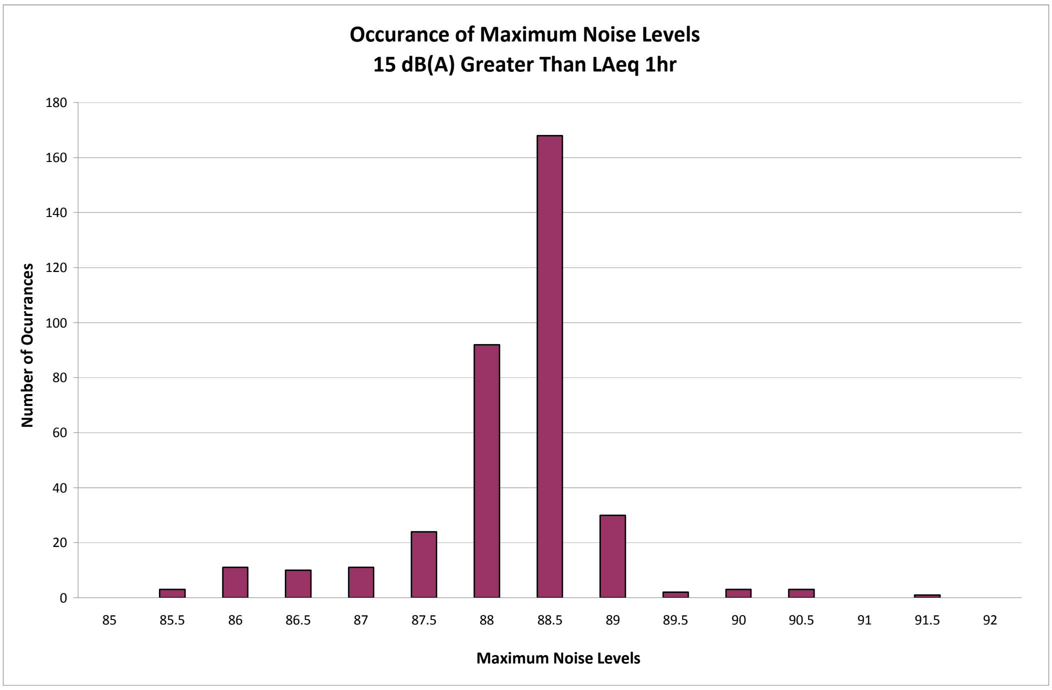
The $L_{Aeq\ 1hr}$ results of the noise measurements have been categorised and are presented in **Table 4-11** for the night time period.

▪ **Table 4-11 Hourly L_{Aeq} night time noise levels at 10 m**

Time	LAeq 1 Hour Noise levels
22:00 – 23:00	73
23:00 – 00:00	73
00:00 – 01:00	73
01:00 – 02:00	72
02:00 – 03:00	72
03:00 – 04:00	71
04:00 – 05:00	72
05:00 – 06:00	70
06:00 – 07:00	71

Maximum noise events are defined as having levels that are 15 dB(A) higher than the $L_{Aeq\ 1hr}$ noise level during the comparable period. The measurements presented in **Table 4-11** range from 70 – 73 dB(A) and based on the definition of a maximum event, the raw data presented in **Figure 4-1** has been further refined to reflect this. **Figure 4-2** presents the graph of maximum noise event that is at least 15 dB(A) above the hourly measured L_{Aeq} at a distance of 10 metres from the road carriageway.

▪ **Figure 4-2 Maximum noise levels – compared to $L_{Aeq\ 1hr}$**



From **Figure 4-2** the maximum noise level that has 1-2 occurrences is in the 91.5 dB(A) range and therefore (with rounding) a value of 92 dB(A) at 10 metres has been used to predict the maximum noise level at each of the receiver locations. Maximum noise level are not easily predicted due to the number of variables involved therefore to facilitate the identification of maximum noise levels for this assessment, the Nordic Road Traffic Noise, 1996, algorithm implemented in the SoundPLAN noise model has been used. This algorithm predicts the maximum road traffic noise level at a receiver location taking into consideration effects such as distance and local topography.

The predictions of the noise model for maximum noise levels at all locations have been included in **Table 5-4** and **Table 5-5** for mitigation requirements. These levels include a 10 dB(A) reduction to account for attenuation within a dwelling with the windows open for ventilation (as per AS3671). Where the predicted maximum noise levels at a residence are 65 dB(A) or higher and mitigation is not currently recommended, an additional acoustic investigation for these locations must be undertaken during the detail design stage to confirm the need for mitigation.

4.11. Rest area assessment

A noise impact assessment has been undertaken for the proposed rest area located in the vicinity of the Nambucca Heads Interchange. As outlined in **Section 3.1.3,** impacts from this aspect of the Proposal are not covered under the ECRTN or ENMM traffic noise guidelines and therefore an assessment in accordance with the INP was used to predict noise impacts at nearby receivers. The application of this form of assessment is consistent with other Pacific Highway upgrade Proposals and represents a conservative approach in estimating adverse impacts.

The rest area would be situated to the north of the Nambucca Heads Interchange as indicated in **Figure 4-3**

■ **Figure 4-3 Proposed rest area**

The internal layout of the rest area would be finalised at the detail design stage however the operational parameters assumed for traffic movements are given in **Table 4-12**.

■ **Table 4-12 Predicted rest area vehicle usage**

Assessment period	Vehicle Movements	
	Cars	Trucks
Day	5	9
Evening	3	12
Night	6	14

An assessment of the rest area was undertaken to determine potential for the use to cause an adverse noise impact at a nearby receiver. Where the closest receiver is predicted to be lower than the most stringent of the operational noise criteria, the activities within the rest area would comply with the INP noise guidelines at all locations. Receiver number 801 from the assessment table is the closest residence located approximately 170 metres away from the rest area, on the eastern side of the existing highway. The noise monitoring data in Section 2 has been used to identify an RBL for this receiver based on a similar receiver location in Section 3 of the Proposal. The RBL for the most stringent of the assessment periods being night time is 49 dB(A), which forms the basis of the intrusive noise goals.

The assessment of the rest area has been undertaken against the guideline noise levels from the INP intrusiveness noise goals, which requires that the $L_{Aeq\ 15\ min}$ noise emissions from the subject development are no more than 5 dB(A) above the RBL. In accordance with the INP, the noise goal for the nearest sensitive receiver would be
54 dB(A) between 10pm and 7 am each day, representing the quietest assessment period. The noise levels used to assess the potential for impacts have been identified based on typical activities and their duration and listed in **Table 4-13**. The maximum duration of an event in **Table 4-13** is 15 minutes as this is equivalent to the $L_{Aeq\ 15\ min}$ intrusive assessment period.

- **Table 4-13 Rest area noise emissions**

Activity	Estimated Noise Level @ 10 m	Number of Events (15 min)
Truck exhaust brake (bleed off)	87 dB(A)	1
Truck movement (slow)	85 dB(A)	4
Truck refrigeration unit (continuous)	77 dB(A)	2
Truck door	76 dB(A)	1
Car starting	76 dB(A)	1
Car boot	73 dB(A)	1

The L_{Aeq} noise emission estimated for the rest area has been calculated using the noise levels in **Table 4-13** and their duration over the 15 minute assessment period. The typical $L_{Aeq\ 15\ minute}$ noise level at the nearest receiver is estimated to be 49 dB(A) and therefore below the INP noise goals of 54 dB(A) for this location.

During the night time when background levels are low and noise emissions from the rest area may be the most noticeable, it is possible for maximum noise levels from the rest area to create sleep disturbance impacts. To assess this potential, the maximum noise level emissions from rest area activities have also been predicted at the nearest receiver. The maximum estimated noise level is expected to be due to the bleed of exhaust brakes and at the most affected location would be approximately L_{Amax} 57 dB(A). This noise level is calculated at the external facade of a dwelling and does not include any transmission loss to the inside of the building. This level is estimated to below the definition level of an L_{Amax} noise event and would generally result in internal noise levels less that 50 dB(A) for this location.

5. Assessment of mitigation measures

While the ECRTN identifies the base criteria for road traffic noise projects, Practice Note IV of the ENMM provides guidance in selecting and designing 'feasible and reasonable' treatment options for both new and redeveloped roads affecting residential receivers. The definition of feasible and reasonable is important in understanding what is possible in terms of mitigation measures for a Proposal. Feasibility relates to engineering considerations and put simply applies to what can be practically built or implemented. These considerations may include:

- The limitations of different techniques to reduce noise emissions from road traffic sources.
- Safety and property/pedestrian access issues.
- Constraints such as space limitations.
- Floodway and storm water flows.
- Maintenance.
- The suitability of buildings for sound proofing treatments.

"Reasonableness" relates to the effects of issues such as:

- The noise reduction provided and the number of people that benefit.
- The cost of the mitigation.
- Community expectations and visual impacts.
- Existing and future noise levels, including changes in noise levels.

Feasible and reasonable considerations must also be weighed against the practicality of the mitigation required. In some instances, it is not possible to achieve the level of noise reduction required to meet project specific noise goals. As a guide to the possible level of noise reduction from a noise barrier, **Table 5-1** presents the noise reduction in dB(A) compared to the degree of difficulty to achieve this level. As the level of difficulty increases the cost of the barrier becomes disproportionate to the amount of noise reduction benefit gained.

- **Table 5-1 Achievable noise reduction values – noise barriers**

Noise Level Reduction	Perception	Acoustic Energy Loss	Degree of Difficulty to Achieve
Less than 3 dB(A)	Not normally noticeable in the field. Barely perceptible reduction.	0.50	Simple to achieve
3 to 5 dB(A)	Readily perceptible reduction.	0.67	Possible to achieve
10 dB(A)	Very noticeable. Half as loud.	0.90	Difficult and/or expensive to achieve
20 dB(A)	One quarter as loud	0.99	Almost impossible to achieve

5.1. Mitigation options

There are several general mechanisms for applying mitigation measures to road traffic noise. These are generally identified as:

- **Source**: **-** Active reduction at the source of the noise emissions such as reducing vehicle noise emissions, low noise pavements, reduced speed zones.
- **Path**:**-** Providing a barrier to the source of the emissions, which increases the distance the noise must travel to reach the receiver location. This is achieved by implementing noise walls or mounds between the receiver location and the noise source.
- **Receiver**: **-** Providing a means of reducing noise emissions into the buildings internal environment by architectural acoustic treatments. This form of mitigation can also include local (at dwelling) noise barriers to reduce impacts at receiver locations but would require further consideration for suitability on private property.

To assist in determining an appropriate solution, the ENMM provides guidelines for the applicability of these methods in collective and individual receiver cases. The ENMM recognises that at the concept stage, where all noise design considerations for the alignment have been implemented, additional treatments such as noise barriers, architectural treatments and quiet road surfaces may also be required to reduce noise levels to the criterion values.

Of these three forms of mitigation, noise barriers and low noise pavements have the potential to benefit a larger number of noise sensitive receivers when the receivers are in close proximity to one another. These measures also benefit the outdoor environment and are therefore the preferred method of noise attenuation. The cost to implement these forms of mitigation and the total noise benefit they would provide to the Proposal must however, be analysed in order to assess their suitability.

The assessment of low noise pavements is largely controlled by the cost implications for the Proposal and to a lesser degree the constructability of low noise pavements in certain areas. In addition, it is believed that the acoustic benefit from low noise pavements potentially can reduce over time. The cost of low noise pavements is highly variable and depends on each specific Proposal application and, as such, providing a cost benefit analysis for the low noise pavement is not possible at the concept stage of a Proposal. However, at the detailed design phase, the costs of construction can be more readily assessed once the construction parameters have been investigated further. For this Proposal the use of low noise pavements have been proposed in certain locations as a noise reduction measure as shown in **Appendix B**. The outcomes of this assessment are detailed in **Section 5.2**.

In a similar way noise barriers must meet certain criteria to be deemed appropriate for implementation on a Proposal. These criteria are also based on the cost of construction and the benefit to the local community. Noise walls are also subject to constructability and aesthetic considerations. The RTA considers a noise wall to generally be reasonable to construct if they meet the minimum performance criteria as follows:

- Any noise barrier must provide a benefit of at least 5 dB(A).
- For noise barriers more than 3m high, the benefit must be more than 5 dB(A) at the most affected residence.
- For barriers which are 5 m high or higher, the benefit must be at least 10 dB(A) at the most affected residence.
- Noise barriers more than 8 m high are generally considered visually unacceptable.
- For the Proposal, the maximum noise wall height is 4.5 metres, which has been recommended to be consistent with other Pacific Highway upgrade projects.

5.2. Project specific mitigation

The assessment of noise mitigation for the Proposal includes determining the eligibility for noise treatments at sensitive receiver locations. The following information has been summarised from the ENMM guidelines and details the consideration applied to both new and redeveloped road criteria:

The RTA ENMM states that it is generally not “reasonable” to take action to reduce predicted noise levels through the adoption of measures (such as noise barriers/mounds, architectural treatments and quieter pavement surfaces) beyond the adoption of all “feasible and reasonable” traffic management and other road design measures. These situations are used to assess the application of noise mitigation for this investigation and are defined as Allowance 1 and Allowance 2 as follows:

ALLOWANCE 1: For proposed “new” roads and road “redevelopments” (see Practice Note i), the RTA believes it is generally not “reasonable” to take action to reduce predicted noise levels to the target noise levels if the noise levels with the Proposal, ten years after Proposal opening, are predicted to be:

- Within 2 dB(A) of “future existing” noise levels (the noise levels from existing sources of road traffic noise predicted for the time of road opening) and.
- No more than 2 dB(A) above the target noise levels set out in columns 2 and 3 of Table 1 in the ECRTN.

This approach is based on the insignificance of the changes in noise levels involved and the insignificant exceedances of the target noise levels.

It applies only if it can be demonstrated that all "feasible and reasonable" traffic management and other road design opportunities for reducing traffic noise have been exhausted.

ALLOWANCE 2: For proposed "redevelopments" of roads where existing noise levels already exceed the ECRTN target noise levels, and all "feasible and reasonable" traffic management and noise-reducing design opportunities have been incorporated into the road design, the RTA believes it is generally not "reasonable" to apply additional treatments such as noise barriers/ mounds, quieter pavement surfaces and architectural treatment of private dwellings if the predicted design year noise levels:

- Do not exceed the ECRTN allowances (in column 4 of Table 1 in the ECRTN) over the "future existing" noise levels (the noise levels from existing sources of road traffic noise predicted for the time of road opening) and .
- Are not acute (i.e. the noise levels are predicted to be less than 65 dB(A) Leq(15hr) (day) and 60 dB(A) Leq(9hr) (night).

Again, this approach is based on the insignificance of the change in noise levels involved, but recognises the increased importance of reducing noise levels where existing or predicted road traffic noise impacts are acute.

If either of these two "exceptions" applies, no further investigation of noise controls is required.

5.3. Low noise pavements

The application of low noise pavements in parts of the Proposal would be implemented by the RTA as an initial noise reduction strategy. Prior to the assessment of the eligibility for additional mitigation at sensitive receiver locations, the inclusion of low noise pavement in the model was used to re-predict the impact at all locations. The proposed sections of low noise pavement for the Proposal are shown in **Table 5-2**.

- **Table 5-2 Proposed sections of low noise pavement**

General Location	Chainage[1]	Length
Warrell Creek	Ch. 3,100 to Ch. 5,400	2,300m
Northern abutment Bridge over Warrell Creek to Old Coast Road	Ch. 6,600 to Ch. 11,750	5,150m
Valla Beach	Ch. 25,100 to Ch. 26,800	1,700m
Northern end of Proposal – Ridgewood Drive to end of Proposal	Ch. 38,800 to Ch. 41,000	2,200m

[1] – To be refined during detailed design

The noise model incorporated these mitigation measures and the modelling of Low Noise Pavement (LNP) was undertaken for the design year operational scenario. The results of the remodelled impacts are shown in **Table 5-3** along with the reduction of noise level impacts in each range.

- **Table 5-3 Number of exceedances – including low noise pavement**

Range of exceedance above base criterion	Number receivers exceeding without LNP	Number of receivers exceeding with LNP	Difference after mitigation
1-2 dB(A)	170	65	101
3-5 dB(A)	100	79	18
6-10 dB(A)	89	68	21
Greater than dB(A)	15	8	7

After the implementation of a LNP, a reduction of the total number of exceedances by 147 receivers was noted. There were 227 noise sensitive receivers that still remained above the ECRTN criterion for night time noise levels. The inclusion of additional mitigation such as noise walls/mounds and architectural treatments have therefore been assessed, incorporating the revised road surface type, being a combination of concrete and low noise pavements.

5.3.1. Secondary noise impacts

The noise from reflections off hard noise barriers such as a masonry wall can have the potential to increase local noise levels in some instances. For a single noise barrier (only on one side of the carriageway), the increase occurs when reflected noise reinforces emissions from passing vehicles to dwellings on the opposite side of the road. With a single barrier the increase in noise may be between 0.5 to 1.5 dB(A), which equates to an insignificant increase only. For dual noise walls in parallel on opposite carriageways, the reduction in performance of the noise wall can be significant up to 6 dB(A) due to reflections.

For this Proposal, the locations identified for single noise walls do not have residences directly opposite and therefore the potential for increases in noise are eliminated. In addition there are no locations where parallel noise walls are recommended for opposite sides of the carriageway.

5.4. Comparison of future existing and design year traffic noise levels

Where the predicted noise levels exceed the base criterion, the allowances identified in **Section 5.2** may be relevant in some instances. The method for assessing the individual mitigation requirements for the Proposal is therefore based on the ECRTN criterion and any allowances applied to both new and redeveloped road categories.   The noise assessment for this Proposal initially identified 2863 potential receivers in the study area. This number was reduced to 374 receivers that exceed the base criterion without mitigation. These receivers were then reassessed after the application of low noise pavements and noise barriers were considered. **Table 5-4** and **Table 5-5** present the list of receivers that would require mitigation for both the redeveloped and new road criterion. The tables show which properties would need architectural treatments after all allowances and the effects of noise barriers have been considered.

The Hibiscus Christian School is approximately 550 metres from the Proposal and has been assessed separately from the residential dwellings due to the different traffic noise criterion. The internal noise level criteria for existing schools is an $L_{Aeq\ 1hr}$ 55 dB(A) when in use, which generally applies to the period between 9:00am and 3:30pm. The predicted noise level for the school during the daytime is 52 dB(A) and allowing a conservative estimate of attenuation of 10 dB(A) from outside to inside the building, the internal noise levels are expected to be approximately 42 dB(A), which is within the criterion for this type of sensitive receiver.

The results presented in **Table 5-4** and **Table 5-5** are also presented graphically In **Appendix 2**, showing the location of the proposed noise barriers and LNP.

Table 5-4 Mitigation requirements – redeveloped road criterion

Receiver number	ECRTN L_{Aeq} 9hr base criterion dB(A)	Future existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with barrier	Meets ECRTN base criterion	Does allowance 1 apply Y/N	Does allowance 2 apply Y/N or acute	Predicted maximum internal level, windows open	Requires architectural treatments	Is level within 1 dB(A) of Criterion
5	55	54	67	67	No	No	Acute	81	Yes	-
8	55	61	66	66	No	No	Acute	78	Yes	-
11	55	59	59	59	No	No	Yes	65	No	-
116	55	54	58	57	No	No	No	64	Yes	-
124	55	55	59	57	No	Yes	Yes	71	No	-
128	55	54	58	56	No	Yes	Yes	70	No	-
130	55	58	63	59	No	No	Yes	77	No	-
132	55	61	61	61	No	No	Acute	72	Yes	-
139	55	59	62	62	No	No	Acute	69	Yes	-
140	55	54	57	57	No	No	No	64	Yes	-
157	55	53	58	56	No	No	No	67	Yes	Yes
162	55	53	58	57	No	No	No	66	Yes	-
1629	55	55	61	61	No	No	Acute	66	Yes	-
1630	55	51	59	59	No	No	No	66	Yes	-
1632	55	58	60	60	No	No	Acute	63	Yes	-
1634	55	55	61	61	No	No	Acute	69	Yes	-
1635	55	58	59	59	No	No	Yes	65	No	-
1636	55	61	64	64	No	No	Acute	72	Yes	-
1637	55	50	56	56	No	No	No	63	Yes	Yes

Receiver number	ECRTN L_{Aeq} 9hr base criterion dB(A)	Future existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with barrier	Meets ECRTN base criterion	Does allowance 1 apply Y/N	Does allowance 2 apply Y/N or acute	Predicted maximum internal level, windows open	Requires architectural treatments	Is level within 1 dB(A) of Criterion
1639	55	53	59	59	No	No	No	64	Yes	-
1640	55	54	60	60	No	No	Acute	64	Yes	-
1642	55	55	61	61	No	No	Acute	67	Yes	-
1643	55	55	61	61	No	No	Acute	66	Yes	-
1644	55	52	57	57	No	No	No	61	Yes	-
1647	55	52	61	61	No	No	Acute	71	Yes	-
1649	55	48	57	57	No	No	No	66	Yes	-
1650	55	57	65	65	No	No	Acute	72	Yes	-
1651	55	51	59	59	No	No	No	66	Yes	-
1652	55	58	61	61	No	No	Acute	69	Yes	-
1653	55	50	57	57	No	No	No	66	Yes	-
1654	55	61	63	63	No	No	Acute	72	Yes	-
1655	55	57	63	63	No	No	Acute	68	Yes	-
1656	55	49	56	56	No	No	No	62	Yes	Yes
1659	55	53	58	58	No	No	No	63	Yes	-
1663	55	52	58	58	No	No	No	65	Yes	-
1666	55	53	59	59	No	No	No	65	Yes	-
1669	55	55	61	61	No	No	Acute	68	Yes	-
1677	55	61	62	62	No	No	Acute	70	Yes	-
1682	55	57	59	59	No	No	Yes	67	No	-

Receiver number	ECRTN L_{Aeq} 9hr base criterion dB(A)	Future existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with barrier	Meets ECRTN base criterion	Does allowance 1 apply Y/N	Does allowance 2 apply Y/N or acute	Predicted maximum internal level, windows open	Requires architectural treatments	Is level within 1 dB(A) of Criterion
1714	55	52	58	58	No	No	No	66	Yes	-
1722	55	52	58	58	No	No	No	66	Yes	-
1734	55	61	59	59	No	No	Yes	68	No	-
1755	55	54	57	57	No	No	No	68	Yes	-
1762	55	53	56	56	No	No	No	63	Yes	Yes
1766	55	55	57	57	No	Yes	Yes	65	No	-
1770	55	53	56	56	No	No	No	63	Yes	Yes
1771	55	54	57	57	No	No	No	64	Yes	-
1782	55	54	56	56	No	Yes	Yes	62	No	-
1788	55	55	57	57	No	Yes	Yes	68	No	-
1791	55	59	61	61	No	No	Acute	71	Yes	-
1794	55	56	61	61	No	No	Acute	72	Yes	-
1795	55	59	60	60	No	No	Acute	71	Yes	-
1799	55	54	56	56	No	Yes	Yes	63	No	-
1800	55	56	63	63	No	No	Acute	73	Yes	-
1805	55	53	56	56	No	No	No	62	Yes	Yes
1809	55	54	61	61	No	No	Acute	67	Yes	-
1810	55	50	56	56	No	No	No	62	Yes	Yes
1816	55	56	59	59	No	No	No	69	Yes	-
2837	55	51	56	56	No	No	No	63	Yes	Yes

Receiver number	ECRTN L_{Aeq} 9hr base criterion dB(A)	Future existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with barrier	Meets ECRTN base criterion	Does allowance 1 apply Y/N	Does allowance 2 apply Y/N or acute	Predicted maximum internal level, windows open	Requires architectural treatments	Is level within 1 dB(A) of Criterion
2851	55	46	56	56	No	No	No	65	Yes	Yes

■ **Table 5-5 Mitigation requirements – new road criterion**

Receiver Number	ECRTN L_{Aeq} 9hr Base Criterion dB(A)	Future Existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with Barrier	Meets ECRTN Base Criterion	Does Allowance 1 Apply Y/N	Does Allowance 2 Apply Y/N or Acute	Predicted Maximum Internal Level, Windows Open	Requires Architectural Treatments	Is Level Within 1 dB(A) of Criterion
6	50	54	60	60	No	No	Acute	66	Yes	-
10	50	54	62	62	No	No	Acute	69	Yes	-
191	50	55	54	54	No	No	-	61	Yes	-
192	50	46	55	55	No	No	-	60	Yes	-
194	50	54	54	54	No	No	-	61	Yes	-
197	50	50	56	56	No	No	-	64	Yes	-
198	50	52	56	56	No	No	-	62	Yes	-
199	50	59	52	52	No	Yes	-	52	No	-
201	50	49	56	56	No	No	-	63	Yes	-
203	50	58	52	52	No	Yes	-	54	No	-
204	50	56	52	52	No	Yes	-	55	No	-
205	50	54	57	57	No	No	-	64	Yes	-

Receiver Number	ECRTN L_{Aeq} 9hr Base Criterion dB(A)	Future Existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with Barrier	Meets ECRTN Base Criterion	Does Allowance 1 Apply Y/N	Does Allowance 2 Apply Y/N or Acute	Predicted Maximum Internal Level, Windows Open	Requires Architectural Treatments	Is Level Within 1 dB(A) of Criterion
15	50	57	59	59	No	No	-	65	Yes	-
16	50	58	55	55	No	No	-	61	Yes	-
20	50	55	52	52	No	Yes	-	56	No	-
29	50	44	54	54	No	No	-	58	Yes	-
31	50	51	55	55	No	No	-	62	Yes	-
46	50	45	52	52	No	No	-	61	Yes	-
48	50	50	54	54	No	No	-	62	Yes	-
56	50	46	55	54	No	No	-	64	Yes	-
57	50	50	56	56	No	No	-	65	Yes	-
65	50	57	51	51	No	Yes	-	57	No	-
69	50	59	51	51	No	Yes	-	58	No	-
71	50	59	51	51	No	Yes	-	57	No	-
75	50	60	51	51	No	Yes	-	56	No	-
77	50	52	56	56	No	No	-	66	Yes	-
83	50	57	52	52	No	Yes	-	58	No	-
86	50	47	51	51	No	No	-	58	Yes	Yes
88	50	46	52	51	No	No	-	61	Yes	Yes
89	50	56	53	53	No	No	-	61	Yes	-
94	50	48	52	51	No	No	-	58	Yes	Yes
96	50	49	52	52	No	No	-	53	Yes	-

Receiver Number	ECRTN L_{Aeq} 9hr Base Criterion dB(A)	Future Existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with Barrier	Meets ECRTN Base Criterion	Does Allowance 1 Apply Y/N	Does Allowance 2 Apply Y/N or Acute	Predicted Maximum Internal Level, Windows Open	Requires Architectural Treatments	Is Level Within 1 dB(A) of Criterion
98	50	56	56	56	No	No	-	68	Yes	-
103	50	50	53	53	No	No	-	52	Yes	-
111	50	53	57	56	No	No	-	69	Yes	-
156	50	51	55	53	No	No	-	62	Yes	-
172	50	47	54	54	No	No	-	59	Yes	-
184	50	46	53	53	No	No	-	59	Yes	-
373	50	47	51	51	No	No	-	57	Yes	Yes
375	50	47	52	52	No	No	-	58	Yes	-
379	50	48	53	53	No	No	-	59	Yes	-
381	50	48	53	53	No	No	-	60	Yes	-
385	50	48	54	54	No	No	-	61	Yes	-
388	50	47	56	56	No	No	-	64	Yes	-
389	50	48	56	56	No	No	-	63	Yes	-
393	50	48	58	58	No	No	-	67	Yes	-
415	50	49	61	61	No	No	Acute	72	Yes	-
416	50	49	60	60	No	No	Acute	71	Yes	-
417	50	49	60	60	No	No	Acute	70	Yes	-
419	50	49	59	59	No	No	-	69	Yes	-
422	50	49	59	59	No	No	-	68	Yes	-
423	50	49	58	58	No	No	-	67	Yes	-

Receiver Number	ECRTN L_{Aeq} 9hr Base Criterion dB(A)	Future Existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with Barrier	Meets ECRTN Base Criterion	Does Allowance 1 Apply Y/N	Does Allowance 2 Apply Y/N or Acute	Predicted Maximum Internal Level, Windows Open	Requires Architectural Treatments	Is Level Within 1 dB(A) of Criterion
424	50	49	58	58	No	No	-	66	Yes	-
425	50	49	57	57	No	No	-	66	Yes	-
426	50	49	57	57	No	No	-	65	Yes	-
428	50	49	56	56	No	No	-	64	Yes	-
430	50	49	56	56	No	No	-	64	Yes	-
431	50	49	53	53	No	No	-	60	Yes	-
434	50	49	55	55	No	No	-	63	Yes	-
436	50	49	55	55	No	No	-	63	Yes	-
437	50	49	55	55	No	No	-	62	Yes	-
439	50	49	54	54	No	No	-	62	Yes	-
441	50	50	54	54	No	No	-	61	Yes	-
445	50	50	54	54	No	No	-	61	Yes	-
446	50	50	53	53	No	No	-	60	Yes	-
447	50	50	53	53	No	No	-	60	Yes	-
449	50	50	52	52	No	Yes	-	59	No	-
452	50	50	52	52	No	Yes	-	59	No	-
461	50	50	51	51	No	Yes	-	58	No	-
472	50	51	51	51	No	Yes	-	57	No	-
581	50	52	61	61	No	No	Acute	71	Yes	-
597	50	53	53	53	No	No	-	59	Yes	-

Receiver Number	ECRTN L_{Aeq} 9hr Base Criterion dB(A)	Future Existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with Barrier	Meets ECRTN Base Criterion	Does Allowance 1 Apply Y/N	Does Allowance 2 Apply Y/N or Acute	Predicted Maximum Internal Level, Windows Open	Requires Architectural Treatments	Is Level Within 1 dB(A) of Criterion
600	50	54	52	52	No	Yes	-	59	No	-
601	50	54	53	53	No	No	-	59	Yes	-
604	50	54	53	53	No	No	-	60	Yes	-
605	50	54	53	53	No	No	-	60	Yes	-
608	50	54	53	53	No	No	-	60	Yes	-
609	50	54	54	54	No	No	-	61	Yes	-
610	50	54	52	52	No	Yes	-	59	No	-
612	50	54	52	52	No	Yes	-	58	No	-
613	50	54	54	54	No	No	-	61	Yes	-
616	50	54	52	52	No	Yes	-	58	No	-
617	50	54	54	54	No	No	-	61	Yes	-
618	50	54	54	54	No	No	-	62	Yes	-
624	50	55	56	56	No	No	-	63	Yes	-
639	50	55	54	54	No	No	-	61	Yes	-
666	50	56	59	59	No	No	-	65	Yes	-
701	50	52	54	54	No	No	-	60	Yes	-
711	50	47	57	57	No	No	-	59	Yes	-
729	50	52	54	53	No	No	-	60	Yes	-
745	50	51	53	52	No	Yes	-	59	No	-
758	50	50	52	51	No	Yes	-	59	No	-

Receiver Number	ECRTN L_{Aeq} 9hr Base Criterion dB(A)	Future Existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with Barrier	Meets ECRTN Base Criterion	Does Allowance 1 Apply Y/N	Does Allowance 2 Apply Y/N or Acute	Predicted Maximum Internal Level, Windows Open	Requires Architectural Treatments	Is Level Within 1 dB(A) of Criterion
775	50	42	55	53	No	No	-	63	Yes	-
780	50	43	54	52	No	No	-	62	Yes	-
783	50	47	52	51	No	No	-	60	Yes	Yes
785	50	47	57	57	No	No	-	67	Yes	-
786	50	47	57	57	No	No	-	65	Yes	-
788	50	46	55	55	No	No	-	56	Yes	-
790	50	45	58	58	No	No	-	69	Yes	-
798	50	44	55	52	No	No	-	61	Yes	-
801	50	44	52	52	No	No	-	52	Yes	-
806	50	40	56	56	No	No	-	67	Yes	-
809	50	43	56	51	No	No	-	66	Yes	Yes
810	50	43	58	53	No	No	-	68	Yes	-
811	50	42	60	54	No	No	-	72	Yes	-
812	50	41	62	62	No	No	Acute	72	Yes	-
813	50	42	54	52	No	No	-	58	Yes	-
815	50	41	55	54	No	No	-	64	Yes	-
822	50	40	57	57	No	No	-	65	Yes	-
825	50	40	60	60	No	No	Acute	68	Yes	-
964	50	34	63	63	No	No	Acute	73	Yes	-
966	50	37	54	54	No	No	-	58	Yes	-

Receiver Number	ECRTN L_{Aeq} 9hr Base Criterion dB(A)	Future Existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with Barrier	Meets ECRTN Base Criterion	Does Allowance 1 Apply Y/N	Does Allowance 2 Apply Y/N or Acute	Predicted Maximum Internal Level, Windows Open	Requires Architectural Treatments	Is Level Within 1 dB(A) of Criterion
974	50	38	51	51	No	No	-	50	Yes	Yes
1007	50	38	53	53	No	No	-	61	Yes	-
1107	50	38	52	52	No	No	-	58	Yes	-
1825	50	58	57	57	No	No	-	64	Yes	-
1841	50	54	57	57	No	No	-	56	Yes	-
1859	50	38	51	51	No	No	-	53	Yes	Yes
1860	50	44	52	52	No	No	-	58	Yes	-
1922	50	43	54	54	No	No	-	58	Yes	-
1958	50	38	56	56	No	No	-	62	Yes	-
2117	50	37	51	51	No	No	-	56	Yes	Yes
2137	50	37	51	51	No	No	-	55	Yes	Yes
2200	50	41	54	54	No	No	-	60	Yes	-
2221	50	41	53	53	No	No	-	59	Yes	-
2260	50	42	56	56	No	No	-	60	Yes	-
2267	50	42	55	55	No	No	-	56	Yes	-
2268	50	39	59	59	No	No	-	64	Yes	-
2294	50	34	55	55	No	No	-	63	Yes	-
2318	50	39	62	62	No	No	Acute	67	Yes	-
2736	50	45	53	53	No	No	-	60	Yes	-
2741	50	44	59	59	No	No	-	65	Yes	-

Receiver Number	ECRTN L_{Aeq} 9hr Base Criterion dB(A)	Future Existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with Barrier	Meets ECRTN Base Criterion	Does Allowance 1 Apply Y/N	Does Allowance 2 Apply Y/N or Acute	Predicted Maximum Internal Level, Windows Open	Requires Architectural Treatments	Is Level Within 1 dB(A) of Criterion
2744	50	45	53	53	No	No	-	59	Yes	-
2751	50	45	52	52	No	No	-	58	Yes	-
2752	50	44	59	59	No	No	-	64	Yes	-
2754	50	43	51	51	No	No	-	52	Yes	Yes
2759	50	46	58	58	No	No	-	71	Yes	-
2762	50	44	54	54	No	No	-	59	Yes	-
2763	50	47	51	51	No	No	-	55	Yes	Yes
2764	50	46	58	58	No	No	-	62	Yes	-
2766	50	47	56	56	No	No	-	59	Yes	-
2768	50	43	53	53	No	No	-	59	Yes	-
2771	50	50	52	52	No	Yes	-	53	No	-
2772	50	48	56	56	No	No	-	65	Yes	-
2775	50	47	57	57	No	No	-	63	Yes	-
2776	50	43	54	54	No	No	-	54	Yes	-
2778	50	43	54	54	No	No	-	61	Yes	-
2779	50	50	55	55	No	No	-	61	Yes	-
2782	50	52	55	55	No	No	-	63	Yes	-
2783	50	49	57	57	No	No	-	62	Yes	-
2785	50	56	51	51	No	Yes	-	57	No	-
2786	50	59	51	51	No	Yes	-	57	No	-

Receiver Number	ECRTN L_{Aeq} 9hr Base Criterion dB(A)	Future Existing 2012 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A)	Design 2022 L_{Aeq} 9hr dB(A) with Barrier	Meets ECRTN Base Criterion	Does Allowance 1 Apply Y/N	Does Allowance 2 Apply Y/N or Acute	Predicted Maximum Internal Level, Windows Open	Requires Architectural Treatments	Is Level Within 1 dB(A) of Criterion
2788	50	55	54	54	No	No	-	57	Yes	-
2789	50	53	56	56	No	No	-	63	Yes	-

5.5. Discussion of mitigation options

Certain locations along the Proposal alignment have been identified as having small communities (including clusters of houses) that may benefit from localised noise mitigation measures such as noise barriers. While noise barriers are considered for the entire Proposal, these locations have dwellings concentrated in a small area and therefore have the potential to receive the greatest cost/benefit from this type of noise attenuation. Areas that were specifically identified for potential noise barriers were:

- Donnellyville.
- Bald Hill Road.
- Letitia Close / Mattick Road.
- Old Coast Road.
- Florence Wilmont Drive.
- East West Road.
- South Arm Road.
- Short Cut Road.
- Ridgewood Drive.

The noise impact assessment also considered the following additional locations that were identified as noise barrier candidates along the Proposal:

- O'Dells Road.
- Rosewood Road.
- Wedgewood Drive.
- Gumma Road.

The noise assessment considered the sensitive receivers in **Table 5-4** and **Table 5-5** that were identified as requiring noise mitigation in addition to the road design considerations. Testing of barrier options included the minimum performance requirements for noise barriers outlined in **Section 5.1**. Other considerations by the RTA include the general cost/benefit guide in Practice note (IV) of the ENMM, which states:

> *"If residences are closely grouped in numbers of three or less, architectural treatments are preferred over roadside barriers, as it is likely that the cost per residence for barriers would be at least twice that for architectural treatments."*

The preferred method of mitigation for noise impacts for this Proposal is by implementing noise barriers, firstly using noise mounds and then noise walls so that the ambient level at a residential receiver is at or below the noise criterion for both day and night time periods. Other forms of noise mitigation such as treatments to buildings are considered where noise barriers are not effective or not feasible due to cost or engineering/topographic constraints.

Many of the locations along the Proposal precluded the effective implementation of noise barriers due to topographic effects or large distances between receivers. Topographic constraints occur when a residential receiver is located higher than the road carriageway and “look down” on the traffic stream. In these instances, noise walls do not block the line of sight of traffic and the minimum noise reduction of 5 dB(A) required in the design of a noise barrier cannot be achieved.

In situations where dwellings are not close to each other or situated on rural residential blocks separated by large distances, the length of noise walls required to provide the minimum noise reduction would be considered unreasonable for the number of receivers that would benefit.

The graphic representations (artists’ impressions) below are taken from the computer generated alignment and are used to illustrate locations adjacent to the Proposal that are affected by these issues. It should be noted that these representations are indicative only.

Rosewood Road

At Rosewood Road the dwellings are situated higher than the road and do not receive the maximum benefit from a noise wall.

Wedgewood Drive

Residences on the eastern side of Wedgewood Drive would have line of sight to the alignment across Gumma Flats. The receivers in this location are elevated and therefore noise barriers have a reduced benefit and the extents of the noise barrier required to provide the minimum noise reduction to the residences is not cost effective.

River Road/Gumma Road – Looking north to Letitia Close

At Gumma Road, the alignment is elevated as it crosses the Nambucca River. The residences at this location are exposed to a long open section of the road, which would require significant lengths of noise barriers for attenuation. Noise barriers at this location do not meet the minimum requirements for cost effective implementation due to the height and the extents required to meet the project noise goals.

Letitia Close – Looking north to Mattick Road

Letitia Close residences are situated in an elevated position above the Proposal. To the south of the overpass, residences are situated above the alignment with a line of sight to the carriageway over the Nambucca River. To the north (pictured) residences are once again in an elevated position that has a line of sight to the section of the carriageway in fill. In these locations roadside barriers provide little to no noise reduction benefit.

South Arm Road – Looking north

The view of Proposal looking north from South Arm Road shows the location of the residences above the carriageway. In this location the implementation of a noise barrier does not provide the required noise reduction. Residences affected by the alignment in this section of the Proposal are generally separated by larger distances making the use of noise barriers ineffective.

Ridgewood Drive – Looking South

The residences on both the eastern and western side of the alignment have a line of sight to the road carriageway. Noise walls in this location do not provide the required noise reduction.

The locations where noise barriers are recommended include Donnellyville, Bald Hill, Letitia Close and Mattick Road. Other receivers identified in **Table 5-4** and **Table 5-5** that indicate an exceedance of the noise criteria would require consideration of architectural treatments to residential dwellings in order to mitigate additional noise impacts.

Architectural treatments can include treatment of the building or local noise mounds or barriers, where residents prefer this option. The use of local noise barriers, however, would be subject to a cost/benefit analysis to determine their appropriate application. The recommendations for noise mitigation are based on the current road alignment and road surface type, and should be flexible in their application on the Proposal to allow alternatives that may provide additional benefits to noise affected locations in the future.

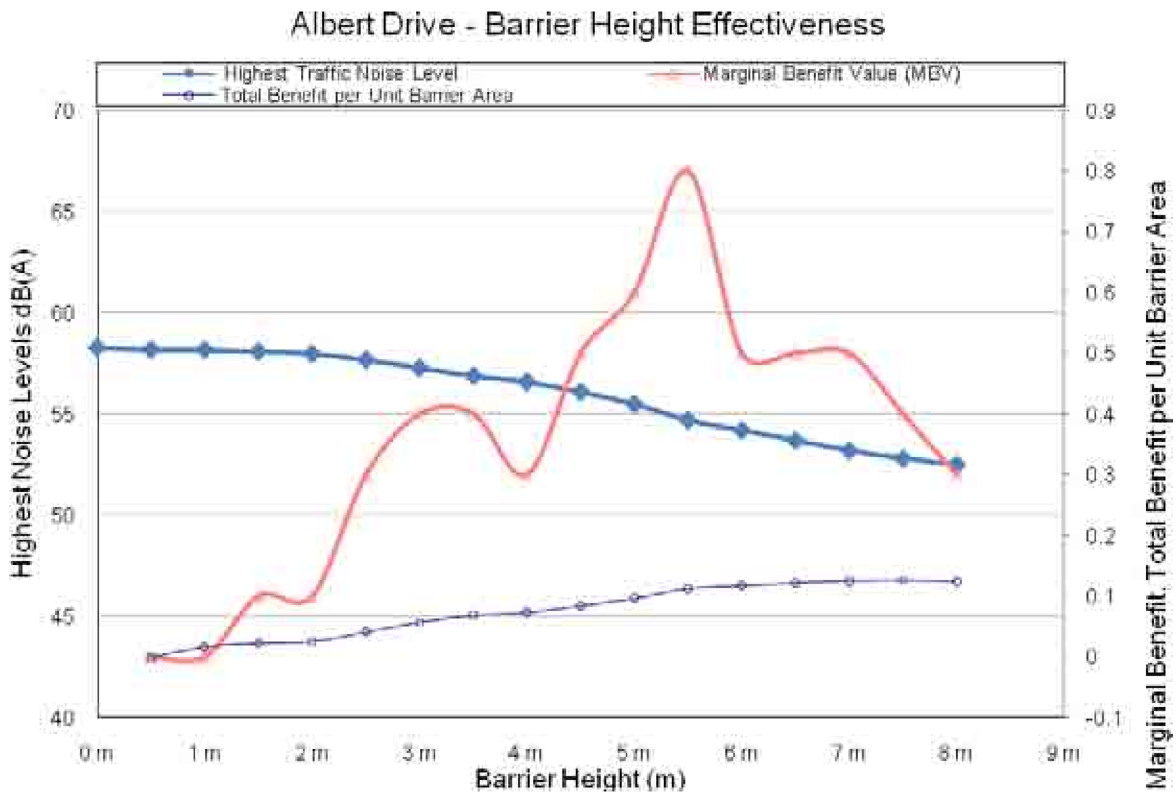
Noise barrier locations have been determined from an analysis of the benefits to residential receivers for acoustic and visual amenity outcomes. The locations of proposed noise mounds/barriers for the Proposal are detailed in **Table 5-6**, the balance of receivers would be considered for treatments to reduce noise at the dwelling. The location of the noise mounds and residences considered for architectural treatments are shown graphically in **Appendix 2**.

- **Table 5-6 Noise barrier locations**

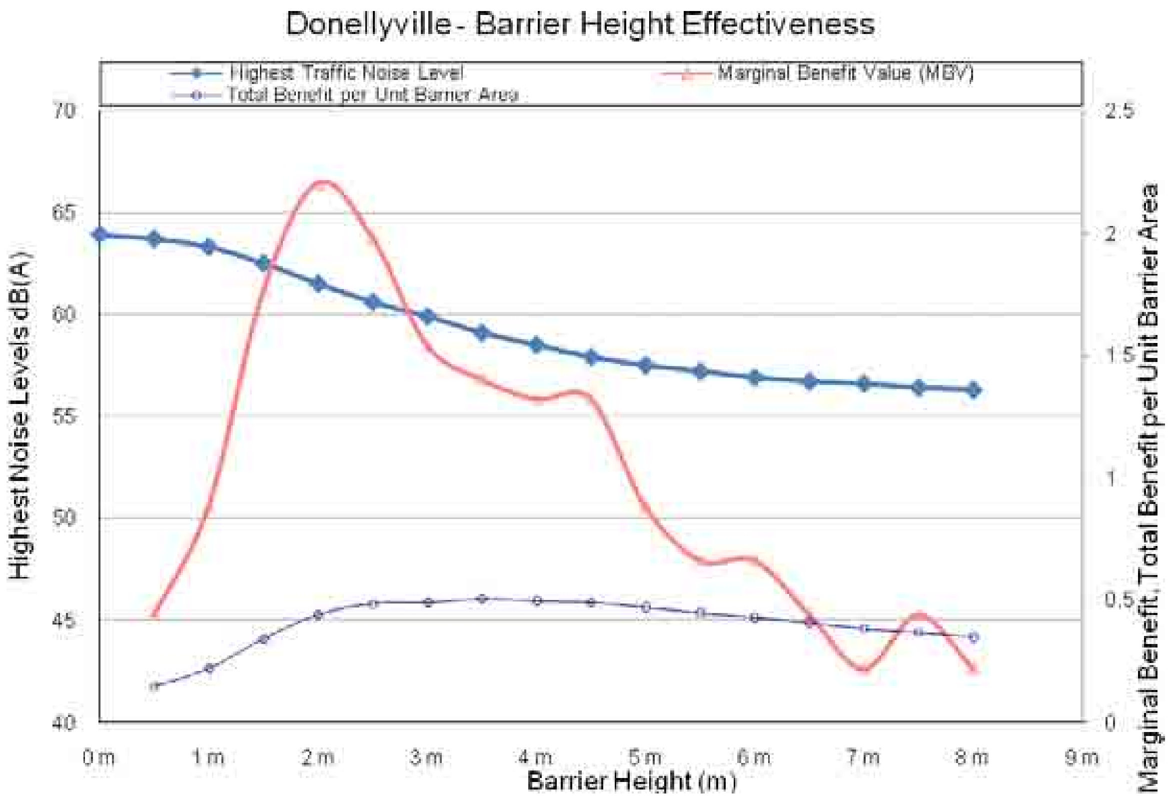
Location	Type	Chainages	Height Above Ground
Albert Drive to Donnellyville	Wall	4500-5000 eastern side	4.5m
Donnellyville, adjacent to south bound lane	Wall	5000 – 5300 eastern side	4.5m
Bald Hill Interchange, adjacent to South bound on ramp	Wall	7100 – 7450 eastern side	4.0m
Mattick Road	Wall	12325-12900 eastern side	4.5m

Where space permits and where placement of a noise mound instead of wall does not impact on environmental or social constraints, a mound would be the preferred option from an aesthetic and economic perspective. This has the benefit of reducing the visual impacts of the barriers by setting them within the surrounding landscape. Implementation of a noise mound instead of a barrier would be subject to the availability of excess fill and further feasibility studies at each location.

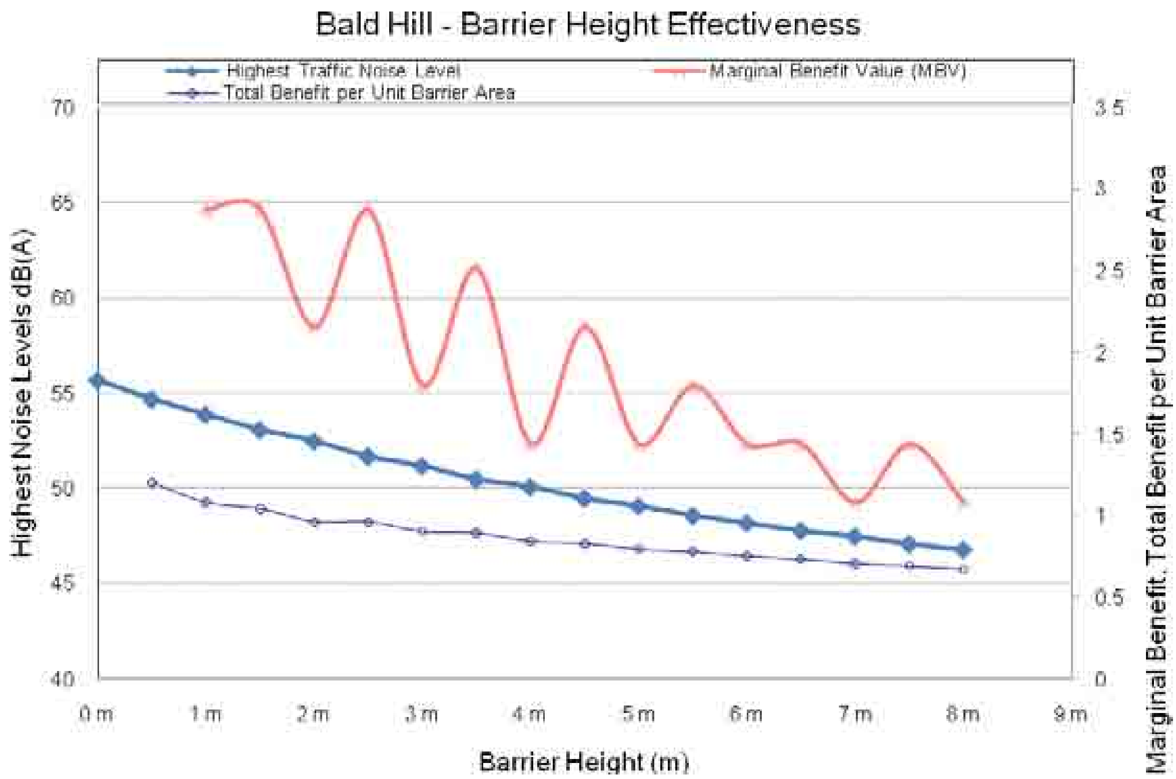
A cost effectiveness study for the proposed noise barriers has been undertaken using the methodology adopted in the RTA ENMM Practice Note IV. For each of the proposed barrier locations the barrier height required to meet the noise goals, known as the target barrier, is assessed against the barrier height that provides the greatest benefit per unit area, which is known as the assessed barrier. The results of this assessment are presented graphically for each of the proposed barrier locations in **Table 5-6.**



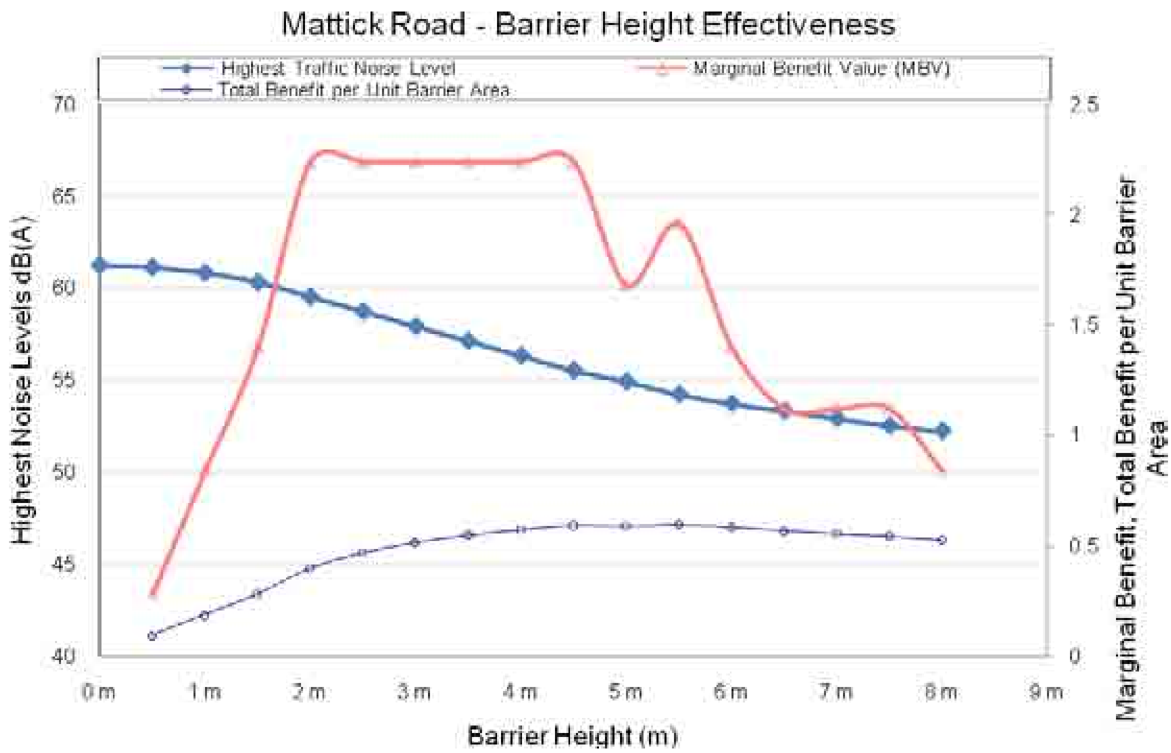
The target barrier height at Albert Drive is 5.5 metres, however the height limit for noise barriers on the Warrell Creek to Urunga Proposal is 4.5 metres, which becomes the assessed barrier height for this location. The highest marginal benefit value for this location coincides with the target barrier height.



At Donellyville the night time noise levels are predicted to be above the criteria for acute noise impacts in some locations. The target barrier height to reduce noise levels to the ECRTN requirement for an upgraded highway would be in excess of 8 metres at this location. The assessed barrier height at this location is 2 metres however, this height does not achieve the required insertion loss of 5 dB(A). A barrier height of greater than 3.5 metre barrier reduces noise levels to below the acute night time level of 60 dB(A), while a 4.5 metre barrier height provides the maximum possible reduction in noise levels at the Proposal barrier height limit.



At Bald Hill the target barrier height is 4m. This barrier height represents a minimum for the marginal benefit and a mid point for the total benefit per unit area which is reducing with increased barrier height. The target barrier height meets the noise criteria at this location.



At Mattick Road the target noise level cannot be met with a barrier height of 8 metres. The highest marginal benefit occurs with a noise barrier between 2 and 4.5 metres. The total benefit per unit area rises steadily to a maximum at about 4.5 metres, which is the assessed barrier height for this location.

The cost effectiveness analysis provides an indication of the economy of the barrier construction versus the height and length however, factors affecting these parameters may change between the concept and detail design and therefore should be re-analysed during the detailed design phase.

Visual mounds are proposed for other areas recommended for visual screening and have been discussed in Working Paper No. 2, Visual Amenity and Design (refer to **Table 5-7**). These screens are likely to be constructed as earth mounds and are additional to the noise barriers identified in **Table 5-6**. Note that while these screens have been proposed as visual mounds they also provide a small acoustic benefit to some receivers.

- **Table 5-7 Visual barrier locations**

Location	Type	Chainages
Rosewood Rd to Albert Drive Visual Mound with some noise benefits	Mound	3550-4300
Letitia Close Visual mound with possible noise benefits	Mound	11500 - 11800

Location	Type	Chainages
Mattick Road	Mound	12400-12650 western side
Ridgewood Drive Visual mound with possible noise benefits	Mound	39100-39650 (to Short Cut Road bridge) western side
South Arm Road	Mound	39200-39600 eastern side
Short Cut Road	Mound	39700-39900 eastern side

6. Assessment of construction noise and vibration impacts

6.1. Construction noise guidelines

The NSW DECCW (2009) has established an *Interim Construction Noise Guideline* (ICNG) that supersedes any previous guidance on management of construction noise impacts. This Proposal has been assessed in accordance with the guideline requirements and management of noise impacts has been recommended when guideline noise levels are expected to be exceeded.

This risk of adverse impact of construction noise within a community is determined by the extent of its emergence above the existing background noise level, the duration of the event, and the characteristics of the noise. In view of this, the DECCW has identified two forms of assessment based on the expected duration of the works. For new public infrastructure or major developments, a quantitative assessment is required. For shorter duration works such as maintenance and repair, a qualitative assessment may be satisfactory.

The ICNG recommends standard hours for construction work as summarised in **Table 6-1**. Although these hours may be varied where necessary to undertake work for safety or accessibility reasons, which may include:

- Delivery of oversized plant or structures;
- Emergency work; and
- Work where the proponent demonstrates and justifies a need to operate outside the recommended standard hours.

Table 6-1 Recommended standard hours for construction work

Work type	Recommended standard hours of work
Normal construction	Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays
Blasting	Monday to Friday 9 am to 5 pm Saturday 9 am to 1 pm No blasting on Sundays or public holidays

Recommended noise levels for airborne noise at sensitive receivers and advice on how they should be applied are provided in **Table 6-2**. The RBL described in the table is the overall single-figure background noise level measured in each relevant assessment period (during or outside the approved construction hours).

▪ **Table 6-2 Recommended noise management levels (DECCW 2009)**

Recommended Standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. ▪ Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. ▪ The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	▪ The highly noise affected level represents the point above which there may be strong community reaction to noise. ▪ Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: ▪ 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. ▪ 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	▪ A strong justification would typically be required for works outside the recommended standard hours. ▪ The proponent should apply all feasible and reasonable work practices to meet the noise affected level. ▪ Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. ▪ For guidance on negotiating agreements see section 7.2.2, ICNG.

* Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence.
-Noise levels may be higher at upper floors of the noise affected residence.

The ICNG states that the noise management level applies at any property boundary that is most exposed to the construction noise, at a height of 1.5 m above ground level. In cases where the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. It is also noted that noise levels may be higher at upper floors of the noise affected residence and therefore should be considered where necessary in an impact assessment.

In addition to the management level provided in **Table 6-2**, management levels for noise at other sensitive land uses are presented in **Table 6-3**. These levels are applicable only when the property is being used. Levels indicated as internal are measured in the centre of the occupied room, whilst those marked as external are to be measured inside the affected property, within 50 m of the boundary.

- **Table 6-3 Construction noise goals – other sensitive land uses**

Land use	Management level, LAeq (15 min) – when land is utilised
Class rooms at schools and other educational institutions	Internal noise level 50 dB(A)
Hospital wards and operating theatres	Internal noise level 40 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas (such as parks and sports grounds or playgrounds)	External noise level 65 dB(A)
Passive recreation areas (such as outdoor grounds used for teaching, outdoor cafes or restaurants)	External noise level 60 dB(A)

For the Proposal there are no non-residential sensitive land uses (listed in **Table 6-3**) currently identified that may be impacted by construction noise. These management levels should however be referred to during the detail design and construction phase to ensure any future changes of land use would be accounted for.

For other land uses such as commercial and industrial premises, there are three categories of noise management levels, measured externally at the most affected occupied point of the premises:

- Industrial premises: external $L_{Aeq(15min)}$ 75 dB(A)
- Offices, retail outlets: external $L_{Aeq(15min)}$ 70 dB(A)
- Other business that may be sensitive to noise: project specific.
  (Internal noise levels from *AS2107 Acoustics – Recommended design sound levels and reverberation times for building interiors* (Standards Australia 2000) may assist.)

The noise goals for residential, other sensitive land uses and industrial/commercial premises would be adopted as project specific criteria for the proposed upgrade.

6.2. Construction hours

Construction would normally be limited to the following hours:

- Between 6am and 6pm Monday to Friday.
- Between 7am and 4pm Saturday.

There would be no works outside these hours or on Sundays or public holidays except:

a) Works that do not cause construction noise to be audible at any sensitive receivers.

b) For the delivery of materials required outside these hours by the Police or other authorities for safety reasons.

c) Where it is required in an emergency to avoid the loss of lives, property and/or to prevent environmental harm.

d) Any other work as agreed through negotiations between the RTA and potentially affected sensitive receivers. Any such agreement must be recorded in writing and a copy kept on site for the duration of the works.

e) Where the work is identified in the Construction Noise and Vibration Management Plan (CNVMP) and approved as part of the Construction Environmental Management Plan.

f) As agreed by DoP and the DECCW.

Local residents and the DECCW must be informed of the timing and duration of work approved under items (d) and (e) at least 48 hours before that work commences. Hours of work would be addressed in the CNVMP, which would be finalised in consultation with the Department of Planning and the DECCW.

6.2.1. Project-specific noise objectives

Based on measured noise levels as described in **Section 2** the project-specific construction noise objectives for each representative monitoring location have been determined and are presented in **Table 6-4**. Considering the possibility that works would be undertaken outside standard construction hours additional management levels for these times are also included in the construction noise goals.

Table 6-4 Project-specific construction noise objectives

Location	Setback from existing highway (m)	Standard hours 7:00 am – 6:00 pm M-F 8:00 am – 1:00 pm Sat		Extended hours 6:00 am – 7:00 am M-F 7:00 am – 8:00 am Sat		Extended hours 6:00 pm – 7:00 pm M-F 1:00 pm – 4:00 pm Sat	
		RBL dB(A)	Noise objective	RBL dB(A)	Noise objective	RBL dB(A)	Noise objective
1	620	39	49	42	47	41	46
2	400	42	52	41	46	40	45
3	80	49	59	47	52	44	49
4	250	48	58	45	50	40	45
5	380	41	51	38	43	34	39
6	200	43	53	39	44	32	37
7	160	39	49	41	46	37	42
8	1300	37	47	41	46	40	45

6.3. Construction noise assessment

6.3.1. Construction activities

Although a detailed program of construction is not yet available, based on previous road construction projects, the specific construction stages described in **Table 6-5** may be expected. The noise impacts of each of these activities have been considered separately and cumulatively in this section.

Table 6-5 summary of road construction stages and associated activities

Stage / activity	Description
Clearing and grubbing	Felling of trees and shrubs as well as removal of man-made structures; removing stumps, roots and general vegetation.
Earthworks	Bulk earthworks including rock hammering, topsoil stripping, cut and fill (which may include blasting), excavation of culverts and basins, construction of batters and landscaping. Culvert construction, drainage installation, diversion drains to sedimentation basins.
Bridgeworks	Casting and formwork, piling, concrete pouring, pre-cast element installation and demolition as required.
Paving and asphalting	Application of road surface pavement to road base slab including batch plants, pouring of concrete base and sub-base, supplication of sprayed bitumen seals; laying of asphalt, saw cutting, finishing open drains and installation of road furniture and medians.

Activities associated with the construction Proposal are likely to include the following:

- Concrete batching — A temporary concrete batching plant is likely to be required to supply concrete to the Proposal. This would involve deliveries of aggregate and cement/fly ash as well as generate significant truck movements for concrete delivery.
- Blasting — It may be necessary to clear hard rock from cuttings by blasting.
- Site compound and workshop — An administrative and maintenance area is likely to be required.
- Deliveries — Deliveries to site may include heavy machinery, construction materials and other consumables.

The potential noise and vibration impacts of these activities are also assessed in this section.

Based on the most recent available data from current similar projects elsewhere in NSW, **Table 6-6** summarises the likely equipment to be utilised across the Proposal and the achievable source sound power levels for plant items.

- **Table 6-6 Equipment expected to be utilised during each construction stage and estimated associated sound power levels.**

Activity Description	Plant Noise Source	L_{Aeq} Sound Power Level re: 1pW, dB(A)
Stage 1 - Clearing and Grubbing	30t Excavator	103
	Rigid Trucks	107
	Bulldozer	110
	Chainsaws	114
	Tub Grinder	109

Activity Description	Plant Noise Source	L_{Aeq} Sound Power Level re: 1pW, dB(A)
Stage 2 - Drainage, Earthworks	Excavator	105
	D11 Bulldozer	114
	D9 Bulldozer	113
	Compactor	112
	Grader	111
	Water Cart	107
	Haul Truck	112
	Dump Truck	110
	651 Scraper	108
	637 Scraper	107
	Backhoe	110
	Vibrating / Compaction Roller	113
	Front End Loader	114
Stage 3 - Bridgeworks	Impact Piling Rig	121
	Bored Piling Rig	114
	Pneumatic Hammer	113
	Excavator	112
	Haul Truck	112
	Generator	111
	Mobile Crane	110
	Concrete Truck	110
	Concrete Pump	107
	Compressor	105
Stage 4 - Paving & Asphalting	Generator	111
	Backhoe	110
	Asphalt Paver	111
	Concrete Paver	111
	Pneumatic-tyred Roller	111
	Concrete Truck	110
	Concrete Vibrator	105
	Concrete Saw	109
	Concrete Batch Plant	111
	Bobcat	104

6.3.2. Construction Noise Level Predictions

The magnitude and nature of the noise level likely to be experienced at identified sensitive receivers is primarily dependent on the equipment in use and the proximity to the sensitive receiver. Intervening factors such as topography and meteorology will also have an influence on the predicted value.

The L_{Aeq} sound pressure levels at various distances from the construction sources have been predicted based on four scenarios, representing each stage of construction, at any location on the construction corridor, as follows.

- Stage 1 1 x 30 t truck, 1 x excavator and 1 x chainsaw
- Stage 2 2 x CAT 651 scrapers, 1 x compactor, 1 x D11 bulldozer
- Stage 3 1 x mobile crane, 1 x concrete truck, 1 x concrete pump
- Stage 4 1 x concrete paver, 1 x open-topped haul truck

Although the equipment types and numbers are likely to vary in practice, these scenarios provide a suitable indication of the likely magnitude of construction noise impacts.

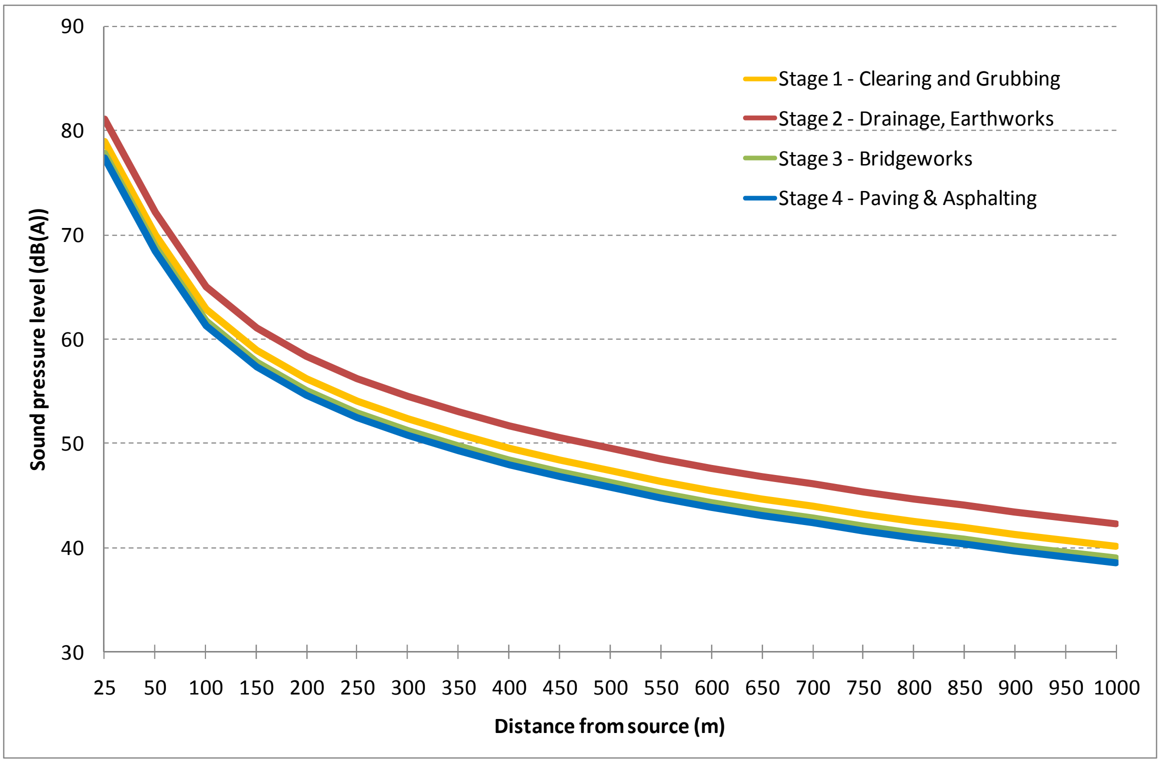
Based on the above scenarios and sound power levels listed in **Table 6-6** and incorporating estimated attenuation due to distance as well as ground and atmospheric absorption, predicted L_{Aeq} sound pressure levels for increasing distance from the construction sources are presented graphically in **Figure 6-1**.

The noise management levels for daytime periods (refer **Table 6-4**) indicate a project-specific construction noise criteria range of between 47 and 59 dB(A), which varies with the distance from the existing highway. Closer to the highway the existing RBLs would be more affected by traffic noise which would tend to mask the construction noise. At locations further away shielding from topographic features would provide a quieter noise environment which is like to be representative of the areas where new sections of road would be built.

Locations 1 and 8, being approximately 600 and 1300 metres from the road respectively, indicate that noise goals between 47-49 dB(A) are required to be achieved to meet the project-specific construction noise criteria for receivers in areas of new road development. **Figure 6-1** indicates that a distance of between approximately 400 metres is required before the daytime noise affected management levels are achieved and that any receivers within 50 m of construction are likely to be highly noise affected, i.e. exceeding the target level of L_{Aeq} 75 dB(A) during the daytime in areas of new road development.

For noise sensitive receivers closer to the noise influences from the existing highway, the background noise levels are elevated and a corresponding increase in the project-specific construction noise criteria would be apparent. In these areas the noise goal range is like to be between 52-59 dB(A), depending on local noise attenuation factors, and therefore locations between approximately 100 to 400 metres may be within the project-specific construction noise criteria.

- **Figure 6-1 Estimated reduction of construction noise (sound power to sound pressure) with distance from the source.**



Based on the outcome of these predictions, the construction contractor should apply all feasible and reasonable work practices to minimise noise. A selection of recommended mitigation measures is provided in **Section 6.10**.

6.4. Concrete batching

6.4.1. Batching noise assessment criteria

Batching requirements for the Proposal would be determined at a time closer to construction. However, it is expected that either a concrete or asphalt batching plant (or both) would be required for producing paving material. Since any batching plant would operate in the same location on a semi-continuous basis during the Proposal, it is considered to be similar to operational facilities rather than construction noise sources. Therefore, the INP (see **Section 3**) would be applicable for setting appropriate noise assessment criteria, rather than the project-specific construction noise criteria outlined in **Section 6.2.1**.

Given a batching plant is likely to operate during all periods, the assessment criteria would apply to the day (7:00 am to 6:00 pm); evening (6:00 pm to 10:00 pm) and night (10:00 pm to 7:00 am) periods, in accordance with the INP. Since the location of the batching plant site is not known at this stage, appropriate criteria cannot be determined in this assessment. As a guide, presuming a rural/residential setting, a planning noise level of approximately L_{Aeq} 50 dB(A) would be anticipated during the day, based on the INP. At night time this would be a lower criterion based on the pre existing background noise level.

6.4.2. Batching noise sources

For the purpose of this assessment, a concrete batching plant has been used to predict the potential noise impact on sensitive receivers. The predicted impacts from a concrete plant should be representative of those from an asphalt batching plant. However, during detailed design, the actual batching facility selected would require further assessment.

The concrete batching process generally involves loading of aggregate, cement, water and fly-ash into the batching plant, in which it is mixed and the concrete loaded into waiting open-topped tip-trucks. Previous experience has identified an operational noise emission from this type of process as having sound power of approximately 110 dB(A) – 112 dB(A). **Table 6-7** summarises some of the potentially dominant noise sources at an operational batching plant, based on observations at other batching plants.

- **Table 6-7 Potential noise sources at an operational batching plant.**

Noise source	Description
Aggregate loading	A front end loader (FEL) used to load aggregate and sand from the stockpiles into the hoppers.
Aggregate hopper gates	The aggregate may loaded onto the conveyors via gates which are controlled by compressed-air power rams, which generate a significant air release each time gates are opened.
Aggregate conveyor	The aggregate is loaded to the mixing drum via a conveyor. The conveyor is driven by an electric motor and runs on rollers, which may squeal if not properly lubricated.
Dust extraction fan	Externally mounted fans for controlling dust in cement and fly-ash silo
Vibratory aggregate hopper cleaner	May be associated with the aggregate hopper and activates each batch to ensure all product has been loaded - emits a mid-frequency hum
Mixing drum	Rotation by hydraulic or electric drive
Truck movements	Trucks are a significant noise source for a batching plant, with a high number of movements and rapid turnaround time Other truck movements include aggregate and cement deliveries at a lower frequency of movement
Compressor	Used to operate gates, externally mounted
Generator	Where the site is not connected to 3-phase power a generator would be required to power the plant. Even with power, a generator would be installed for emergency use
Cement loading	Cement is pneumatically loaded to the silo using a blower on the silo.

Noise source	Description
Reverse beepers	Trucks are typically required to reverse into the loading bay

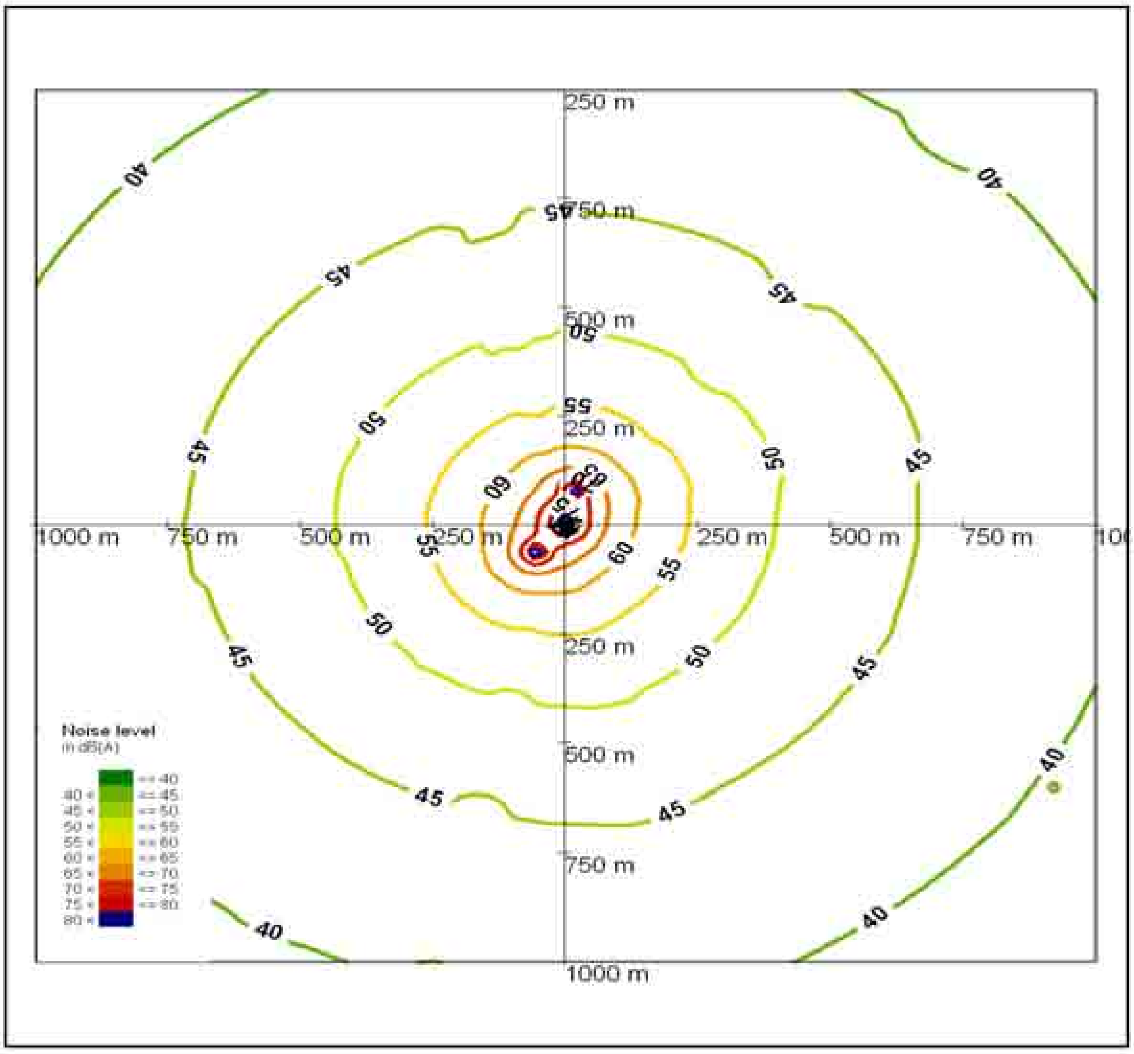
6.4.3. Predicted noise levels

Based on the estimated noise emissions from a batching plant the L_{Aeq} sound pressure levels have been predicted using a SoundPLAN model at nominal distances from the plant. The prediction is generic and does not account for attenuation due to topographical or structural barriers and assumes worst-case meteorological conditions, i.e. stable atmosphere and light breeze from source to receiver.

The noise contours are presented in **Figure 6-2** and demonstrate that within 250 m of the plant, noise levels are likely to be approximately 55 dB(A), whilst at 500 m, the L_{Aeq} noise levels is expected to be approximately 48 dB(A); and at 1000 m, the predicted noise level is 41 dB(A).

For the concrete batching activities, assuming a rural environment and a project noise level of 50 dB(A), a buffer zone of up to approximately 300 m would be required to minimise noise impacts from the batching operations. This assessment should be referred to during the detail design stage when locations for the batching plant are being considered. At this stage a more detailed assessment of noise impacts would be required.

- **Figure 6-2 Predicted noise levels with increasing distance from the batching plant.**



6.5. Blasting

6.5.1. Blasting impact assessment criteria

Blasting activities produce ground-borne vibration and air blast overpressure, both of which can cause discomfort and, at higher vibration levels, potential damage to property.

The *ANZECC Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* have been adopted by the DECCW and establish ground vibration and airblast over-pressure criteria for potentially effected locations.

The blast charge configuration should be selected to ensure that DECCW goals are not exceeded. Before blasting can commence at a site, critical locations should be identified and appropriate measures taken to limit over pressure and vibration to acceptable levels. Blasts should be monitored initially at these locations to ensure that predicted over-pressure and vibration levels are not exceeded.

The recommended goals for blasting during the Project are based on the ANZECC guidelines, *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration*. These state that: “Blasting should generally only be permitted during the hours of 9:00am to 5:00pm Mondays to Saturday” and that “Blasting should not take place on Sundays or Public Holidays”.

Table 6-8 shows the limiting blast over-pressure and ground vibration for the control of blasting impact on residential premises.

- **Table 6-8 Limiting criteria for the control of blasting impact at residences**

Day	Time of Blasting	Blast Over Pressure Level, dB (linear)	Ground Vibration, Peak Particle Velocity, (mm/sec)
Monday to Saturday	9am-5pm	115	5
Sunday, Public Holiday	Anytime	0	0

In addition, any exceedance above an over pressure of 115dB (linear) should be limited to not more than 5% of the total number of blasts. On these infrequent occasions a maximum limit of 120dB (linear) should not be exceeded at any time. Ground vibrations above 5 mm/sec should also be limited to not more than 5% of the total number of blasts. On these infrequent occasions a maximum limit of 10 mm/sec should not be exceeded at any time.

6.6. Blasting impact assessment

At this preliminary stage, blasting and seismic details for the project are unknown and it would be necessary to carry out noise and vibration predictions later once the proposed charge and blast configuration information becomes available. However, it is important that the actual buffer zone associated with this site be identified and appropriate measures taken to limit over-pressure and vibration to acceptable levels at critical locations.

The distance estimates relating to vibration have been determined using Australian Standard 2187.2-1993, applicable to free face blasting in ‘average field conditions’:

$$V = 1140\left(\frac{R}{Q^{-1/2}}\right)^{-1.6}$$

where

- V = ground vibration as peak particle velocity in mm/s
- R = distance between charge and point of measurement in metres
- Q = effective charge mass per delay or maximum instantaneous charge in kilograms

The distance estimates relating to over-pressure are determined from the results of a regression analysis of noise data obtained from a number of mine sites in the Hunter Valley. The distance per Maximum Instantaneous Charge (MIC) may vary significantly depending on the geological conditions, local shielding and meteorological factors at the site but provide an appropriate indication of over-pressure magnitude.

In the absence of specific blasting information and seismic details of the site, **Table 6-9** provides general guidance for estimating the likely minimum distance from blasting that may be required to meet over-pressure and vibration criteria described above, for a range of MIC values.

- **Table 6-9 Minimum distances to comply with blasting vibration and over-pressure limits for various MIC values.**

Maximum Instantaneous Charge (MIC)	Minimum Distance Limits (metres)	
	Vibration	Over-Pressure
5	70	290
10	100	350
20	140	430
50	220	560
100	300	670
200	430	750

The above distances are only estimates, hence should only be referred to for guidance, however, it is evident that the degree of impact is strongly dependent on the size of the blast and that a greater separation distance is required to comply with the over-pressure limit than the vibration limit. Therefore, in terms of buffer distances, the over-pressure limit is more stringent than the vibration limit and therefore would become the limiting blast criterion for the project. As there are a significant number of cuttings on the project it is expected that blasting may be required during the earthworks phase. Where blasting is necessary within the minimum buffer distances, additional management strategies would be required.

6.7. Site compound and deliveries

The impact of noise from the establishment and operation of the site compound on nearby sensitive receivers is not likely to be significant however would be considered. While these locations would be confirmed at the detail design stage, the potential site compound locations are presented in **Table 6-10**.

- **Table 6-10 Potential site compound locations**

Chainage	Eastern/Western side	Location
1800	Eastern side	North of Upper Warrell Creek and the North Coast Railway
2800	Western side	Between the North Coast Railway and Rosewood Road
4200	Western side	Albert Drive
5050	Eastern side	Albert Drive
7800	Western side	Bald Hill Road
9800	Eastern side	South of River Street
11150	Eastern side	North of existing Pacific Highway
11100	Western side	North of existing Pacific Highway
11900	Eastern side	Off Old Coast Road
21050	Eastern side	Nambucca Interchange
22200	Western side	Valla Road
26200	Western side	North of East West Road
29800	Split both sides	South of Ballads Road
30200	Split both sides	South of Ballads Road
35550	Eastern side	South of Kalang River
35600	Western side	South of Kalang River
35900	Eastern side	North of Kalang River
36700	Eastern side	North of Kalang River
40400	Western side	Adjacent to Raleigh Industrial Estate

During establishment of the site, anticipated activities include clearing and grading and the installation of pre-fabricated portable site offices and a maintenance workshop area. Sources of noise during this time, although typically relatively noisy, are anticipated to be of limited duration. They include mobile machinery (e.g. scrapers, graders compactors and mobile cranes) and stationary plant (e.g. generators, compressors). Vibration sources are not likely to be significant and would be rapidly attenuated with distance.

Operation of the site compound would be required to support construction activities and the predominant noise source would likely be vehicle movements (e.g. staff transport and delivery of construction supplies). It has been assumed that the location of the construction compounds would be near transport facilities for delivery and access reasons and therefore the additional vehicle movements are not likely to present a significant noise or vibration impact on sensitive receivers.

The use of hand tools during vehicle maintenance may result in audible noise at sensitive receivers; however their use would reflect the existing rural land use and would not be a continual noise source. Any noise and vibration generated during the operation of the site compound should be managed under a specific Construction Noise and Vibration Management Plan, which includes monitoring, noise mitigation and community consultation as a minimum as well as measures to identify and mitigate any unforeseen significant noise sources from the sites.

6.8. Construction traffic

6.8.1. Construction programming and temporary road works

The proposed construction works would be programmed to minimise the interaction between the construction works and the local and regional road network. This would minimise disruption to local and through traffic. Construction of the northern and southern interchanges would enable traffic to be switched between the existing highway and the project to facilitate the continual flow of traffic through around the Proposal corridor.

Spoil haulage

The Proposal is not likely to generate excess spoil as the design seeks to achieve balanced earthworks. If spoil haulage is required, vehicles would use the proposed construction haul roads and the existing road network. Vehicle movements would be relatively small, difficult to detect above normal daily fluctuations in traffic.

Access impacts

Site compounds

Access to this compound would be via the new northbound on-ramp that would be constructed at the northern interchange. Until the ramp is constructed, a temporary access would connect to the existing highway near the northern tie-in. Vehicles leaving the site compound during the early evening are likely to experience higher traffic volumes on the highway.

Construction access

Access points at the northern and southern tie-ins would be required to facilitate construction activities. Right-turn lanes and widened shoulders would be provided at the site compound entry, and where construction turning volumes are likely to be high or where adverse geometry exists. All access points would:

- Have safe intersection sight distances.
- Accommodated the turning movements of the largest heavy vehicles.

Local Roads

During construction, some temporary changes to access arrangements may be needed for local roads in and around the Proposal. Temporary changes to access arrangements would consider the turning requirements of school buses and would be finalised during the detailed design.

Properties

Property access would be maintained for the duration of the construction. If required temporary or alternative access would be provided in consultation with the affected landowner(s).

6.9. Construction vibration

6.9.1. Assessment criteria – human comfort

Assessing Vibration; a technical guideline (DECC 2006) provides guidance on disturbance to human occupants of buildings as a result of vibration. This document provides criteria which are based on the British Standard BS 6472-1992, '*Evaluation of human exposure to vibration in buildings (1-80Hz)*'. For the purpose of this report, vibration can be defined as follows (DECC 2006):

- Continuous – where vibration occurs uninterrupted for a defined period (usually throughout the day-time and/or night-time) and can include sources such as machinery and steady road traffic.
- Impulsive – where vibration occurs as a rapid build up of the vibration energy to a peak followed by a decay that may or may not involve several cycles of vibration (depending on the frequency of the system). It can also consist of a sudden application of several cycles at approximately the same amplitude, provided that the duration is short, typically less than 2 seconds. This may include activities such as occasional dropping of heavy equipment or loading / unloading activities.
- Intermittent – where continuous vibration activities are regularly interrupted, or where impulsive activities recur. This may include activities such as rock hammering, drilling, pile driving and passing heavy vehicles or trains.

The criteria are applied to a single weighted root mean square (rms) acceleration source level in each orthogonal axis, as required in the guideline. Preferred and maximum values for continuous and impulsive vibration are defined in **Table 6-11**.

Table 6-11 Preferred and Maximum Weighted rms Values for Continuous and Impulsive Vibration Acceleration (m/s^2) 1-80Hz

Location	Assessment period	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous Vibration					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or Night-time	0.020	0.014	0.040	0.028
		0.04	0.029	0.080	0.058
Workshops	Day or Night-time	0.04	0.029	0.080	0.058
Impulsive Vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Nighttime	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or Night-time	0.64	0.46	1.28	0.92
Workshops	Day or Night-time	0.64	0.46	1.28	0.92

Note: Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am, in accordance with *Assessing Vibration; a technical guideline* (DECC 2006)

Intermittent vibration is to be assessed using vibration dose values (VDV). The VDV method is more sensitive to peaks in the acceleration waveform and makes corrections to the criteria based on the duration of the source's operation. The VDV can be calculated using the overall weighted rms acceleration of the vibrating source in each orthogonal axis and the total period during which the vibration may occur. Weighting curves are provided in each orthogonal axis in the DECC guideline. Preferred and maximum VDV's are defined in Table 2.4 of the DECC guideline and are reproduced in **Table 6-12**.

Table 6-12 Acceptable VDV for Intermittent Vibration ($m/s^{1.75}$) Impacts

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools,	0.40	0.80	0.40	0.80

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
educational institutions and places of worship				
Workshops	0.80	1.60	0.80	1.60

Note: Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am, in accordance with *Assessing Vibration; a technical guideline* (DECC 2006)

6.9.2. Assessment criteria – structural damage

The Australian Standard AS2187.2-2006 *Explosives – Storage, Transport and Use* (Appendix J) provides guidance for the assessment of structural damage to buildings caused by vibration. This section of the standard is based on the British Standard 7385: Part 2 "*Evaluation and measurement of vibration in buildings*" and is used as a guide to assess the likelihood of building damage from ground vibration including piling, compaction, construction equipment and road and rail traffic. BS 7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

BS 7385 recommends that the peak particle velocity is used to quantify vibration and specifies damage criteria for frequencies within the 4Hz to 250Hz range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The levels from the standard are given in **Table 6-13**.

- **Table 6-13 BS 7385 Structural Damage Criteria**

Group	Type of Structure	Peak Component Particle Velocity, mm/s		
		4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15 to 20	20 to 50	50

The levels set by this standard are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular types of buildings. These values relate to intermittent vibrations. Continuous vibration can give rise to magnifications due to resonances and may need to be reduced by up to 50%.

6.9.3. Vibration impact assessment

This section provides guidance on the magnitude of vibration that may be expected from the construction activities of each scenario. **Table 6-14** summarises the anticipated level of vibration for each stage of construction. It can be inferred that activities such as compaction and rolling, as well as ripping would be the dominant sources of vibration during construction of the Proposal.

- **Table 6-14 Summary of Anticipated Vibration Levels for Various Construction Activities.**

Stage	Activity	Vibration guidance
Clearing and grubbing	Clearing of vegetation, trunk and root removal, processing of timber waste	In general, the activities carried out during this stage of works generate low levels of vibration and areas close to residences are generally already cleared. Vibration impact is considered unlikely.
Earthworks	Bulldozers ripping	1mm/s to 2mm/s at distances of approximately 5m. At distances greater than 20m, vibration are usually below 0.2mm/s.
	Compactors	20mm/s at distances of approximately 5m, 2mm/s at distances of 15m. At distances greater than 30m, vibration is usually below 0.3mm/s.
	Vibratory rollers	Up to 1.5mm/s at distances of 25 m. Higher levels could occur at closer distances, however, no damage would be expected for any building at distances greater than approximately 12m (for a medium to heavy roller).
	Truck traffic (on normal smooth road)	0.01mm/s to 0.2mm/s at the footings of buildings located 10m-20m from a roadway. (Very large surface irregularities can cause levels up to five to ten times higher).
Bridgeworks	Impact piling	The typical levels of ground vibration from pile driving range from 1 mm/s to 3 mm/s at distances of 25 m to 50 m, depending on ground conditions and the energy of the pile driving hammer
Paving and asphalting typical operations	Paver, concrete cutter	None of the construction plant used during paving and asphalting would be major sources of ground vibration

Vibration generated by construction plant was estimated at various distances and expected vibration impacts are shown in **Table 6-15**. There is a possibility that adverse comment as a result of earthworks activity may occur from residents within 20 m of road works although only during ripping or use of vibratory rollers. Structural damage as a result of these works is unlikely. With respect to annoyance from ramp/bridge construction, there is a possibility of adverse comment from residents in the immediate vicinity of the works.

- **Table 6-15 Potential Vibration Impact**

Approximate Distance	Comment on Potential Vibration Impact
Stage 2 – Earthworks	
Up to 10m	Adverse comment as a result of use of bulldozer, compactor & vibratory roller is

Approximate Distance	Comment on Potential Vibration Impact
Stage 2 – Earthworks	
	probable.
10 - 20m	Low probability of adverse comment for most activities. Adverse comment as a result of ripping and use of vibratory rollers is possible. Structural damage is unlikely.
20 - 30m	Adverse comment as a result of ripping or use of heavy vibratory rollers is possible a this level, however, no receivers are likely to be affected. Structural damage is unlikely.
30 - 50m	Adverse comment as a result of ripping is possible. Structural damage is unlikely.
50 - 100m	Adverse comment as a result of ripping is possible. Structural damage is unlikely.
100m+	Low probability of adverse comment for all activities
Stage 3 – Bridgeworks	
50m	Adverse comment as a result of piling is possible. Structural damage is unlikely.
100m+	Low probability of adverse comment from piling activities

6.10. Construction noise and vibration mitigation measures

There is the potential for adverse impacts on sensitive receivers as a result of construction of the Proposal and therefore all feasible and reasonable mitigation measures would need to be implemented to ensure these impacts are maintained at their practical minimum.

Table 6-16 provides a description of general mitigation measures that should be incorporated in a Construction Noise and Vibration Management Plan (CNVMP) to systematically address and manage known and unidentified construction noise and vibration impacts on sensitive receivers.

- **Table 6-16 Recommended construction noise and vibration mitigation measures.**

Ref	Recommended control measures and safeguards
Administrative measures	
1	Ensure compliance with approved construction hours: Proposed from 6:00 – 6:00 pm (M-F), 7 am-4 pm (Sat) and at no time Sundays and public holidays (unless otherwise approved). This requirement to be communicated to all staff through inductions and toolbox meetings.
2	Prepare an out-of-hours works procedure to minimise the impact of any necessary works outside normal hours
3	Provide an induction to site personnel (including s/c) addressing the requirements of this CNVMP and their responsibilities with regard to noise and vibration management.
4	Implement a community liaison program to ensure that the public is kept informed and that any concerns regarding noise and vibration are promptly addressed.
5	Provide continuous education of supervisors, operators and sub-contractors on the need to minimise noise through Toolbox meetings and on-site coaching.
6	A protocol should be developed for handling noise complaints that includes recording, reporting and acting on complaints.
On-site activities	
7	Identify the location of compounds and design these facilities to minimise noise exposure and

Ref	Recommended control measures and safeguards
	impacts to nearby noise receivers (i.e. consider access, storage and maintenance areas, barriers/shielding etc)
8	Select quieter alternatives to noisy activities if practical/feasible , i.e. use bored piling where practical
9	Select appropriate sized vibratory compactors and other rock excavation equipment and design procedures for their use in order to comply with vibration emission limits.
10	Erect noise barriers and tree screening as early as practical in construction.
11	Ensure equipment is operated in the correct manner including replacement of engine covers, repair of defective silencing equipment, tightening of rattling components, repair of leakages in compressed air lines and shutting down equipment not in use.
12	Position plant on site to reduce emission of noise to the surrounding neighbourhood.
13	Select site access points and haul road locations away from sensitive receivers.
14	Keep horn signals between drivers to a minimum.
15	Regularly grade access roads to reduce noise from trucks rattling.
16	During clearing and grubbing, select ‘quiet’ plant and fit residential grade mufflers where required. Since excavators are much quieter than chainsaws, excavators with grabs and rake attachments should be used in lieu of chainsaws wherever possible.
17	Tub grinding should not occur within 500 m of sensitive receivers
18	Topsoil would be stockpiled, where practicable within the width of easement, in noise sensitive areas to provide shielding to residences.
19	Ensure all equipment is equipped with noise control (residential class mufflers, silenced exhausts acoustic enclosures for any diesel generators and/or air compressors etc)
20	Ensure equipment and diesel combustion engines (including delivery and disposal trucks) are turned off when not in use.
21	Ensure machinery used is appropriately sized to prevent overloading and associated over-revving.
23	Where possible, locate construction equipment in a position that provides the most acoustic shielding from buildings and topography.
24	Ensure traffic movement is kept to a minimum, e.g. ensure trucks are fully loaded so that the volume of each delivery is maximised and the number of trips is therefore minimised.
25	Ensure plant and equipment is adequately maintained.
26	In accordance with Best Practice Environmental Management principles, where noise assessment indicates reverse beepers are likely to result in adverse impacts on amenity, alternative beepers, such as “white noise beepers” or other complying warning systems should be considered.
Monitoring	
27	Monitor construction noise levels at construction commencement to verify compliance with the Noise and Vibration Management plan and noise impact statements.
28	Undertake monitoring of noise levels from fixed and mobile plant every six months and ensure that levels are not degraded by lack of maintenance and comply with respective Australian Standards (Refer AS 2436 -1981).
29	Undertake regular monitoring of overall noise and vibration levels at sensitive receivers to check for compliance.
30	Undertake vibration monitoring in the early stages of the Proposal to determine the potential for inducing vibration at locations within potentially affected buildings. (Blast design can then be modified to ensure criteria are met).
31	Undertake vibration monitoring during works within 50 m of residences where vibration may be generated by equipment.

Ref	Recommended control measures and safeguards
Batch plant	
32	Locate noisy equipment away from sensitive receivers or behind sound barriers (e.g. stockpiles)
33	Enclose noisy compressors or pumps and fit silencers to any pressure operated equipment and engines
34	Line hoppers with sound absorbing materials such as rubber
35	Seal roads and site with bitumen or concrete and position access points away from sensitive receivers
36	Use visual alarms where possible in preference over audible alarms and employ personnel paging devices rather than hooters or PA systems
37	Undertake maintenance and other noisy works in enclosed sheds where possible
38	Maintain an adequate buffer between the site and sensitive receivers
39	Erect screens and barriers where necessary to reduce noise transmission
40	Strictly comply with construction hours of the Proposal
41	Develop Construction Method Statement for Batching
Blasting	
42	Develop a blast management strategy to ensure vibration and over-pressure limits are complied with.

7. Conclusion

SKM has undertaken a noise and vibration assessment for the Warrell Creek to Urunga Pacific Highway Proposal. This assessment has identified the potential noise sensitive receivers in the investigation area and undertaken an impact analysis against the *Environmental Criteria for Road Traffic Noise* and the *Environmental Noise Management Manual*.

Measurements of the existing noise environment were made to provide information for the validation of the noise model as well as providing additional details used in the assessment of potential construction noise impacts.

Based on the measurement of the existing traffic noise and the predicted traffic profile for the Proposal, the night time noise levels were identified as being the critical assessment values for the proposed upgrade. The noise levels at all receiver locations were predicted using noise modelling software, which identified potential exceedances of the noise criteria. The balance of the noise sensitive receivers was predicted to be within the base noise criterion or within the allowance tolerances detailed in the guidelines.

The concept design for the Proposal has incorporated the use of the existing topography to provide noise reduction measures using cuttings and landform features including ridges where possible. Where exceedances of the traffic noise criteria were identified, additional noise mitigation using low noise pavements was incorporated in where benefits to local communities was possible. Due to the topographic constraints and sparsely populated rural areas, the effective implementation of noise barriers is limited for the Proposal. This technical paper has identified the areas where low noise pavements can provide a beneficial reduction in traffic noise impacts. Other locations would require consideration of treatments at the property to ensure noise levels are reduced to acceptable amenity levels.

8. References

Environment Protection Authority, 2000, *Industrial Noise Policy*, Sydney

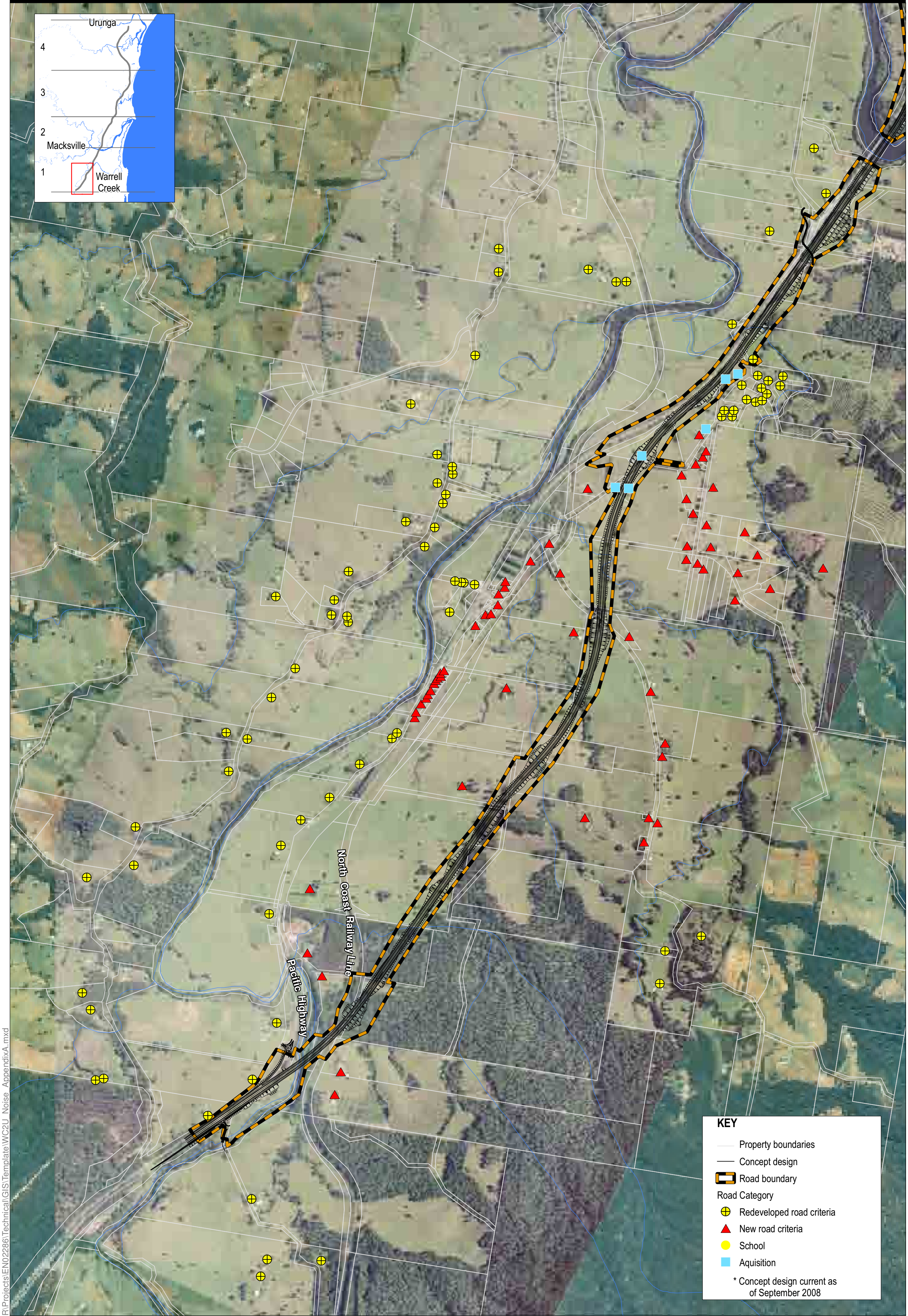
Environment Protection Authority, 1999, *Environmental Criteria for Road Traffic Noise*, Sydney

Roads and Traffic Authority, 2001, *Environmental Noise Management Manual*, Sydney

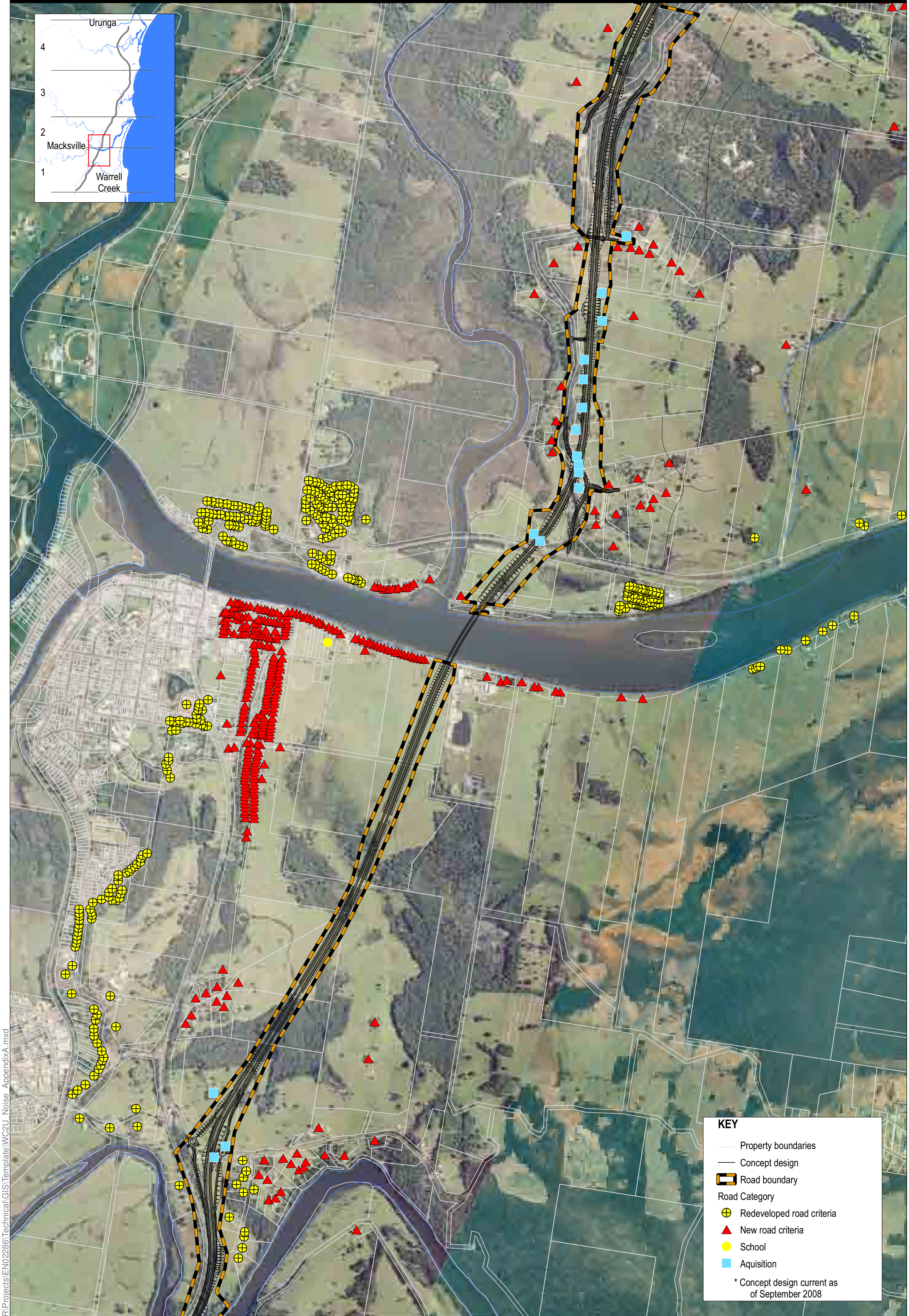
German standard DIN 4150: Part 3 – 1999 *Effects of Vibration on Structures*

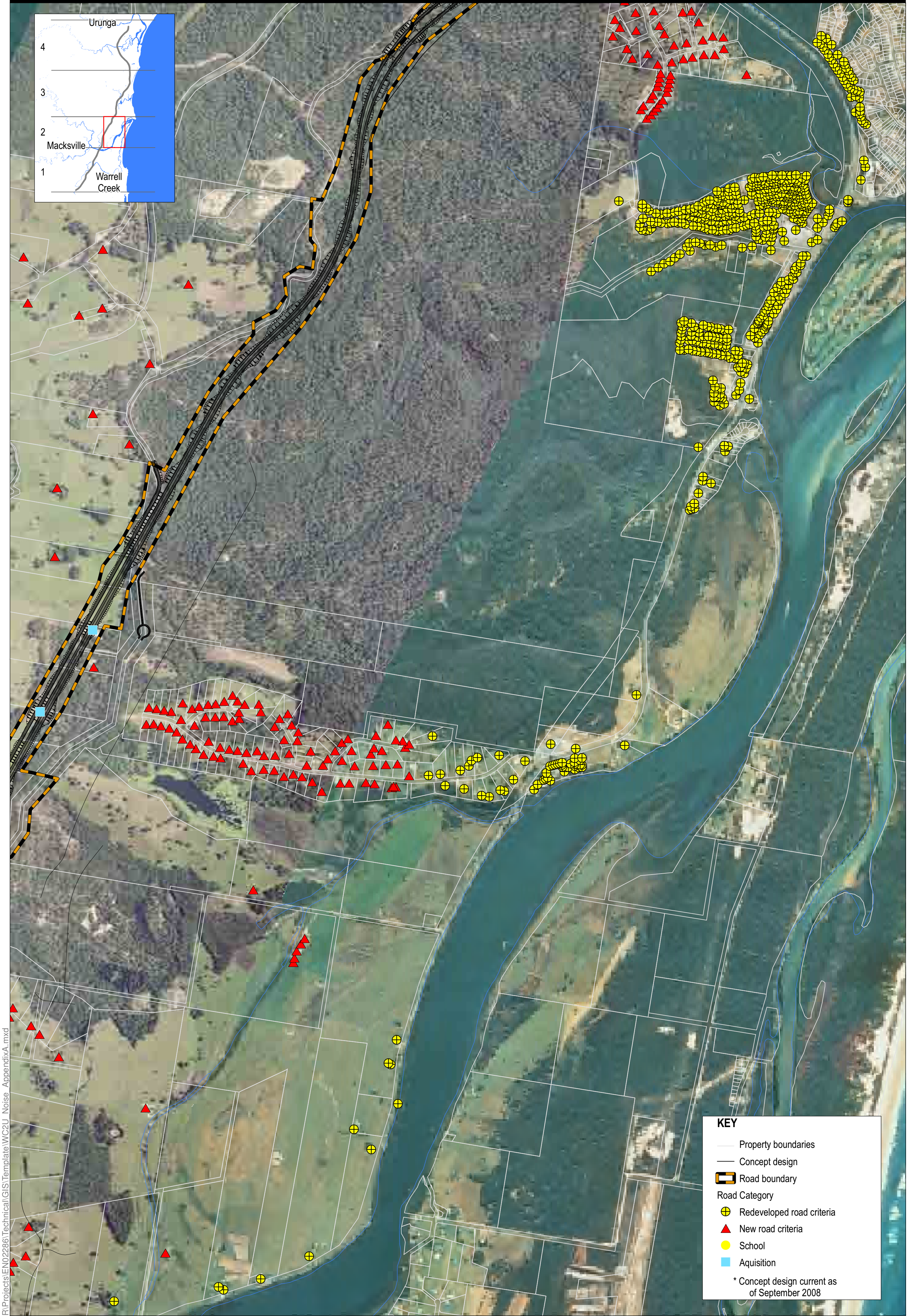
British Standard BS 6472: - 1992 *Evaluation of Human Exposure to Vibration in Buildings*

Appendix A Sensitive Receiver Locations



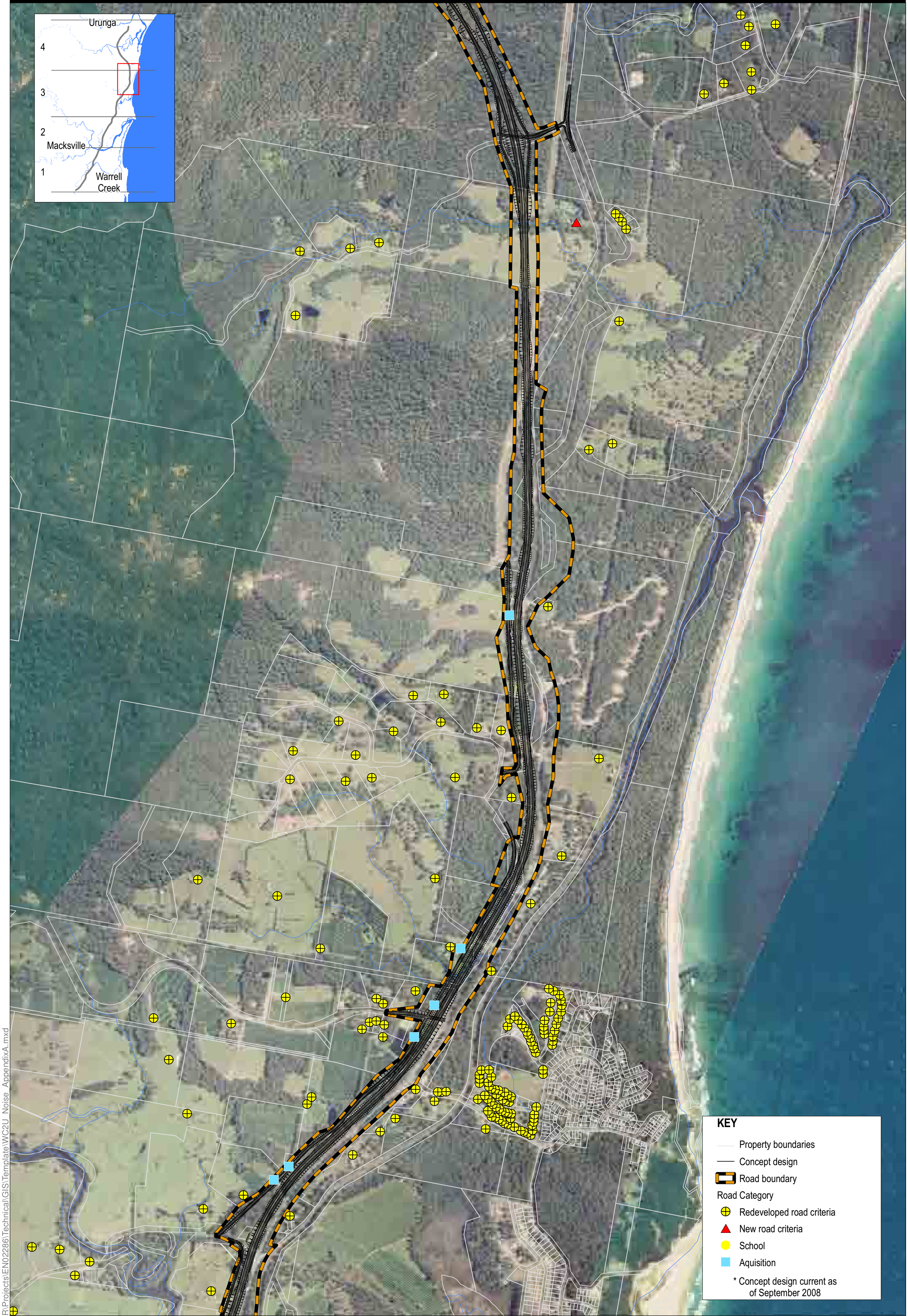
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixA.mxd


Urunga
4
3
2
Macksville
1
Warrell
Creek
KEY
Property boundaries
Concept design
Road boundary
Road Category
Redeveloped road criteria
New road criteria
School
Aquisition
* Concept design current as
of September 2008
0
200
400 Metres

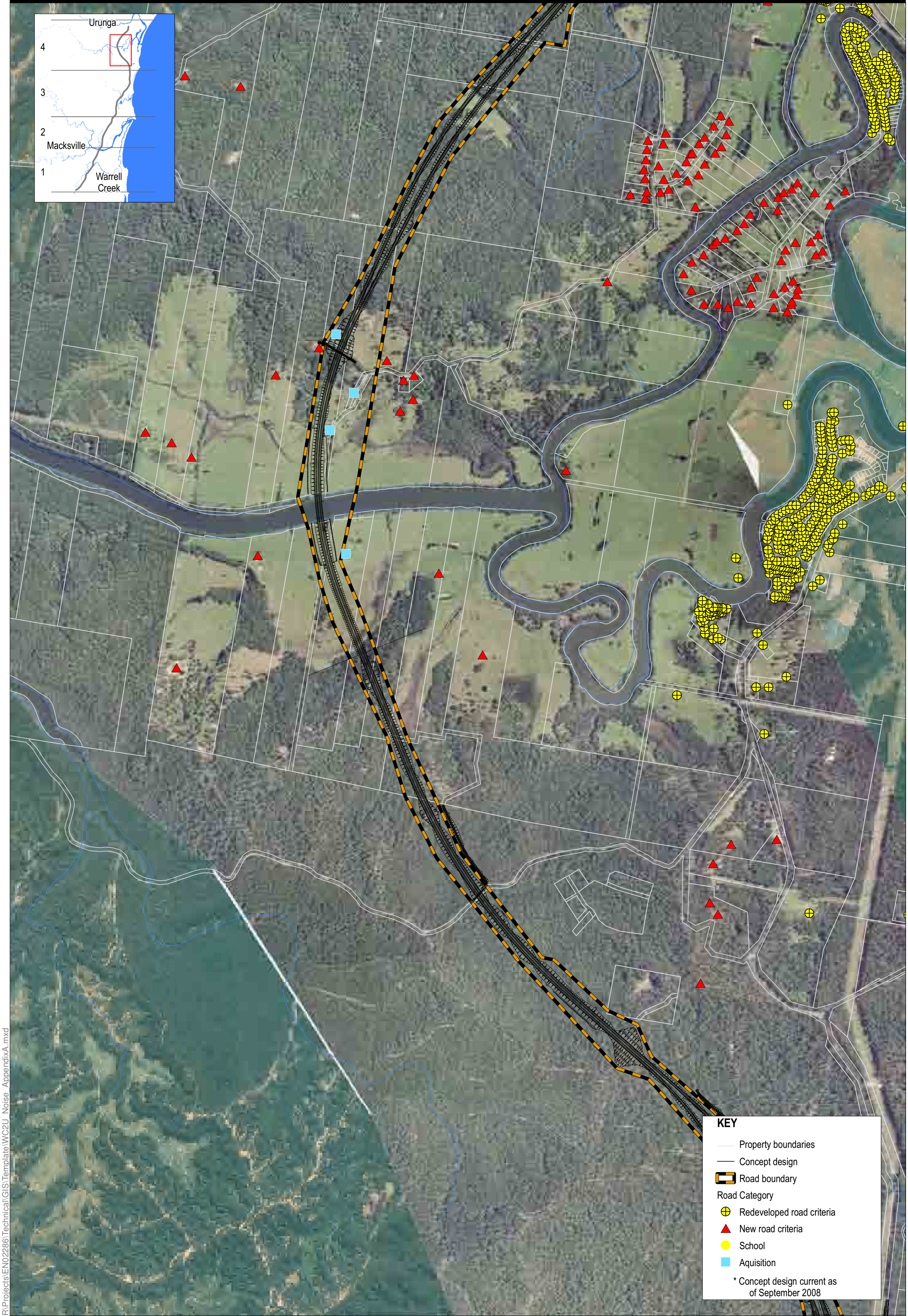


I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixA.mxd

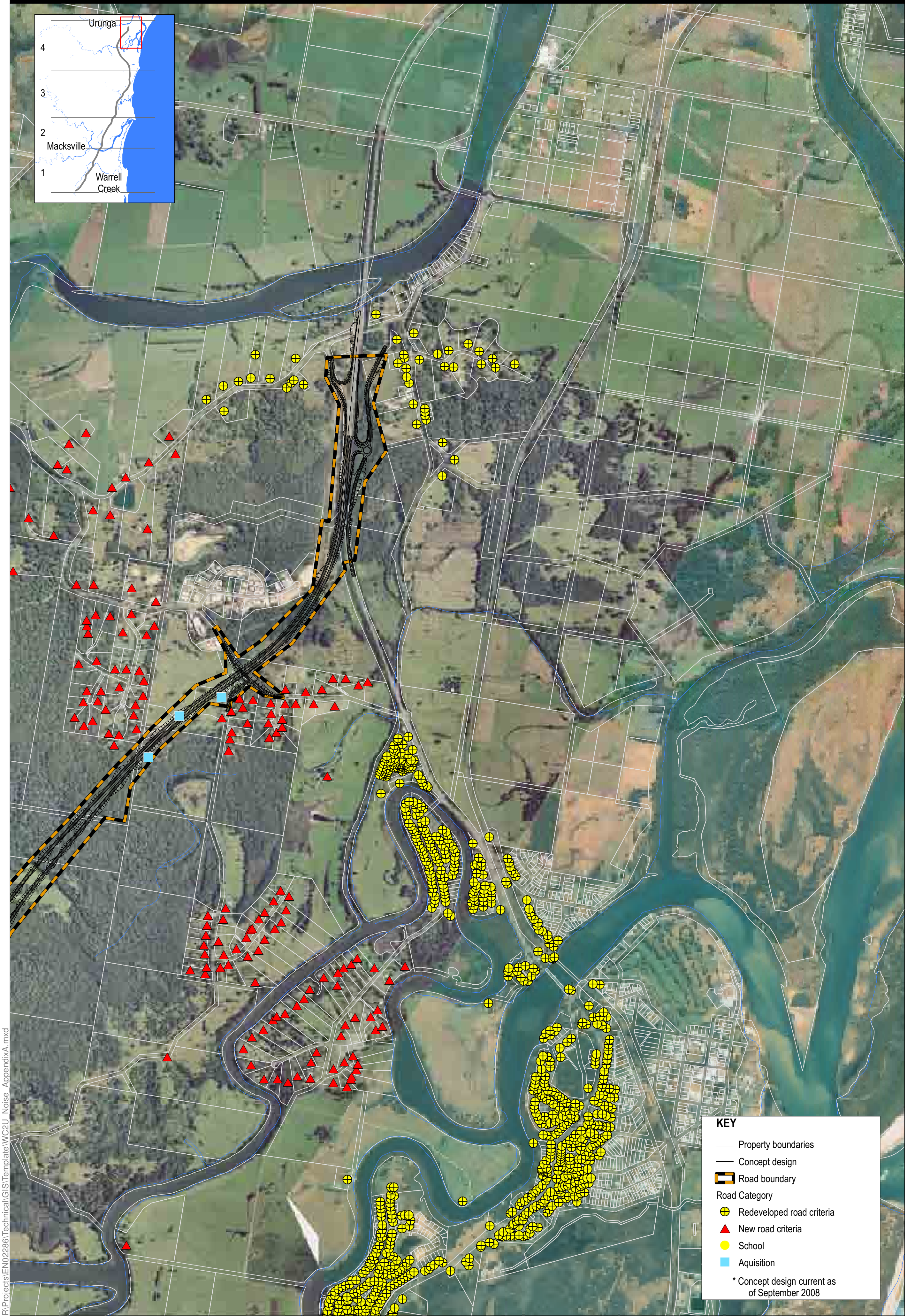
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixA.mxd



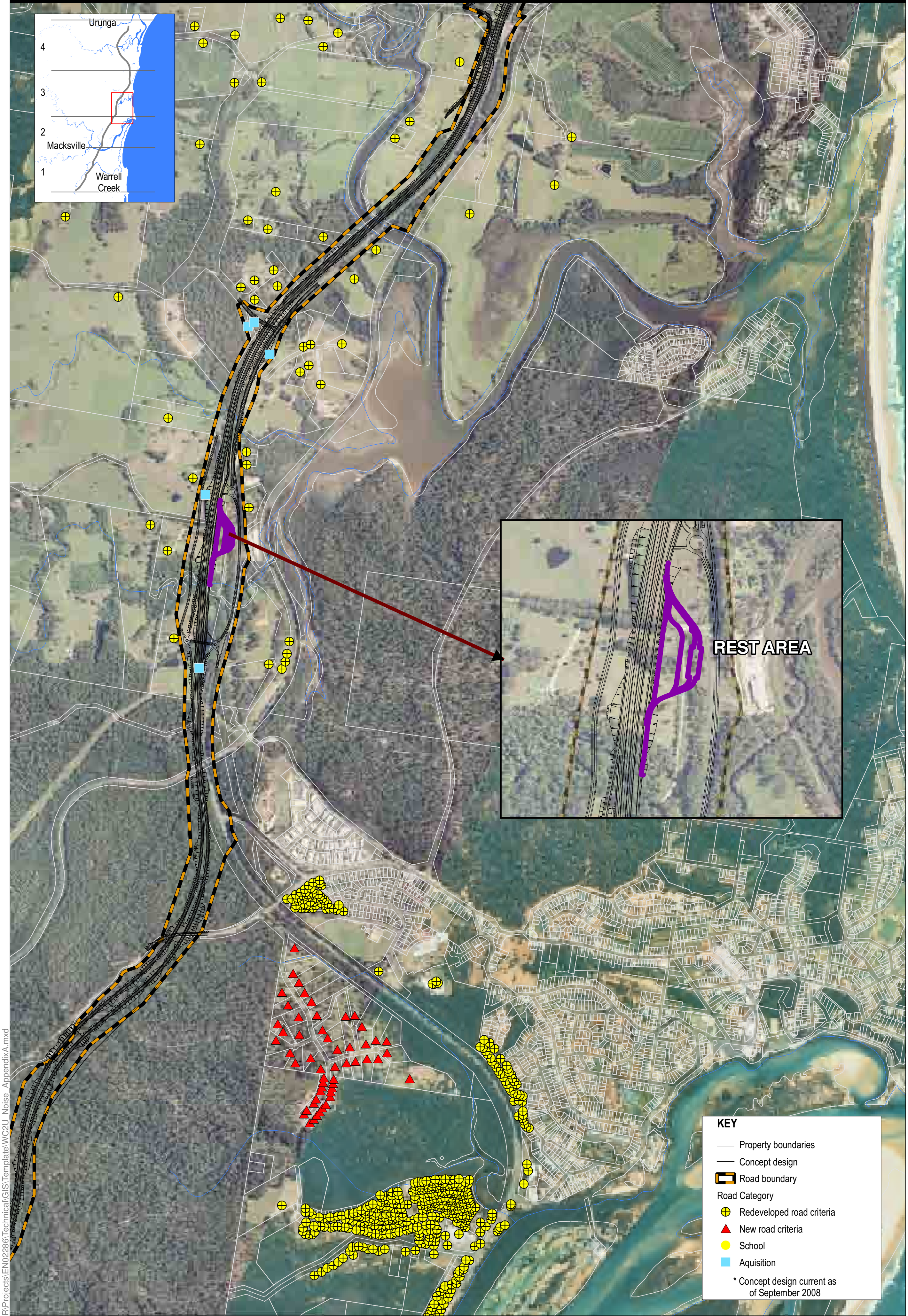
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixA.mxd



I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixA.mxd

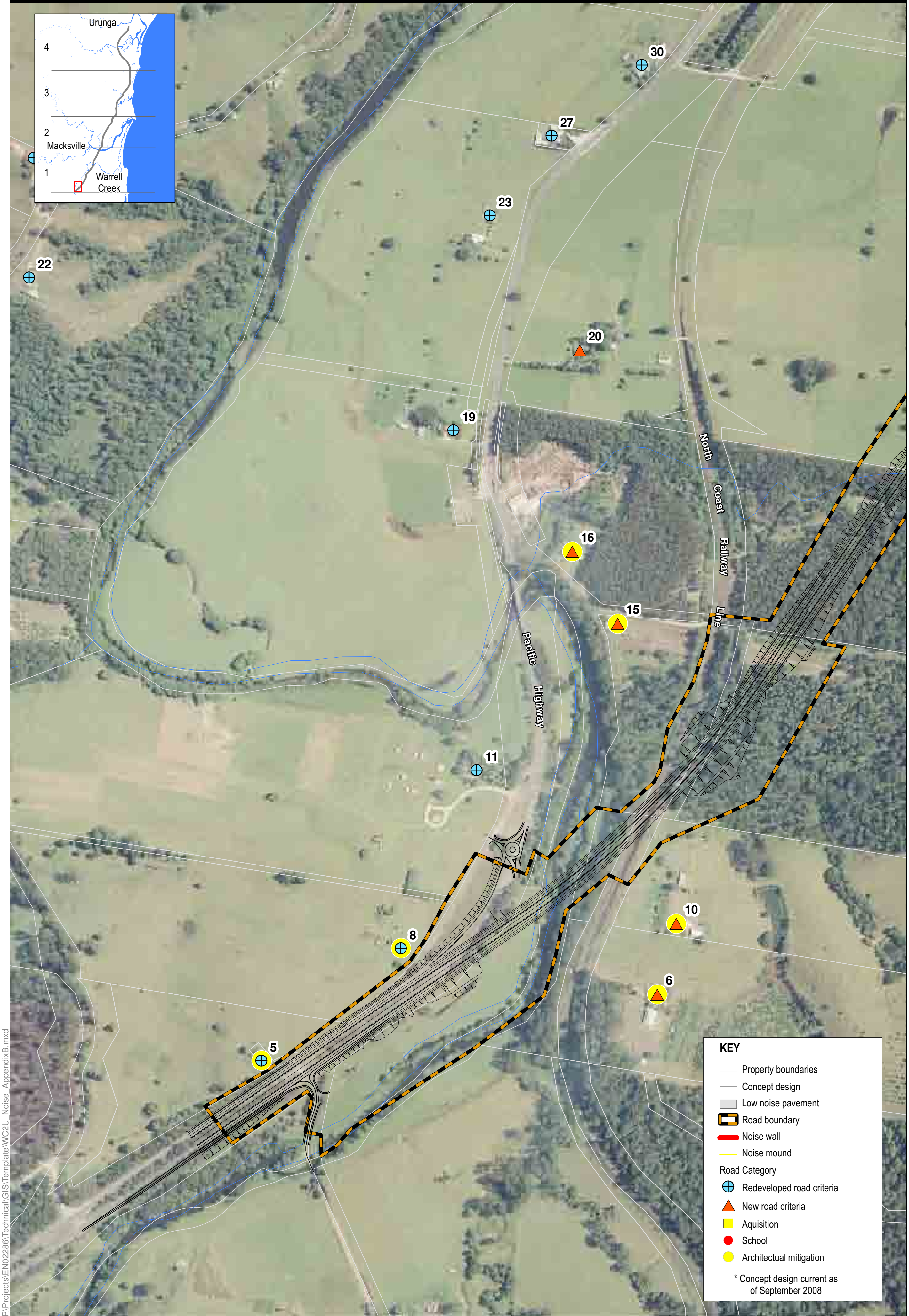


I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixA.mxd

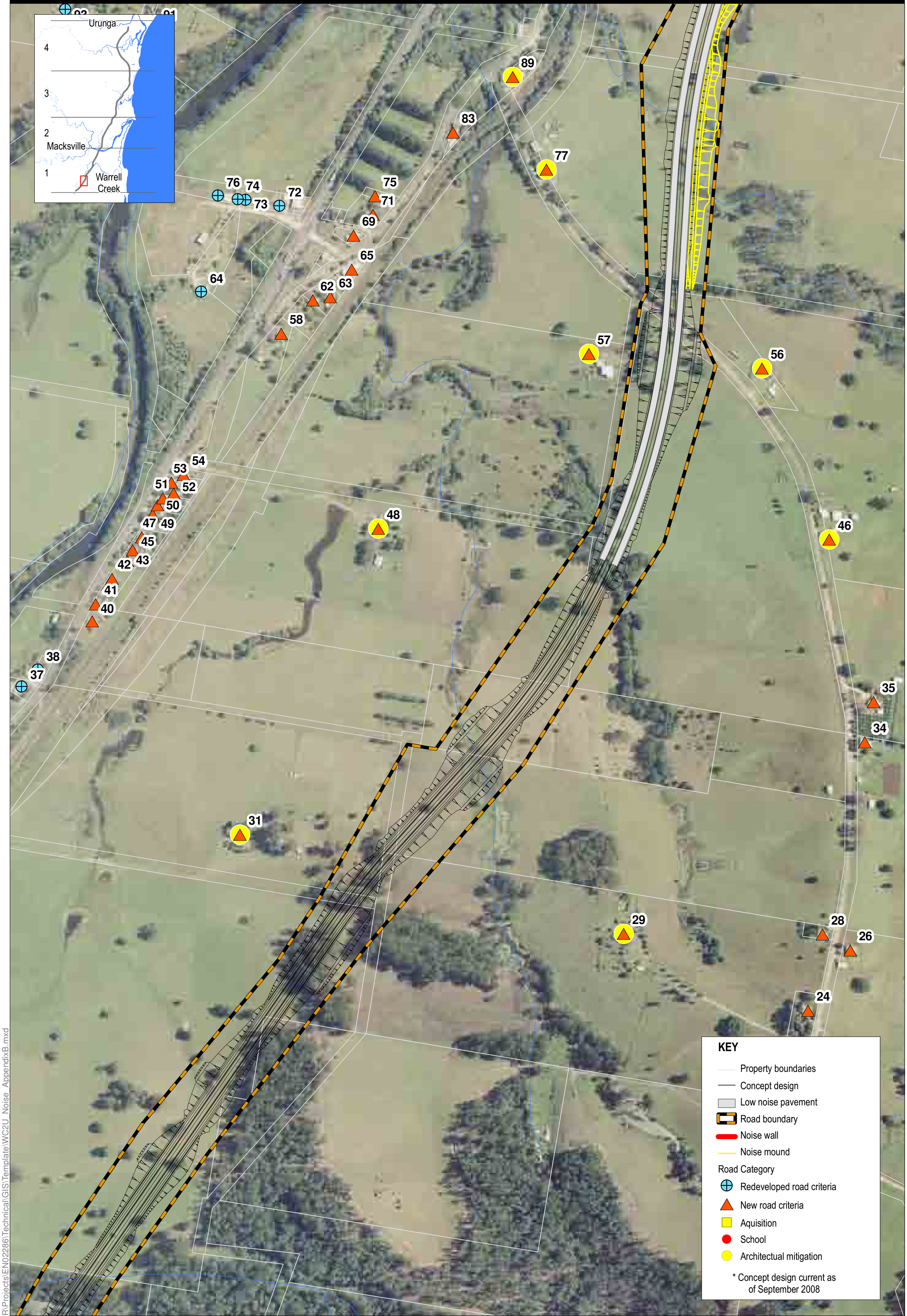


I:\ENVR\Projects\EN02286\Technical\WC2U\GIS\Template\WC2U_Noise_AppendixA.mxd

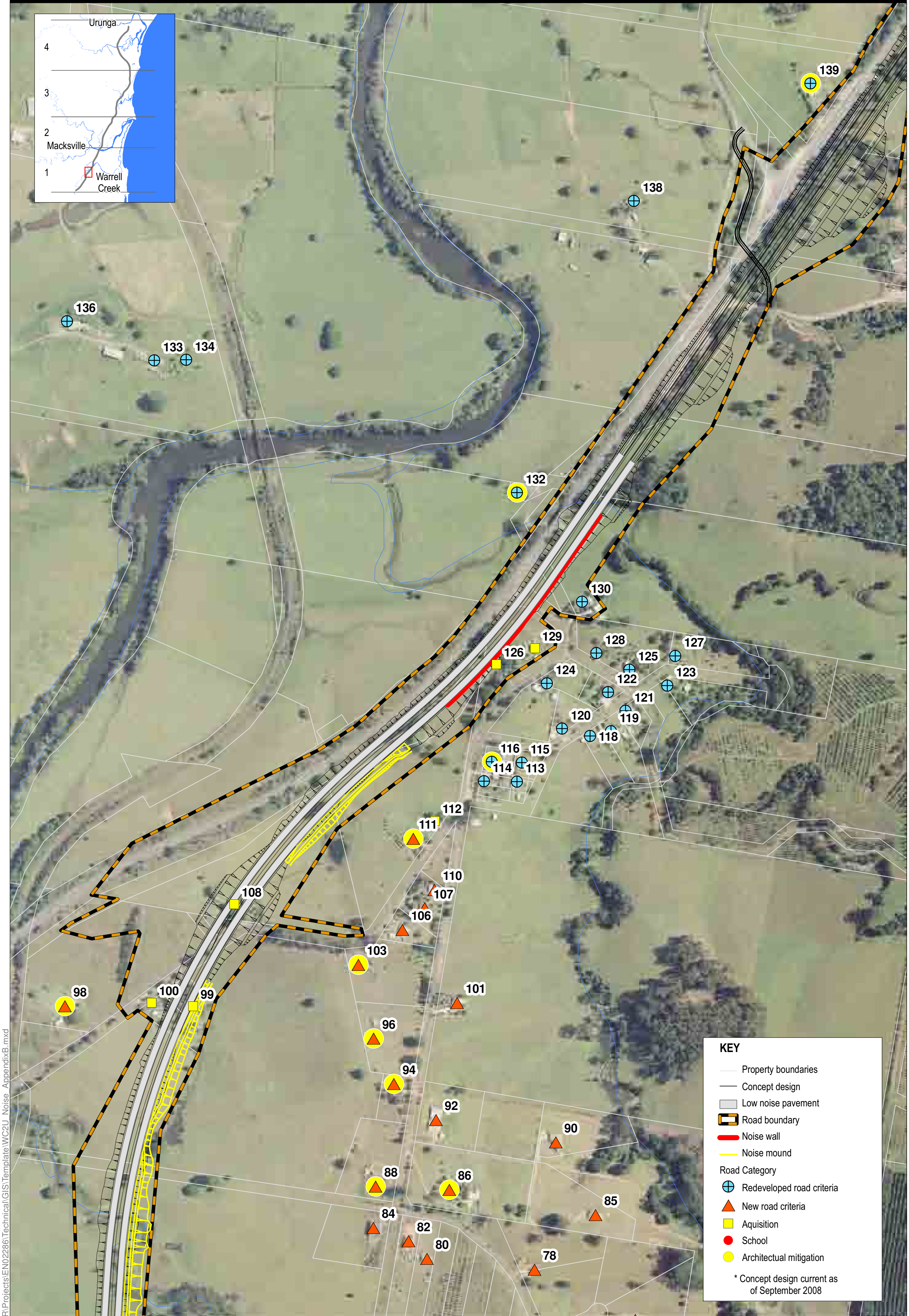
Appendix B Recommended Treatment Options



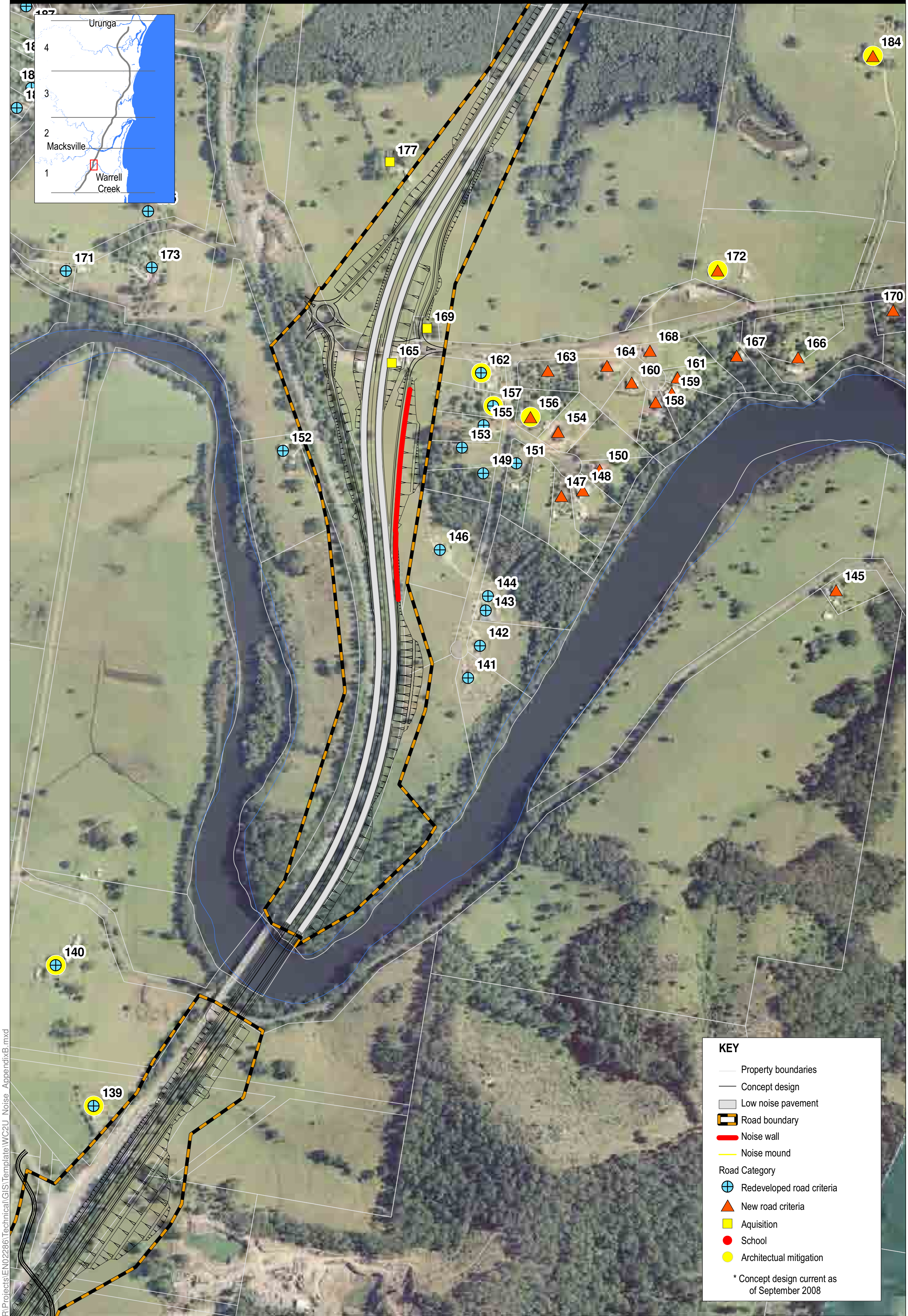
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd



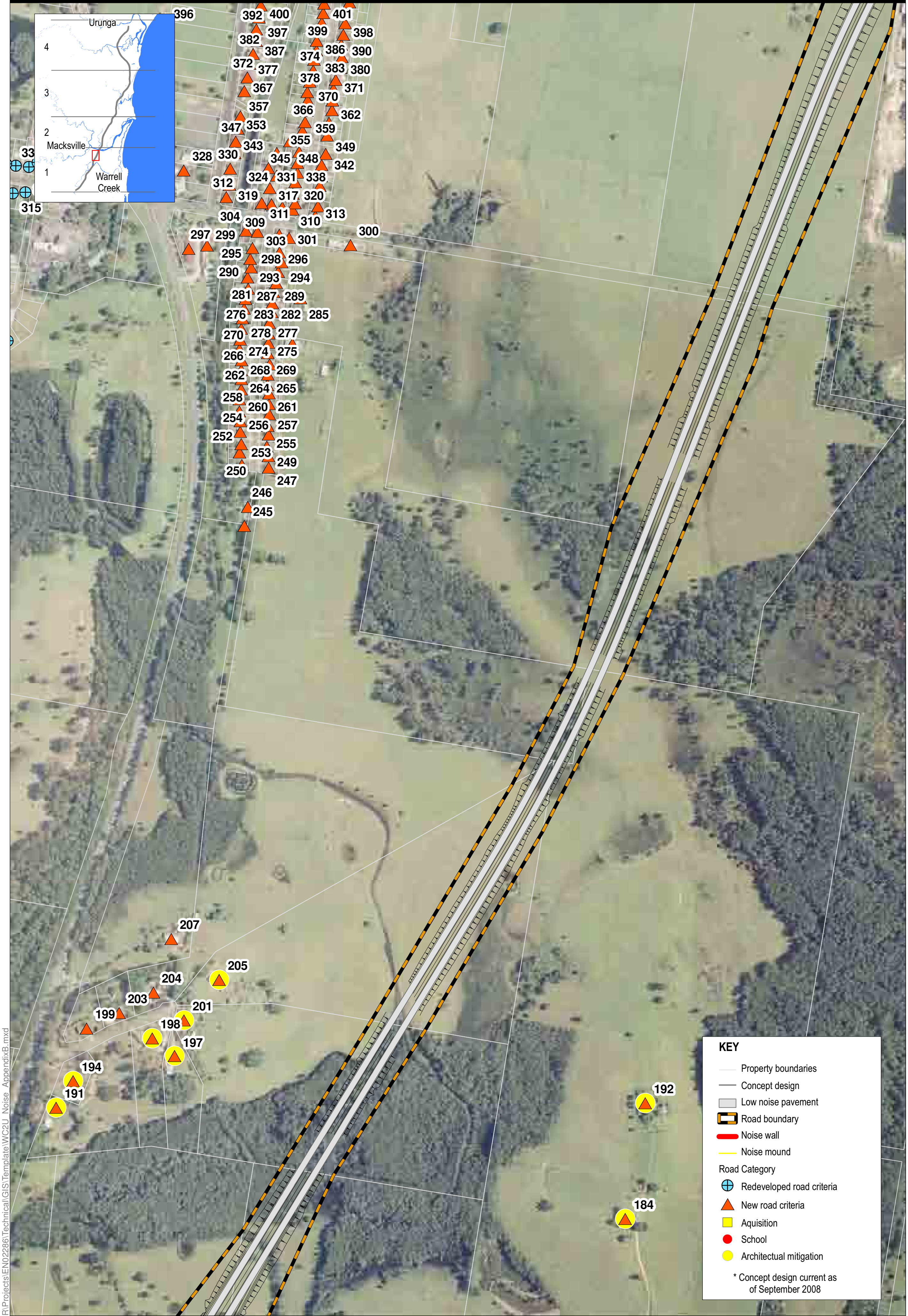
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd



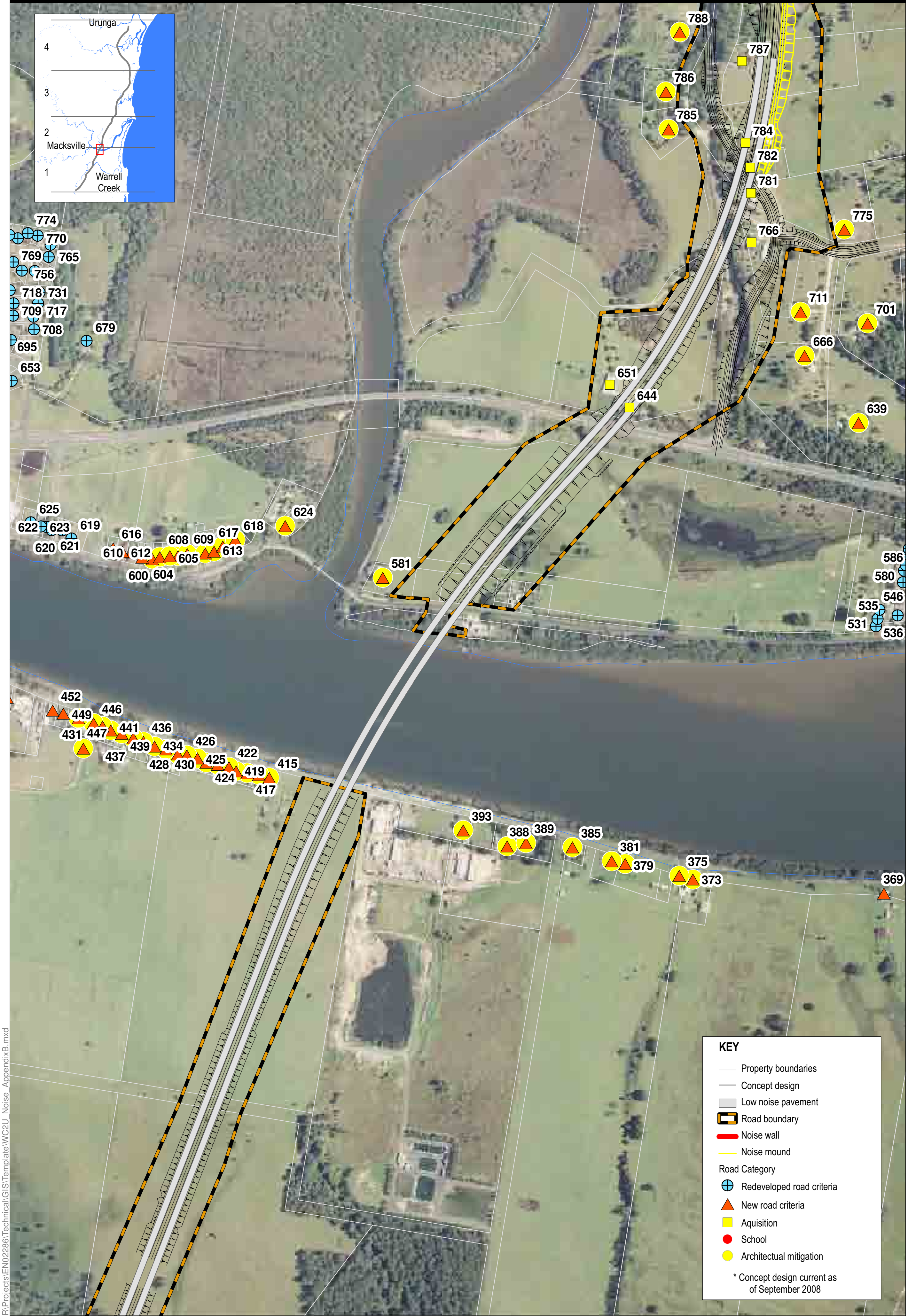
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd

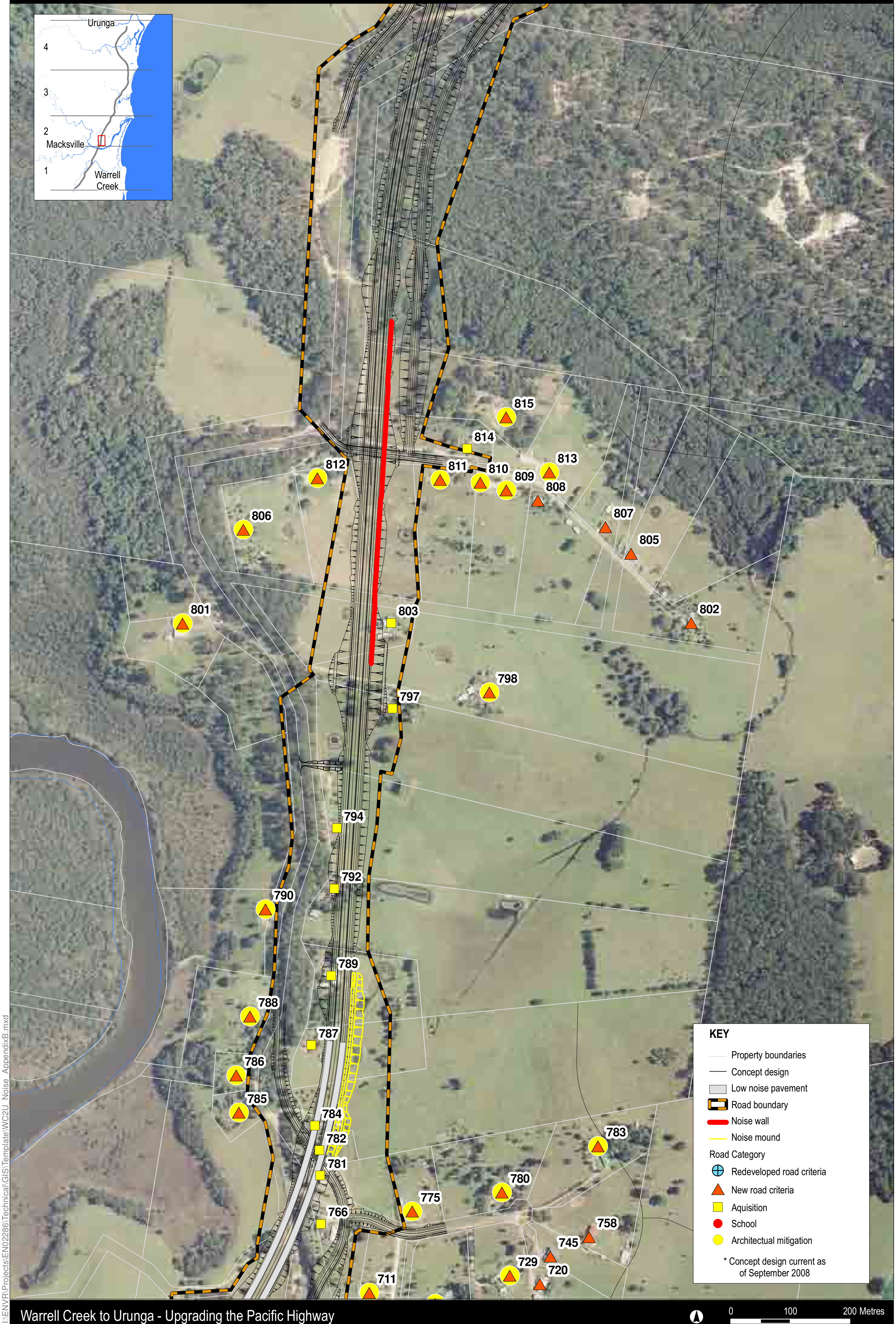


I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd

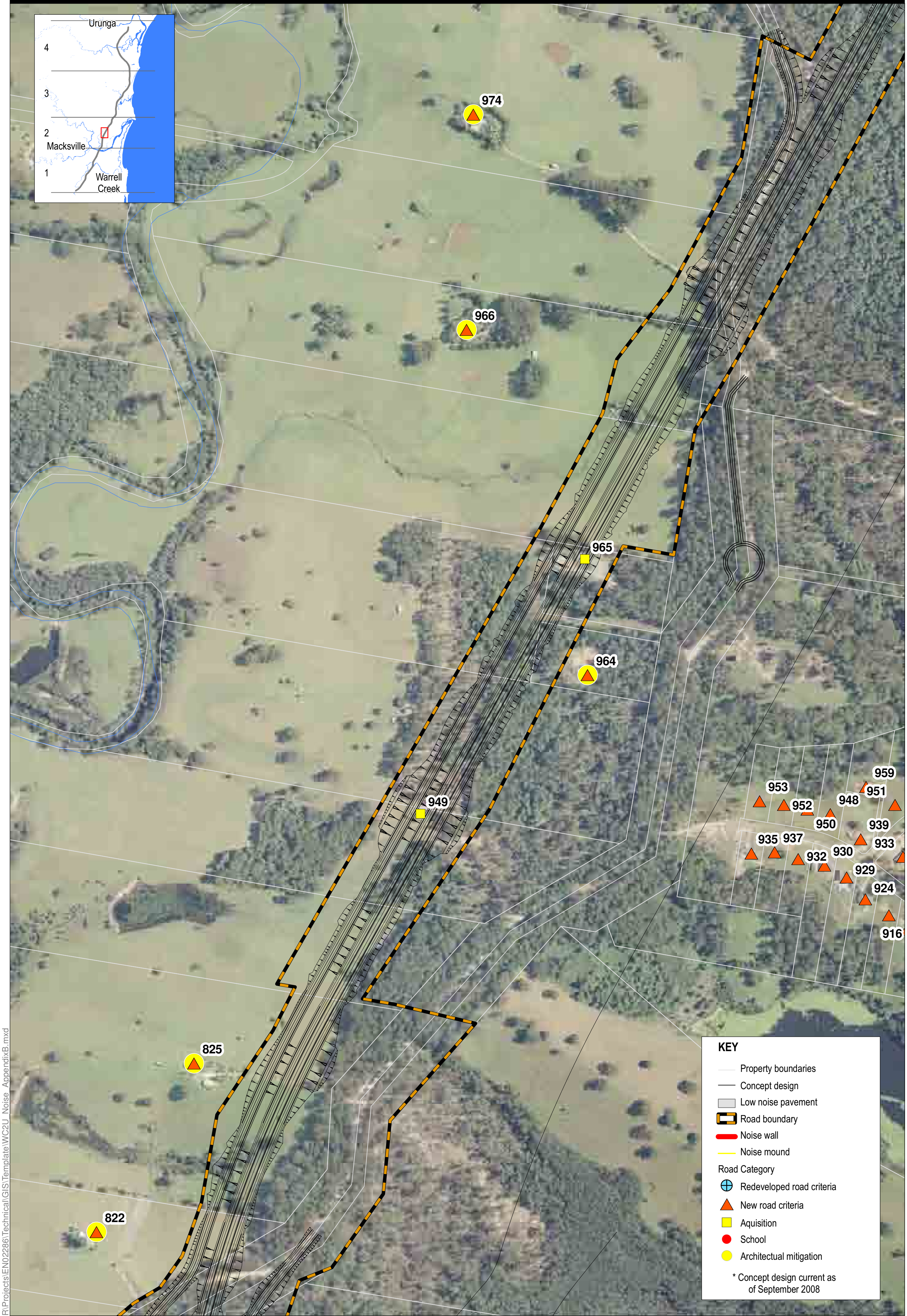


I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd

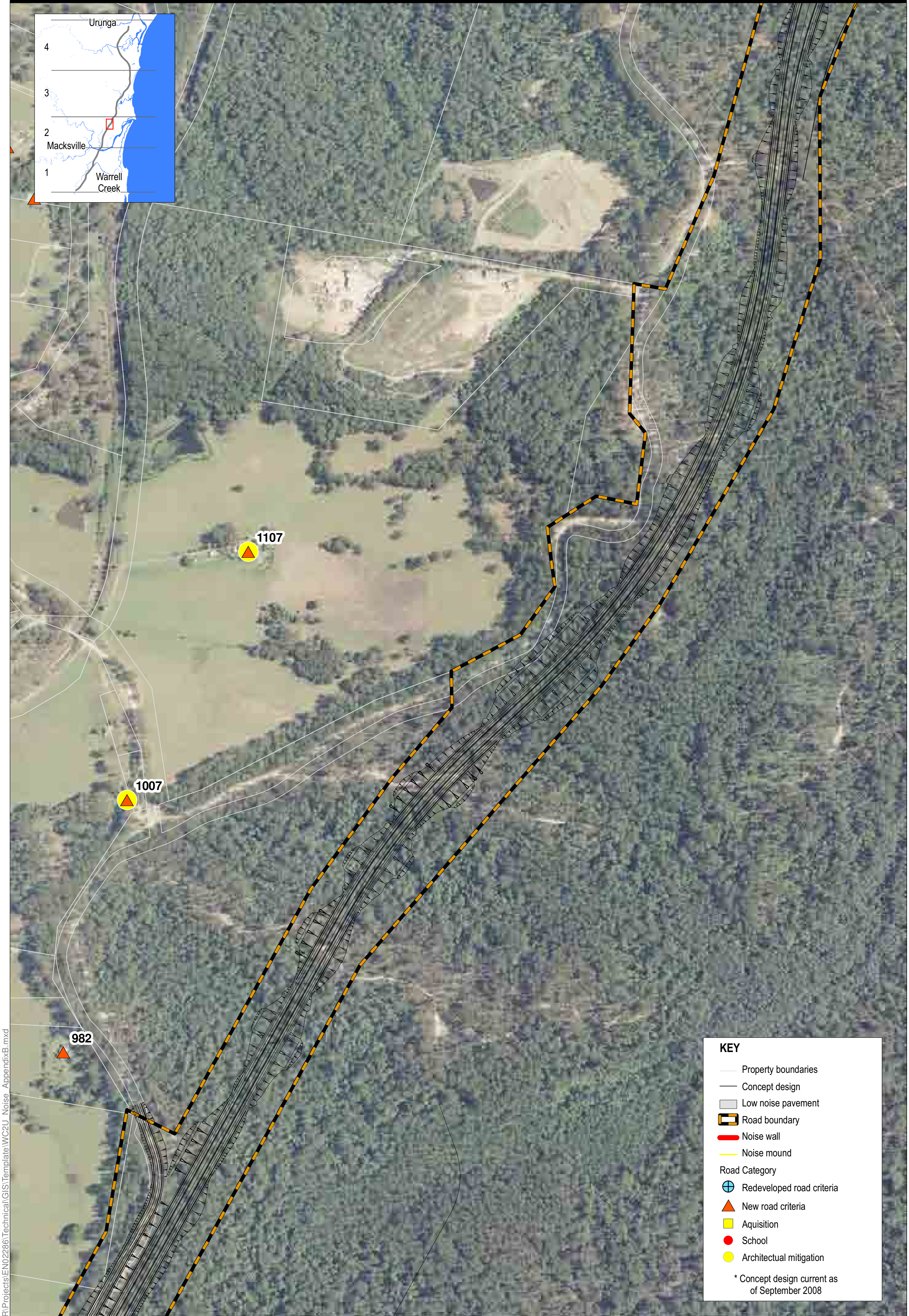

Urunga
4
3
2
Macksville
1
Warrell Creek
788
787
786
785
784
782
781
775
766
711
701
666
651
644
639
774
770
769
765
756
718
731
709
717
708
679
695
653
625
622
623
619
621
620
616
610
612
608
609
617
618
624
613
605
600
604
581
586
580
546
535
531
536
452
449
446
431
447
441
436
437
439
434
426
428
430
425
422
424
419
415
417
393
388
389
385
381
379
375
373
369
KEY
Property boundaries
Concept design
Low noise pavement
Road boundary
Noise wall
Noise mound
Road Category
Redeveloped road criteria
New road criteria
Aquisition
School
Architectural mitigation
* Concept design current as of September 2008
0
100
200 Metres



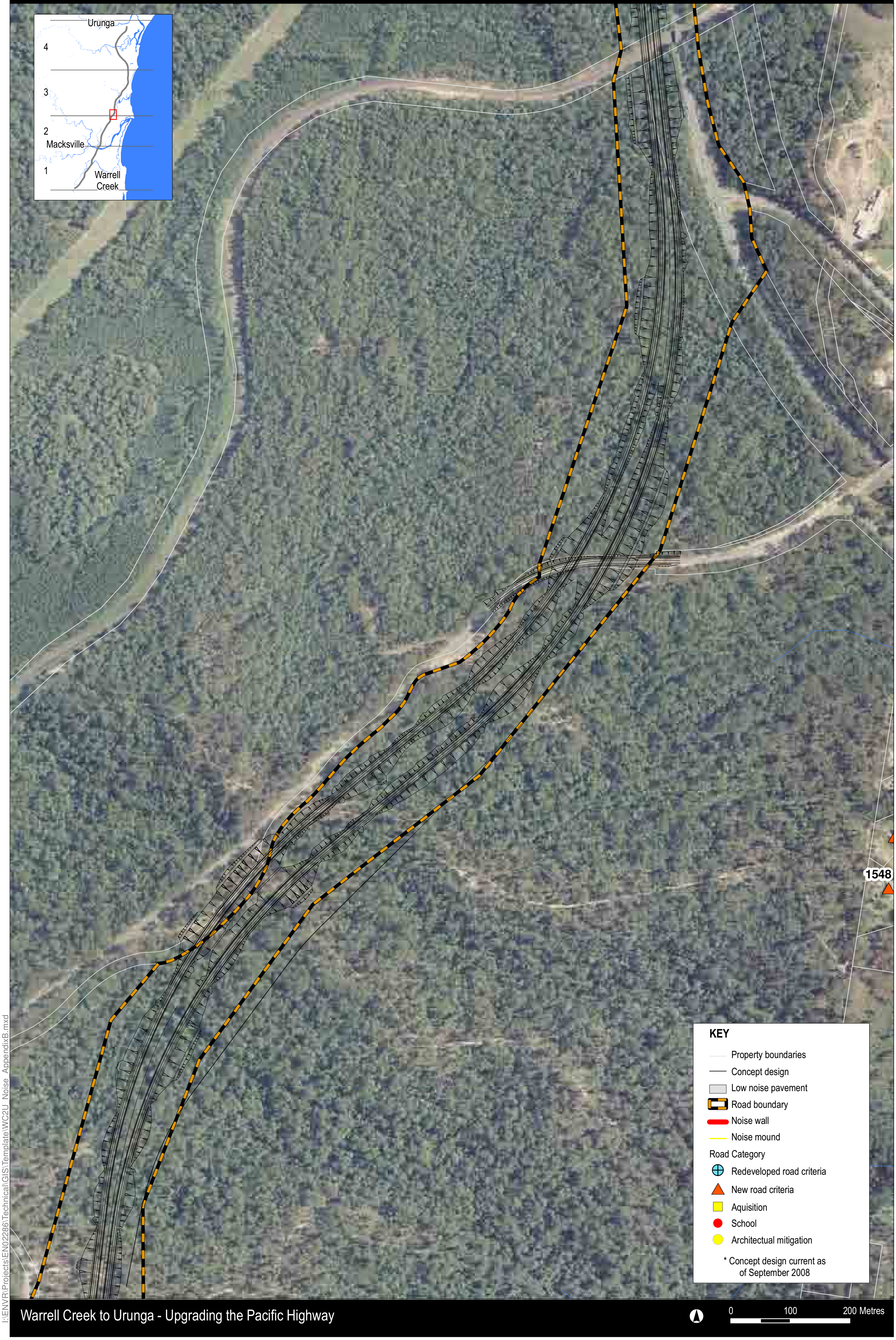
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd

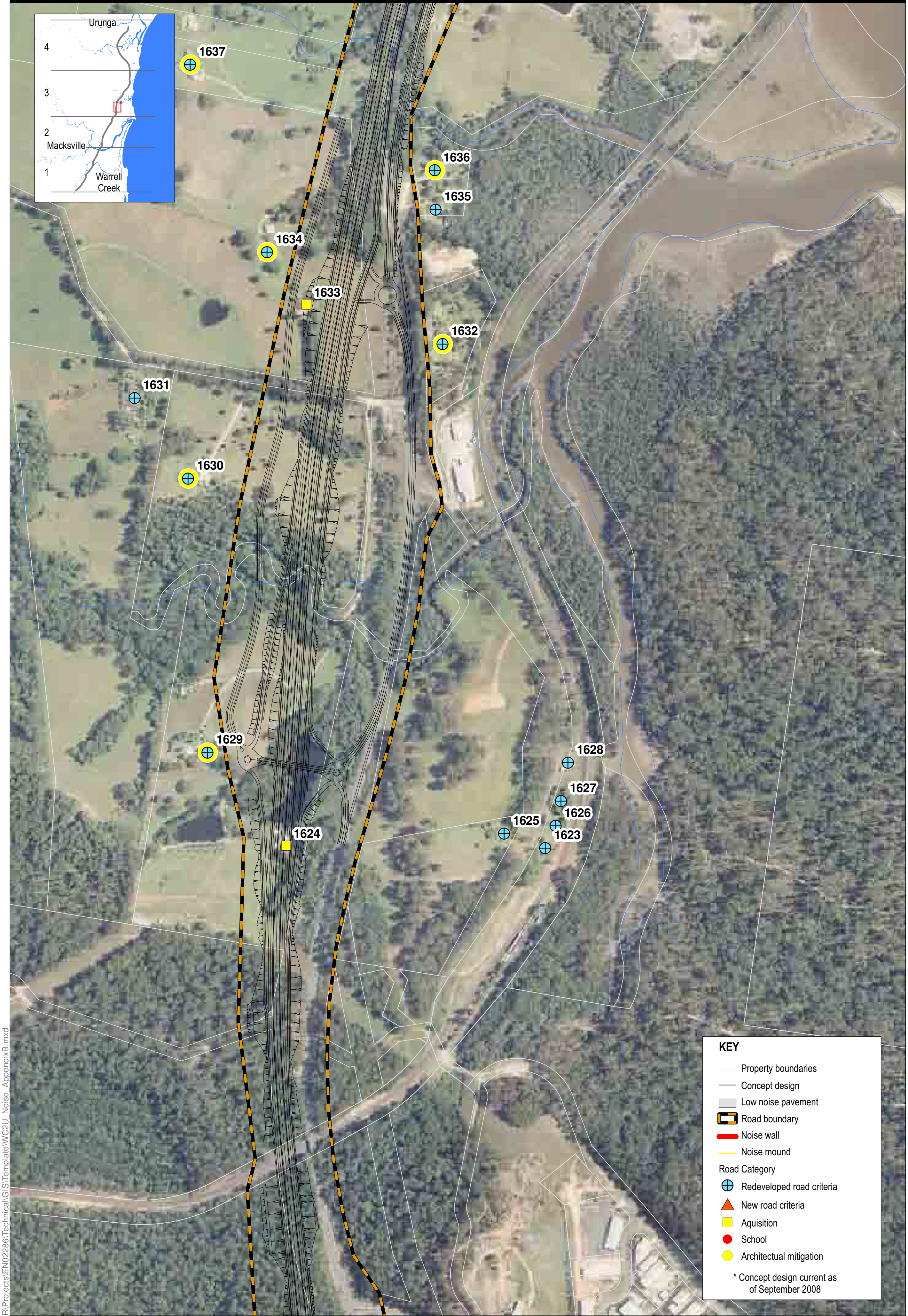


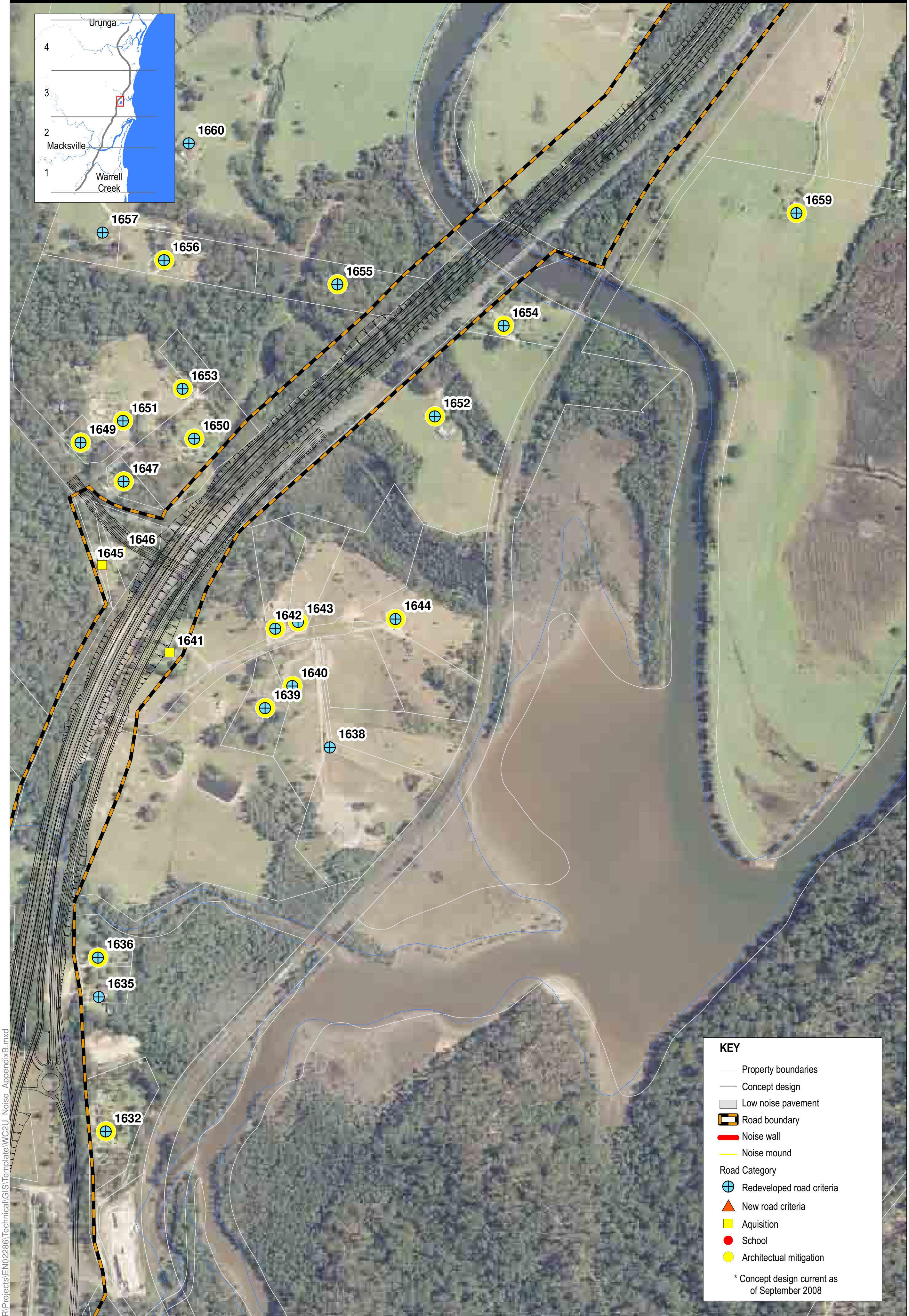
Urunga
4
3
2
Macksville
1
Warrell Creek
974
966
965
964
949
825
822
953
952
959
951
948
950
939
935
937
932
930
933
929
924
916
KEY
Property boundaries
Concept design
Low noise pavement
Road boundary
Noise wall
Noise mound
Road Category
Redeveloped road criteria
New road criteria
Aquisition
School
Architectual mitigation
* Concept design current as of September 2008
0
100
200 Metres
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd

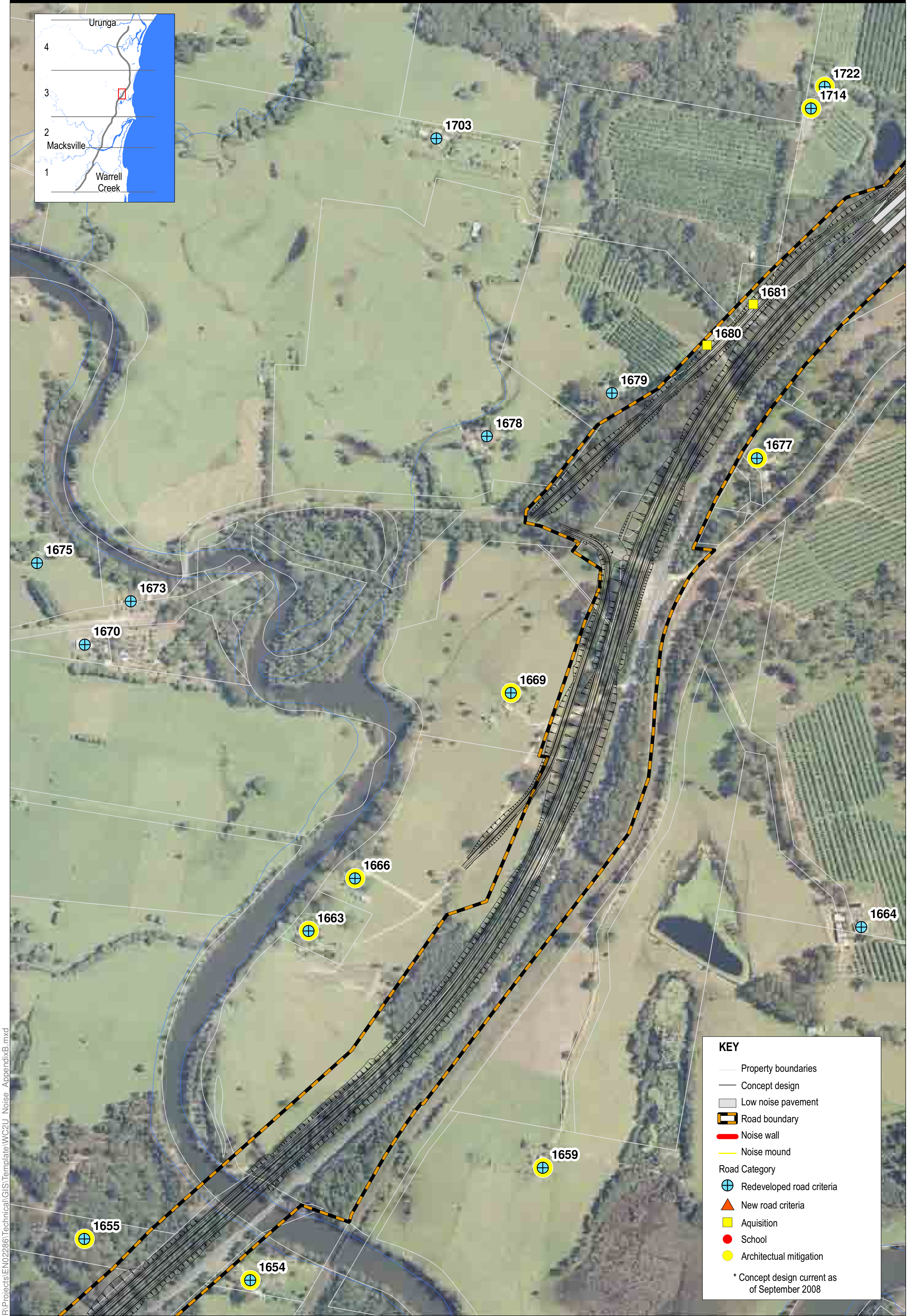


I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd

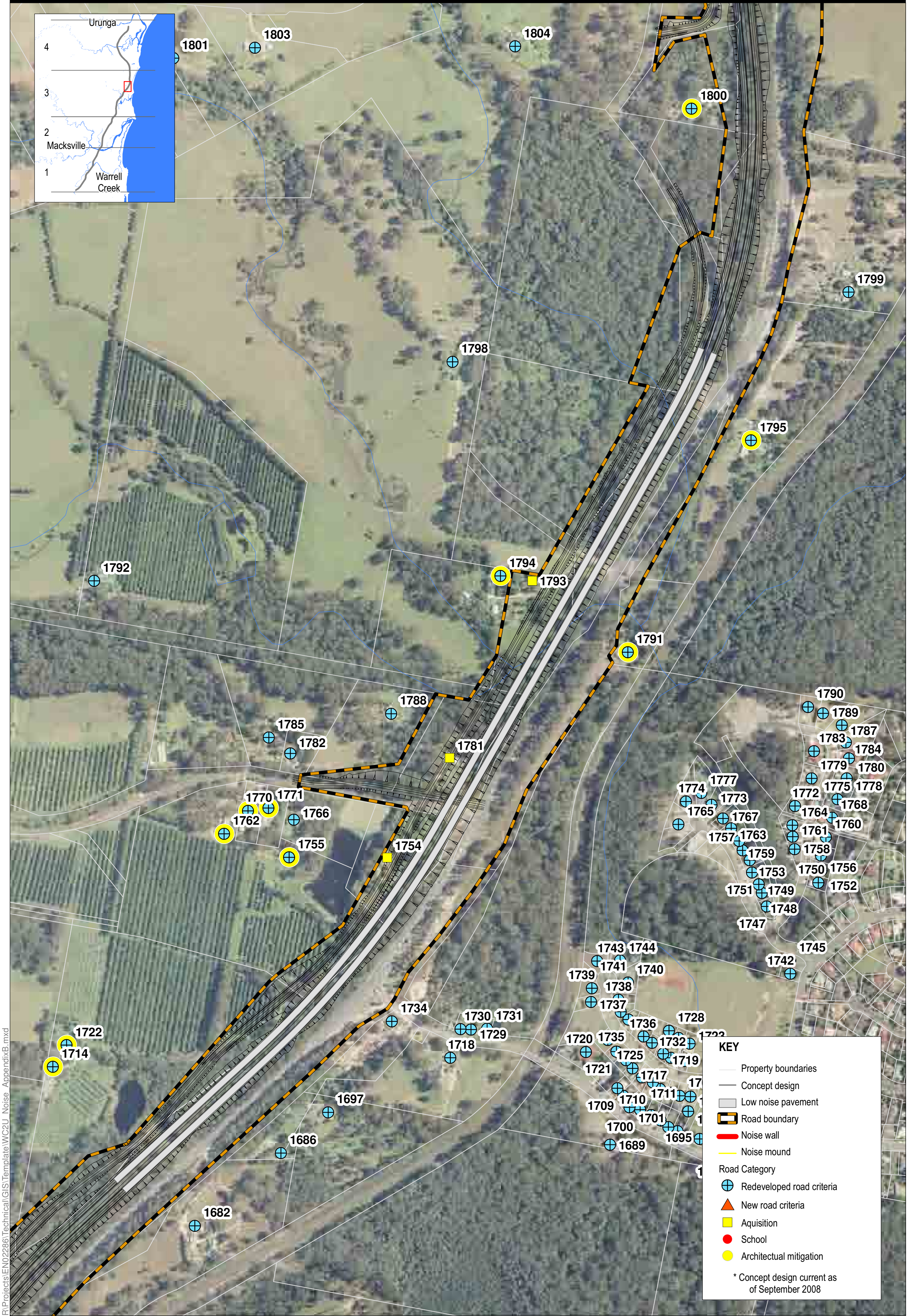

Urunga
4
3
2
Macksville
1
Warrell
Creek
1548
KEY
Property boundaries
Concept design
Low noise pavement
Road boundary
Noise wall
Noise mound
Road Category
Redeveloped road criteria
New road criteria
Aquisition
School
Architectual mitigation
* Concept design current as
of September 2008
0
100
200 Metres


Urunga
4
3
2
Macksville
1
Warrell
Creek
1637
1636
1635
1634
1633
1632
1631
1630
1629
1628
1627
1626
1625
1623
1624
KEY
Property boundaries
Concept design
Low noise pavement
Road boundary
Noise wall
Noise mound
Road Category
Redeveloped road criteria
New road criteria
Aquisition
School
Architectural mitigation
* Concept design current as of September 2008
0
100
200 Metres

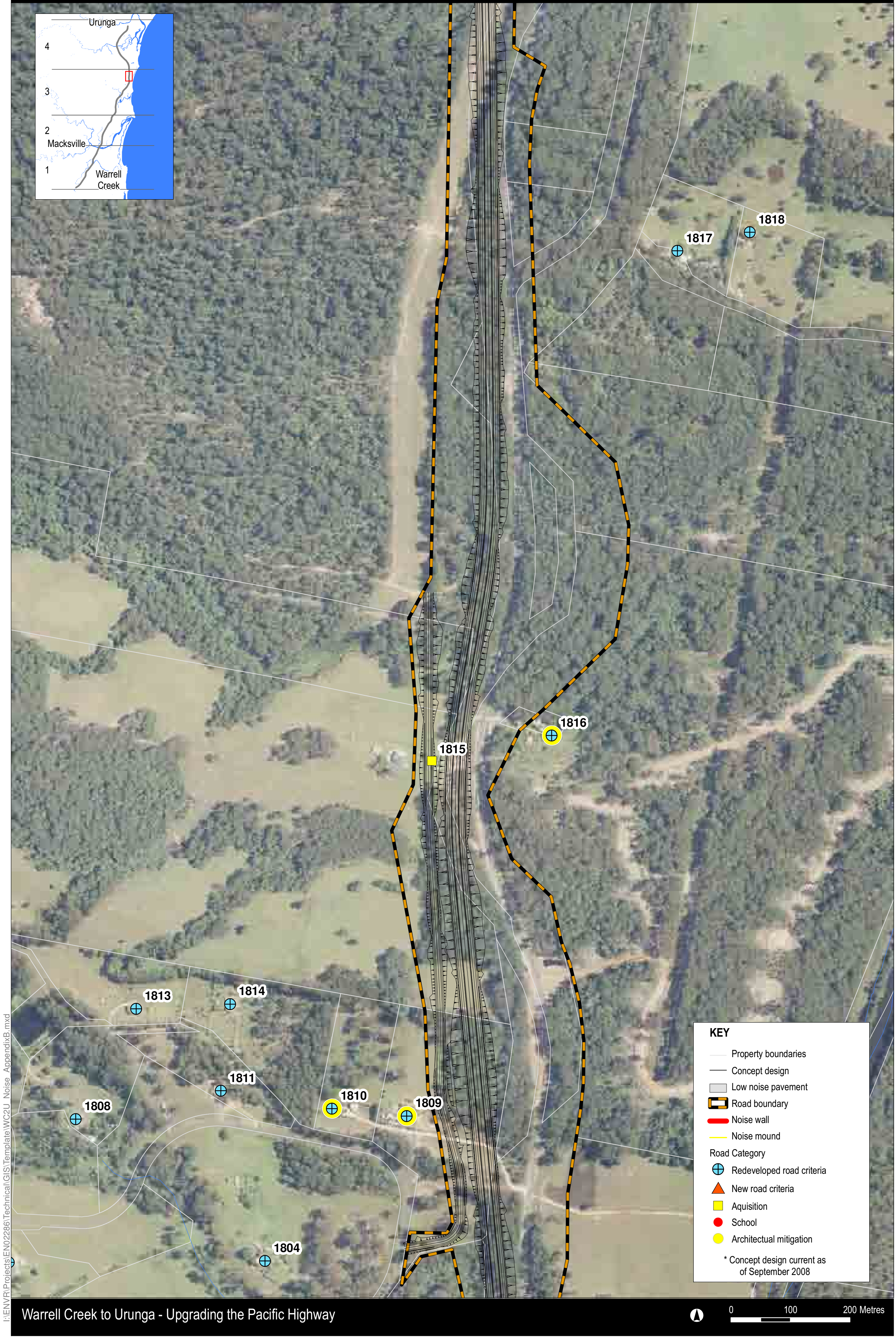

Urunga
4
3
2
Macksville
1
Warrell
Creek
1660
1657
1656
1655
1654
1659
1653
1651
1649
1650
1652
1647
1646
1645
1644
1643
1642
1641
1640
1639
1638
1636
1635
1632
KEY
Property boundaries
Concept design
Low noise pavement
Road boundary
Noise wall
Noise mound
Road Category
Redeveloped road criteria
New road criteria
Aquisition
School
Architectural mitigation
* Concept design current as
of September 2008
0
100
200 Metres
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd



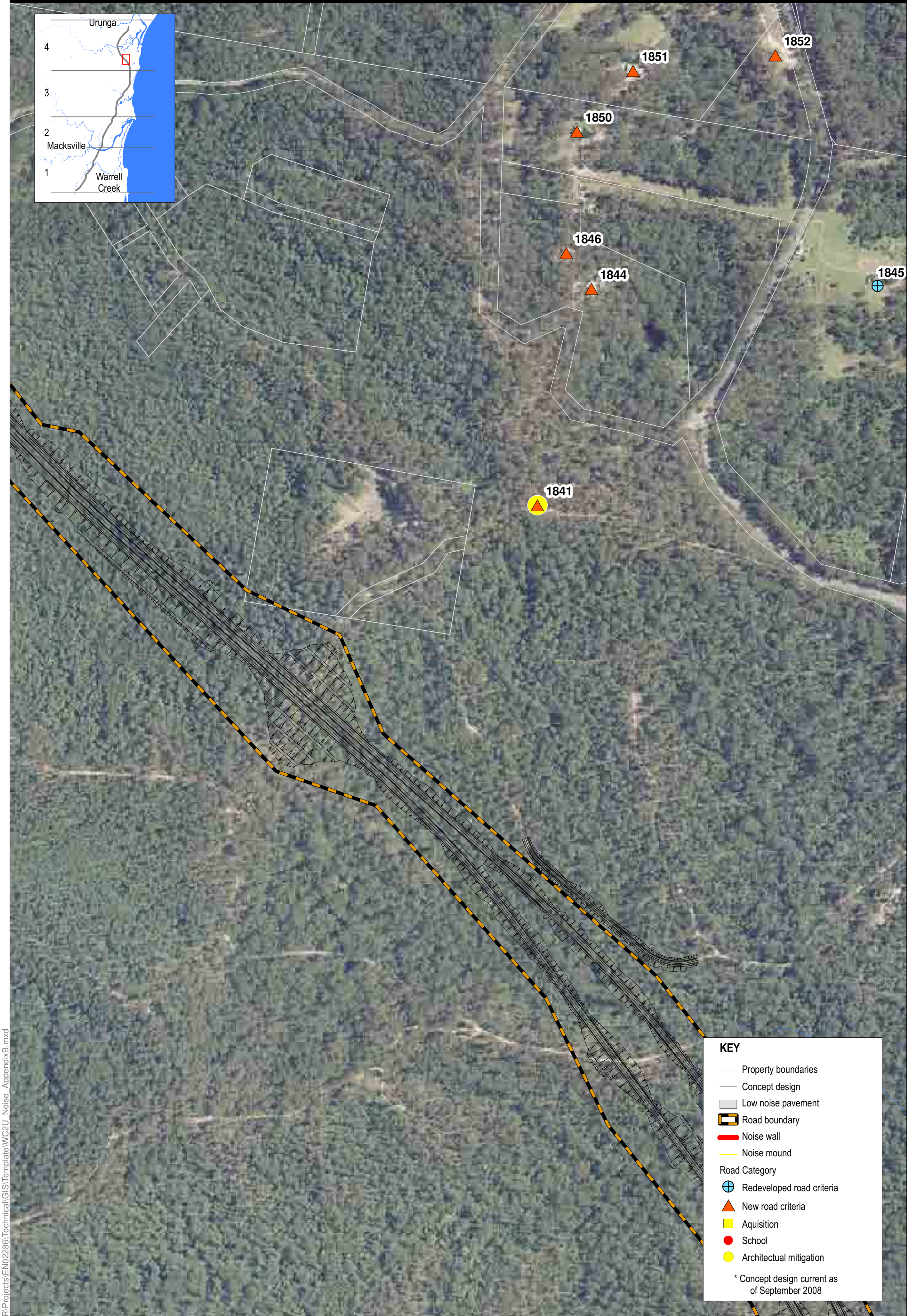
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd



I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd

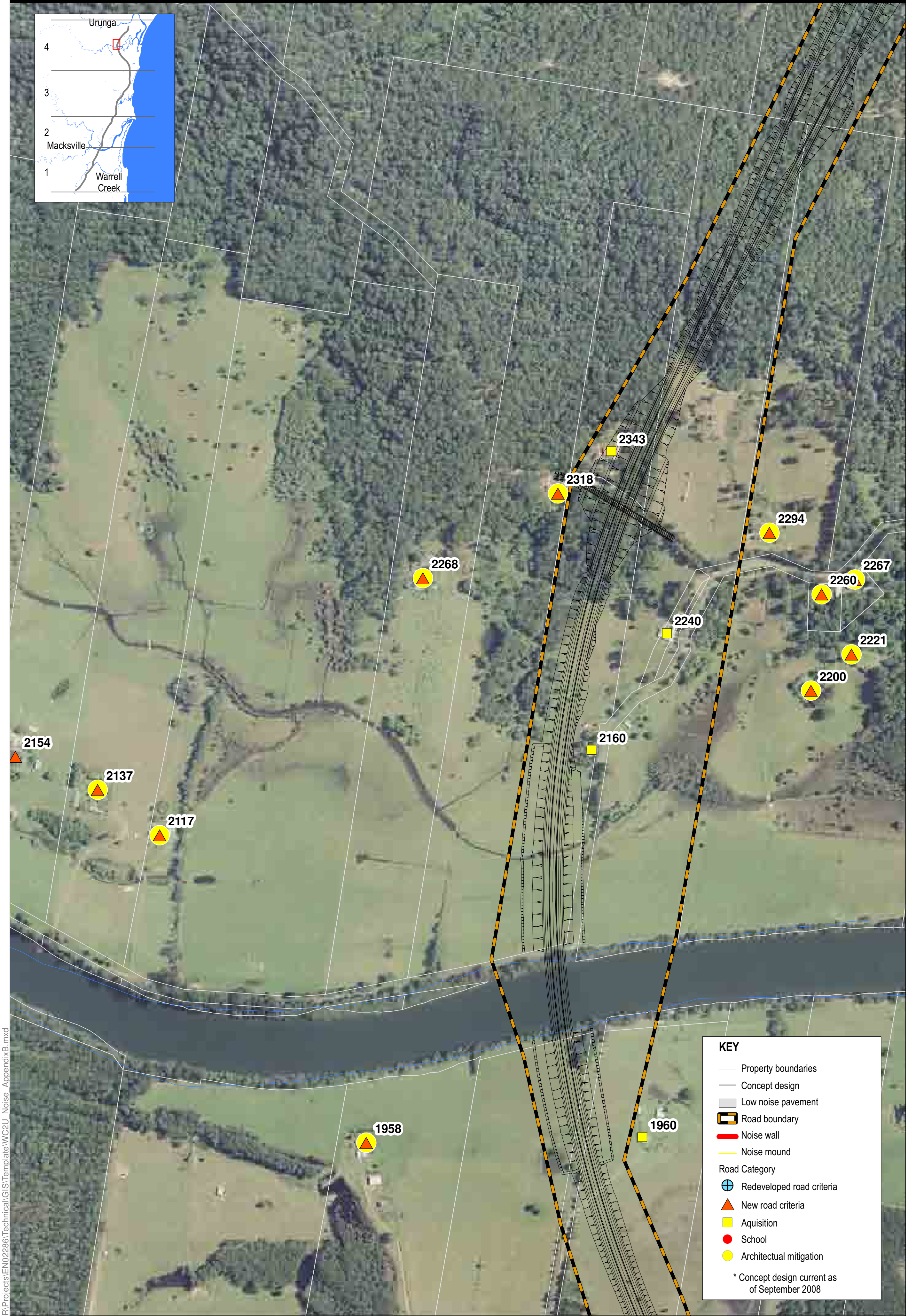

Urunga
4
3
2
Macksville
1
Warrell
Creek
1818
1817
1816
1815
1813
1814
1811
1810
1809
1808
1804
KEY
Property boundaries
Concept design
Low noise pavement
Road boundary
Noise wall
Noise mound
Road Category
Redeveloped road criteria
New road criteria
Aquisition
School
Architectural mitigation
* Concept design current as
of September 2008
0
100
200 Metres
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd


Urunga
4
3
2
Macksville
1
Warrell
Creek
1828
1827
1825
1826
1824
KEY
Property boundaries
Concept design
Low noise pavement
Road boundary
Noise wall
Noise mound
Road Category
Redeveloped road criteria
New road criteria
Aquisition
School
Architectual mitigation
* Concept design current as
of September 2008
0
100
200 Metres

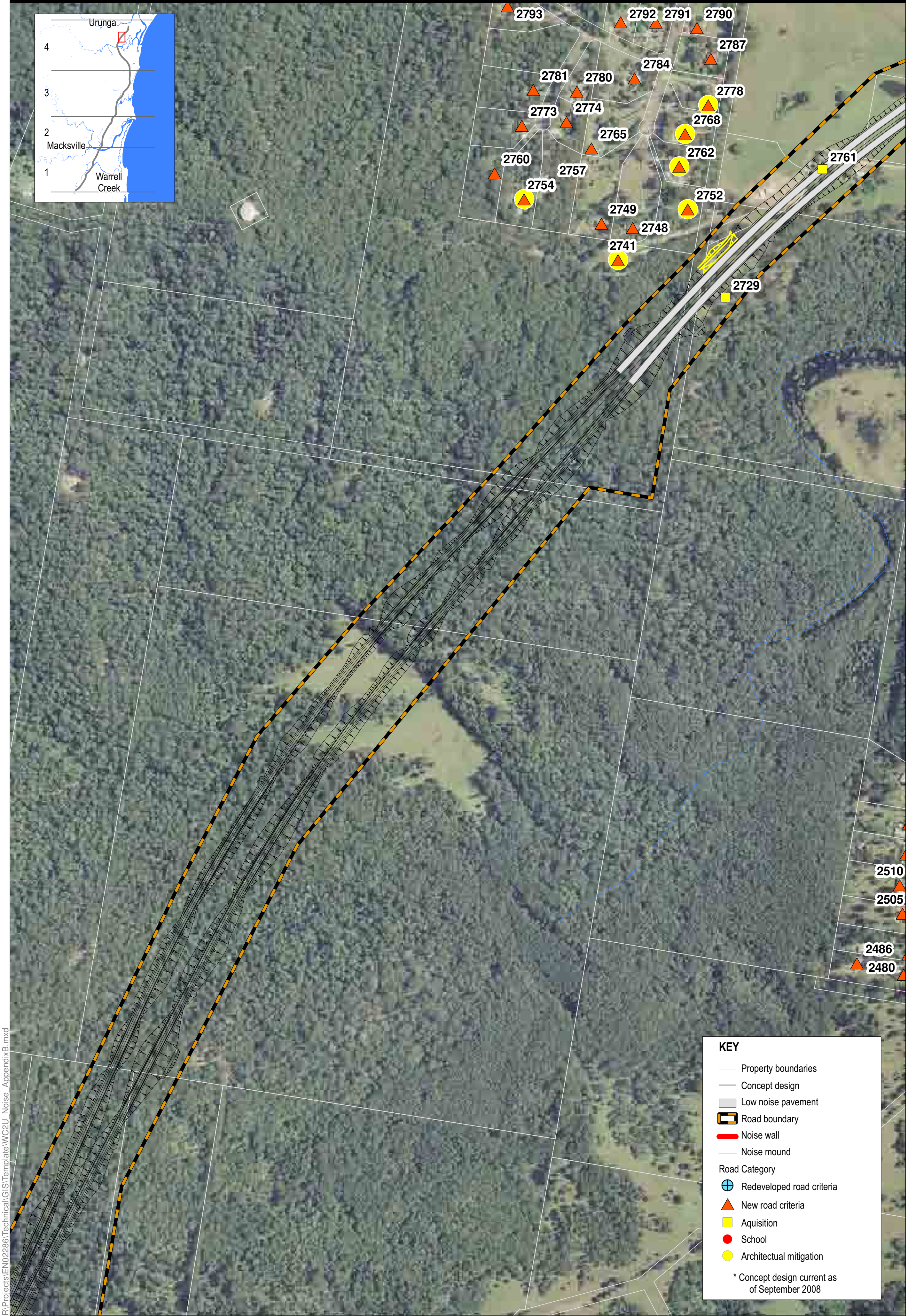


0 100 200 Metres

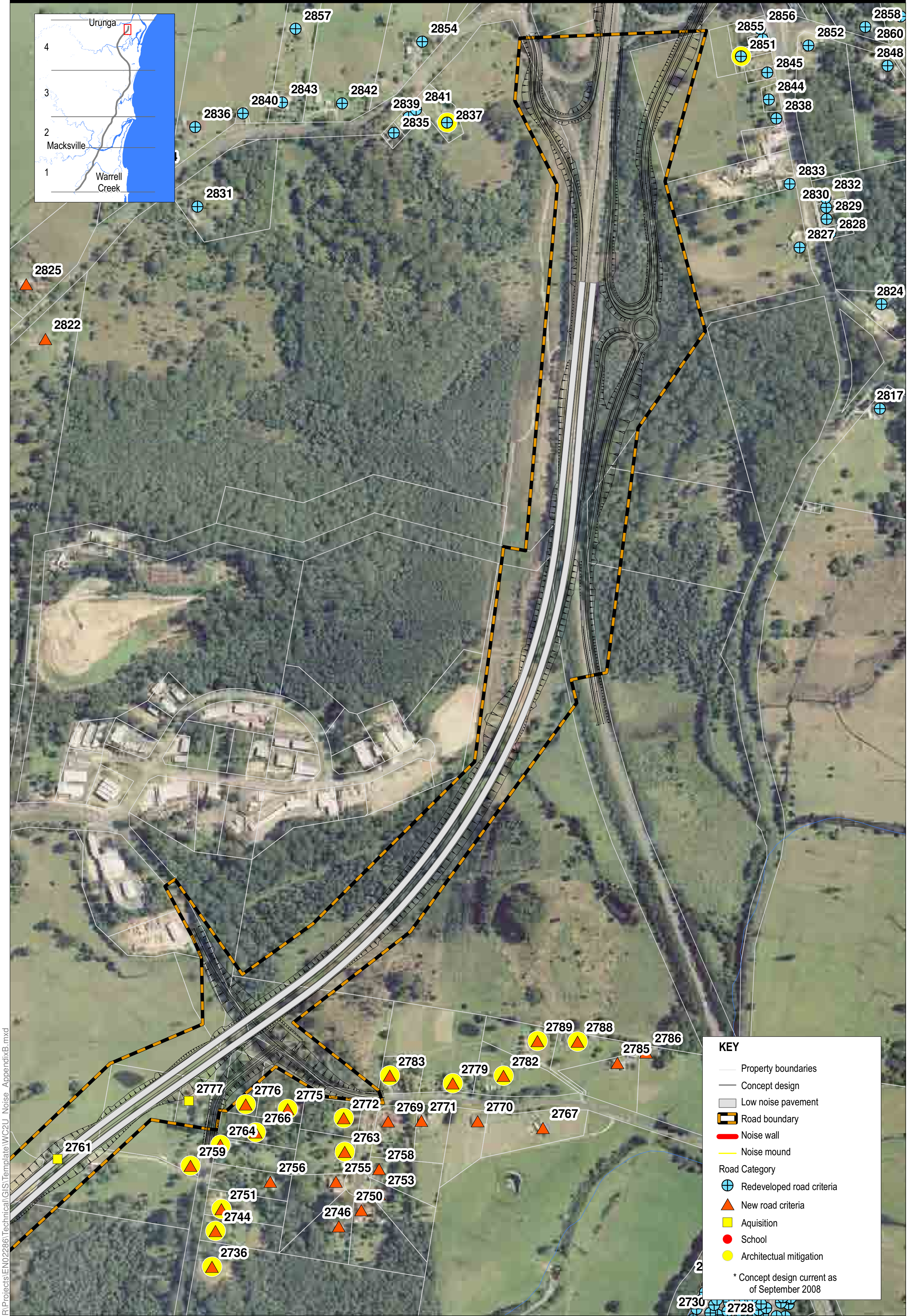
I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd



I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd



I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd



I:\ENVR\Projects\EN02286\Technical\GIS\Template\WC2U_Noise_AppendixB.mxd