Powerlink Kamerunga to Woree Transmission Line Replacement and T274 Substation Development

Noise and Vibration Assessment

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Revision Table

Report revision	Date	Description	Author	Reviewer
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Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Day	Between 7 am and 6 pm.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of loudness.
Evening	Between 6 pm and 10 pm.
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second.
L_{A10}	A-weighted noise level exceeded for 10 % of the measurement time. The L_{10} level represents the typical upper noise level and is often used to represent traffic or music noise.
L_{A90}	A-weighted noise level exceeded for 90 % of the measurement time. The L_{90} level is commonly referred to as the background noise level.
L_{Aeq}	A-weighted equivalent noise level—Energy averaged noise level over the measurement time.
$L_{Aeq,adj,T}$	A-weighted equivalent noise level adjusted for annoying characteristics and assessed over the time period T.
L_{Amax}	The maximum A-weighted instantaneous noise level.
$L_{Amax,adj,T}$	Maximum A-weighted noise level adjusted for annoying characteristics and assessed over the time period T.
mm/s	Units of vibration velocity.
Night	Between 10 pm on one day and 7 am on the following day.
Non-Standard Hours – Day / Evening	Monday – Friday 6 pm – 10 pm, Saturdays 1 pm – 10 m, Sundays and Public Holidays 7 am – 10 pm.
Non-Standard Hours – Night	Between 10 pm and 7 am on any day.
NSA	Noise Sensitive Area used to group residential land uses that are considered to have a similar acoustic environment and proximity to the construction works.
Peak Particle Velocity (PPV)	Vibration velocity can be measured in a number of ways. For some projects vibration levels can be given in terms of Peak Particle Velocity (PPV).
Sound power level	A measure of the total sound energy emitted by a source, independent of the distance from that source or other local factors.
Sound pressure level	The amount of sound at a specified point.
Standard Hours	Monday – Friday 7 am – 6 pm and Saturday 7 am – 1 pm as per standard Cairns Regional Council hours.

Table of Contents

1 Introduction

Powerlink Queensland (Powerlink) has an existing 132 kilovolt (kV) connection between the Kamerunga and Woree substations in Cairns. The 132 kV double circuit overhead transmission line was constructed on a 20 m wide easement in the early 1960's. Operation in a tropical coastal environment has advanced the corrosion of the galvanised steel components that make up most of the infrastructure, including the transmission towers and cables, and is nearing the end of its useful life.

As such, Powerlink propose to replace the overhead line with a new double circuit line comprising both underground cable and overhead conductor sections:

- Kamerunga to Redlynch: Replacement of the existing transmission line between the Kamerunga Substation and the proposed overhead to underground structure within Redlynch. The replacement requires a new 40 m wide easement on which a new overhead line will be built.
- Redlynch to Woree: From the Redlynch overhead to underground structure, the proposed underground transmission line will be located below both local and State Controlled road reserves through the suburbs of Redlynch, Kanimbla, Mooroobool, Earlville and Woree, before connecting into the Woree Substation.

Additionally, Powerlink's Kamerunga Substation (T053) was constructed in 1976. The Powerlink owned equipment within the Kamerunga Substation is approaching end-of-life and two additional feeder circuits are required to supply Powerlink at 132 kV. Powerlink are looking to construct a new substation (T274) on a greenfield site approximately 250 m east of the current Substation location, off Stewarts Road.

JBS&G Pty Ltd (JBS&G) has engaged Resonate to undertake a construction noise and vibration assessment to assess potential amenity impacts arising from noise and vibration during construction, and to recommend appropriate mitigation measures. Operational noise from the new substation has also been assessed.

This report sets out:

- Appropriate noise and vibration assessment criteria for construction and operation of the transmission line and substation.
- An assessment of potential noise and vibration impacts associated with the transmission line (both overhead and underground).
- An assessment of the operational noise impacts associated with the new T274 substation location.
- Recommended mitigation measures to address the identified impacts for the transmission line and substation.

2 Site description

2.1 Alignment

The Project involves the replacement of an existing transmission line with a new 132 kV line between Kamerunga and Woree, divided into two stages:

- Stage 1: Kamerunga to Redlynch – Replacement of the existing overhead transmission line between Kamerunga and Redlynch with a new replacement line generally adjacent to the existing line. Four kilometres of 132kV overhead transmission line will be constructed between the existing Kamerunga Substation to the new T274 Substation (located on 1/RP716266 and 3/SP173007) and then on to a transition site in Redlynch (located on 2/SP279529).
- Stage 2: Redlynch to Woree – Replacement of the transmission line between Redlynch and the existing Woree substation which involves 10.3 kilometres of 132kV underground transmission line which traverses from:
  - A site in Redlynch southwest of the Cairns Western Arterial Road where it connects to Stage 1 via an underground to overhead structure.
  - The alignment heads south before connecting into the Cairns Western Arterial Road near View Street at Brinsmead and following the Cairns Western Arterial Road south.
  - At the Cairns Western Arterial Road / Ramsey Drive intersection at Kanimbla, the alignment turns south and follows Ramsey Drive / Irene Street through to the Irene Street Dog Park at Mooroobool.
  - South of this, it follows Langan Street, Watson Street, Cavendish Street, Downing Street and Henley Street through Earlville to the Henley Street / Bruce Highway intersection.
  - The alignment follows the Bruce Highway southeast before passing along Salter Close and across Ray Jones Drive to connect to the existing Woree Substation.

Additionally, the proposed T274 substation will be relocated from a site near residences on the northern side of Kamerunga Road north of the Barron River to a location approximately 500 m southeast and further away from residential areas.

The alignment is shown on Figure 1.

2.2 Sensitive receivers

The primary sensitive receivers considered for this assessment are residential receivers adjacent to the alignment. These have been grouped into four separate Noise Catchment Areas (NCAs) set at a distance of 500 m around the alignment and identified due to their similar acoustic environments. The NCAs are shown on Figure 1 and described in Table 1.

2.3 Existing environment

As no background noise monitoring has occurred, reference has been made to Appendix A of Australian Standard AS 1055-2:1997 *Description and measurement of environmental noise* (AS 1055-2:1997).

Appendix A of AS 1055-2:1997 provides estimated background noise levels for different environments based on their usage and description. Based on a review of the Alignment, the environment has been considered to be consistent with the R3 designation from AS1055-2:1997, which corresponds to areas with medium density transportation or some commerce or industry.

The adopted background noise levels are as presented in Table 2.

0 500 1,000 1,500 2,000 m

Resonate

Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Proposed T274 Substation
- Noise Catchment Areas
- Educational Use

Powerlink Kamerunga to Woree

Figure 1 - Overall Alignment and Sensitive Uses

Drawn by: XL
Checked by: TRE
Dated: July 2024
Page size: A3
Data sources: (c) Google, JBS&G

Figure

1

Table 1 Sensitive receivers

Sensitive receiver type	Description
Residential – NCA1 Kamerunga to Redlynch	The majority of the NCA1 area is rural farming land. Residential areas located around the Cairns Western Arterial Road and Kamerunga Road. This also includes aged care use at St Johns Community Care at Redlynch.
Residential – NCA2 Redlynch to Kanimbla	Residential areas located around the Cairns Western Arterial Road through Redlynch to Kanimbla.
Residential – NCA3 Kanimbla to Mooroobool	Residential areas located around Ramsey Drive through Kanimbla and Mooroobool.
Residential – NCA4 Earlville to Woree	Residential areas located around the Bruce Highway through Earlville and Woree.
Educational (shown on Figure 1).	St Andrew's Catholic College and Goodstart Early Learning Brinsmead are both located in NCA2 but educational buildings at each are over 350 m away from the alignment. Goodstart Early Learning Kanimbla is located adjacent the alignment under Irene Street in NCA3. Cubby Care Early Learning Centre is also located in NCA3 but is approximately 390 m away from the Project. Balaclava Road Childrens Centre and Goodstart Early Learning Woree are located adjacent the alignment in NCA4. Earlville Early Education and Our Lady Help of Christians School are also located in NCA4 but are approximately 300 m and 400 m away from the Project respectively.
Commercial / industrial	Commercial and industrial uses are located along the alignment and may require consideration when in close proximity to works.

Table 2 Estimated background noise levels from Appendix A of AS 1055.2-1997

Noise area category	Description	Average background A-weighted sound pressure level, dB L_{A90}					
		Monday to Saturday			Sundays and public holidays		
		7 am – 6 pm	6 pm – 10 pm	10 pm – 7 am	9 am – 6 pm	6 pm – 10 pm	10 pm – 9 pm
R3	Areas with medium density transportation or some commerce or industry	50	45	40	50	45	40

2.4 Construction methodology

2.4.1 Overhead transmission line

It is proposed that the Kamerunga to Redlynch section of the transmission line will be new overhead transmission line constructed generally adjacent to the existing alignment up until the transition site in Redlynch.

Table 3 sets out a high level construction methodology identifying four major phases of work including.

Table 3 High level construction methodology for overhead transmission line

Phase	Typical activities
Foundations	• Drilling • Concreting • Earthing
Steel structures	• Delivery • Assembly • Erection
Stringing	• Pulley • Winching and pulley

2.4.2 Underground transmission line

It is proposed that the Redlynch to Woree section of the transmission line will be predominantly underground.

The underground (UG) transmission line will include two electrically separate circuits installed in trenches and filled with an engineered thermal backfill. Concrete cable joint bays will be installed every 800 to 1000 m to join each drum of cable together. Each joint bay is approximately 13 m by 2.5 m in size. The project will include nine sections, with a total of eight joint bays. Additionally, an underground to overhead structure will be required at the Redlynch transition site to transition the overhead transmission line from T274 Substation to the underground component.

The main construction technique of the UG transmission line will be via trenching, however, undercrossing techniques will be utilised in areas to avoid existing in-ground infrastructure, waterways, major roads, or rail lines. Undercrossing types include single shot horizontal directional drilling (HDD), encompassed HDD, pipe jacking and auguring.

Construction of an UG transmission line will be conducted on a number of work fronts (up to six) at the same time, to allow for a reduced construction timeframe. Up to four conduits (6 m per conduit) can be installed in a day (equalling up to 24 m a day). Undercrossing activities are likely to occur once at a time and will be dependent on availability of undercrossing equipment.

Construction activities are expected to take two to three years for the entire project.

Table 4 sets out a high level construction methodology identifying five major phases of work.

Table 4 High level construction methodology for underground transmission line

Phase	Typical activities
Undercrossings	• Site set out • Establish launch and retrieval locations • Install undercrossings • Site reinstatement
Trenching and conduits	• Site set out • Excavate • Install conduits • Backfill with thermal backfill • Temporary surface reinstatement • Final surface reinstatement
Joint bays	• Site set out • Excavate • Install framework • Pour concrete footing and walls • Install covers
Cable installation and jointing	• Clean conduits • Set up cable drums and winching equipment • Pull cable in • Make joints • Testing and commissioning

2.4.3 Substation

The new T274 substation is proposed on a site that is predominately level. The requirement for earthworks is likely to be minimal, and vegetation removal is likely to be restricted to scraping back of the ground layer, with removal of a low number of trees. A pad will be constructed to raise the new substation site above Q200 flood levels to mitigate flood impacts.

The construction period is anticipated to commence in 2026 and take around three years.

The infrastructure will generally be in the form of prefabricated structures, transported to the substation site and assembled.

Once all non-electrical support structures have been erected, the busbars and high voltage electrical equipment will be placed in position and all electrical connections made. Cables that carry the control and protection signals to the control equipment located in the bay buildings will be laid and all connections made. Conductors are strung between the high-level gantries and connections made to the high voltage equipment. The final connection to be made is that of the incoming transmission lines.

The summary of overall works (in staging order) at the substation will comprise:

- Design;
- Civil works;
- Electrical erection;
- Secondary systems installation;
- Construction testing;
- Cut in / energisation works.

2.5 Operation and maintenance

2.5.1 Transmission line

The infrastructure does not require regular maintenance. For the overhead line inspections will be carried out typically over two days, every three years.

For the underground line link boxes (adjacent to joint bays and contained within pits covered by concrete and steel covers) are opened annually, and visual inspections and electrical measurements made . This process will take less than five days per year per circuit.

2.5.2 Substation

T274 will use similar equipment and have similar maintenance requirements as the existing Kamerunga Substation. On average, nine to ten maintenance activities per year will be required.

3 Assessment criteria

3.1 Construction noise

Construction noise criteria have been established with consideration of:

- Queensland *Environmental Protection Act 1994* (EP Act)
- Queensland *Environmental Protection Regulation 2019* (EP Regulation)
- Queensland *Environmental Protection (Noise) Policy 2019* (EPP (Noise))
- Assessment criteria established for other Powerlink projects such as the Genex Kidston Connection Project.

3.1.1 EP Act

The EP Act is the principal legislation for the assessment of potential environmental impacts in Queensland and sets out the general environmental duty that states:

> A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm.

From an acoustic perspective, the objectives of the EP Act can be achieved through compliance with the EP Regulation and EPP (Noise).

It is noted that the EP Act excludes noise associated with maintaining a public infrastructure facility, including a facility for the electricity system, from the provisions relating to environmental noise nuisance.

3.1.2 EP Regulation

The EP Regulation is subordinate legislation to the EP Act. With respect to noise it sets out an Environmental Objective that states:

> The activity will be operated in a way that protects the environmental values of the acoustic environment.

Two Performance Outcomes are set out as follows:

1. Sound from the activity is not audible at a sensitive receptor.
2. The release of sound to the environment from the activity is managed so that adverse effects on environmental values, including health and wellbeing and sensitive ecosystems, are prevented or minimised.

3.1.3 EPP (Noise)

The EPP (Noise) establishes acoustic quality objectives for different environments. The qualities of the acoustic environment to be enhanced or protected under the EPP (Noise) are:

a. the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and

b. the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following—

   i. sleep;

   ii. study or learn;

   iii. be involved in recreation, including relaxation and conversation; and

c. the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

The acoustic quality objectives from the EPP (Noise) that are relevant to the sensitive receivers for the Project are presented in Table 5. It is noted that the objectives are designed to be long-term objectives and are not normally applied to noise from an individual source and particularly not to a temporary source such as construction noise. However, the objectives provide guidance as to the levels at which additional management of construction noise may be necessary.

Table 5 Acoustic quality objectives from EPP (Noise)

Sensitive receiver	Time period	Acoustic quality objectives		
		dB $L_{Aeq,adj,1hr}$	dB $L_{A10,adj,1hr}$	dB $L_{A1,adj,1hr}$
Residence (for outdoors)	Daytime[1] and evening[2]	50	55	65
Residence (for indoors)	Daytime[1] and evening[2]	35	40	45
	Night-time[3]	30	35	40
School or playground (for outdoors)	When in use	55	n/a	n/a
Childcare centre or kindergarten (for indoors)	When in use	30	n/a	n/a

(1) Daytime is defined by EPP (Noise) to be between 7 am to 6 pm on any day.

(2) Evening is defined by EPP (Noise) to be between 6 pm and 10 pm on any day.

(3) Night-time is defined by EPP (Noise) to be between 10 pm on one day and 7 am on the following day.

3.1.4 Construction noise criteria

Construction noise criteria, assessed outdoors at sensitive receivers, have been established on the basis of:

- The higher of the EPP (Noise) objective level or the background noise level plus 5 dB for daytime and evening periods for residential uses and schools.
- The background noise level for uses where sleeping would typically occur, including residences at night and childcare centres during use.

The construction noise criteria are presented in Table 6.

Table 6 Construction noise criteria

Sensitive receiver	Time period	Noise criteria, dB $L_{Aeq,adj,1hr}$	Comment
Residence	Daytime	55	Set at a level 5 dB above the typical background noise level
	Evening	50	Set at a level 5 dB above the typical background noise level
	Night	40	Set at a level consistent with the typical background noise level recognising that this is typically a period of sleep
School / Childcare	Daytime	55	Set at a level 5 dB above the typical background noise level

It is noted that these construction noise criteria are not limits, but are criteria that are used to identify the need for further mitigation and management measures. Where the criteria are exceeded, then additional construction noise

mitigation and management measures would be required as set out in a Construction Noise and Vibration Management Plan (CNVMP).

3.2 Construction vibration

In addition to airborne noise, works associated with the Project have the potential to generate groundborne vibration that is also subject to the general environmental duty under the EP Act. Ground vibration from construction works has three primary potential effects:

- disturbance to building occupants causing annoyance (human comfort)
- damage to buildings
- damage to critical services.

In general, vibration criteria for human comfort are lower than those for building damage, meaning that compliance with the human comfort criteria will result in compliance with the building damage limits.

3.2.1 Human comfort

There is no legislation in Queensland that sets out construction vibration criteria. However, the Department of Transport and Main Roads (DTMR) Code of Practice: Volume 2 *Construction Noise and Vibration, Department of Transport and Main Roads* provides guidance on managing construction noise and vibration. It advises lower and upper human comfort vibration criteria for construction vibration to minimise annoyance as shown in Table 7.

The DTMR Code of Practice states that all reasonable and practicable measures should be implemented to achieve the lower criterion. Exceedance of the upper criterion requires immediate action and extensive community consultation to determine further mitigation measures.

Table 7 Vibration criteria for human comfort

Type of use	Work period	Peak Particle Velocity (PPV), mm/s	
		Lower criterion	Upper criterion
Dwellings (including hotels and motels)	Standard hours[1]	1.0	2.0
	Non-Standard hours[2] – evening	0.3	1.0
	Non-Standard hours[2] – night time		
Educational / research facilities (rooms designated for teaching / research purposes)	While in use		
Commercial (offices) and retail	While in use	1.0	2.0

(1) Standard Hours have been defined as Monday to Friday 7 am to 6 pm and Saturdays 7 am to 1 pm to be consistent with Cairns Regional Council hours.

(2) Non-Standard Hours – Evening have been defined as Monday to Friday 6 pm to 10 pm, Saturdays 1 pm to 10 pm, and Sundays 7 am to 10 pm.

(3) Non-Standard Hours have been defined as – Night as 10 pm to 7 am any day.

3.2.2 Building damage

For the assessment of potential building damage, the DTMR Code of Practice makes reference to both British Standard BS 7385-2:1993 *Evaluation and measurement for vibration in buildings* – Part 2: *Guide to damage levels from groundborne vibration* and German Standard DIN 4150-3:1999 *Structural vibration – Effects of vibration on*

structures. For the purposes of this assessment, the DIN 4150-3 criteria have been adopted as building damage criteria as they are more stringent than those from BS 7385-2.

The DIN 4150-3 short-term vibration criteria are summarised in Table 8 for different building types, and are specified as PPV levels measured directly at the building foundations in any direction. The targets increase with the dominant frequency of the vibration. It is common for construction activities to result in vibration levels at approximately 30 Hz, where the vibration targets are higher than at much lower frequencies.

Table 8 DIN 4150-3 short-term vibration cosmetic and structural damage criteria

Structure type	Peak Particle Velocity (PPV), mm/s			
	Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
	<10 Hz	10-50 Hz	50-100 Hz	
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended above would not necessarily result in damage. Rather it recommends these values as maximum levels of short-term construction vibration at which experience has shown that damage that reduces the serviceability of structures will not occur due to vibration effects.

DIN 4150-3 also provides long-term vibration criteria for structures as presented in Table 9.

Table 9 DIN 4150-3 long-term vibration cosmetic and structural damage criteria

Structure type	PPV, mm/s
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	10
Dwelling and buildings of similar design and/or use	5
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	2.5

Long-term vibration is considered by DIN 4150-3 to be vibration which occurs often enough to cause structural fatigue and which does not produce resonance in the structure being evaluated. In general, construction vibration from the Project is not expected to meet the definition of long-term vibration, although the assessment has been conducted on the basis of the minimum applicable short-term criteria, which are consistent with those for long-term vibration for residential structures, which typically represent the nearest structures.

DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as the Standard considers a reduction in serviceability of the structure is deemed to have occurred if:

- Cracks form in plastered surfaces of walls
- Existing cracks in the building are enlarged
- Partitions become detached from loadbearing walls or floors.

3.2.3 Services

Groundborne vibration also has the potential to affect services. DIN 4150-3 provides generic criteria for buried pipework as detailed in Table 10.

Table 10 DIN 4150-3 generic vibration criteria for buried pipework

Pipe material	PPV, mm/s
Steel (including welded pipes)	100
Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
Masonry, plastic	50

It is noted that the generic vibration criteria in Table 10 are superseded if specific vibration limits are provided by the asset owner.

3.3 Operational noise

Operational noise from the new T274 substation is a relevant consideration for the Project. No operational noise is expected for the transmission line components. While overhead transmission lines can create occasional corona noise, this is not normally a significant risk for 132 kV lines and is not considered to present any additional risk compared to the existing overhead line that is being replaced.

The site of the T274 substation is in the Cairns Regional Council area. The CairnsPlan 2016 does not identify specific operational noise criteria for operational noise sources such as the substation, and therefore reference has instead been made to the EPP (Noise).

The acoustic quality objectives from the EPP (Noise) that are relevant to the noise sensitive receivers were presented in Table 5. At residential uses, the EPP (Noise) specifies both indoor and outdoor noise criteria for daytime and evening but only indoor noise criteria for night. Therefore, in order to develop an external criterion for an assessment of the noise at night, it is necessary to convert the outdoor criteria to indoor criteria.

In considering the indoor criteria from Table 5 and based on previous experience of noise assessments in Queensland, we have assumed a 7 dB difference in noise levels between indoors and outdoors, allowing for a window being open for ventilation. Applying this 7 dB increase to the night-time noise level in Table 5, it can be seen that the night-time outdoor acoustic quality objective from the EPP (Noise) would be 37 dB $L_{Aeq,adj,1hr}$.

The project specific operational noise criteria determined in accordance with the EPP (Noise) are set out below. The noise criteria apply externally at any residence.

Table 11 Operational noise criteria for substation relocation

Time of day	Noise criteria, dB $L_{Aeq,1hr}$
Day (7 am – 6 pm)	42

Time of day	Noise criteria, dB $L_{Aeq,1hr}$
Evening (6 pm – 10 pm)	42
Night-time (10 pm – 7 am)	37

It is noted that the operational criteria would not apply to maintenance activities, which are only expected to occur infrequently, being approximately 2 days every three years for the transmission line and 9-10 activities per year for the substation. Scheduled maintenance activities would be carried out during the day period, which would assist in reducing any occasional noise impact.

4 Noise assessment

4.1 Construction sound power levels

Table 12 presents the overall typical sound power levels assumed for each phase of work, including substation works as part of the Stage 1 activities. Sound power levels for individual plant items for each stage are presented in Appendix A, but the predictions have been carried out on the basis of an overall sound power level for stage as this is considered to best represent the typical worst case construction noise levels that may occur with typical items of plant operating simultaneously.

Table 12 Typical construction works and sound power levels

Project stage	Phase	Typical worst-case overall sound power level, dB L_{WA}
Stage 1 - overhead installation	Foundations	116
	Steel structures	109
	Stringing	111
	Substation works	109
Stage 2 – underground installation	Trench excavation and conduit installation	109
	Undercrossings	113
	Road reinstatement works	114
	Joint bay excavation and installation	108
	Cable installation, jointing and testing	108

4.2 Typical worst-case construction noise levels

The environmental noise prediction methodology provided in the international standard ISO 9613-2 was adopted for the prediction model for construction noise. The methodology takes the following into considerations:

- geometrical divergence
- atmospheric absorption
- ground effect
- reflection from surfaces.

The ISO 9613-2 methodology provides a prediction representative of conditions where the receiver is downwind of the source in a light breeze or under a moderate ground-based temperature inversion.

This preliminary assessment has been based on the conservative assumption that there is no topographic shielding or shielding provided by any intervening buildings. For sensitive uses that are shielded by intervening buildings, the construction noise levels will be lower than presented here.

Table 13 presents the typical worst-case construction noise levels with distance for each phase of works. The distance at which the noise level reaches the daytime construction noise criterion of 55 dB L_{Aeq} is also presented.

Table 13 Typical worst-case construction noise levels with phase

Phase	Typical worst-case sound pressure level at stated distance, dB L_{Aeq}					Distance to achieve 55 dB L_{Aeq} daytime criterion
	25 m	50 m	75 m	100 m	200 m	m
Stage 1 - overhead installation						
Foundations	77	70	66	63	57	240
Steel structures	70	63	59	56	50	115
Stringing	72	65	61	58	52	140
Substation works	70	63	59	56	50	115
Stage 2 - underground installation						
Trench excavation and conduit installation	70	63	59	56	50	115
Undercrossings	74	67	63	60	54	180
Road reinstatement works	75	68	64	61	55	200
Joint bay excavation and installation	69	62	58	55	49	105
Cable installation, jointing and testing	69	62	58	55	49	105

4.3 Discussion

The maps included in Appendix B present the area around each phase of construction where typical worst case construction noise levels are predicted to exceed 55 dB L_{Aeq}. It is noted that these areas are conservative, particularly in the residential areas around Stage 2 where the first row of buildings would be expected to provide shielding to sensitive uses behind them.

4.3.1 Noise Catchment Area 1

Due to the greater separation to residential areas in Noise Catchment Area 1, construction noise impacts are expected to be limited to:

- Residential areas around Yurangi Street when works are occurring at the northernmost end of the Stage 1 alignment.
- Isolated residential land uses around the proposed new Kamerunga substation site. Note that the houses in Stewarts Road nearest to the site are owned by Powerlink Queensland.
- Residential areas around the Cairns Western Arterial Road and Redlynch Bypass Road, predominantly when louder activities associated with the foundations phase, such as bulldozing, are occurring within approximately 240 m of the residential use. During the latter phases of the works for Stage 1, these residential areas are generally not expected to be exposed to construction noise levels above 55 dB L_{Aeq}.

4.3.2 Noise Catchment Area 2

Residential land uses around Shale Street and the Cairns Western Arterial Road are expected to be exposed to construction noise levels in excess of 55 dB L_{Aeq} during all phases of works for Stage 2. In general, this impact would be expected to be limited to the time at which works are occurring near to an individual residential land uses, with noise levels decreasing as works progress along the alignment.

It is noted that as these residential areas are in relatively close proximity to a major road, this is a level of noise that is already likely to be present in this area particularly during the daytime when traffic volumes would be higher.

No educational uses in Noise Catchment Area 2 are predicted to be exposed to construction noise levels in excess of 55 dB L_{Aeq}.

4.3.3 Noise Catchment Area 3

Residential land uses around Ramsey Drive and Irene Street are expected to be exposed to construction noise levels in excess of 55 dB L_{Aeq} during all phases of works for Stage 2. In general, this impact would be expected to be limited to the time at which works are occurring near to an individual residential land uses, with noise levels decreasing as works progress along the alignment.

The following educational uses in Noise Catchment Area 3 are predicted to be exposed to construction noise levels in excess of 55 dB L_{Aeq} at times during the works:

- Goodstart Early Learning Kanimbla when works are occurring within 100 – 200 m depending on the phase of the works.

4.3.4 Noise Catchment Area 4

Residential land uses around Watson Street, Cavendish Street, Henley Street and Mulgrave Street are expected to be exposed to construction noise levels in excess of 55 dB L_{Aeq} during all phases of works for Stage 2. In general, this impact would be expected to be limited to the time at which works are occurring near to an individual residential land uses, with noise levels decreasing as works progress along the alignment.

The following educational uses in Noise Catchment Area 4 are predicted to be exposed to construction noise levels in excess of 55 dB L_{Aeq} at times during the works:

- Balaclava Road Childrens Centre when works are occurring within 100 – 200 m depending on the phase of the works.
- Goodstart Early Learning Woree during undercrossings, road reinstatement or decommissioning works within 160 – 200 m.

4.4 Summary

Construction noise from most phases of works are predicted to present a risk of exceedance of the construction noise criteria, particularly as the alignment passes through residential areas in Noise Catchment Areas 2 to 4. Despite the exceedances, it should be noted that the works immediately adjacent to individual receivers are likely to be completed relatively quickly, typically 1-2 weeks. As such, as the works proceed along the alignment, individual residents are only likely to be exposed to noise levels above the criteria for relatively short periods of time during daytime periods only.

All reasonable and practicable mitigation and management measures should be implemented during the works. Reasonable and practicable mitigation and management measures are discussed in Section 7.

5 Construction vibration assessment

5.1 Predicted construction vibration levels

Works with the potential to produce perceptible vibration are expected to include:

- excavation
- drilling
- truck movements.

Table 14 presents typical vibration levels from key potential construction sources at a distance of 10 m from the works, based on measurements previously conducted by Resonate. Standard vibration propagation loss factors have been used to predict the distance from the works at which the human comfort PPV vibration criteria are achieved.

Table 14 Typical vibration levels from key construction activities

Vibration source	Typical worst-case PPV at 10 m	Typical distance in m to achieve PPV criterion		
	mm/s	2 mm/s	1 mm/s	0.3 mm/s
14T excavator digging	1.2	6	12	25
Drilling (non-percussive)	1.0	5	10	21
20T truck, smooth road	0.5	< 5	6	15
20T truck, rough surface	1.1	5	11	23

5.2 Standard hours works

5.2.1 Residential land uses

It can be seen that the human comfort vibration criteria at residences are anticipated to be achieved for:

- A maximum distance of 6 m for the upper daytime criterion of 2 mm/s. None of the nominated activities would be expected to occur within 6 m of sensitive land uses.
- A maximum distance of 12 m for the lower criterion of 1 mm/s. It is possible that works would occur within this distance within some areas of the alignment close to residential areas.

On the basis of the above, reasonable and practicable mitigation and management measures should be implemented for excavation, drilling and heavy vehicle usage within 15 m of residential receivers during standard hours works. This would generally be expected to involve maximising the offset distance to sensitive receivers so far as reasonably practicable, and providing prior notification to sensitive receivers that they may perceive vibration from construction activities at times.

5.2.2 Other sensitive uses

No non-residential sensitive uses are identified within 15 m of construction activities and, therefore, no vibration impacts during construction are expected at non-residential uses such as educational facilities.

5.3 Non-standard hours works

If works are to be conducted outside of standard hours, then the lower vibration criterion of 0.3 mm/s PPV for residential uses may be exceeded for distances of up to 25 m.

Should works be required outside of standard hours and within this distance from residential uses then reasonable and practicable mitigation and management measures should be implemented for excavation, drilling and heavy vehicle usage. This would generally be expected to involve selecting construction methodologies that reduce the risk of vibration, maximising the offset distance to sensitive receivers so far as reasonably practicable, and providing prior notification to sensitive receivers that they may perceive vibration from construction activities at times.

5.4 Risk of building or services damage

Given that the works do not generally involve vibration intensive equipment, it is not expected that vibration from construction would pose a risk of exceeding the DIN 4150-3 criteria for building damage or damage to underground services. These criteria are predicted to be achieved at less than 5 m from the nominated activities.

Powerlink will work with Cairns Regional Council to place the underground transmission line in order to avoid impacts to existing underground services during construction

6 Operational noise assessment

This section sets out a noise assessment for the relocated Kamerunga substation. As the precise location of the equipment has not been confirmed, this assessment provides information on required separation distances to achieve compliance with the noise criteria.

6.1 Noise sources

It has been assumed that the substation will contain two high voltage transformers with a capacity in the order of 50 MVA.

Table 15 presents the sound power spectra for a 50 MVA transformer based on AS/NZS 60076-10 *Power transformers Part 10: Determination of sound levels*. The sound power levels have been based on the Standard Maximum sound power level from AS/NZS 60076-10. The sound power spectrum distribution was calculated based on a transformer sound spectrum based on previous measurements by Resonate.

Table 15 Transformer sound power spectrum

Equipment	Sound power level in dB L_{WA} at octave band centre frequency (Hz)								Overall
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	dB L_{WA}
50 MVA transformer	76.3	86.4	81.3	82.3	80.6	75.9	69	63.2	89.8

It is understood that the substation may contain other noise sources, such as small air conditioning units to service site buildings and the like, but that these would generally be significantly quieter than the transformers.

6.2 Prediction methodology

The environmental noise prediction methodology provided in the international standard ISO 9613-2 was adopted for the prediction model. The methodology takes the following into considerations:

- geometrical divergence
- atmospheric absorption
- ground effect
- reflection from surfaces.

The ISO 9613-2 methodology provides a prediction representative of conditions where the receiver is downwind of the source in a light breeze or under a moderate ground-based temperature inversion.

Note that, as the precise location of the substation has not been confirmed, this assessment conservatively assumes that there will be no topographic shielding or shielding provided by structures around the substation site.

6.3 Assumptions

In conducting these predictions, the following assumptions have been made:

- A source height of 4 m and receiver height of 1.5 m above ground has been assumed.
- No shielding is provided by topography or other structures. If shielding effects were to be present, then the noise criteria would be able to be achieved at closer distances to the substation.
- No shielding has been assumed for fire walls around the transformers. Should fire walls be located around the transformer and block line of sight to the nearest residential land uses then the noise criteria would be able to be achieved at closer distances from the substation.

- A ground absorption factor of 75% has been assumed, considered typical of grassed areas such as that around the proposed substation site.
- Transformer noise is often tonal in nature. A 2 dB penalty has been applied for tonality in this assessment on the basis that at a noise level of less than 37 dB L_{Aeq} in areas with other noise in the environment (e.g. transportation noise) previous experience indicates that any tonality is only likely to be just perceptible and application of a penalty using the method as set out in the Department of Environment and Science *Noise Measurement Manual* is expected to be in the order of 2 dB.

6.4 Assessment

Based on the assumptions listed above, noise from 2 x 50 MVA transformers is predicted to achieve compliance with the most stringent 37 dB $L_{Aeq,1hr}$ noise criterion for evening and night at a separation distance of 140 m.

The majority of residential land uses around the proposed substation area are significantly further than 140 m from the proposed substation, with the major residential area on the northern side of Kamerunga Road (including residential areas on Yurongi Street) being further than 300 m away. These residences will also benefit from a reduced noise exposure due to the relocation of the existing substation which is located at the western end of Yurongi Street.

It is noted that there is a single residential land use at 48 Stewarts Road that is understood to be owned by Powerlink Queensland and is currently tenanted. Recommendations to address this risk are provided in Section 7.2.

7 Noise and vibration management

7.1 Construction phase

The predicted noise levels during construction exceed the daytime construction noise criteria for most phases of works, necessitating the implementation of reasonable and practicable noise mitigation and management measures.

This section recommends noise and vibration management measures to be implemented as part of the construction works, reflecting the outcomes of the preliminary assessment. It may not be reasonable and practicable to adopt all management measures at all times during construction, but the recommended measures should be documented in a Construction Noise and Vibration Management Plan (CNVMP) for the works and implemented on site where reasonable and practicable.

In relation to the implementation of mitigation measures, practicability addresses engineering consideration regarding what is practical to build. Reasonableness relates to the application of judgment in arriving at a decision, taking into account the following factors:

- noise and/or vibration reduction achieved
- number of people benefited
- cost of the measure
- delay to schedule and whether the measure will prolong exposure to noise and/or vibration
- community views
- pre-construction noise levels at receivers.

While the management measures presented will not necessarily result in mitigating all noise impacts at all times, they are to reduce impacts to levels most stakeholders should find acceptable considering the anticipated benefits of the completed project as a whole.

7.1.1 Works programming

Works should be undertaken during standard construction hours wherever possible. It is recommended that the following standard hours be adopted consistent with the DTMR Code of Practice:

- Monday – Friday 7 am – 6 pm
- Saturday 8 am – 1 pm

Where works are required to occur outside of standard construction hours due to safety or traffic management reasons, preference should be given to scheduling these for weekend or evening hours instead of night hours.

7.1.2 Community notification and consultation

- Notify occupants of sensitive land uses at least one week in advance works where predicted noise levels exceed the applicable noise criteria. Notification to include:
  - the reason for the activity
  - the type of equipment to be on site
  - expected hours of operation
  - likely duration and impact of operation at the site
  - contact details for further information and complaints.
- Implement and maintain a complaint response procedure for the works including a dedicated phone line.

7.1.3 Shielding

- Locate plant and equipment to take advantage of barriers provided by existing site features and structures.
- Where plant and equipment is to be located in one position for long periods of time (e.g. construction compounds), consider installing acoustic enclosures and/or temporary shielding to break line-of-sight to the nearest sensitive land uses. Acoustic enclosures and temporary shielding should be constructed with reference to the guidance provided in AS 2436-2010.

7.1.4 Staff behaviour

- The induction of site staff should include a reference to potential noise and vibration impacts and the identification of sensitive land uses.
- 'Toolbox talks' should include a reference to any noise and vibration management measures being implemented on site at the time.
- Vehicle warning devices, such as horns, should not be used as signalling devices.
- No swearing or unnecessary shouting or loud stereos/radios on site.
- No unnecessary dropping of materials from height, throwing of metal items and slamming of doors.

7.1.5 Site management

- Quieter construction methods should be used where feasible and reasonable.
- Avoid unnecessary noise.
- The offset distance between plant and residences should be maximised.
- The layout of the construction compound should be arranged so that primary noise sources are at a maximum distance from residences, with solid structures (sheds, containers etc) placed between residences and noise sources (and as close to the noise sources as is practical).
- Traffic flow, parking and loading/unloading areas should be planned to avoid the need for reversing near residential areas.
- Loading and unloading of materials should occur as far as possible from residential areas.
- Ensure that truck tailgates are cleared and locked at the point of unloading.
- Site access points, roads and construction traffic routes should be located as far as possible from residential areas.
- Restrict construction traffic to designated roads and avoid unnecessary construction traffic on local roads.

7.1.6 Equipment management

- Plant used intermittently should be shut down or throttled down to a minimum between uses.
- Plant emitting noise in a particular direction should be directed away from residential uses.
- Implement mufflers/silencers on plant and equipment. Undertake regular maintenance of plant and equipment, including silencers, to ensure that noise emissions do not increase over time. Servicing, refuelling and warm-up to be undertaken during standard construction hours.
- Mobile construction equipment that will be on site for more than two days should have non-tonal reversing alarms if working out-of-hours.
- Run plant that has high and low vibration settings on the lowest effective vibration setting.

7.1.7 Monitoring

- Consider implementing noise and/or vibration monitoring in response to complaints, where this is considered an appropriate response.

7.2 Operational phase

For the proposed T274 substation, it is recommended that a minimum separation distance of 140 m be maintained between transformers at the substation and any residential land use that is occupied. It is noted that this risk would only apply to the residential use on Stewarts Road that is owned by Powerlink Queensland and currently tenanted.

If a separation distance of 140 m is not possible for this residential land use and it is to remain tenanted, then one or both of the following controls could be implemented to achieve compliance:

- Select a transformer with a lower sound power level. AS/NZS 60076-10 includes a specification for a Reduced Maximum sound power level that is 8 dB lower than the Standard Maximum. This would reduce the required separation distance for noise levels to 65 m.
- Install a solid barrier, such as a fire wall, around the transformers to block line of sight between the transformers and the potential residence at 48 Stewarts Road. If a barrier installed in close proximity to the transformers can block line of sight between the two, then a reduction in noise level of at least 5 dB would be expected. This would reduce the required separation distance for noise levels to 85 m based on the Standard Maximum sound power level from AS/NZS 60076-10.

8 Conclusion

This report presents a preliminary construction noise and vibration assessment for the Kamerunga to Woree transmission line replacement, to assess potential amenity impacts arising from noise and vibration during construction for the transmission line, and to recommend appropriate mitigation measures. Operational noise from the new substation has also been assessed.

Construction noise from most phases of works is predicted to present a risk of exceedance of the construction noise criteria, particularly as the alignment passes through residential areas in Noise Catchment Areas 2 to 4. Despite the exceedances, it should be noted that the works immediately adjacent to individual receivers are likely to be completed relatively quickly and, as the works proceed along the alignment, individual residents are only likely to be exposed to noise levels above the criteria for relatively short periods of time. Typical construction noise and vibration management measures have been recommended, and it is expected that these would be documented in a CNVMP that is implemented prior to and during the works.

Operational noise from the proposed Kamerunga substation relocation is predicted to be able to achieve compliance with applicable noise criteria subject to appropriate separation being achieved between the site and occupied residential areas, and with due consideration of equipment selection and/or shielding using transformer fire walls.

Construction vibration is considered to generally be low risk considering the proposed plant and equipment for the works. It is expected that construction vibration measures would be identified and implemented through the CNVMP for the project.

Appendix A—Construction plant and sound power levels

This section presents typical expected construction plant based on information supplied by Powerlink via JBS&G and typical sound power levels based on Resonate's in-house database. A typical overall sound power level is also provided for each phase that is indicative of the typical worst-case sound power level expected based on the proposed items. Note that the typical overall sound power level is not a sum of all items of plant as they would not normally be operating simultaneously.

Overhead transmission line

Phase	Major plant items	Typical sound power level, dB L_{WA}
Foundations	Soilmec drilling rig	116
	Concrete agitator	106
	Telehandler	108
	Bobcat	110
	20T truck	108
	Light vehicle	96
	Overall typical worst case sound power for phase	**116**
Steel structures	100T crane	106
	50T crane	103
	20T truck	108
	Light vehicle	96
	Overall typical worst case sound power for phase	**109**
Stringing	Franna crane	106
	Winch truck	110
	Elevated work platform	97
	20T truck	108
	Light vehicle	96
	Overall typical worst case sound power for phase	**111**
Substation	100T crane	106
	50T crane	103
	20T truck	108
	Light vehicle	96
	Overall typical worst case sound power for phase	**109**
Decommissioning	100T crane	106

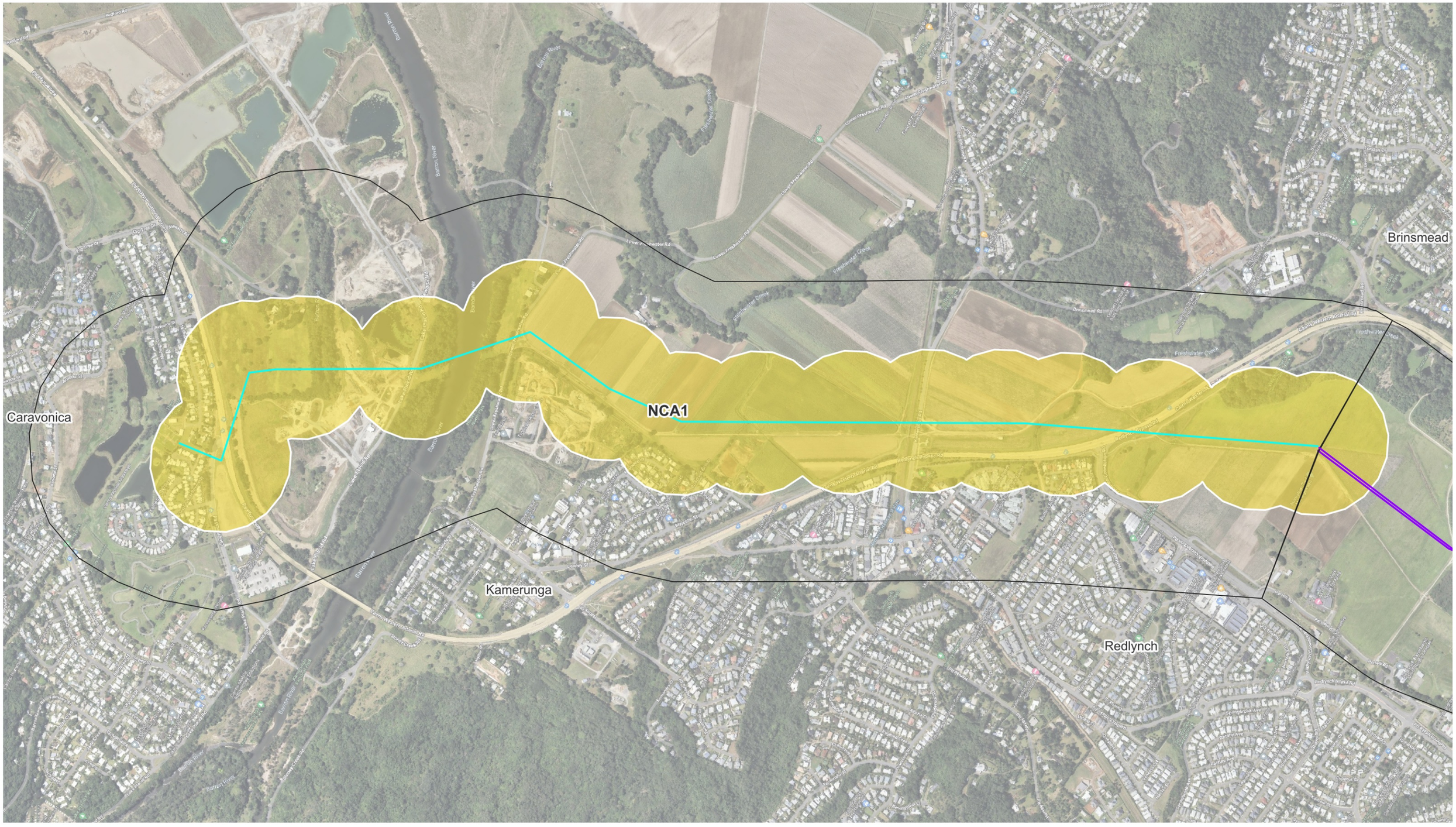
Phase	Major plant items	Typical sound power level, dB L_{WA}
	50T crane	103
	14T excavator with shearer	108
	Elevated work platform	97
	Bobcat	110
	20T truck	108
	Winch truck	110
	Light vehicles	93
	Overall typical worst case sound power for phase	**112**

Underground transmission line

Activity	Item	Typical sound power level, dB L_{WA}
Trench excavation and conduit installation	14T excavator	105
	5T truck	104
	20T truck	108
	Concrete agitator	106
	1T truck	101
	Overall typical worst case sound power for phase	**109**
Undercrossings	14T excavator	105
	5T truck	104
	20T truck	108
	Small drill <50t (assumed non-percussive)	110
	Large drill >50t (assumed non-percussive)	113
	Overall typical worst case sound power for phase	**113**
Road reinstatement works	14T excavator	105
	5T truck	104
	20T truck	108
	Milling machine	114
	1T truck	101
	Overall typical worst case sound power for phase	**114**
	9T backhoe	104
	10T truck	106

Activity	Item	Typical sound power level, dB L_{WA}
Joint bay excavation and installation	20T truck	108
	1T truck	101
	Overall typical worst case sound power for phase	**108**
Cable installation, jointing and testing	Cable trailer 70T	108
	10T truck	106
	5T truck	104
	1T truck	101
	Light vehicle	96
	Overall typical worst case sound power for phase	**108**
Decommissioning	100T crane	106
	50T crane	103
	14T excavator with shearer	108
	Elevated work platform	97
	Bobcat	110
	Trucks	108
	Winch truck	110
	Light vehicles	93
	Overall typical worst case sound power for phase	**112**

Appendix B—Construction noise maps



0 200 400 600 800 m

Resonate

Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Noise Catchment Areas
- Educational Use
- Typical worst-case construction noise level >55 dB LAeq

Powerlink Kamerunga to Woree

Stage 1: Overhead Line
Foundation Works

Drawn by: XL
Checked by: TRE
Dated: July 2024
Page size: A3
Data sources: (c) Google, JBS&G

Figure

B1

0 200 400 600 800 m

Resonate

Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Noise Catchment Areas
- Educational Use
- Typical worst-case construction noise level >55 dB LAeq

Powerlink Kamerunga to Woree

Stage 1: Overhead Line
Steel Structures

Drawn by: XL
Checked by: TRE
Dated: July 2024
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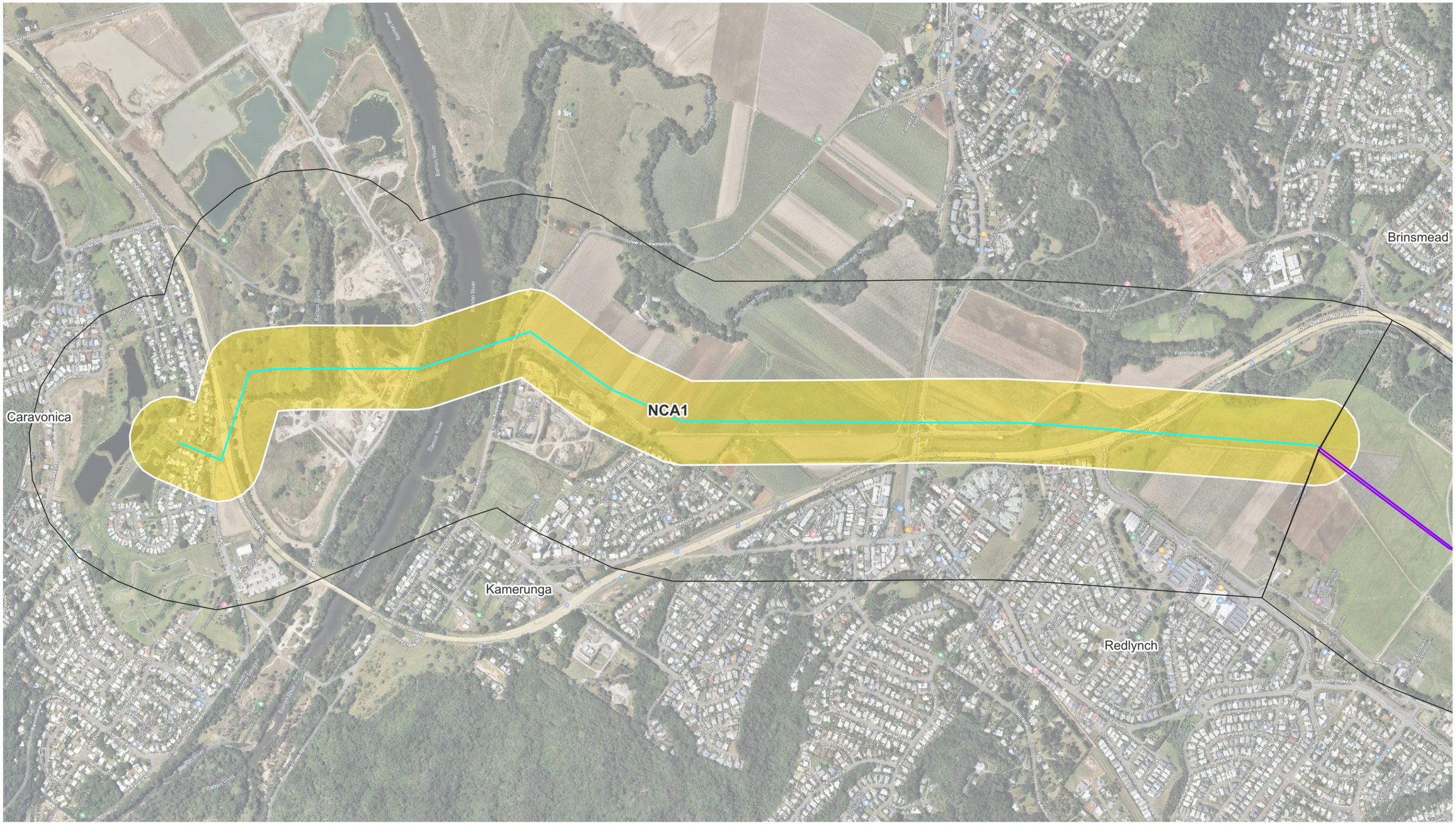
Data sources: (c) Google, JBS&G

Figure

B2



0 200 400 600 800 m

Resonate

Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Noise Catchment Areas
- Educational Use
- Typical worst-case construction noise level >55 dB LAeq

Powerlink Kamerunga to Woree

Stage 1: Overhead Line Stringing

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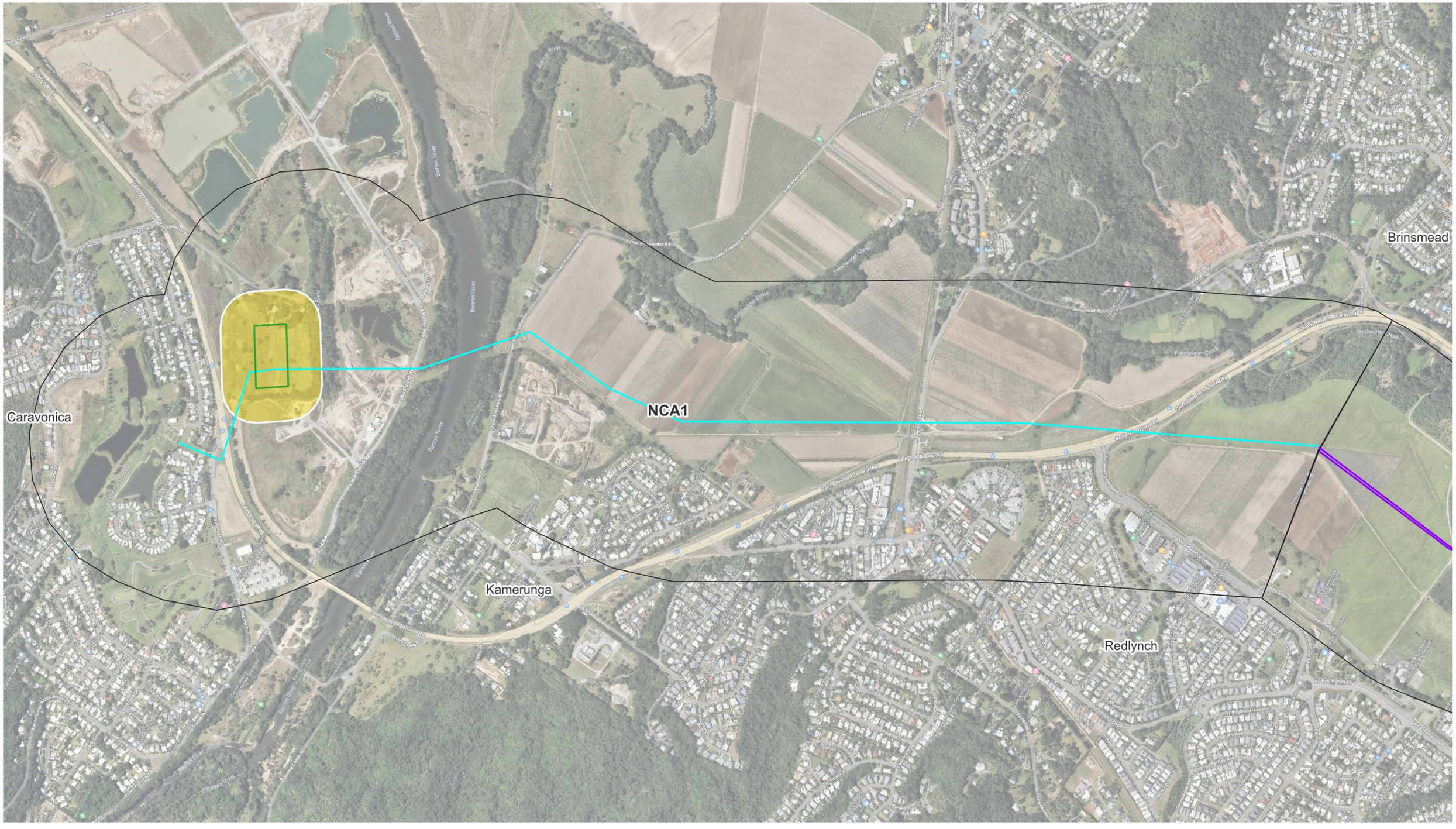
Data sources: (c) Google, JBS&G

Figure

B3



Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Noise Catchment Areas
- Educational Use
- Proposed T274 Substation
- Typical worst-case construction noise level >55 dB LAeq

Resonate

Powerlink Kamerunga to Woree

Stage 1: Overhead Line
Substation Works

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Dated: July 2024
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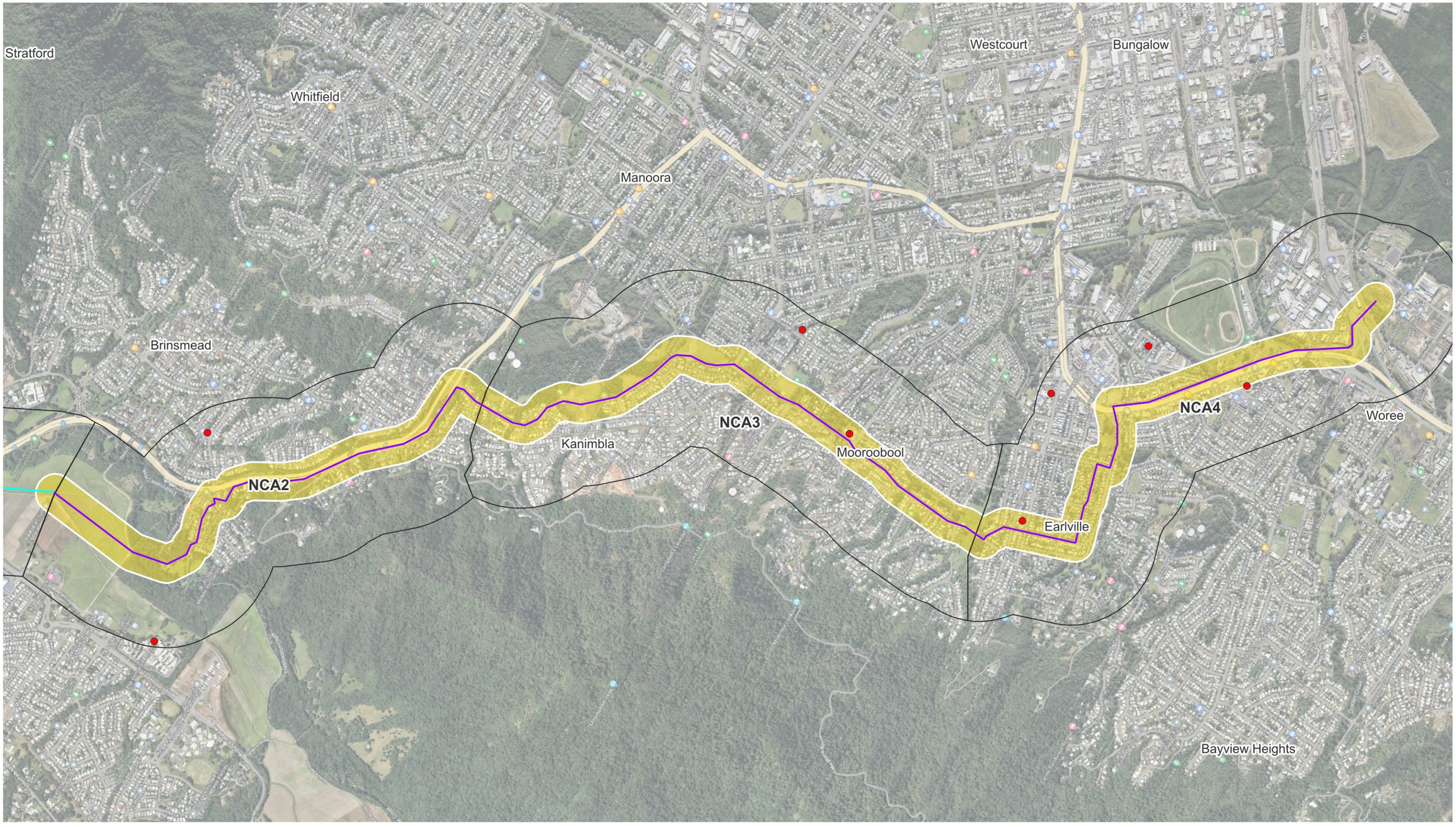
Data sources: (c) Google, JBS&G

Figure

B4



0 400 800 1,200 1,600 m

Resonate

Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Noise Catchment Areas
- Educational Use
- Typical worst-case construction noise level >55 dB LAeq

Powerlink Kamerunga to Woree

Stage 2: Underground Line
Trench Excavation and Conduit Installation

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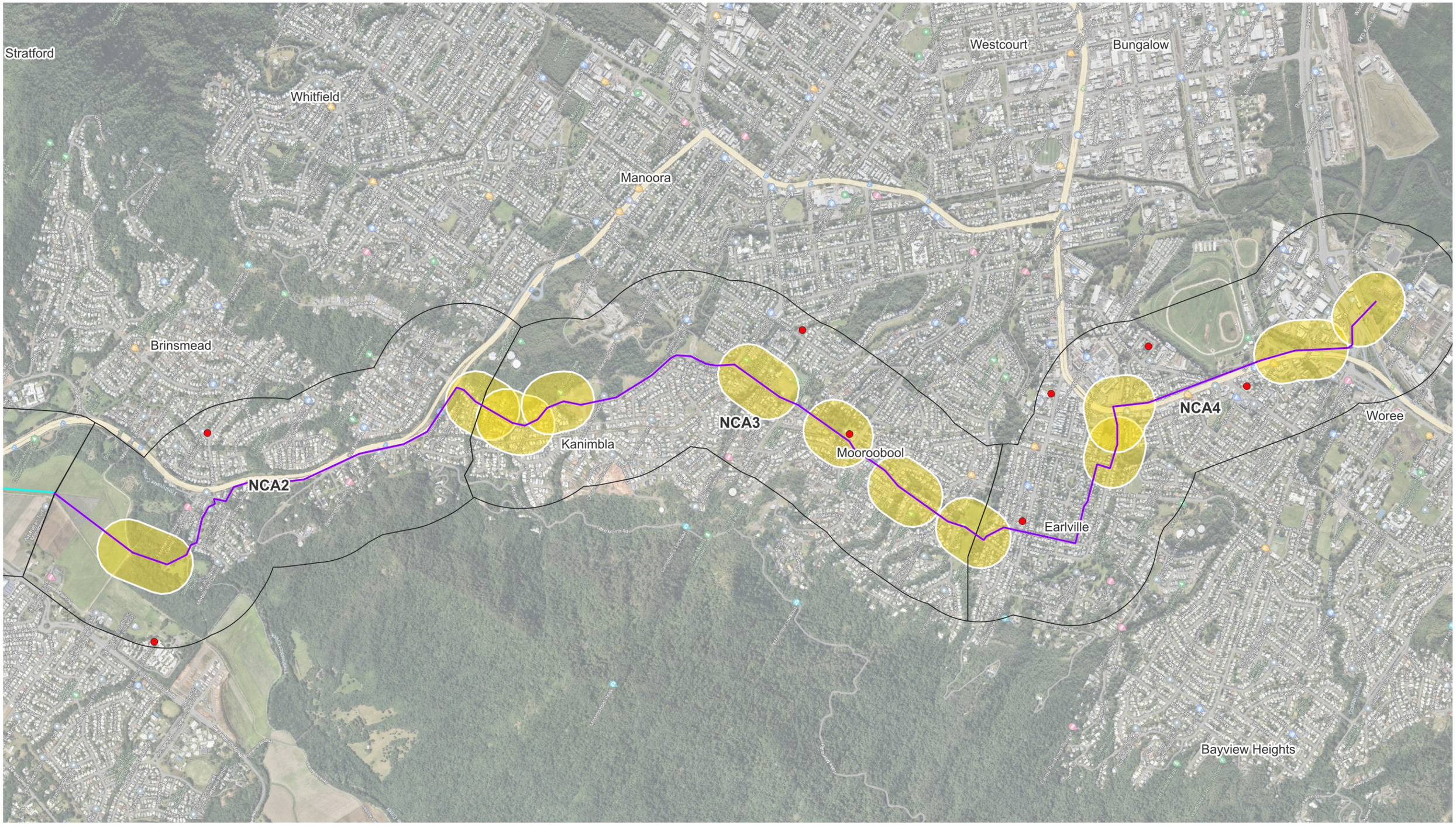
Data sources: (c) Google, JBS&G

Figure

B5



0 400 800 1,200 1,600 m

Resonate

Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Noise Catchment Areas
- Educational Use
- Typical worst-case construction noise level >55 dB LAeq

Powerlink Kamerunga to Woree

Stage 2: Underground Line Undercrossings

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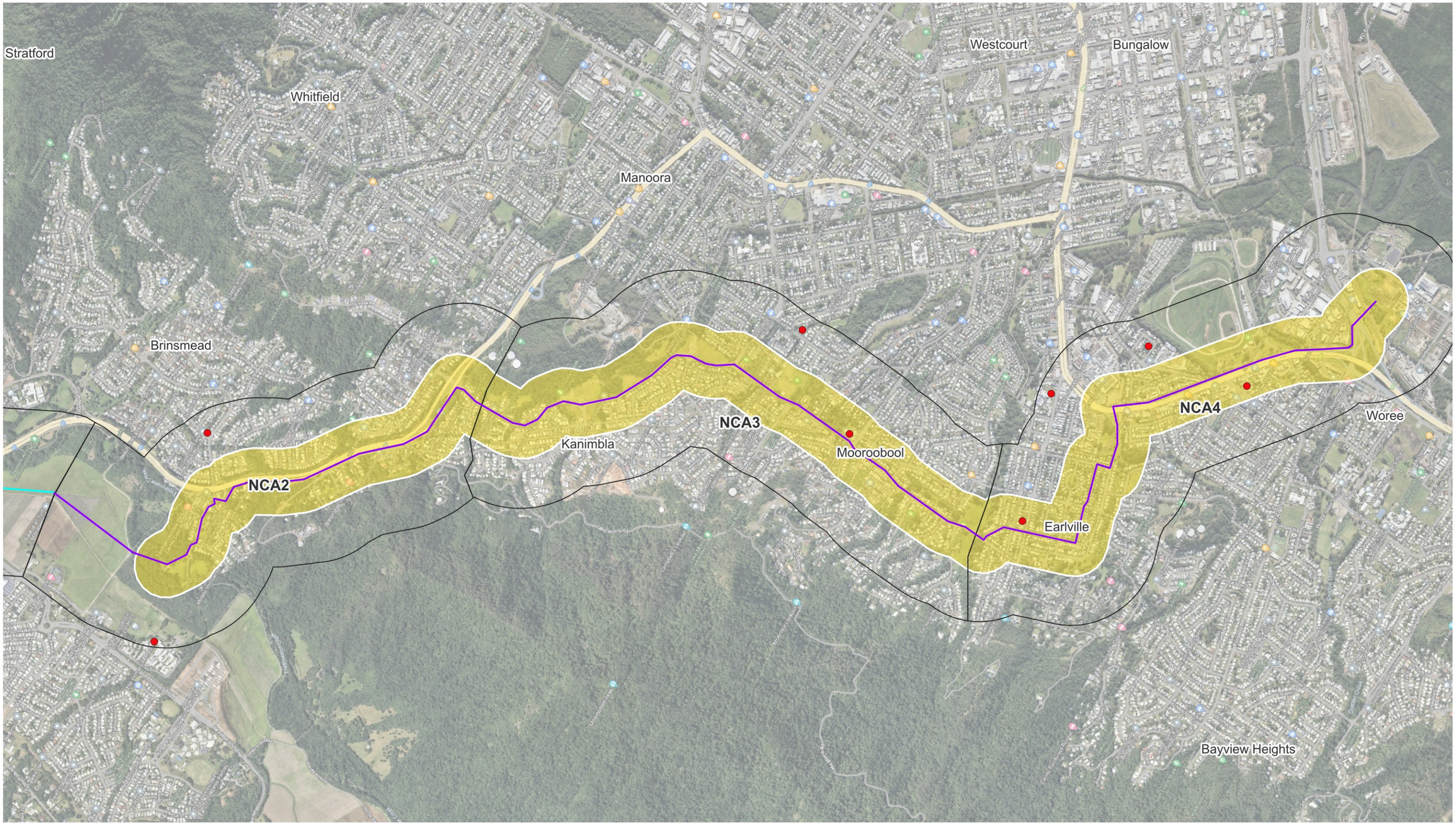
Data sources: (c) Google, JBS&G

Figure

B6



0 400 800 1,200 1,600 m

Resonate

Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Noise Catchment Areas
- Educational Use
- Typical worst-case construction noise level >55 dB LAeq

Powerlink Kamerunga to Woree

Stage 2: Underground Line
Road Reinstatement Works

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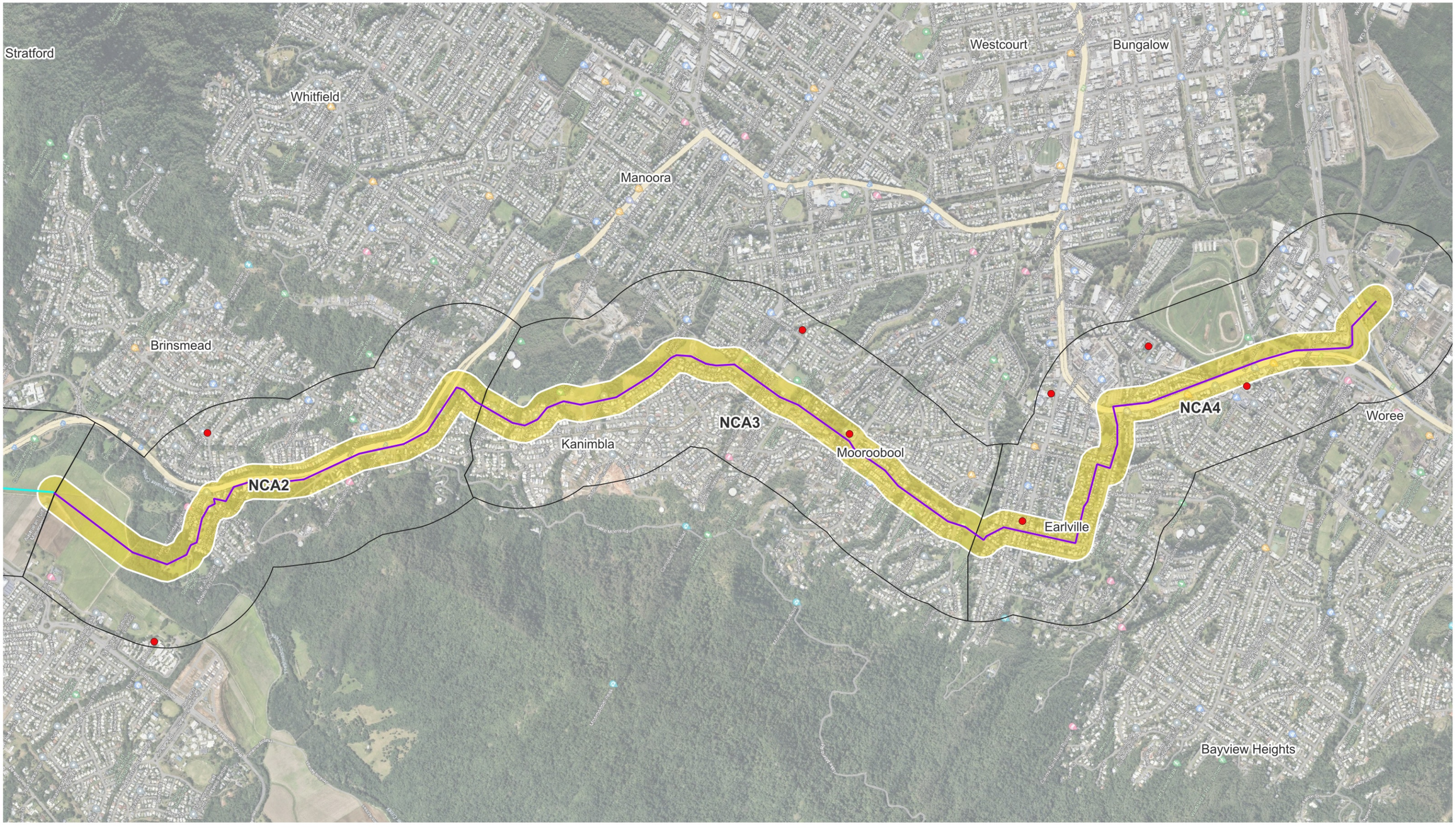
Data sources: (c) Google, JBS&G

Figure

B7



0 400 800 1,200 1,600 m

Resonate

Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Noise Catchment Areas
- Educational Use
- Typical worst-case construction noise level >55 dB LAeq

Powerlink Kamerunga to Woree

Stage 2: Underground Line
Joint Bay Excavation and Installation

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Dated: July 2024
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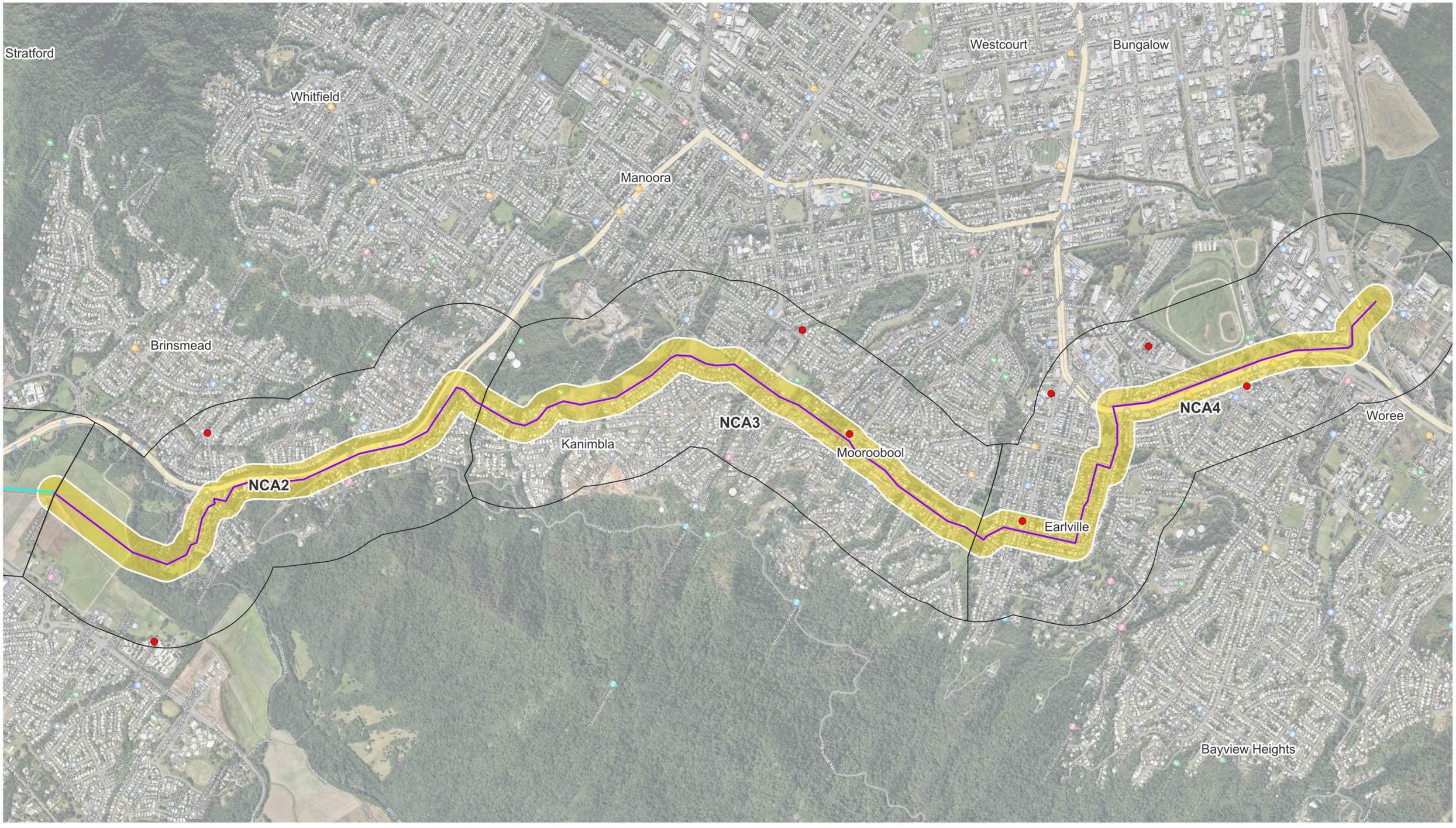
Data sources: (c) Google, JBS&G

Figure

B8



0 400 800 1,200 1,600 m

Resonate

Legend

- Stage 1 Alignment
- Stage 2 Alignment
- Noise Catchment Areas
- Educational Use
- Typical worst-case construction noise level >55 dB LAeq

Powerlink Kamerunga to Woree

Stage 2: Underground Line
Cable Installation Jointing and Testing

Drawn by: XL
Checked by: TRE
Dated: July 2024
Page size: A3
Data sources: (c) Google, JBS&G

Figure

B9