Regional Rail Link Authority

Regional Rail Link

Noise Impact Management Report

RRL-2000-EAC-REP-0001

9 December 2010

Revision H

KBR ARUP

Regional Rail Link Authority

Regional Rail Link

Noise Impact Management Report

December 2010

KBR Arup Joint Venture ABN 85 807 465 350
Kellogg Brown & Root Pty Ltd ABN 91 007 660 317
Arup Pty Ltd ABN 18 000 966 165

KBR Arup Joint Venture
Level 34, 80 Collins Street
Melbourne, VIC 3000, Australia
Tel +61 3 8629 4100 Fax +61 3 9654 8715

This is an uncontrolled document if printed out

Job number RRL

Job title	Regional Rail Link	Job number RRL	
Document title	Noise Impact Management Report	File reference	
Document ref	RRL-2000-EAC-REP-0001		

Revision	Date	Filename	RRL-2000-EAC-REP-0001.docx		
Revision A	09/06/10	Description	Issued for review		
			Prepared by	Checked by	Approved by
		Name	Kym Burgemeister	Sarah Alper/Simon Ham	Chris Crellin
		Signature			
Revision B	30/09/10	Filename	RRL-2000-EAC-REP-0001.docx		
		Description			
			Prepared by	Checked by	Approved by
		Name	Kym Burgemeister	Sarah Alper	Andy Marks
		Signature			
Revision C	04/08/10	Filename	RRL-2000-EAC-REP-0001.docx		
		Description			
			Prepared by	Checked by	Approved by
		Name	Kym Burgemeister	Sarah Alper	Andy Marks
		Signature			
Revision D	30/09/10	Filename	RRL-2000-EAC-REP-0001.docx		
		Description	Issued for review		
			Prepared by	Checked by	Approved by
		Name	Kym Burgemeister	Sarah Alper	Andy Marks
		Signature			

Issue Document Verification with Document ✓

Job title	Regional Rail Link	Job number
Document title	Noise Impact Management Report	File reference
Document ref	RRL-2000-EAC-REP-0001	

Revision	Date	Filename	RRL-2000-EAC-REP-0001.docx		
Revision E	30/09/10	Description	Issue to review		
			Prepared by	Checked by	Approved by
		Name	Kym Burgemeister	Sarah Alper	Andy Marks
		Signature			
Revision F	07/10/10	Filename	RRL-2000-EAC-REP-0001.docx		
		Description			
			Prepared by	Checked by	Approved by
		Name	Kym Burgemeister	Sarah Alper	Andy Marks
		Signature			
Revision G	22/11/10	Filename	RRL-2000-EAC-REP-0001.docx		
		Description			
			Prepared by	Checked by	Approved by
		Name	Kym Burgemeister	Sarah Alper	Andy Marks
		Signature			
Revision H	09/12/10	Filename	RRL-2000-EAC-REP-0001.docx		
		Description	Issue for information		
			Prepared by	Checked by	Approved by
		Name	Kym Burgemeister	Sarah Alper	Andy Marks
		Signature			

Issue Document Verification with Document ✓

Contents

Appendices

1 Introduction

The Regional Rail Link (RRL) is a project funded by both the Victorian and Federal governments. It aims to increase railway capacity and reliability for the Geelong, Ballarat and Bendigo passenger rail services.

The RRL consists of a new segregated rail link from west of Werribee heading north to the vicinity of Deer Park and then east, through Sunshine and then south to Southern Cross Station along the existing northern group corridor. Specifically the project will include:

- Up to 50 km of dedicated regional tracks from West Werribee to Southern Cross Station, allowing regional services direct access into Melbourne
- Separating metropolitan and regional rail services onto dedicated tracks
- New stations for the growing western suburbs of Wyndham Vale and Tarneit
- A new station at West Footscray, and modification of the existing Footscray and Sunshine stations.

RRL frees capacity on the metropolitan railway system for Werribee, Williamstown, Sydenham and Craigieburn lines. It also allows diesel-powered passenger trains from regional centres to travel at speeds of up to 160 km/h.

The KBR Arup joint venture has been appointed by the Regional Rail Link Authority (RRLA) to provide design services for RRL.

RRL is presented as two sections:

Section 1: Southern Cross Station to Deer Park Bypass

Section 2: Deer Park Bypass to West Werribee.

This document presents the Noise Impact Management Report for Section 2 of the Regional Rail Link. Section 2 will provide a two track railway within a corridor of generally 60 m width, and will also include railway stations and associated infrastructure, grade separations and road intersections, and, ultimately, stabling yards.

This report and the supporting technical work has been peer reviewed by Dr Rob Bullen of Wilkinson Murray, in accordance with the requirements of the Minister for Planning's conditions.

Acoustic terminology used in this report is defined in Appendix A.

1.1 Requirements of the Noise Impact Management Report

The Minister for Planning has decided that an Environment Effects Statement under the *Environment Effects Act 1978* is not required for RRL Section 2. However, the Minister's decision includes several conditions, including the requirement for the preparation of this Noise Impact Management Report.

In accordance with the Minister's decision, this Noise Impact Management Report addresses the following:

EES Condition (1) i Provide a clear justification of proposed noise standards for operation of the railway

EES Condition (1) ii Refine the assessment of noise sources and noise generation scenarios for both construction and operation of the railway

EES Condition (1) iii Identify specific railway design, train design, rail service scheduling and any other measures that are proposed to mitigate noise impacts

EES Condition (1) iv Provide an assessment of the likely residual noise impact of both construction activities and relevant operational scenarios on existing

	houses and residential estates in the vicinity of the preferred rail alignment, if proposed noise mitigation measures are implemented
EES Condition (1) v	Provide an assessment of appropriate buffers or off-site mitigation measures needed in residential areas that are yet to be developed in order to enable a high measure of compliance with the suitable noise standards
EES Condition (1) vi	Identify any other feasible noise mitigation measures and assess their likely cost-effectiveness

A response to each of these conditions is provided in this report.

In addition, the Minister's Conditions also require the preparation of a draft Noise Management Plan (NMP) and a peer review report prepared by an independent specialist. These reports are provided separately.

1.2 Approach

The approach to the development of this Noise Impact Management Report is detailed below:

- Identify and review existing and proposed sources of noise and vibration.
- Identify relevant regulations, guidelines and criteria with respect to sources of noise and vibration.
- Conduct 'baseline' noise measurements at noise sensitive locations and at other strategic locations.
- Conduct source noise and vibration measurements.
- Develop an acoustic model of the operational railway and proposed construction processes.
- Predict railway noise levels at noise sensitive locations for the following project phases:
    - Phase 1: Day 1 RRL (2014)
    - Phase 4: Ultimate capacity (2030)
- Predict noise and vibration from proposed construction processes.
- Identify measures that are proposed to mitigate noise impacts, and an assessment of the likely residual noise impacts.

This report has been prepared at the concept design stage of the project. As the project is planned to be procured as a 'design and construct' (D&C) based contract, it is possible that further design solutions may be adopted by the construction contractor as detailed design progresses, or there may be other modifications that will alter the modelled noise assessment results.

Operational vibration from the railway is not considered in detail in this report. While railways do generate vibration, for surface tracks such as that proposed for RRL, the impact of groundborne vibration from the railway is generally insignificant compared with the impacts from airborne noise.

2 Railway Noise and Vibration

Public transport, and railways in particular, has been shown to provide a series of environmental and sustainability benefits compared with alternative transport options. However, railways have the potential to create noise and vibration adjacent to the track alignment during their construction and operation.

Noise and vibration from the operation of railway vehicles generally comes from the following sources:

- Rolling noise from the wheel–rail interface; this is dependent on the combined wheel–rail roughness amplitude and speed of the rail vehicle.
- Engine and motor noise; this varies between engine types.
- Aerodynamic noise; typically only at above speeds of 250 km/h (vehicles on the RRL will not exceed 160 km/h).

The noise and vibration generated from these sources may be perceptible at sensitive locations adjacent to railway alignments in the following forms:

- Airborne noise: noise propagated through the air to the receiver.
- Groundborne vibration: vibration propagated through the ground and into building structures, generally perceptible at very low frequencies (i.e. 4–80 Hz) and can cause rattling of building fixtures.
- Groundborne noise: low frequency airborne noise that is reradiated from vibrating structures, generally heard indoors as a ‘rumble’.

For ‘at grade’ railways (i.e. built directly at or near the natural ground surface), the airborne noise impacts are typically higher and therefore more critical than the impacts of groundborne noise and vibration. It is usually only underground railways or railways with significant shielding (e.g. in deep cuttings), where the airborne noise is reduced to a very large extent, that vibration and groundborne noise are the predominant impacts.

In addition to the track and rolling stock, noise can also be generated by fixed railway infrastructure, such as the railway stations, signalling and electrical infrastructure. Noise and vibration are also generated during the construction of the railway.

Therefore, in this assessment of Section 2 of the RRL, noise and vibration associated with the following are considered:

- operational noise from the railway
- construction noise and vibration
- noise from fixed infrastructure sites.

2.1 Subjective Response of Humans to Railway Noise

The subjective response of humans to noise varies between individuals. Broadly, the potential impacts of noise for the community in the vicinity of the rail alignment include:

- loss of amenity
- discomfort
- adverse health effects (stress, loss of concentration, increase in blood pressure)
- sleep arousal
- interference with sensitive instrumentation

Railway noise has generally been found to be significantly less annoying to nearby receivers than equivalent noise levels from road traffic[1,2,3].

1 Fastl, H., Fruhmann, M. and Ache, S., *Railway bonus for sounds without meaning?*, Proc. Eighth Western Pacific Acoustics Conference, April 2003.

2 Flindell, I, *A comparison of exposure-response relationships for railway noise and road traffic noise*, J. Sound and Vibration, **87**(2), 1983.

3 Miedema, H.M.E., Vos, H. *Exposure-response relationships for transportation noise*, J. Acousical Soc. America, **104**, 1998.

3 Project Description

This Noise Impact Management Report is for Section 2 of the RRL, from the Deer Park Bypass to West Werribee Junction. This section of the RRL is predominantly a greenfield corridor, with no existing railway infrastructure, except near the tie-ins to existing track infrastructure at each end. Figure 1 below shows an overview of the Section 2 alignment.

RRL will allow diesel-powered passenger trains from the City (Southern Cross Station) to Geelong to travel at speeds of up to 160 km/h. Section 2 consists of a two track railway within a corridor approximately 60 m wide. The project includes two railway stations at Wyndham Vale/Manor Lakes and at Tarneit, and associated infrastructure, grade separations and road intersections. Stabling yards are likely to be necessary in the future, but are not provided as a part of the RRL.

Rolling stock that will use the RRL alignment will include:

- V/Locity and Sprinter diesel multiple units (DMUs)
- N class locomotives
- P class locomotives

It is expected that newer V/Locity type rolling stock will eventually replace the older N and Pclass locomotives and carriages that are currently being used. Freight is not proposed for the RRL and has not been considered as part of this study.

The proposed railway alignment generally passes through agricultural land and low-density housing areas. However, through Tarneit and Wyndham Vale/Manor Lakes, the alignment is adjacent to more highly developed residential areas. The corridor passes in a deep cut through an existing transport reserve through Wyndham Vale (see indicative cross section in Figure 2). The cutting provides significant mitigation of noise emission from the railway.

It is noted that much of the land near the RRL corridor has been declared to be within the Melbourne Growth Boundary under the Melbourne 2030 and Melbourne @ 5 million planning strategies, and it is anticipated that this land will be developed for urban and residential purposes in the future.

The project phases for rail operations that have been considered are based on those documented in the Regional Rail Link Capacity Upgrade Phases[4], which are;

- Phase 1: Day 1, opening of RRL (2014)
- Phase 4: Ultimate capacity (2030)

4 Regional Rail Link Rail Capacity Upgrade Phases, Department of Transport, 2010.

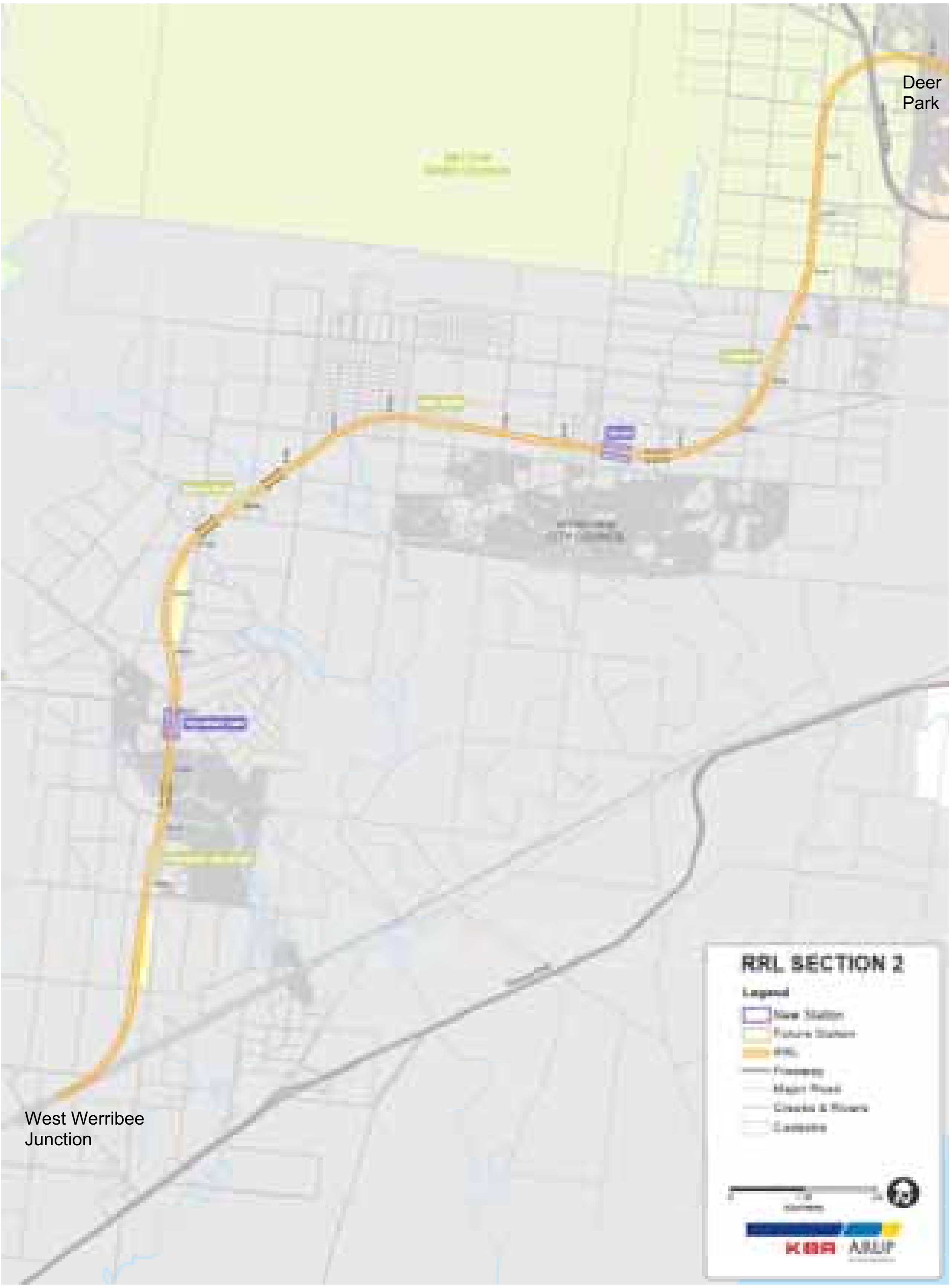


Figure 1 RRL Section 2 Alignment Overview

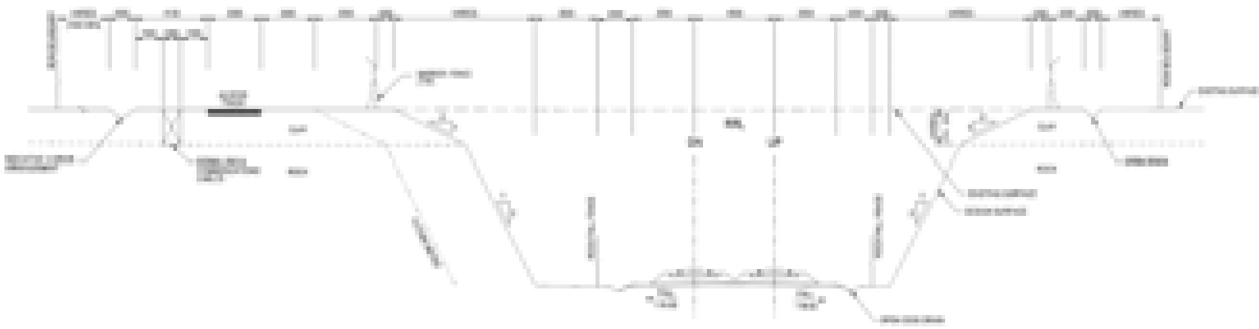


Figure 2 Indicative cross-section of Wyndham Vale cutting

4 Approach to Noise Mitigation

Noise mitigation elements are an important part of railway design, and must be carefully integrated with other key design constraints to ensure a safe, reliable and maintainable railway.

Several elements of the project concept design for Section 2 assist in mitigating noise from the railway. The noise controls for Section 2 are set out in the RRL Section 2 noise impact management plan (RRL-2000-EAC-REP-0002).

4.1 Route Selection

The primary way that noise impacts from the railway have been mitigated is by the careful selection and optimisation of the railway corridor and proposed track alignment. A detailed route selection process was undertaken by the Department of Transport in 2009, and documented in the preliminary assessments considered by the Department of Planning and Community Development.

The corridor has been selected on the basis of a wide range of design constraints, including minimising the potential noise impacts to residential receivers. The corridor is located as far as practical from high-density residential developments, except in Wyndham Vale, where it is within a zoned transport corridor.

4.2 Alignment Design Factors

All new intersections are proposed to include grade separated crossings, rather than level crossings, minimising the noise from bells, signals, and traffic.

Tight radius curves can result in noise from flanging and wheel squeal, which are commonly controlled using gauge face lubrication or top-of-rail friction modifiers supplied from trackside applicators. This type of noise is normally only prevalent on tracks with a curve radius less than 400 m. The RRL has generally been designed with large-radius curves to avoid wheel contact noise, and the minimum radius curve is 450 m.

Finally, lightweight steel bridge and viaduct structures are known to result in increased railway noise due to increased noise radiation from the structure. Bridges and viaducts for the RRL are proposed to be concrete or composite steel–concrete structures with ballasted decks. These do not result in significantly increased noise radiation compared to at-grade ballasted track.

4.3 Control of Railway Noise Emission

Noise from operation of railway vehicles generally comes from the following sources:

- Engine and motor noise (sometimes called ‘traction noise’); this varies between engine types
- Aerodynamic noise; typically only at above speeds of 250 km/h (vehicles on the RRL will not exceed 160 km/h).
- Rolling noise from the wheel–rail interface; this is dependent on the combined wheel–rail roughness amplitude and speed of the rail vehicle.

Noise from brake squeal can be problematic on some networks and is usually due to the choice of brake pad compound and disk material (which are selected for pad life and stopping efficiency, rather than noise), and the condition of the braking surfaces. Brake squeal is not known to be a major issue on the Victorian passenger fleet, and is reasonably controlled by regular ongoing maintenance.

The primary source of railway noise is from the wheel–rail interface due to:

- roughness of the rail and wheel (including wheel flats)

- rail corrugation
- wheel squeal on track curves
- impact on rail imperfections (spalls, rail burns), joints and special trackwork, e.g. switches and crossings.

The approaches that have been adopted to control noise emission from the wheel–rail interface are as follows:

- Continuous welded rail (CWR) is proposed in order to minimise the number of rail joints and thereby reduce the level of impact noise.
- In common with the existing track infrastructure and fleet, the accredited rail operator (ARO) will regulate the track and wheel roughness by undertaking regular maintenance of the track profile, including track grinding, and the wheels. This maintenance removes wear and track defects such as corrugation and uneven welds.

Resilient rail fixings, such as Cologne Eggs, are sometimes specified for railways to control groundborne noise and vibration emissions by the track support and substructure. However, it is noted that these types of fixing do not reduce the extent of airborne noise emission from the railway (and can sometimes increase noise emissions through increased rail mobility). It is therefore not proposed to use resilient rail fixings, beyond those necessary for rail operations.

Similarly, rail dampers have sometimes been used to reduce noise emission from the rail itself, particularly when highly resilient rail fixings are used which increase rail mobility. However, highly resilient rail fixings are not necessary for the RRL to control groundborne noise from the railway, and the rail mobility will be relatively low. Therefore, rail dampers are not expected to be necessary for the RRL since they will not provide any significant control of airborne noise emissions from the rail.

Within railway reserves, noise barriers are sometimes used to control airborne noise. However, noise barriers are not a preferred approach since they also lead to overshadowing and loss of solar access, and are visually intrusive and subject to vandalism. From the railway operator's point of view, noise barriers can present a security hazard and can affect signal sighting distances.

Section 251B of the *Victorian Transport (Compliance and Miscellaneous) Act* specifically excludes noise from passenger rolling stock from constituting a nuisance, and there are no Victorian or project-specific numerical noise standards that apply to noise emission from the railway. Therefore, the project authority does not propose to provide noise barriers to control noise emissions from the railway as part of the RRL project.

Off-reservation treatments, such as architectural acoustic treatments to individual properties (e.g. double glazing, building design) do not result in increased external amenity but may be incorporated into new developments as urban change occurs.

4.4 Planning Controls

It is recommended that planning authorities adopt appropriate planning controls for the areas adjacent to the railway reserve. The Growth Area Framework Plans (2006) for Melton/Caroline Springs and Wyndham set out broad strategic planning directions for those areas including focusing urban development along the rail corridor, including commercial, residential and community uses. The precinct structure plans being developed by the Growth Area Authority give further definition to these principles.

The detailed railway route selection process undertaken by the Department of Transport in 2009 considered potential noise impacts to adjoining land parcels, particularly in existing and future urban areas and areas with existing rail traffic. This assessment concluded that as urban development proceeds around the rail corridor, strategic land use decisions and mitigation measures will be required to ensure that new sensitive land uses are appropriately located and designed. This reflects the balance required by planning policy for development to be integrated with the railway while providing reasonable levels of amenity.

Planning controls for land adjacent to the railway reserve may include zoning controls and, for sites that are likely to be developed or re-developed with a sensitive use, controls such as the (Clause 43.02) design and development overlay (DDO). Appropriate schedules to the DDO could require new developments to be designed and configured in a way that provides reasonable protection to the amenity of occupants of new buildings.

Such an overlay is considered appropriate given the objective of the DDO is:

> *To identify areas which are affected by specific requirements relating to the design and built form of new development.*

Schedules to the DDO should require careful site layout and appropriate buffers to limit noise impacts on future development in proximity to RRL Section 2, and put an assessment process in place to ensure that building designs include appropriate treatments to maximise building envelope sound insulation, and minimise operational railway noise ingress into buildings used for noise-sensitive land-uses.

4.5 Other Controls

Design elements should also be considered as a means to supplement or provide an alternative to statutory regulations for the management and mitigation of amenity impacts, such as noise. The Regional Rail Link Urban Design Strategy describes and considers elements (refer Section 4.0 RRL Elements) such as retaining walls, embankments and earthworks, barriers, and fencing that may be used in appropriate locations.

5 Noise and Vibration Standards

Sections 5.1 to 5.6 discuss the noise and vibration policy and standards that apply to Section 2 of the RRL project.

5.1 Policy Framework

The Victorian integrated and sustainable transport policy is outlined in *Towards an integrated and sustainable transport future: A new legislative framework for transport in Victoria* (Policy Statement July 2009) and in the *Transport Integration Act 2010*.

The *Transport Integration Act* provides the overarching policy framework for transport legislation, and provides guidance and direction for decisions in key areas that impact on transport, including planning and local government. The policy statement notes that the challenges facing the transport system and the community's expectations for transport are very different than they were a generation ago.

While the policy statement and Act do not provide any specific guidance in relation to noise impacts from railways, the vision statement (Part 2.6) does note the *'aspiration of Victorians for an integrated and sustainable transport system that contributes to … an environmentally responsible State'*, and Part 2.10(c), that *'[the] transport system should actively contribute to environmental sustainability by avoiding, minimising and offsetting harm to the local and global environment, including through transport related emissions and pollutants [and the loss of biodiversity]'*.

5.2 Proposed Noise Standards for Operation of the Railway

Victoria does not currently have any legislative requirements or guidance limits on noise and vibration from passenger railway movements. Section 251B of the Victorian *Transport (Compliance and Miscellaneous) Act 1983* specifically excludes noise emanating from passenger rolling stock as constituting a nuisance, and states that the *Environment Protection Act 1970* does not apply to noise from rolling stock. Therefore a series of project specific *qualitative standards* are proposed to manage operational noise.

The *qualitative standard* noise controls which must be observed include:

- one of the considerations in route selection is operational train noise
- all new intersections are to be designed to avoid noise from bells, signals and braking traffic
- the track alignment must be designed with a minimum turning radius of 500 m to limit wheel contact noise
- bridges and viaducts must be constructed from concrete or composite steel–concrete structures with ballasted decks to avoid lightweight structures that increase noise radiation
- the track must be constructed using continuous welded rail to minimise the number of rail joints
- the operator of the rail system must undertake regular maintenance of the track profile and the train wheels to reduce noise caused by track and wheel roughness

Additional noise controls are described in Section 4.

5.3 Fixed Infrastructure Sites

Operational noise associated with fixed infrastructure sites, including stations, maintenance facilities and stabling, is required to comply with the State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1).

The goal of SEPP N-1 is to protect people from commercial, industrial or trade noise that may affect the beneficial uses made of noise sensitive areas while recognising the reality of the existing land use structure in the metropolitan region.

A SEPP N-1 assessment includes the following:

- Determination of the 'effective noise level' based upon the noise level measured with adjustments for noise character, duration and measurement position (for each time period, day, evening, night)
- Determination of the noise limit based upon the background noise level measured and the land use structure (for each time period)
- A comparison between the 'effective noise level' and the noise limit; the effective noise level is not to exceed the noise limit (for each time period).

Where two or more premises contribute to the effective noise level in a noise sensitive area, each is to be controlled so that the contribution from each of the premises, when combined, will meet the noise limit at the noise sensitive receiver.

5.4 Construction Noise and Vibration

There is no legislation for construction noise and vibration levels in Victoria. The relevant guidelines are the Environmental Guidelines for Major Construction Sites (February 1996) and the Noise Control Guidelines Publication 1254 (October 2008), published by the Victorian EPA.

The main requirements of these guidelines are to implement measures to control noise emission from construction sites, initiate community consultation, and to restrict construction hours. Details of the recommendations of the EPA guidelines are provided in Sections 5.4.1, 5.4.2 and 5.4.3.

Detailed requirements for construction noise management in accordance with these guidelines will be addressed in the noise management plan (NMP).

5.4.1 EPA Environmental Guidelines for Major Construction Sites

The EPA Environmental Guidelines for Major Construction sites have the objective of ensuring nuisance from noise and vibration does not occur.

Suggested measures include:

- Fit and maintain appropriate mufflers on earth-moving and other vehicles on the site.
- Enclose noisy equipment.
- Provide noise attenuation screens, where appropriate.
- Where an activity is likely to cause a noise nuisance to nearby residents, restrict operating hours to between 0700 hrs and 1800 hrs weekdays and 0700 hrs to 1300 hrs Saturdays, except where, for practical reasons, the activity is unavoidable.
- Noise should not be above background levels inside any adjacent residence between 2200 hrs and 0700 hrs.
- Advise local residents when unavoidable out-of-hours work will occur.
- Schedule deliveries to the site so that disruption to local amenity and traffic is minimised.

- Conduct a study on the impact of ground vibration from construction activities where these operations occur within 50 m of a building and take appropriate action.
- Minimise air vibrations.

5.4.2 EPA Noise Control Guidelines Publication 1254

The Noise Control Guidelines provide recommendations for protecting nearby residential premises from unreasonable noise. It recommends that commercial and other premises affected by noise should be considered and reasonable measures implemented to reduce impact on these premises. These include:

(i) Community consultation and work scheduling

Community consultation is essential for large-scale projects or high-impact works. Where the community will be significantly impacted, consult on the benefits and drawbacks of different scheduling, planning and remediation options.

(ii) Work requirements

Noise reduction measures should be developed through initial project planning, tenders for equipment and subcontracts. Larger projects should develop a noise management plan (potentially part of a broader environmental management plan) and may require advice from an acoustic specialist, particularly if works are proposed outside of normal working hours.

The following measures apply:

- Where work is conducted in a residential area or other noise-sensitive location, use the lowest-noise work practices and equipment that meet the requirements of the job.
- Site buildings, access roads and plant should be positioned so that the minimum disturbance occurs to the locality. Barriers such as hoardings or temporary enclosures should be used. The site should be planned to minimise the need for reversing of vehicles.
- All mechanical plant is to be silenced by the best practical means with current technology.
- Mechanical plant, including noise-suppression devices, should be maintained to the manufacturer's specifications. Internal combustion engines are to be fitted with a suitable muffler in good repair.
- Fit all pneumatic tools operated near a residential area with an effective silencer on their air exhaust port.
- Install less noisy movement or reversing warning systems for equipment and vehicles that will operate for extended periods, during sensitive times or in close proximity to sensitive sites e.g. broadband sounders in preference to tonal sounders.
- Occupational health and safety requirements for use of warning systems must be followed.
- Turn off plant when not being used.
- All vehicular movements to and from the site are only to occur during the scheduled normal working hours, unless approval has been granted by the Principal's Representative.
- Where possible, no truck associated with the work should be left standing with its engine operating in a street adjacent to a residential area.
- Special assessment of vibration risks may be needed, such as for pile driving or works structurally connected to sensitive premises.

- Noise from the site needs to comply with the requirements of the schedule, except for unavoidable works and night period low-noise or managed-impact works approved by the Principal's Representative.
- Unavoidable works are works that cannot practicably meet the schedule requirements because the work involves continuous work, such as a concrete pours, or would otherwise pose an unacceptable risk to life or property, or risk a major traffic hazard. Affected premises should be notified of the intended work, its duration and times of occurrence. Approval for unavoidable works must be sought from the Principal's Representative and notified to the local authority (Wyndham City Council, Shire of Melton or the EPA as appropriate).
- Low-noise or managed-impact works are works approved by the Principal's Representative that are inherently quiet or unobtrusive (for example, manual painting, internal fit-outs, cabling) or where the noise impacts are mitigated (for example, no impulsive noise and average noise levels over any half hour do not exceed the background) through actions specified in a noise management plan supported by expert acoustic assessment.
- Low-noise or managed-impact works do not feature intrusive characteristics such as impulsive noise or tonal movement alarms.

5.4.3 Operational Schedule for Construction and Demolition Sites

The noise control guidelines (EPA 1254) recommend the following operational schedule.

Table 1 Operational Schedule/Noise Limits (ref: EPA Noise Control Guidelines, Publication 1254)

Operational Schedule/Noise Limits

Normal Working Hours

7:00—18:00 hours Monday to Friday

7:00—13:00 hours Saturdays

Weekend/evening work hours

Noise level at any residential premises is not to exceed background noise by:

- 10 dB(A) or more for up to 18 months after project commencement (ie *significant* construction commencing in a particular area)
- 5 dB(A) or more after 18 months

during the hours of:

- 18:00—22:00 hours Monday to Friday
- 13:00—22:00 hours Saturdays
- 07:00—22:00 hours Sundays and public holidays

Night period

Noise inaudible within a habitable room of any residential premises during the hours of:

- 22:00—7:00 hours Monday to Sunday

5.4.4 NSW TIDC Railway Infrastructure Construction Noise Guidance

In NSW, the Transport Infrastructure Development Corporation (TIDC) has published a Construction Noise Strategy[5] which relates specifically to construction noise and vibration

[5] *Construction Noise Strategy (Rail Projects)*, Transport Infrastructure Development Corporation NSW, November 2007.

emissions associated with the construction of rail projects. This provides helpful guidance in relation to the assessment and control of noise from railway construction activities. The NSW guideline focuses on night-time works, which are relatively common for railway construction because of access restrictions.

A key aspect of the TIDC guidance is the recommendations for additional mitigation measures, where works are particularly intrusive or undertaken 'out of hours' (i.e. evening or night-time work). These recommendations are shown in Table 2.

Table 2 Additional mitigation measures matrix for airborne construction noise (TIDC Construction Noise Strategy)

Time Period		Mitigation Measures $L_{A10,15min}$ noise level above background (RBL) Qualitative assessment of noise levels			
		0 to 10 dBA Noticeable	10 to 20 dBA Clearly audible	20 to 30 dBA Moderately intrusive	> 30 dBA Highly intrusive
Standard	Monday to Friday (0700 - 1800 hours)	-	-	Letter box drop Monitoring	Letter box drop Monitoring
	Saturday (0800 - 1300 hours)				
	Sunday and Public Holiday (Nil)				
Out-of-hours (evening)	Monday to Friday (1800 - 2200 hours)	-	Letter box drop	Monitoring Letter box drop	Monitoring Individual briefing Letter box drop Respite offer Phone calls Specific notification
	Saturday (1300 - 2200 hours)				
	Sunday and Public Holiday (0800 - 1800 hours)				
Out-of-hours (night)	Monday to Friday (2200 - 0700 hours)	Letter box drop	Monitoring Letter box drop	Monitoring Individual briefing Letter box drop Phone calls Specific notification	Alternative accommodation Monitoring Individual briefing Letter box drop Phone calls Specific notification
	Saturday (2200 - 0800 hours)				
	Sunday and Public Holiday (1800 - 0700 hours)				

Note: activities are for residents identified as affected by construction noise.

5.5 Construction Vibration

Vibration from construction works has the potential to impact on sensitive receivers near the railway corridor. Since human response to vibration is much more sensitive than the structural sensitivity of buildings, construction vibration impacts are usually limited to some subjective discomfort for occupants in nearby buildings. The risk of cosmetic or structural damage to buildings is only found to be due to extreme vibration levels, relative to what humans would find tolerable. Appropriate guidelines for vibration due to construction activities, based on potential effects on human comfort and building damage, are discussed in detail in Appendix B.

For human comfort, it is recommended to use Curve 1.4 and 2 of AS2670.2[6] as limits for night-time and daytime construction vibration respectively. The criteria curves are shown in Figure 3 as r.m.s. vibration velocity criteria.

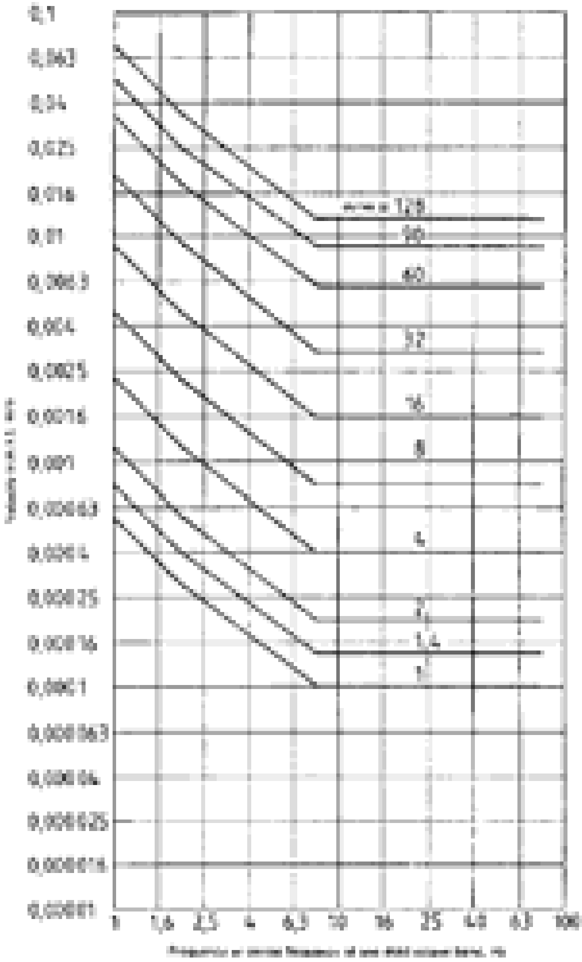


Figure 3 r.m.s vibration velocity combined-direction criteria curves (Ref: AS2670.2, Figure 5b)

Table 3 gives a summary of recommended international vibration limits for buildings to prevent damage. The most stringent limit is in the German and Swiss standards and is 3 mm/s. However, this is applicable to particularly sensitive constructions such as heritage buildings. Therefore, the next most stringent level of 5 mm/s has been conservatively chosen as an appropriate limit for standard residential buildings whilst the construction work is carried out. This limit should be met across the full frequency range of relevance, which is typically 4–250 Hz encountered in building construction.

6 AS2670.2-1990 Evaluation of human exposure to whole-body vibration - continuous and shock induced vibration in buildings (1 to 80 Hz), Standards Australia.

Table 3 Summary of Current International Vibration Standards

Standard	Type of building	Recommended vibration limit	Comments
DIN 4150	Structures of particular sensitivity or worthy of protection	3–20 mm/s at < 10 Hz 3–40 mm/s at 10–50 Hz 8–50 mm/s at > 50 Hz Also measurement at the top floor with limit of 8–40 mm/s across frequency range	Limit is for peak particle velocity in x,y, and z directions Measurement on the top floor in x and y directions only
BS 7385	Un-reinforced or light framed	15 mm/s at 4 Hz rising to 20 mm/s at 15 Hz then rising to 50 mm/s at 40 Hz and above	Limit is for peak particle velocity in x, y, and z directions
AS 2187	Houses and low-rise residential, commercial buildings not of reinforced or steel construction	5 mm/s	For buildings particularly susceptible to vibration. Limit is for peak *resultant* particle velocity, measured on the ground adjacent to the structure
SN 640 312	Structures of particular sensitivity	3–12 mm/s at 10–30 Hz 3–18 mm/s at 30–60 Hz	Limit is for peak particle velocity in x, y, and z directions

5.6 Blasting Noise and Vibration

Blasting may be necessary to remove rock in some areas of the alignment. Ground vibration and airblast (also called blast overpressure) are two environmental impacts from blasting. The airblast is generally more noticeable than the ground vibration. High levels of vibration transmitted through the ground and the airblast could annoy residents, or in extreme circumstances, cause damage to buildings or structures.

There is no specific guidance for noise and vibration from blasting during construction in Victoria. However, Appendix J of AS2187.2[7] provides general guidance on appropriate limits for ground vibration and airblast overpressure from blasting based on limiting the human response impacts of blasting. This is expected to be below the level likely to cause structural damage.

For residential receivers, this standard provides lower limits for longer term works, and a higher limit for short-term works, as detailed in Table 4.

7 AS 2187.2-2006 *Explosives - Storage, transport and use, Part 2 Use of explosives*, Standards Australia, 2006.

Table 4 Ground vibration and airblast over pressure limits (Source: AS2187.2 Tables J4.5(A) and J5.4(B))

Type of Blasting Operations	Peak Component Particle velocity limit (mm/s)	Peak Sound Pressure Level limit (dBL re 20 μPa)
Operations lasting longer than 12 months or more than 20 blasts	5 mm/s for 95% of blasts 10 mm/s maximum unless higher limit agreed with occupier	115 dBL for 95% of blasts 120 dBL maximum unless higher limit agreed with occupier
Operations lasting less than 12 months or less than 20 blasts	10 mm/s maximum unless higher limit agreed with occupier	120 dBL for 95% of blasts 125 dBL maximum unless higher limit agreed with occupier

Recommended limits for the vibration level and blast overpressure from blasting are also found in guidelines from the Australian and New Zealand Environment Conservation Council (ANZECC)[8]. These limit blast overpressure to 115 dB (lin, peak) at any residence, and ground vibration to 5 mm/s peak particle velocity (PPV). The guidelines also restrict blasting to between 9 am and 5 pm on weekdays and Saturdays, and recommend only one detonation per day. Blasting at night should be avoided unless it is absolutely necessary. These are generally slightly more stringent than those documented in AS2187.2-2006.

It is recommended that the AS2187.2 limits are adopted for Section 2 of RRL because building damage is unlikely to be caused below these vibration levels, while building damage and human discomfort will be minimal below the overpressure limits. ‘Conventional’ blasting at ‘normal’ distances is unlikely to create ground vibration levels of sufficient magnitude to cause building damage. Cracks in buildings are far more likely to be caused by local ground and foundation movements caused by the settlement and swell of the ground due to prolonged wet or dry weather.

8 *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration*, Australia and New Zealand Environment Council, September 1990.

6 Ambient Noise Measurements

Ambient noise measurements were conducted between February 2009 and May 2010 at various locations along Section 2 of the proposed RRL corridor. The measurement locations are shown in Figure 4a and 4b, and are considered to be representative of the various types of locations found in the study area. Ambient measurements were conducted at a range of locations- near roads, in housing estates currently being built, and on isolated rural properties (see Table 5). Initial noise level measurements were undertaken in February 2009, as part of the previous route selection process. These are included in this report along with the more recent measurements undertaken in April and May 2010.

The purpose of these measurements is to document the existing noise levels adjacent to the corridor and broadly describe the major contributions to the existing noise climate. Background noise measurements are also necessary as a basis for determining the potential noise impacts of construction works.

Figure 4a Ambient noise level measurement locations.

Figure 4b Ambient noise level measurement locations.

The measurement periods at each location are shown in Table 5 below.

Table 5 Measurement locations and measurement periods

Location	Start date	End date
4 Manor Road, Little River	12 February 2009	17 February 2009
4 Broadwater Road, Wyndham Vale	12 February 2009	17 February 2009
2 Silvergum Street, Wyndham Vale	15 April 2010	22 April 2010
9 Clarence Street, Wyndham Vale	15 April 2010	22 April 2010
780 Armstrong Road, Wyndham Vale	22 April 2010	29 April 2010
35 Academy Way, Wyndham Vale	22 April 2010	29 April 2010
40 Hobbs Road, Wyndham Vale	12 February 2009	17 February 2009
Lot 3 Hobbs Road, Wyndham Vale	22 April 2010	29 April 2010
1122 Sayers Road, Tarneit	22 April 2010	29 April 2010
1106 Leakes Road, Mount Cottrell	6 May 2010	13 May 2010
3 Becard Way, Tarneit	9 February 2009	12 February 2009
830 Leakes Road, Tarneit	6 May 2010	13 May 2010
625 Derrimut Road, Tarneit	6 May 2010	13 May 2010
690 Derrimut Road, Tarneit	29 April 2010	6 May 2010
548 Hopkins Road, Truganina	12 February 2009	17 February 2009
678 Boundary Road, Truganina	9 February 2009	12 February 2009

6.1 Methodology

The procedure for the measurement of noise from railways is based on the procedure for measuring road traffic noise in Victoria. Therefore the measurements were conducted 1 m from the centre of the window at the most exposed façade.

The height of the microphone was typically 1.2–1.5 m. Data were recorded at hourly intervals.

Details of the measurement equipment are provided in Table 6. Each item of equipment has current NATA[9] calibration certification. The calibration of equipment was checked in the field before and after each set of measurements.

[9] National Association of Testing Authorities

Table 6 Noise measurement instrumentation

Manufacturer	Name of Instrument	Serial Number
RTA Technology	Noise Logger	RTA02-016
RTA Technology	Noise Logger	RTA02-029
RTA Technology	Noise Logger	RTA02-034
RTA Technology	Noise Logger	RTA04-007
RTA Technology	Noise Logger	RTA04-008
RTA Technology	Noise Logger	RTA04-009
RTA Technology	Noise Logger	RTA04-010
Acoustic Research Laboratories	Noise Logger	Ngara 878060
Acoustic Research Laboratories	Noise Logger	Ngara 878061
Brüel & Kjær	Acoustical Calibrator Type 4231	2136569

6.2 Results

A summary of the ambient noise measurements is provided in Table 7. More detailed results are provided in Appendix C.

Table 7 Summary of daytime and night-time average and background noise levels, dB re 20μPa

Location	Average Noise Level dBL_{Aeq}		Lowest repeatable Background Noise Level, dBL_{A90}	
	Daytime	Night-time	Daytime	Night-time
4 Manor Road, Little River	56	50	34	32
4 Broadwater Road, Wyndham Vale	52	46	35	29
2 Silvergum Street, Wyndham Vale	56	47	33	30
9 Clarence Street, Wyndham Vale	54	49	37	36
780 Armstrong Road, Wyndham Vale	56	45	31	27
35 Academy Way, Wyndham Vale	57	46	30	27
40 Hobbs Road, Wyndham Vale	52	47	36	26
Lot 3 Hobbs Road, Wyndham Vale	55	44	35	25
1122 Sayers Road, Tarneit	56	42	25	22
1106 Leakes Road, Mount Cottrell	45	37	25	21
3 Becard Way, Tarneit	58	50	37	27
830 Leakes Road, Tarneit	59	44	35	24
625 Derrimut Road, Tarneit	55	48	40	28
690 Derrimut Road, Tarneit	53	47	34	27
548 Hopkins Road, Truganina	57	58	44	23
678 Boundary Road, Truganina	55	47	39	34

Generally, in isolated rural areas the measured noise levels were low and the audible sources were wildlife (such as crickets), trees rustling and occasional traffic in the distance. At properties near main roads, regular light traffic was audible. In housing estates, construction of houses in the estate was often audible along with occasional distant traffic. There was generally no significant existing freeway, rail or aircraft noise at any of the measurement locations.

7 Operational Railway Noise Predictions

The Nordic Rail Prediction Method[10], developed by Kilde, has been used to predict airborne railway noise levels adjacent to the proposed alignment. The Nordic method is commonly used for railway noise prediction in Australia because it provides both average and maximum noise level predictions. Predictions of the daytime average ($L_{Aeq,15\ hr}$), night-time average ($L_{Aeq,9\ hr}$) and maximum noise level (L_{Amax}) have been conducted.

The Nordic methodology has been implemented in SoundPLAN version 7.0, a well-established software package for environmental noise prediction. The computer acoustic model has been validated against spot calculations at specific locations.

7.1 Source Noise Levels

The acoustic analysis is based on the source noise levels for the following scenarios:

- Phase 1: Day 1 RRL (2014)
- Phase 4: Ultimate capacity (2030).

The type and number of rail vehicles assumed to be travelling in the corridor in each of the scenarios are based on the service plans provided in the report on rail capacity upgrade phases[4]. This suggests a peak hour service frequency of 8 trains per hour (tph) in Phase 1, rising to 16 tph in Phase 4. The report shows that the train length will be 8-cars for both Phase 1 and Phase 4. The current vehicle lengths on the Geelong line are generally between 2 and 7 cars.

Baseline hourly schedules have been developed from the June–July 2009 V/Line working timetables for the Melbourne-Geelong lines, and scaled to the future peak-hour and off-peak/counter-peak capacity.

The existing fleet mix has been developed from the current vehicle allocations to the regional lines. For the future phases of RRL operation, the fleet mix has been determined on the assumption that existing N and P class locomotives and carriages will be phased out by Phase 4 (2030), and that these will have been replaced with diesel multiple unit vehicles.

The schedules used in the acoustic model for Phases 1 and 4 are shown in Table 8 and Table 9 respectively. These schedules show the average number of trains of each type per hour, and average length (based on the average number of cars) during the 15-hour daytime period (7am - 10pm) and 9-hour night-time period (10 pm – 7 am).

Table 8 Train frequency, length and speed: Phase 1, Day 1 RRL (2014)

Section	Train type	Trains per hour, day	Trains per hour, night	Average train length, day (m)	Average train length, night (m)	Maximum train length	Train speed (km/h)
Deer Park to West Werribee	V'locity	1.5	0.6	202	93	202	160
	Sprinter	0.3	0.1	64	35	100	160
	Locomotive	1.2	0.4	93	87	90	115
West Werribee to Deer Park	V'locity	1.7	0.4	202	93	202	160
	Sprinter	0.3	0.1	64	35	100	160
	Locomotive	1.3	0.4	93	87	90	115

10 Nordic Council of Ministers, *Railway Traffic Noise- The Nordic Prediction Method,* TemaNord 1996:524

Table 9 Train frequency, length and speed: Phase 4, Ultimate capacity (2030)

Section	Train type	Trains per hour, day	Trains per hour, night	Average train length, day (m)	Average train length, night (m)	Maximum train length	Train speed (km/h)
Deer Park to West Werribee	V'locity	2.8	1.0	202	93	202	160
	Sprinter	0.2	0.1	64	35	100	160
	Locomotive	0.0	0.0	-	-	-	-
Deer Park to Wyndham Vale	V'locity	2.8	1.0	202	93	202	160
	Sprinter	0.2	0.1	64	35	100	160
	Locomotive	0.0	0.0	-	-	-	-
West Werribee to Deer Park	V'locity	3.1	0.8	202	93	202	160
	Sprinter	0.2	0.1	64	35	100	160
	Locomotive	0.0	0.0	-	-	-	-
Wyndham Vale to Deer Park	V'locity	3.1	0.8	202	93	202	160
	Sprinter	0.2	0.1	64	35	100	160
	Locomotive	0.0	0.0	-	-	-	-

Since some trains are expected to operate express services, train speeds through the stations have been assumed to be as for the surrounding track. This means that the predictions of average noise level in the vicinity of the stations are expected to be somewhat conservative, since some trains will slow down and stop at the stations.

7.1 Reference Source Noise Levels

The basic source noise levels for the railway vehicles depend on the type of vehicle (DMU, locomotive), car arrangement, vehicle speed and the combined wheel–rail interface roughness.

While there is some variation between individual rail vehicles, it is common to determine a reference source noise spectrum or noise level for various types of vehicle at a reference speed (usually 80 km/h) and distance (usually 10 m).

The reference source noise levels for Victorian rail vehicles have not previously been established. However, source noise levels for similar electric and diesel rail vehicles in NSW were documented by Rail Access Corporation (now RailCorp)[11]. These reference source noise levels have been based on a statistical analysis of hundreds of individual rail movements of various vehicle types.

The source noise levels given in Table 10 have been adopted for the various classes of trains that will use the corridor, and are based on a ballasted track support with continuous welded rail, which is proposed for the RRL. The levels for DMU and locomotive sources have been validated against noise level measurements undertaken adjacent to the existing Geelong, Ballarat and Bendigo lines (see Section 7.2).

Sound exposure levels (SELs) are used to determine the L_{Aeq} levels (by correcting for the number of events during the time period) and are measured 100 m from the train according to the Nordic Methodology. The reference distance for L_{Amax} levels is 10 m, as specified by Nordic Methodology.

11 *Rail Noise Database: State II Noise Measurements and Analysis*, Rail Access Corporation Report 00091 Version A, August 2000.

These reference noise levels are also adjusted for the actual speed of the vehicles based on the NSW source level data, as follows;

$L_{Aeq,\ DMU}\ (S) = L_{A,SEL}(\mathrm{ref}) + 13 \log (S/80)$

$L_{Amax,\ DMU}\ (S) = L_{Amax}(\mathrm{ref}) + 16.8 \log (S/80)$

$L_{Aeq,\ Loco}\ (S) = L_{A,SEL}(\mathrm{ref}) + 5.8 \log (S/80)$

$L_{Amax,\ Loco}\ (S) = L_{Amax}(\mathrm{ref}) + 8 \log (S/80)$

Where *S* is the actual vehicle speed.

Table 10 Reference source noise levels of vehicles used for acoustic modelling

Train Type	$L_{A,SEL}$ † $L_{Aeq,\ passby}$ (dB)	L_{Amax} (dB)	Reference Speed (km/h)
Diesel multiple unit (DMU) (V/locity, Sprinter)	83	92	80
N and P Class Locomotive	83	92	80
Passenger wagon	74†	- *	80

* Since passenger wagons are always hauled by an accompanying locomotive, the maximum noise level is determined by the locomotive.

An increase in source noise level of +10 dB(A) to account for impact noise from points and crossings has been applied at locations where these features are included in the track design.

No noise level penalty has been applied to account for general curving noise (eg. flanging or grinding) or wheel-squeal in tight-radius curves, since the track alignment has been designed with large-radius curves that are not subject to these effects. Similarly, no allowance has been made for train idling in stabling areas or passing loops, since their potential usage is not sufficiently defined at this stage and operational railway noise from these areas is unlikely to significantly influence the prediction results.

7.2 Validation Measurements

Site measurements of noise levels of DMU and locomotive rail vehicles have been undertaken adjacent to the existing Geelong, Ballarat and Bendigo lines. These measurements can be compared with the noise levels predicted using the reference noise levels in Table 10 to validate the reference source levels used in the modelling. The measurements have been taken at either 10 m or 15 m from the nearest track centreline in the free-field, depending on the level of access to the track wayside, and corrected to the reference distance.

Comparisons between the SEL at 100 m from the track and the L_{Amax} noise level 10 m from the track for DMU's are presented in Figure 5 and Figure 6. In each case the noise levels have been normalised to an eight-car DMU, and to the reference distance. Validation comparisons for the locomotive source are shown in Figure 7 and Figure 8.

The figures indicate that the source levels used for the predictions are broadly representative of the average noise level generated by the existing rolling stock.

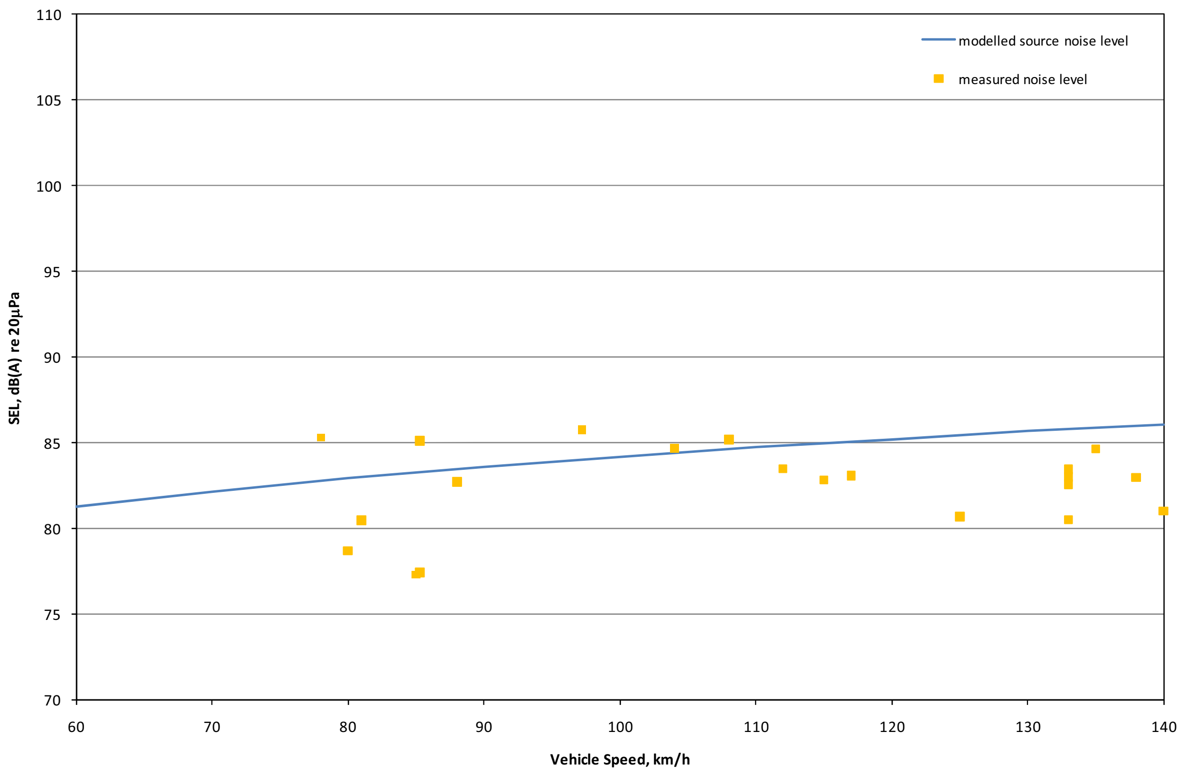


Figure 5 **Comparison between V/Locity and Sprinter prediction and measured sound exposure levels, SEL (dB(A) re 20 µPa), normalised to eight-car DMU at 100 m**

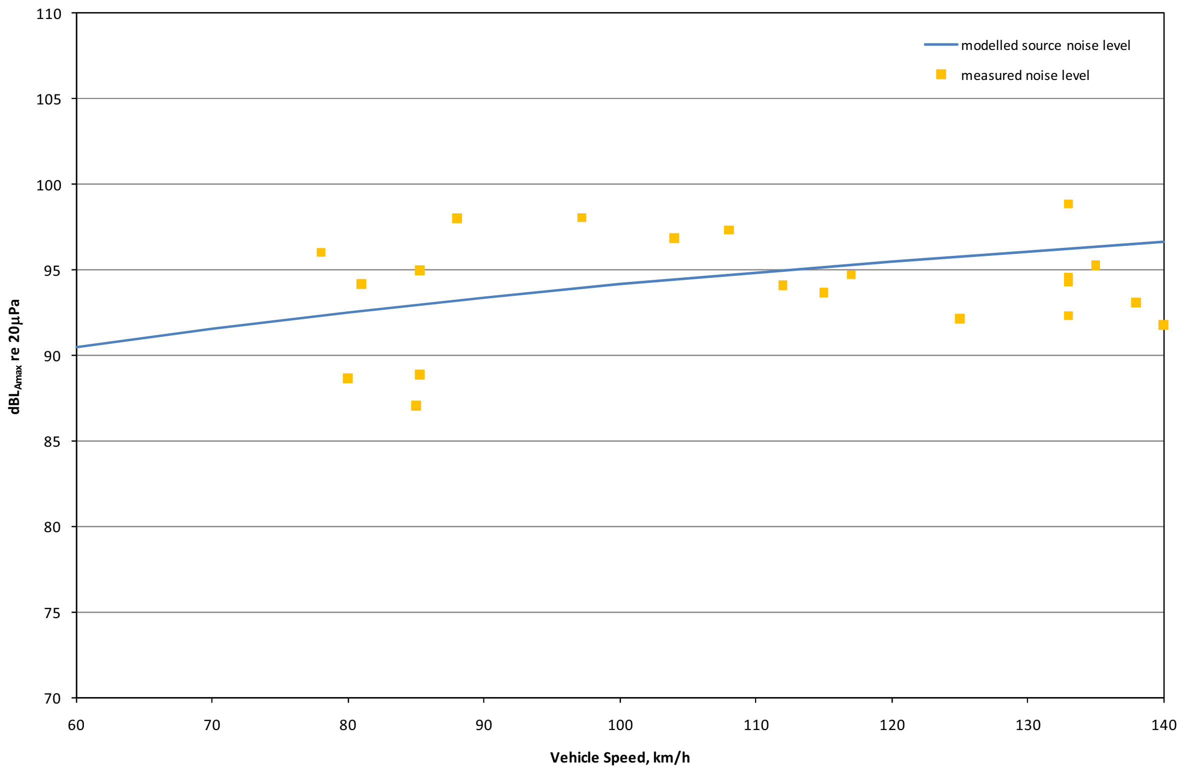


Figure 6 **Comparison between V/Locity and Sprinter prediction and measured maximum noise level, L_{Amax} (dB re 20 µPa), normalised to eight-car DMU at 10 m**

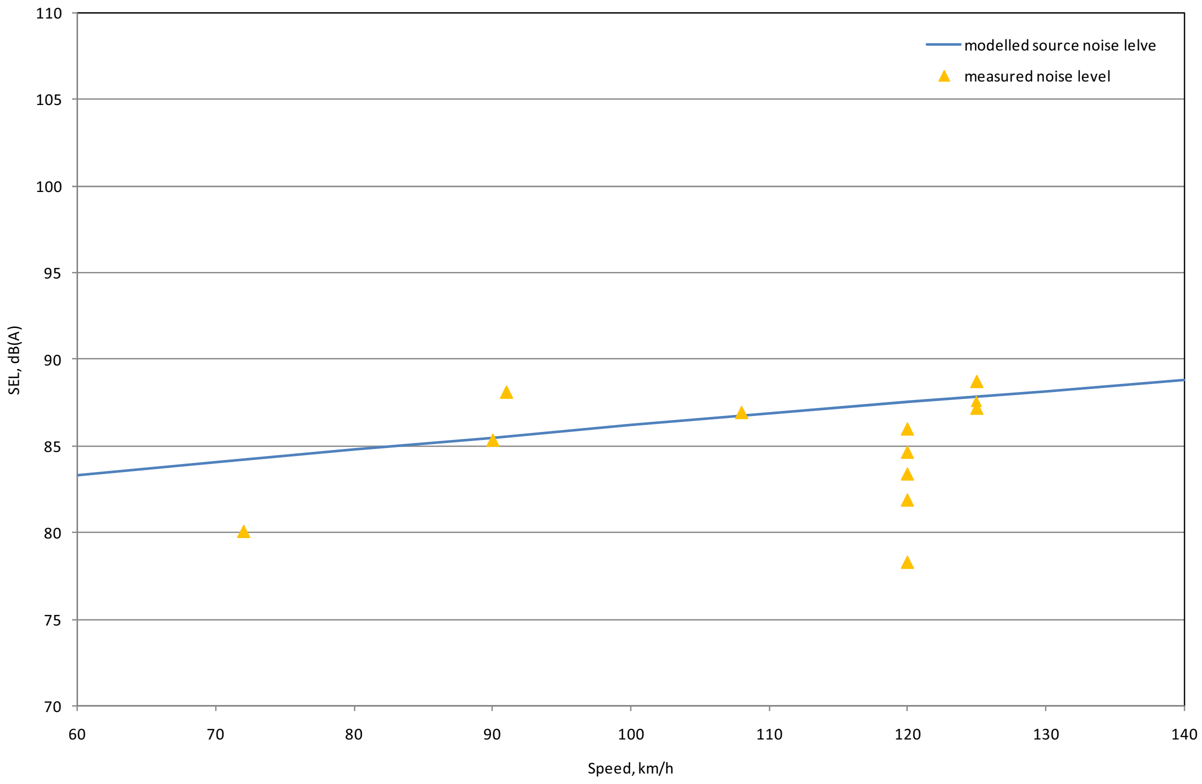


Figure 7 **Comparison between locomotive prediction and measured sound exposure levels, SEL (dB(A) re 20 μPa), at 100 m**

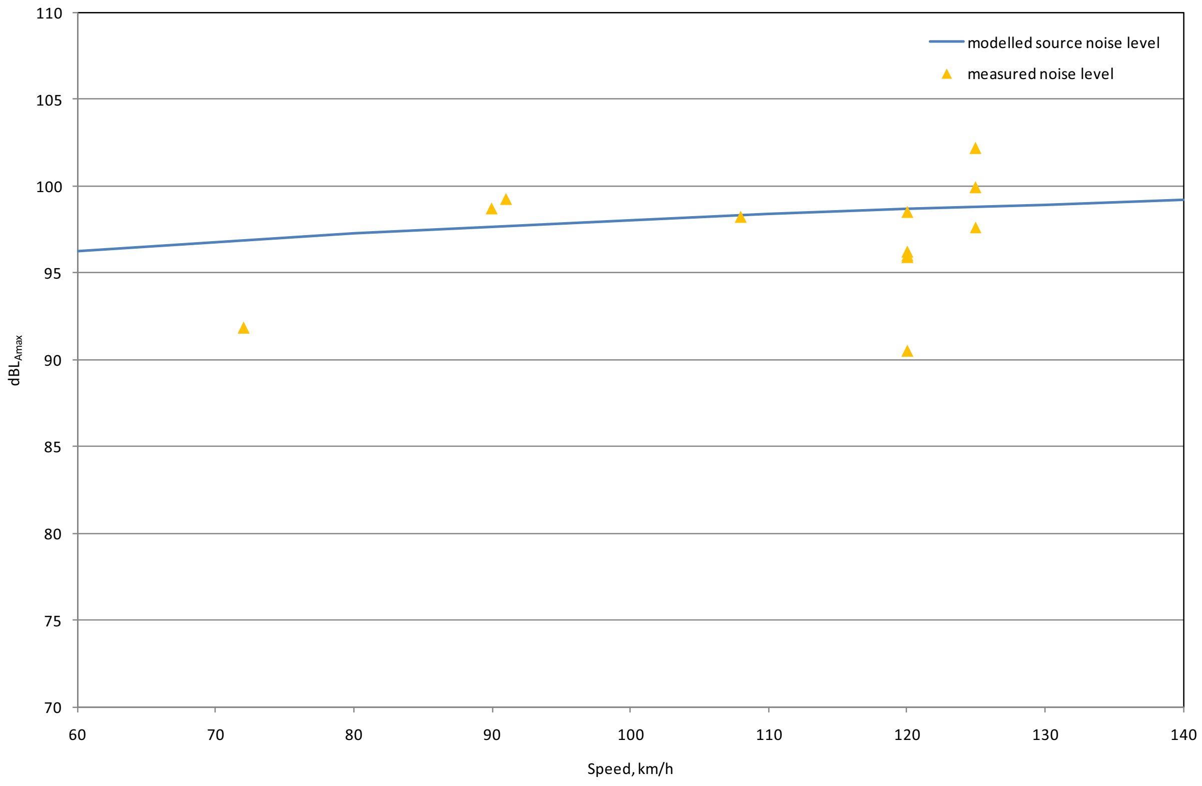


Figure 8 **Comparison between locomotive prediction and measured maximum noise level, L_{Amax} (dB re 20 μPa), at 10 m**

7.3 Topography

Terrain features were modelled using 1 m terrain survey contours. A ground absorption factor of 0.6 has been used since this has been found to be representative of ground absorption experienced in similar suburban locations. Shielding from existing terrain and the RRL earthworks concept design has been included in the model.

The railway alignment design is based on the reference design. Details of the input data used to construct the acoustic model are provided in Appendix D.

7.4 Noise Sensitive Receivers

All buildings representing potential noise sensitive receivers within approximately 500 m each side of the railway corridor are included in the noise model, with the receiver height set at 1.5 m. Where photogrammetric data were available, existing building locations and heights were imported into the acoustic model. Where photogrammetric data were not available for a particular building, the building location was traced off the aerial photography and a height of 3.5 m was assumed.

8 Operational Noise Prediction

8.1 Results

The daytime and night-time average (L_{Aeq}) and maximum (L_{Amax}) airborne noise levels predicted at individual residential properties along the alignment for Phases 1 and 4 are summarised in Figures 9 to 14.

The noise level predictions are estimates of the average and maximum noise levels likely to be experienced external to properties adjacent to the alignment based on the input assumptions described in Section 7. The predicted noise levels may change if the input variables, particularly the horizontal and vertical alignment, or number and type of rail vehicles, change during detailed design or operation of the railway.

These figures provide a summary of the likely daytime and night-time average, and maximum railway noise levels at all of the potentially affected existing residences located within approximately 500 m of the proposed railway.

Phase 4 (2030) average noise levels are expected to be 2 - 3 dB higher than during Phase 1 (2014), due to intensification of rail traffic over that period.

Detailed noise contours overlaid on aerial photography of the corridor, for each of the daytime and night-time noise indices, and Phases 1 and 4, are presented in Appendix E.

These noise contours can be used by planning authorities to understand the predicted extent of noise emissions from Section 2 of RRL, and develop planning controls for future developments adjacent and near to the railway alignment.

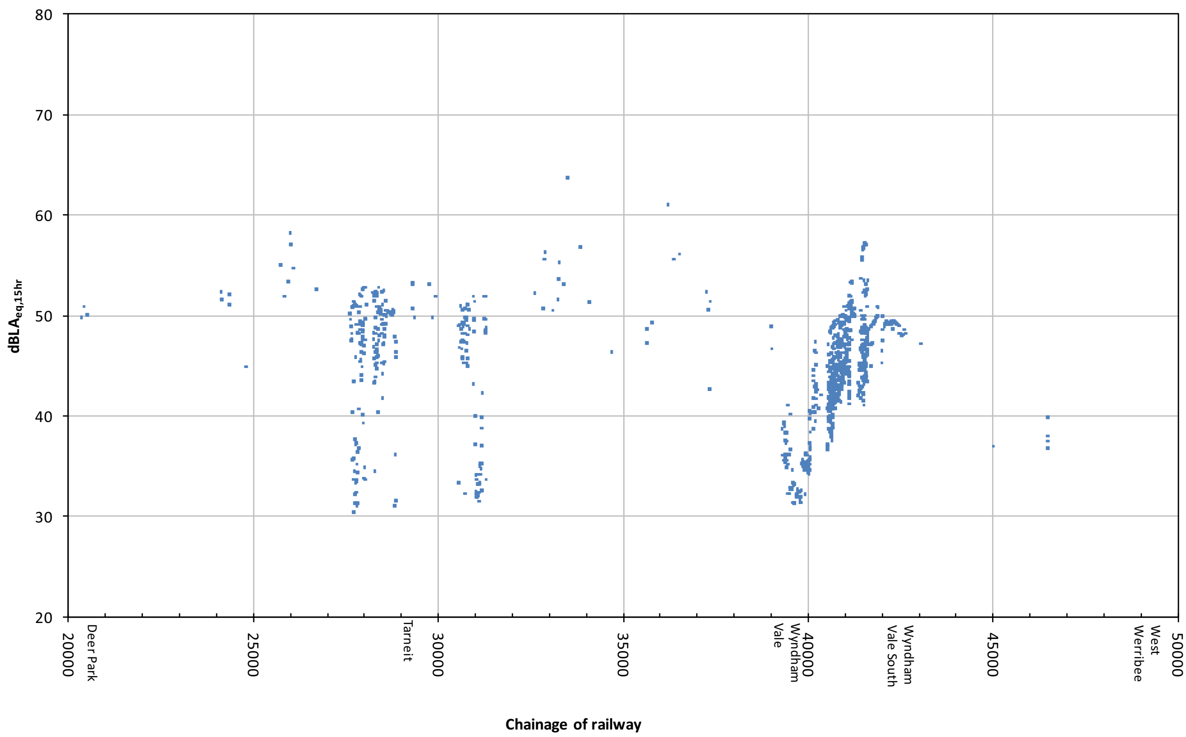


Figure 9 **Predicted daytime average railway noise level at each residence: Phase 1, Day 1 RRL (2014), dB$L_{Aeq,15hr}$ re 20 µPa**

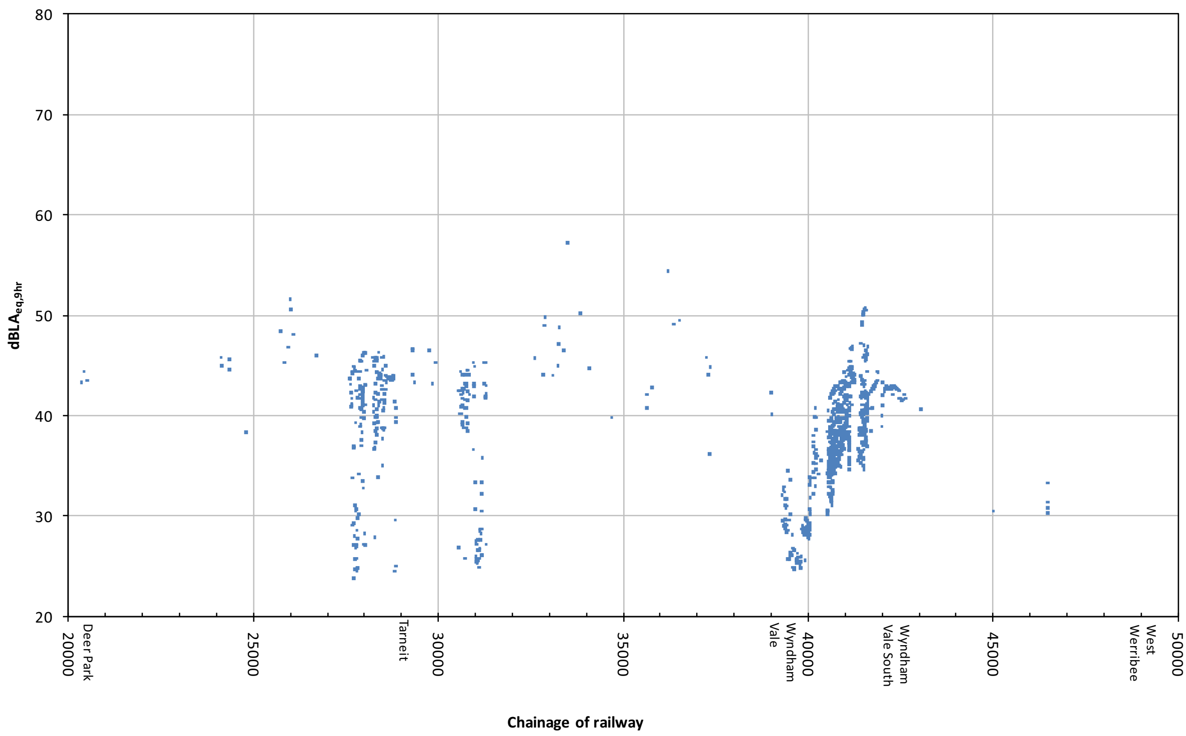


Figure 10 **Predicted night-time average railway noise level at each residence: Phase 1, Day 1 RRL (2014), dB$L_{Aeq,9hr}$ re 20 µPa**

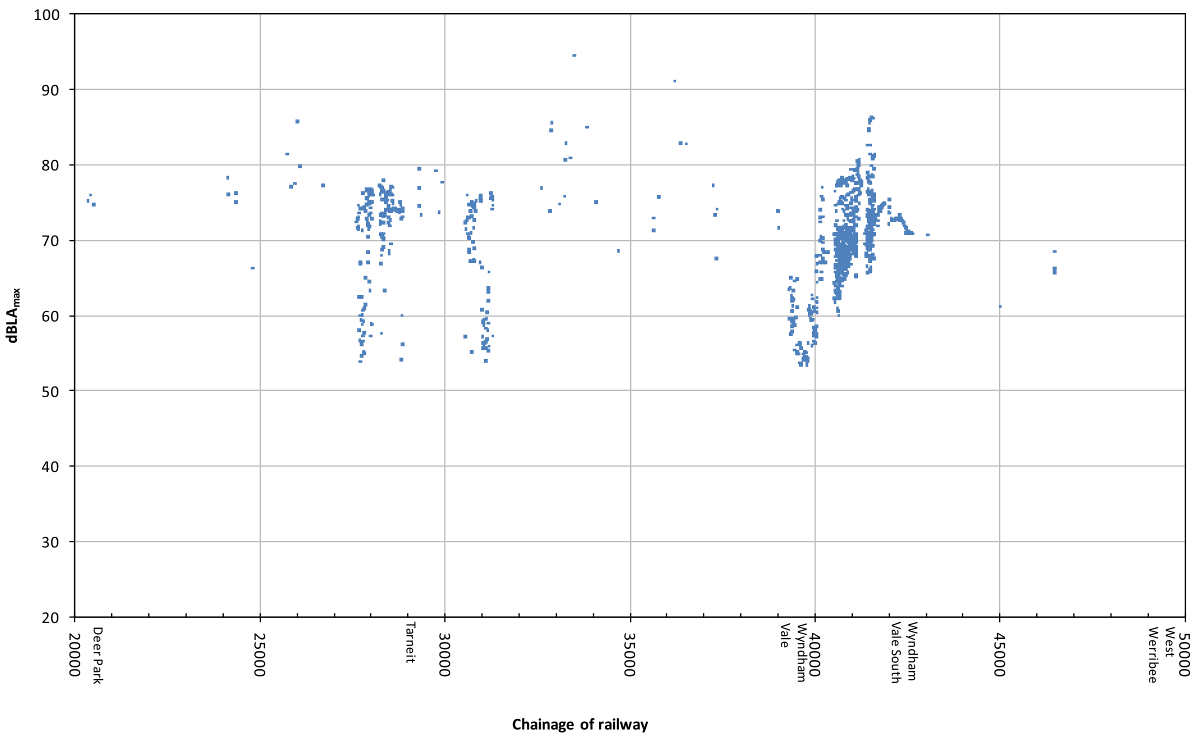


Figure 11 **Predicted maximum railway noise level at each residence: Phase 1, Day 1 RRL (2014), dBL_{Amax} re 20 µPa**

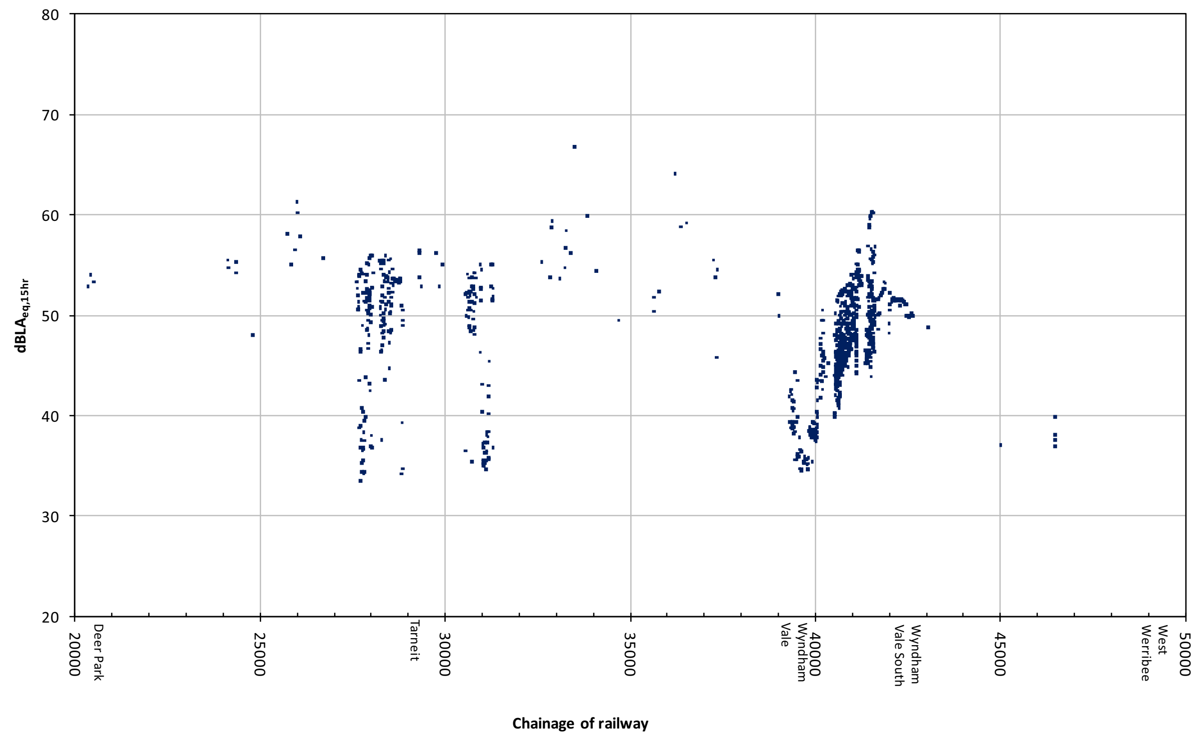


Figure 12 **Predicted daytime average railway noise level at each residence: Phase 4, Ultimate capacity (2030), $dBL_{Aeq,15hr}$ re 20 µPa**

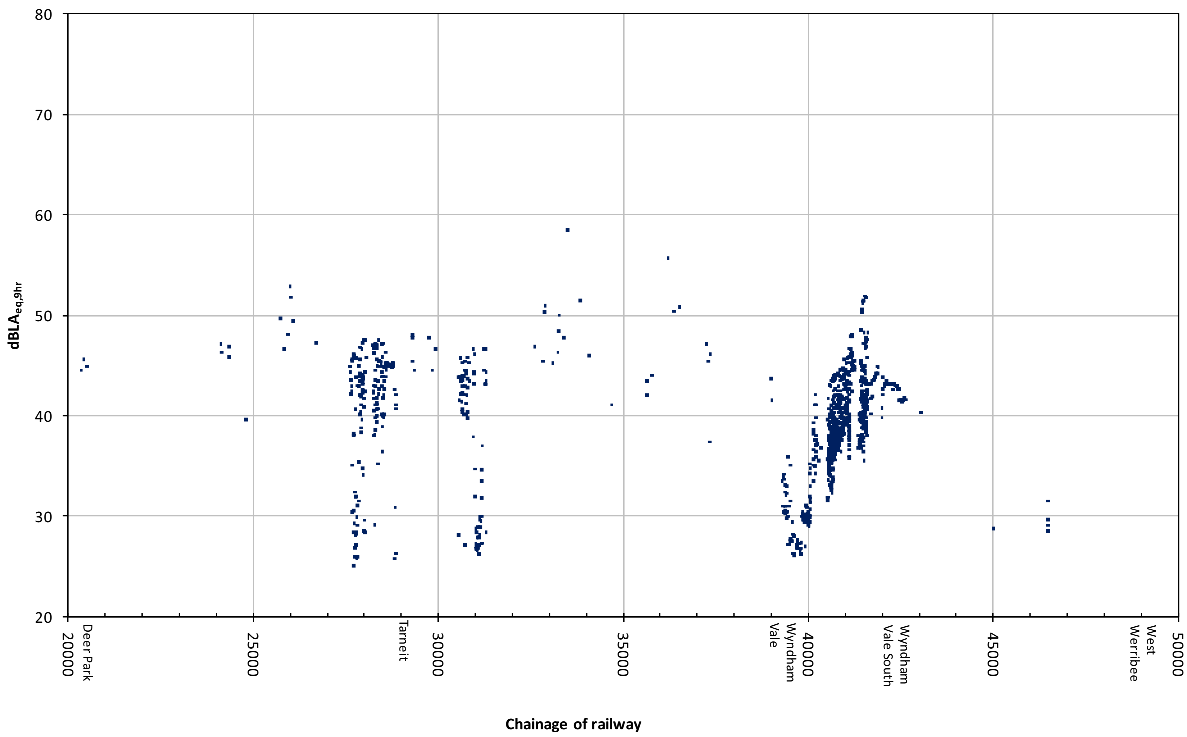


Figure 13 **Predicted night-time average railway noise level at each residence: Phase 4, Ultimate capacity (2030), $dBL_{Aeq,9hr}$ re 20 μPa**

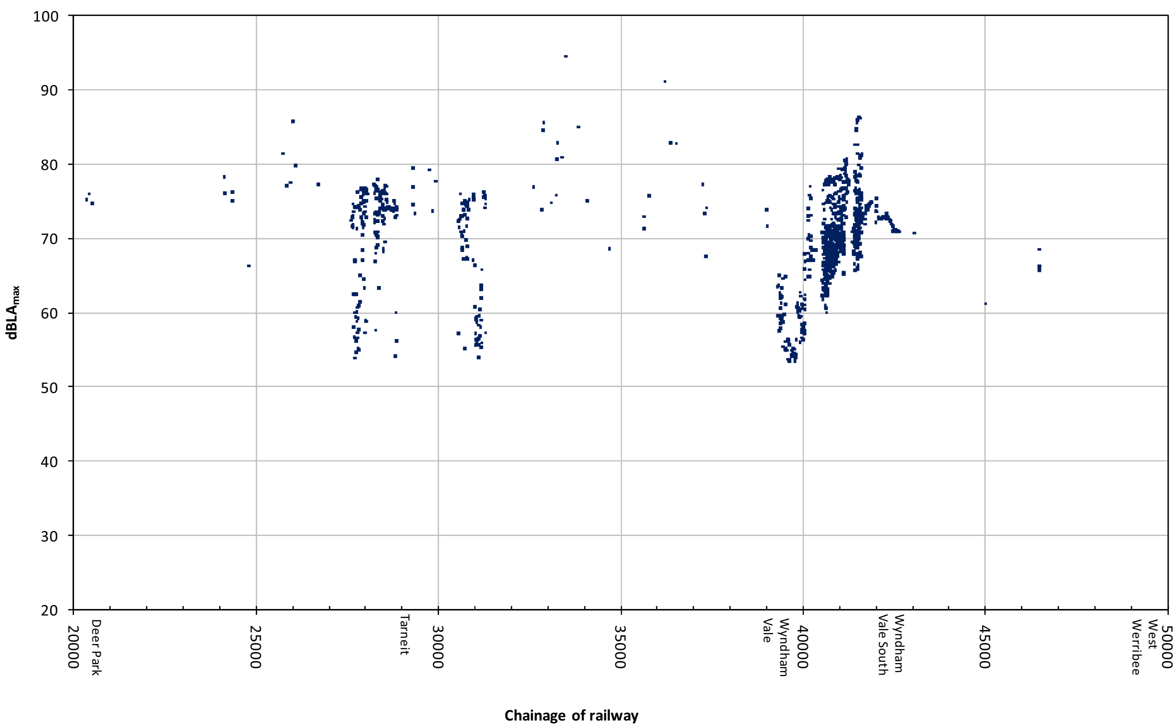


Figure 14 **Predicted maximum railway noise level at each residence: Phase 4, Ultimate capacity (2030), dBL_{Amax} re 20 μPa**

9 Construction Noise and Vibration

Construction of railways has the potential to create noise and vibration. Heavy construction equipment is typically used, and work sometimes needs to be undertaken at night-time and on weekends, times at which people are particularly sensitive to noise and vibration. Since the Section 2 alignment is largely through greenfield areas, the need for out-of-hours possessions to undertake the works is substantially minimised.

Sections 9.1 to 9.3 provide a summary of the primary construction works that are likely to result in significant noise and vibration emissions, and an estimate of the construction noise levels that may be generated.

9.1 Construction Noise

In order to model construction noise, typical construction scenarios likely to be required to undertake the works have been considered. For each scenario, a typical set of construction plant has been assumed, based on experience and advice from KBR Arup civil design engineers. The noise levels for construction activities have been modelled with the noisiest activities expected and the equipment has been modelled as all running simultaneously, which represents a conservative estimate of highest likely noise levels from these sources.

Areas where residential properties are near to potential construction locations have been chosen for noise predictions. These are representative of the range of rail and residential locations within Section 2 of RRL, and represent worst case noise impacts. They include station construction, road realignments, rail crossings, with both bored pile and spread footings, and other permanent way construction activities.

The railway is proposed to be constructed on multiple worksites. Works such as earthworks and construction of the permanent way will occur along the entire route, with specific local worksites for the construction of the stations and bridges at road crossings. Local residents may therefore be exposed to noise at various times over the entire construction period.

The predicted noise levels are based on the assumptions described in this section. The actual construction noise levels could vary, dependent on the particular construction methodology, sequencing or the individual pieces of construction equipment used by the construction contractor.

SoundPLAN 7.0 software has been used to predict construction noise. Predictions of instantaneous A-weighted sound pressure levels (SPLs) have been made according to the CONCAWE environmental noise propagation model[12]. Source heights have been taken to be 2 m above ground level for plant.

Eighteen areas were chosen for noise predictions. These are representative of the range of rail and residential locations within Section 2 of RRL. The plant assumed for each of the eight modelled scenarios are shown in Table 11. The construction activities included for noise modelling at each chosen location are shown in Table 12.

12 'The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighbouring Communities'. CONCAWE, Den Haag, May 1981.

Table 11 Plant associated with Section 2 construction scenarios

Construction Scenario	Plant	Quantity
Rail at grade	Hydraulic Vibratory Compactor	2
	Dumping truck	3
	Grader	1
	Tracked excavator (demolishing)	2
	Tracked excavator (ground excavation/earthworks)	2
	Wheeled loading truck	1
Rail in cut	Hydraulic Vibratory Compactor	2
	Dumping truck	3
	Grader	1
	Tracked excavator (demolishing)	2
	Tracked excavator (ground excavation/earthworks)	2
	Wheeled loading truck	1
	Rock Breakers	4
Tarneit station	Hydraulic Vibratory Compactor	1
	Concrete truck	1
	Crane	1
	Dozer	2
	Dump Truck (tipping fill)	1
	Grader	1
	Piling rig	1
	Tracked excavator	2
Wyndham Vale station	Hydraulic Vibratory Compactor	1
	Crane	1
	Dozer	2
	Dump truck (tipping fill)	1
	Grader	1
	Piling rig	1
	Tracked excavator	2
	Wheeled loader	1
Rail Crossings – Spread Footings	Hydraulic Vibratory Compactor	1
	Concrete truck	1
	Crane	1
	Dozer	1
	Piling rig	1
	Tracked excavator	2
	Wheeled loading truck	1

Construction Scenario	Plant	Quantity
Rail Crossings – Bored pile foundations	Hydraulic Vibratory Compactor	1
	Crane	1
	Dozer	1
	Dumping truck (tipping fill)	1
	Grader	1
	Piling rig	1
	Tracked excavator	1
	Wheeled loading truck	1
Road re-alignment (building road)	Dozer spreading fill	1
	Grader	1
	Tracked excavator (road construction)	2
	Hydraulic Vibratory Compactor	2
	Wheeled loading truck	1
Rail embankment construction	Hydraulic Vibratory Compactor	1
	Dumping truck	1
	Grader	1
	Tracked excavator (demolishing)	1
	Wheeled loading truck	1
	Dozer spreading fill	1

Table 12 Construction activities modelled

Location	Activity
1. Doherty's Road	Rail crossing – bored piled foundations
	Road re-alignment
	Rail at grade
2. Woods Road	Road re-alignment
	Rail at grade
3. Skeleton Creek Crossing	Rail crossing – bored piled foundations
	Rail at grade
4. Tarneit Station	Station construction
	Rail at grade
5. Derrimut Road	Rail crossing – spread footings
	Road re-alignment
	Rail at grade
6. Tarneit Road	Rail crossing – spread footings
	Road re-alignment
	Rail at grade

Location	Activity
7. Leakes Road	Rail crossing – spread footings Road re-alignment Rail at grade
8. Ballan Road	Rail crossing – spread footings Road re-alignment Rail at grade
9. Wyndham Vale station	Station construction Rail in cut
10. Manor Lakes Boulevard	Rail crossing – bored pile foundations Road re-alignment Rail in cut
11. Lollypop Creek Crossing (North)	Rail crossing – spread footings Rail at grade
12. Greens Road	Rail crossing – bored pile foundations Road re-alignment Rail at grade
13. Black Forrest Road	Rail crossing – bored piled foundations Road re-alignment Rail at grade
14. Riding Boundary Road	Road re-alignment Rail at grade
15. Middle Road	Rail crossing – spread footings Rail at grade
16. Robinsons Road	Road re-alignment Rail at grade
17. Christies Road (between Middle Road and Boundary Road)	Road re-alignment
18. Between Tarneit station and Skeleton Creek	Rail embankment construction

9.1.1 Rail Construction Equipment Noise Levels

Since the exact location of equipment and operating times are not known at this stage, all equipment associated with each construction activity has been assumed to be operating simultaneously. This represents a 'worst-case' estimate of the noise impact to local properties since, in practice, it is unlikely that all equipment will operate simultaneously.

Construction equipment used for each construction scenario have been modelled as separate point noise sources, placed at approximately 6 m intervals around the modelled construction area. Input noise levels are based on the DEFRA noise database[13] and

13 'Update of Noise Database for Prediction of Noise on Construction and Open Sites', Department for Environment Food and Rural Affairs (DEFRA), UK 2005.

AS 2436-2010[14], with the chosen level being the higher overall level (dBL_{Aeq}). AS 2436 has overall levels only, so spectra from DEFRA have been scaled to an equivalent overall level (dBL_{Aeq}).

Piling rig noise levels have been based on a large rotary bored piling rig, since driven piling is unlikely to be used.

Construction noise levels are shown in Table 13.

Table 13 Reference source sound power levels for construction of at-grade railway, dB re 10^{-12} W

Source	Activity	Overall Sound Power Level	Octave Band Centre Frequency, Hz 63	125	250	500	1k	2k	4k	8k
Dump truck	Tipping fill	117	123	112	116	111	111	112	105	101
Hydraulic vibratory compactor	Compacting	113	107	109	105	108	108	108	104	101
Tracked excavator	Ground excavation and earthworks	107	125	114	109	103	100	98	94	87
Tracked excavator	Demolishing	111	107	105	104	105	106	106	101	94
Wheeled Loading Truck	Loading	108	113	111	104	103	103	100	100	89
Concrete mixer truck		108	111	102	94	97	98	106	88	83
Large rotary bored piling rig	Piling	111	112	120	109	108	106	104	96	89
Tracked mobile crane		104	115	111	103	101	96	94	95	85
Dozer		109	113	102	104	101	100	106	90	84
Grader		110	104	109	112	107	105	102	96	90
Rock breaker		120	107	112	110	112	116	113	112	110

9.1.2 Construction Noise Predictions

Noise levels (SPLs) have been predicted for 18 different scenarios of construction activities proposed for Section 2 of the RRL as described in Table 12. The predictions have all plant associated with a particular construction scenario operating simultaneously and therefore represent worst case scenarios, since all plant is unlikely to operate at the same time.

Construction noise levels should not exceed background noise at residential properties by more than 10 dB during the evening period and be inaudible inside residences in the night period, as recommended by the *Noise Control Guidelines* (Publication 1254), described in Section 5.4. Noise surveys included in the Construction Noise and Vibration Management Plan, that forms part of the Environmental Management Plan, to be provided by the Contractors, will be used to determine the appropriate noise limits.

Plots showing noise predictions can be found in Section E2 of Appendix E.

Noise levels up to around 70 dB(A) are predicted at residential locations near to typical construction works. This is consistent with measurements undertaken by Arup at recent railway construction works for the Springvale Road Rail Grade Separation Project.

14 AS2436-2010 Guide to noise and vibration control on construction, demolition and maintenance, sites. Standards Australia.

Construction noise levels are therefore likely to be between 20–30 dB(A) above the prevailing background noise level at many locations near the alignment. This indicates that any works undertaken near to residential areas during the evening or night-time period are likely to require specific noise mitigation or temporary relocation of nearby residents.

9.2 Construction Vibration

The vibration produced by construction of the railway is highly dependent on the particular construction processes and equipment that are employed, and on the local geotechnical conditions.

Generally, since humans are more sensitive than building structures to vibration, adverse human response is expected to occur at greater distances from the works than those where building damage might occur. Nevertheless, vibration impacts from construction works would only be expected in close proximity to the works, and for processes such as piling or hammering which generate relatively high levels of vibration.

Guidance on typical safe working distances (i.e. distances likely to comply with human response and building damage criteria) has been developed by TIDC in its Construction Noise Strategy[5].

Table 14 provides recommendations reproduced from the TIDC guidance.

Table 14 Recommended Safe Working Distances for Vibration (reproduced from Table 3, TIDC Construction Noise strategy)

Equipment	Rating/Description	Safe Working Distance (m)	
		Cosmetic Damage	Human Response
Vibratory roller	< 50 kN (1–2 t)	5	15–20
	< 100 kN (2–4 t)	6	20
	< 200 kN (4–6 t)	12	40
	< 300 kN (7–13 t)	15	100
	> 300 kN (13–18 t)	20	100
	> 300 kN (> 18 t)	25	100
Small hydraulic hammer	300 kg to 5–12 t excavator	2	7
Medium hydraulic hammer	900 kg to 12–18 t excavator	7	23
Large hydraulic hammer	1600 kg to 18–34 t excavator	22	73
Vibratory pile driver	Sheet piles	2–20	20
Pile boring	≤ 800 mm	2 (nominal)	N/A
Jackhammer	Hand held	1 (nominal)	Avoid contact with structure

For general construction works, vibration impacts are expected to be negligible.

It can be seen that, where vibratory rollers are required, there is a low risk of building damage at distances up to around 20 m from the works, while some adverse human impacts could be expected for up to 75–100 m.

9.3 Noise and Vibration from Blasting

Major blasting works are likely to be necessary for the construction of Wyndham Vale cut. Some minor rock blasting is also expected to be necessary at several other locations along the corridor to accommodate the required vertical alignment.

Many site factors will influence the transmission of vibration through the ground, such as the lithography and topography between the blast site and the receiver locations.

AS2187.2[7] provides a methodology for estimating ground vibration levels, and should be used for sizing of blasts to meet the limits recommended by the standard (see Table 4). In addition, AS2187.2[7] provides recommendations for reducing the effects of ground vibration and overpressure levels including the following:

- Reduce the maximum instantaneous charge (MIC) or charge mass per delay by the use of delays of sufficient length, reduced hole diameter or deck loading
- Remove broken rock and excessive humps or toe prior to the firing of the main blastholes
- Optimise blast delay (change burden and spacing) by altering drilling patterns or delay layout or alter hole inclination from the vertical
- Exercise strict control over the location, spacing and orientation of all blast drill holes and use the minimum practicable sub-drilling which gives satisfactory toe conditions.
- Establish times of blasting to suit the situation.

It is expected that the charge sizes and blast design can be optimised to ensure that the criteria in Table 4 can be reasonably achieved.

10 Fixed Infrastructure Sites

Fixed infrastructure sites such as stations and plant (including transformers and signalling) have the potential to generate noise. Noise emissions from these elements of the project are required to comply with the site-specific noise limits developed in accordance with SEPP N-1.

However, at this stage, specific locations of these services and the type of equipment is not known. It is therefore not possible to undertake any detailed assessment. This will need to be undertaken by the Construction Contractor at the detail design stage.

Appendix A

Acoustic Terminology

A1 Acoustic Terminology

dB(A)

The unit generally used for the measurement of environmental, transportation or industrial noise is the A-weighted sound pressure level in decibels, denoted dB(A). The A-weighting is based on the frequency response of human hearing (for a given sound pressure level, low frequency sounds do not seem as loud as mid or high frequency sounds) and has been found to correlate well with human subjective reaction to various sounds.

An A-weighting network is built into sound level measuring instrumentation such that sound levels can be read directly from the meter in dB(A). An increase or decrease in sound level of approximately 10 dB(A) corresponds to a subjective doubling or halving in loudness. A change in sound level of 2 to 3 dB(A) is subjectively barely noticeable.

dBL_{Aeq}

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

$L_{Aeq,15hr}$

The L_{Aeq} noise level for the period 7:00 hours to 22:00 hours. It is the average daytime noise level over a 15 hour period.

$L_{Aeq,9hr}$

The L_{Aeq} noise level for the period 22:00 hours to 07:00 hours. It is the average night time noise level over a 9 hour period.

L_{Amax}

The maximum instantaneous noise level during the measurement period. The L_{Amax} level for electric trains most influenced by the traction system and the wheel-rail interface. The L_{Amax} level diesel trains is most influenced by the exhaust.

Structureborne Noise

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structure borne noise is controlled by structural discontinuities, ie expansion joints and floating floors.

Vibration

Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing human comfort or structureborne noise issues. Vibration amplitude may be quantified as a peak value, or as a root mean squared (rms) value. The rms value is of benefit because it takes into account both time history variation and energy content.

Vibration amplitude can be expressed as an absolute value eg 1mms^{-1} or as a ratio on a logarithmic scale in decibels:

vibration velocity level, dB = 20 log (V/V_{ref}).

(where the preferred reference level, V_{ref}, for vibration velocity = 10^{-9} ms^{-1}.)

The decibel approach has advantages for manipulation and comparison of data.

Typical Noise Levels

Some typical noise levels are given below:

Noise Level dB(A)	Example
130	Threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside night-club
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud radio (in typical domestic room)
60	Office or restaurant
50	Domestic fan heater at 1m
40	Living room
30	Theatre
20	Remote countryside on still night
10	Sound insulated test chamber
0	Threshold of hearing

Appendix B

Construction Vibration Guidelines

B1 Construction Vibration Guidelines

B1.1 Human Comfort

Guidelines for acceptable levels for human exposure to vibration in buildings are provided in Australian Standard AS 2670.2[1]. Guidelines are given in terms of satisfactory vibration levels related to the minimum adverse comment level by building occupants.

Table B1 provides the vibration limits for both continuous and intermittent vibration to prevent adverse comment in residential buildings. Daytime is between 7 am and 10 pm and night-time is between 10 pm and 7 am. These limits apply at the site boundary.

Table B1 Guideline vibration velocity limits, source: AS2670.2

Place	Time	Multiplying Factors (Curve No.)	
		Continuous Vibration	Intermittent or Impulsive
Residential	Day	2	60
	Night	1.4	20

Typically, curve 1.4 is taken to be the threshold of perception.

More recently, the NSW DECC has adopted a dose based approach, using the ibration dose value (VDV) as documented in its vibration assessment guideline[2] and BS6472[3]. The preferred and maximum values of VDV for residential receivers are listed in Table B2.

Table B2 Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$), source: NSW Assessing Vibration: a technical guideline

	Preferred Value	Maximum Value
Day	0.20	0.40
Night	0.13	0.26

B1.2 Building Damage

There is little reliable information on the threshold of vibration-induced damage in buildings. Although vibrations induced in buildings by ground-borne excitation are often noticeable, there is little evidence that they produce even cosmetic damage.[4] This lack of data is one of the reasons that for variation between international standards, for the British Standards Institution (BSI) not providing guidance before 1992 and for the absence of International Organisation for Standardisation (ISO) guidance limits.

However, there are several standards that can be referred to.

B1.2.1 German Standard

The relevant German standard is DIN 4150: Part 3[5]. This standard provides guidelines for short-term and steady-state structural vibration. For short-term vibration in buildings the limits are listed in Table B3.

1 AS 2670.2-1990 Evaluation of human exposure to whole-body vibration – Continuous and shock induced vibration in buildings (1 to 80 Hz)

2 Assessing vibration: A technical guideline, NSW DEC, February 2006.

3 BS6472-1992 Evaluation of human exposure to vibration in buildings (1-80 Hz). BSI.

4 Building Research Establishment (1995), 'Damage to Structures from Ground-borne Vibration', *BRE Digest*

5 DIN 4150-3 (1999-02) Structural vibration - Effects of vibration on structures

Table B3 Guideline Values of Vibration Velocity, v_i, for Evaluating the Effects of Short-term Vibration. Source: DIN4150

Structural type	Vibration Velocity, v_i, in mm/s			
	Foundation			Plane of floor of uppermost full storey
	less than 10Hz	10–50Hz	50–100Hz	Frequency mixture
Commercial, Industrial or Similar	20	20 to 40	40 to 50	40
Dwellings or Similar	5	5 to 15	15 to 20	15
Particularly Sensitive	3	3 to 8	8 to 10	8

The guidelines state that:

'Experience to date has shown that, provided the values given in Table [B3] are observed, damage due to vibration, in terms of a reduction in utility value, is unlikely to occur. If the values of Table [B3] are exceeded, it does not necessarily follow that damage will occur. Should these values be significantly exceeded, further investigation is necessary'.

B1.2.2 Swiss Standard

The relevant Swiss standard is SN 640 312:1978. For steady-state vibration, from machines, traffic and construction in buildings, the limits are given in Table B4.

Table B4 Guideline Values of Vibration Velocity, v_i, for Evaluating the Effects of Steady State Vibration

Structural type	Vibration Velocity, v_i, in mm/s	
	Foundation	
	10 to 30Hz	30 to 60Hz
Commercial, Industrial including retaining walls	12	12 to 18
Foundation walls and floors in concrete or masonry. Retaining walls and ashlar construction	8	8 to 12
Foundations and basement floors concrete, with wooden beams on upper floors. Brick walls.	5	5 to 8
Particularly sensitive.	3	3 to 5

B1.2.3 British Standard

The relevant British standard is BS7385: Part 2: 1993[6]. This standard was developed from an extensive review of UK data, relevant national and international documents and other published data, which yielded very few cases of vibration-induced damage. This standard contains the most up-to-date research on vibration damage in structures. Part 2 of the standard gives specific guidance on the levels of vibration below which building structures are considered to be at minimal risk.

The standard proposes the limits listed in Table B5 for the foundations of the building.

6 BS 7385: Part 2: 1993 Evaluation and Measurement for vibration in Buildings: Guide to damage levels from ground-borne vibration

Table B5 Transient Vibration Guide Values for Cosmetic Damage

	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15Hz and above
Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

The standard states in Annex A, that, *'the age and existing condition of a building are factors to consider in assessing the tolerance to vibration. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other ground-borne disturbance.'*

B1.2.4 Australian Standard

There is no specific Australian Standard referring to structural vibration in buildings. However, Appendix J of AS 2187.2 - 1993[7] recommends maximum peak particle velocities measured at the ground surface due to blasting. The lower recommended peak particle velocity is 5 mm/s. The standard states, however, that structures which may be particularly susceptible to ground-borne vibration should be examined on an individual basis. It is suggested that in the absence of a particular site-specific study then a maximum peak particle velocity of 5 mm/s is used.

7 AS 2187.2 - 1993 Explosives - Storage, transport and use. Part 2: Use of explosives

Appendix C

Noise Monitoring

C1 Noise Survey Detailed Results

Table C1 Summary of Results for 4 Manor Road, Little River*
(* Measurements carried out in 2009)

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	53	42
Tuesday	-	-
Wednesday	-	-
Thursday	-	56
Friday	57	44
Saturday	55	44
Sunday	56	40

Table C2 Summary of Results for 4 Broadwater Road, Wyndham Vale*
(* Measurements carried out in 2009)

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	50	43
Tuesday	-	-
Wednesday	-	-
Thursday	-	51
Friday	53	45
Saturday	52	43
Sunday	54	45

Table C3 Summary of Results for 2 Silvergum Street, Wyndham Vale

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	59	46
Tuesday	55	51
Wednesday	56	40
Thursday	-	46
Friday	52	52
Saturday	58	39
Sunday	54	40

Table C4 Summary of Results for 9 Clarence Street, Wyndham Vale

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	54	48
Tuesday	53	52
Wednesday	53	48
Thursday	-	48
Friday	54	48
Saturday	55	48
Sunday	54	51

Table C5 Summary of Results for 780 Armstrong Road, Wyndham Vale

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	62	42
Tuesday	47	42
Wednesday	52	41
Thursday	-	51
Friday	51	45
Saturday	57	39
Sunday	48	39

Table C 6 Summary of Results for 35 Academy Way, Wyndham Vale

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	54	47
Tuesday	56	47
Wednesday	56	48
Thursday	-	47
Friday	56	44
Saturday	62	43
Sunday	54	45

Table C 7 Summary of Results for 40 Hobbs Road, Wyndham Vale*
(* Measurements carried out in 2009)

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	51	46
Tuesday	-	-
Wednesday	-	-
Thursday	-	51
Friday	52	45
Saturday	51	42
Sunday	53	46

Table C 8 Summary of Results for Lot 3 Hobbs Road, Wyndham Vale

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	56	43
Tuesday	53	45
Wednesday	57	47
Thursday	-	44
Friday	55	43
Saturday	56	43
Sunday	52	44

Table C 9 Summary of Results for 1122 Sayers Road, Tarneit

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	53	42
Tuesday	53	42
Wednesday	59	43
Thursday	-	41
Friday	57	42
Saturday	56	43
Sunday	54	42

Table C 10 Summary of Results for 1106 Leakes Road, Mount Cottrell

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	43	40
Tuesday	46	36
Wednesday	42	36
Thursday	-	38
Friday	44	30
Saturday	41	34
Sunday	49	35

Table C 11 Summary of Results for 3 Becard Way, Tarneit*
(* Measurements carried out in 2009)

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	-	49
Tuesday	57	51
Wednesday	58	50
Thursday	-	-
Friday	-	-
Saturday	-	-
Sunday	-	-

Table C 12 Summary of Results for 830 Leakes Road, Tarneit

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	55	48
Tuesday	58	42
Wednesday	63	42
Thursday	-	44
Friday	60	37
Saturday	57	39
Sunday	55	42

Table C 13 Summary of Results for 625 Derrimut Road, Tarneit

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	56	52
Tuesday	56	51
Wednesday	54	47
Thursday	-	46
Friday	55	44
Saturday	55	44
Sunday	53	46

Table C 14 Summary of Results for 690 Derrimut Road, Tarneit

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	54	44
Tuesday	53	50
Wednesday	55	47
Thursday	-	47
Friday	53	45
Saturday	49	41
Sunday	52	50

Table C 15 Summary of Results for 548 Hopkins Road, Truganina* (* Measurements carried out in 2009)

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	56	59
Tuesday	-	-
Wednesday	-	-
Thursday	-	60
Friday	58	58
Saturday	56	53
Sunday	56	58

Table C 16 Summary of Results for 678 Boundary Road, Truganina*
(* Measurements carried out in 2009)

	Measurement results	
Day of the week	$L_{Aeq,15hr}$, dB	$L_{Aeq,9hr}$, dB
Monday	-	46
Tuesday	54	49
Wednesday	55	45
Thursday	-	-
Friday	-	-
Saturday	-	-
Sunday	-	-

C2 Measured noise level graphs

Figure 1 4 Manor Road, Little River

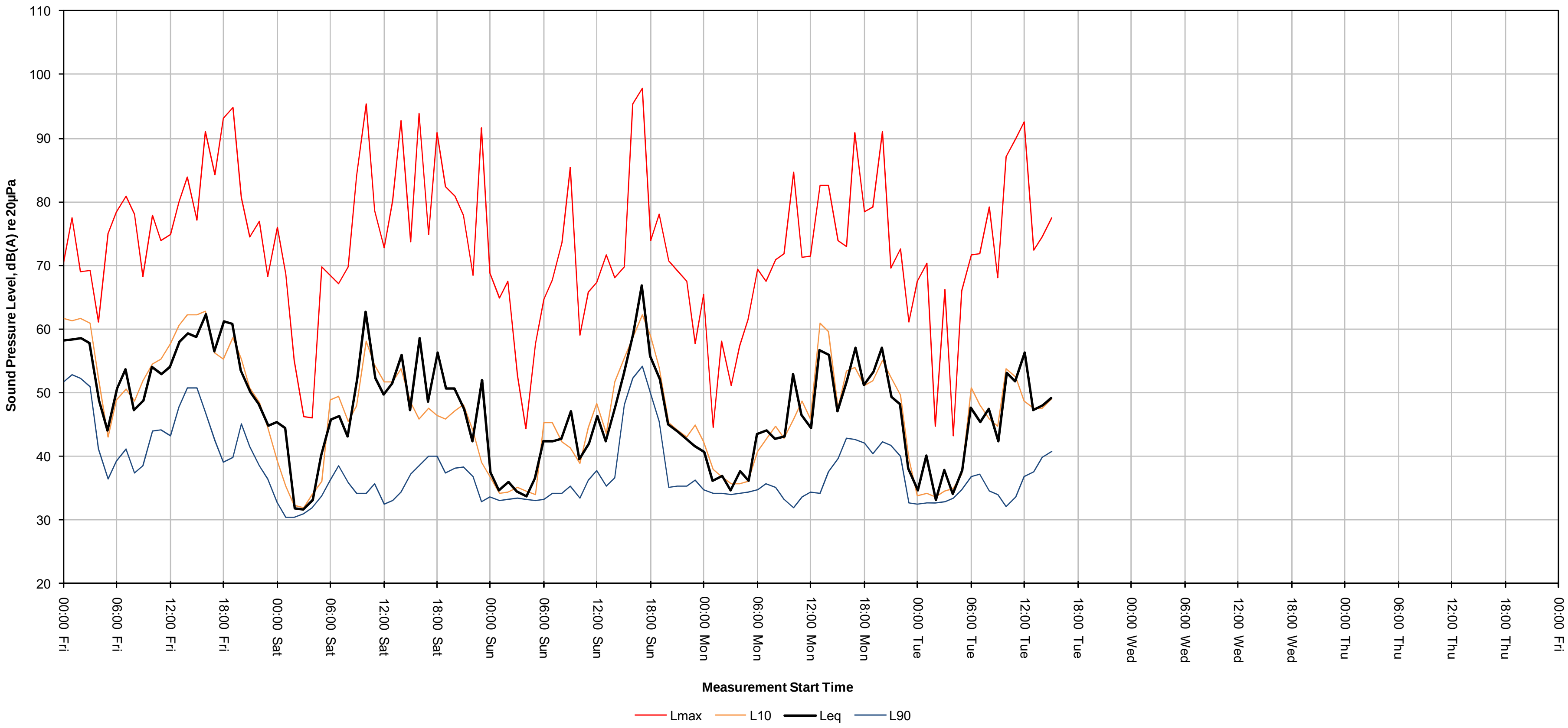


Figure 2 4 Broadwater Road, Wyndham Vale

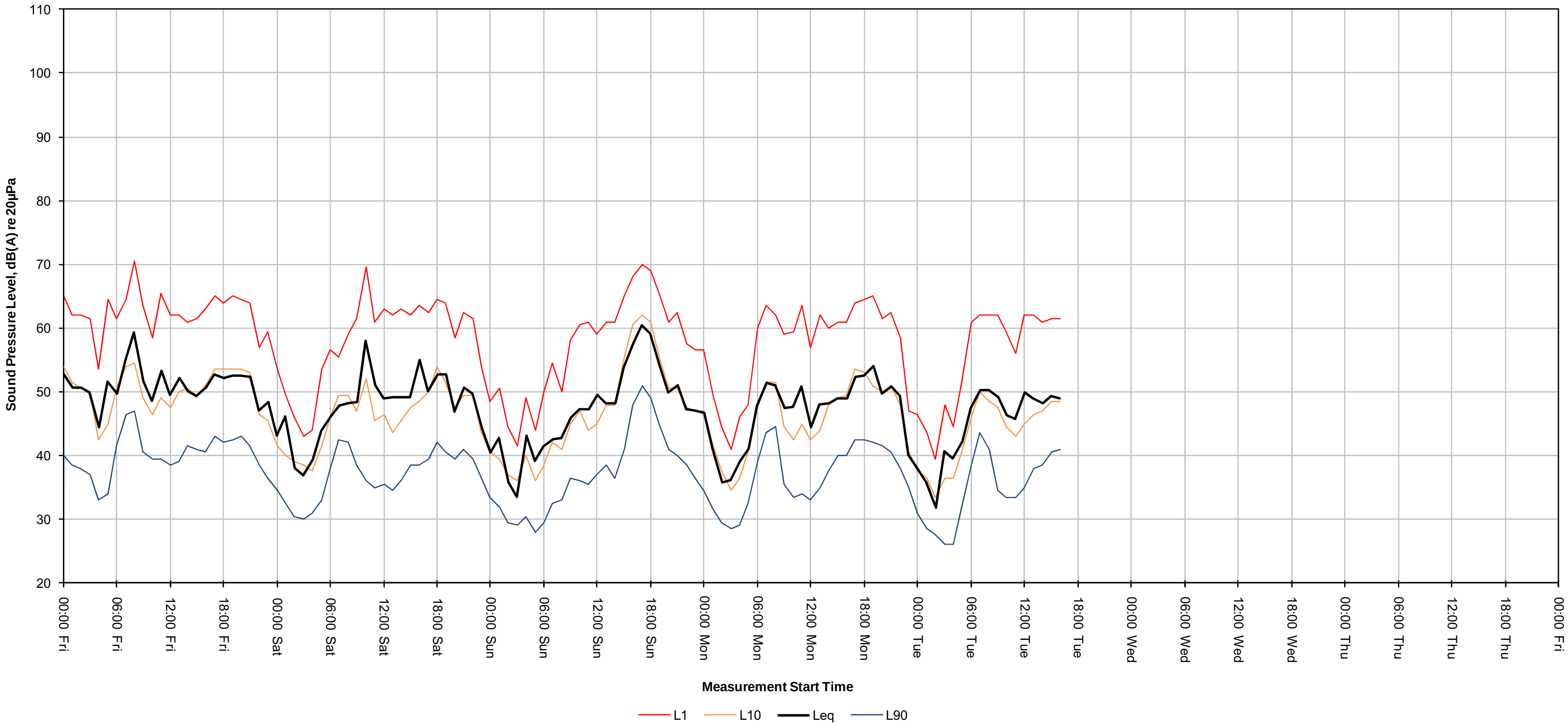


Figure 3 2 Silvergum Street, Wyndham Vale

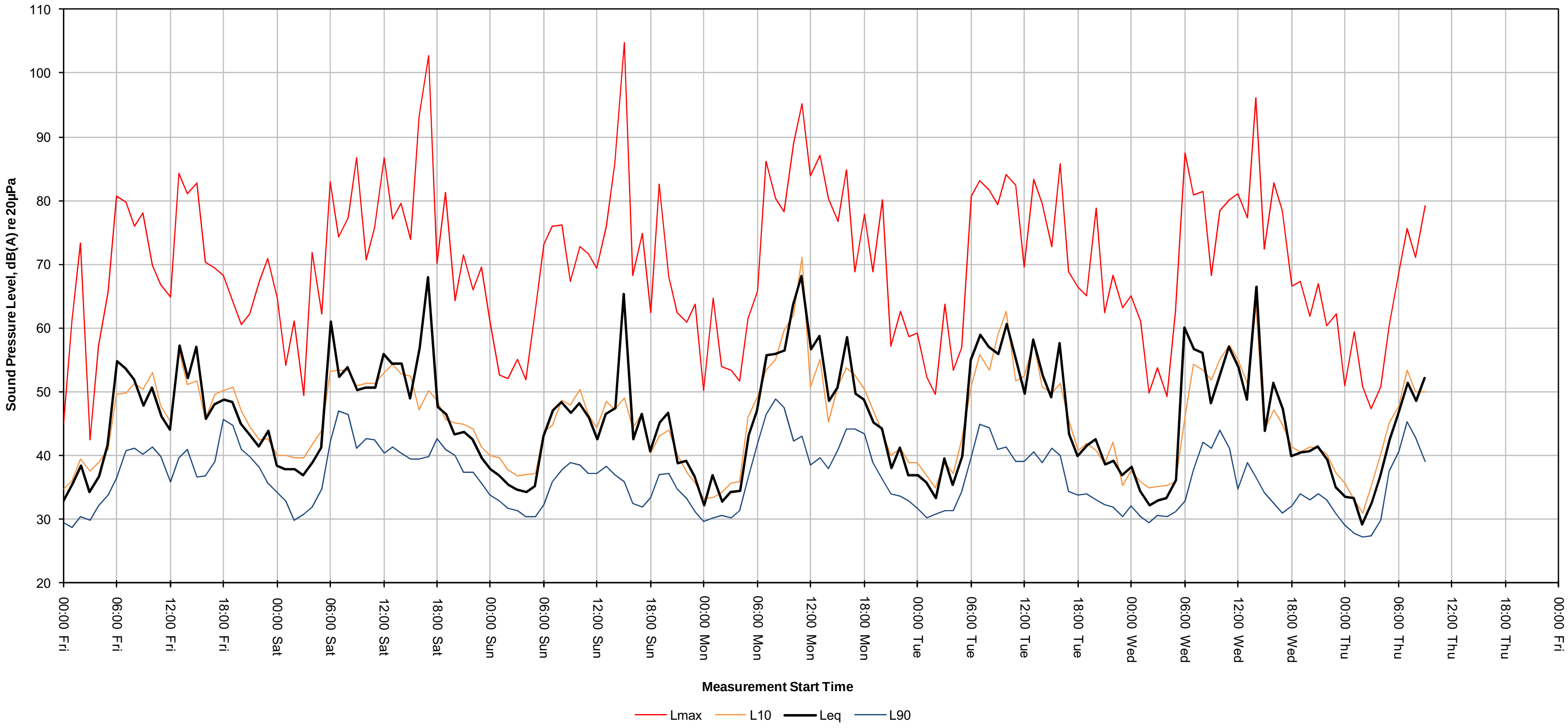


Figure 4 9 Clarence Street, Wyndham Vale

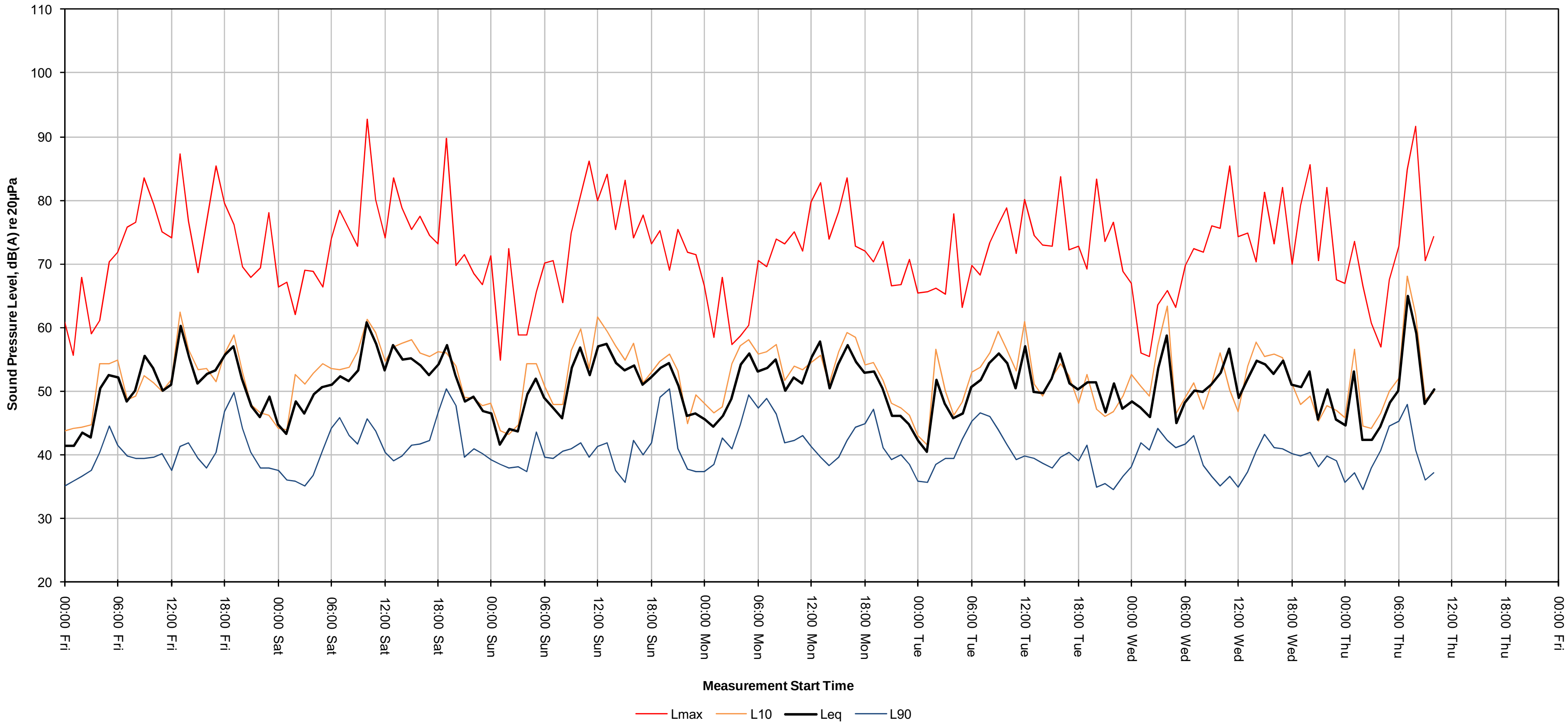


Figure 5 780 Armstrong Road, Wyndham Vale

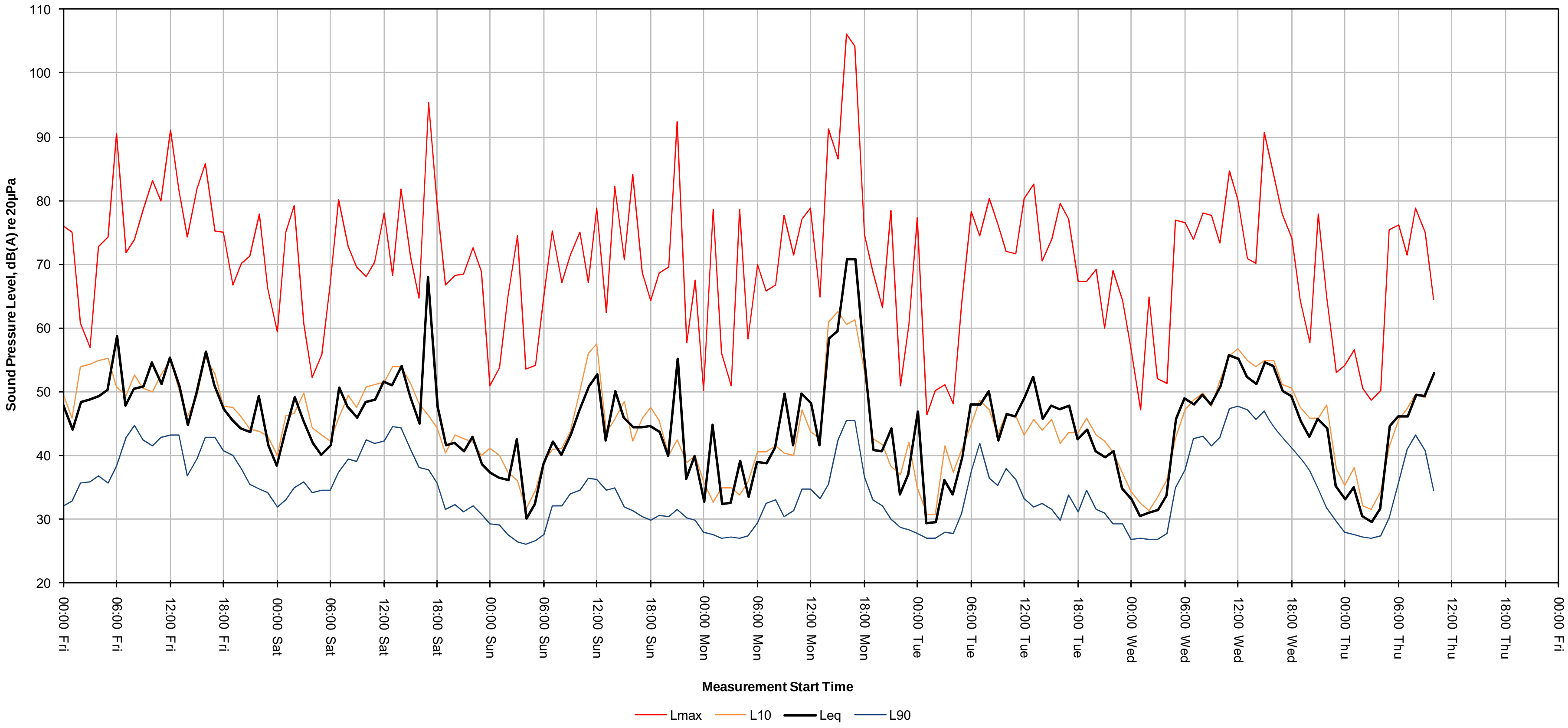


Figure 6 35 Academy Way, Wyndham Vale

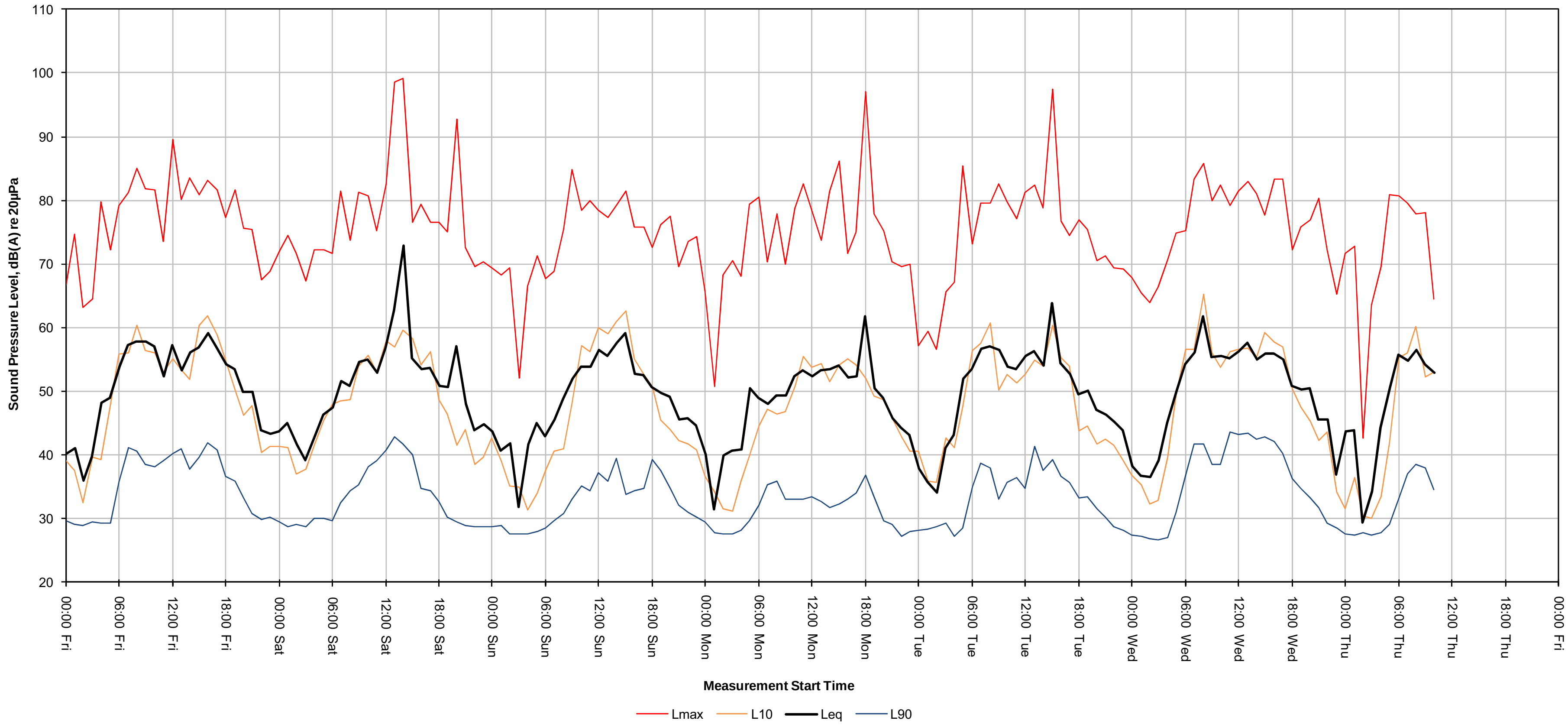


Figure 7 40 Hobbs Road, Wyndham Vale

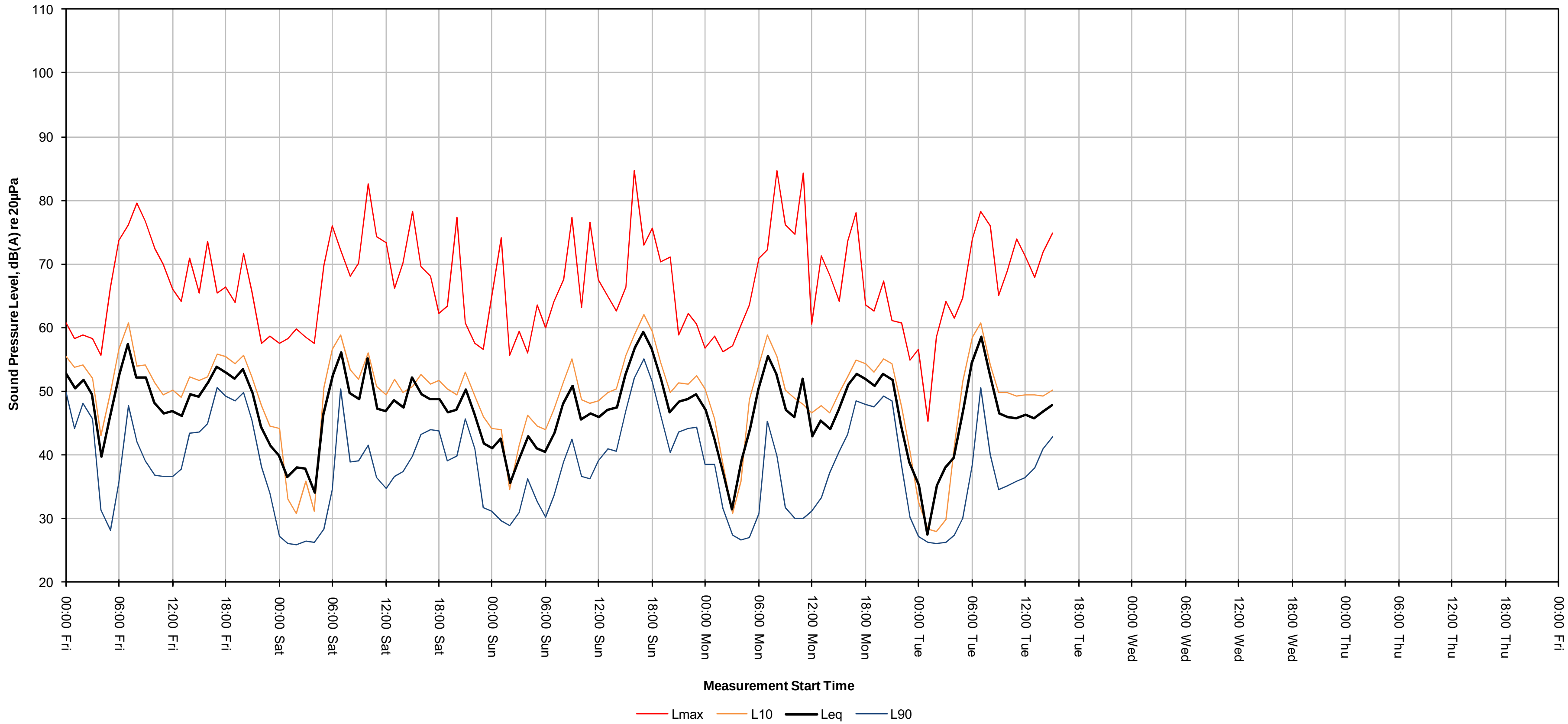


Figure 8 Lot 3 Hobbs Road, Wyndham Vale

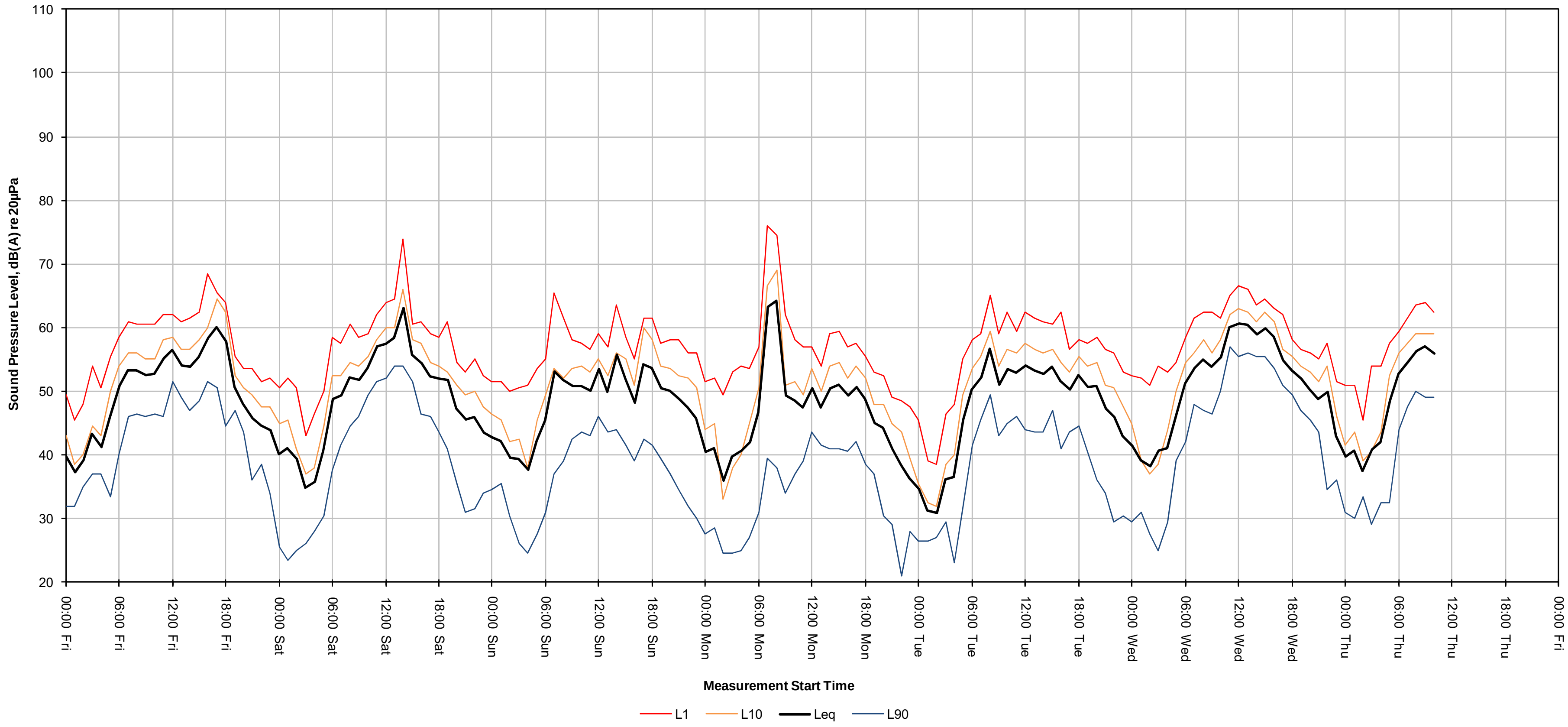


Figure 9 1122 Sayers Road, Tarneit

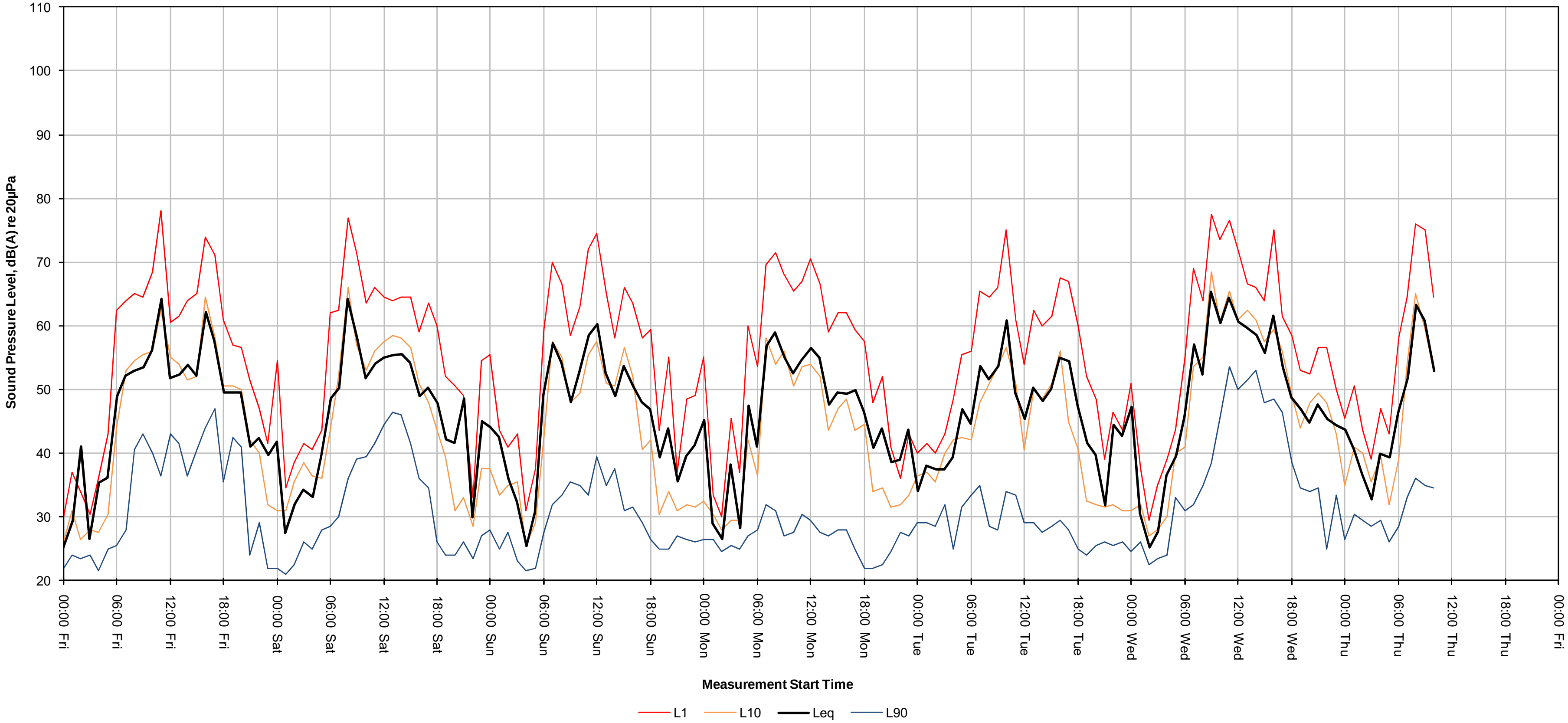


Figure 10 1106 Leakes Road, Mount Cottrell

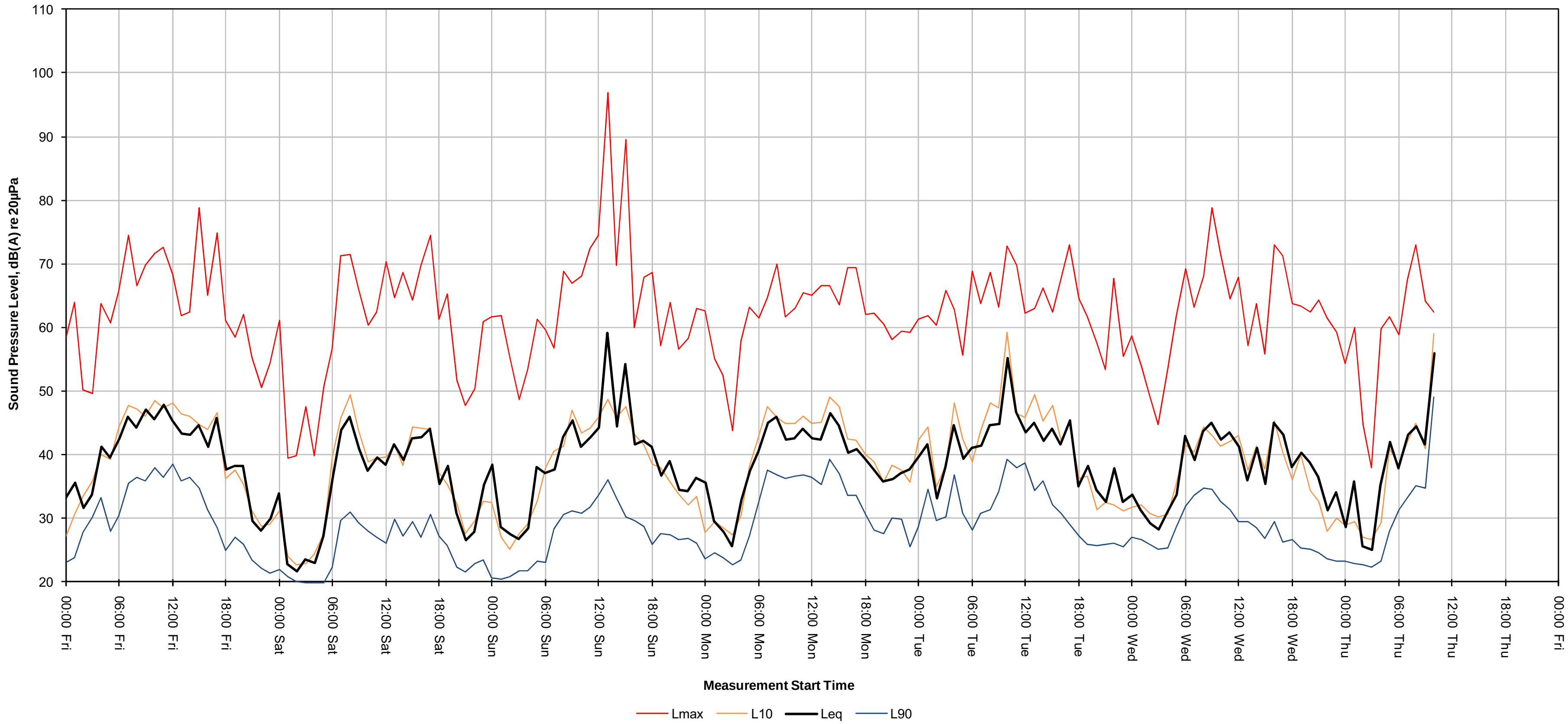


Figure 11 3 Becard Way, Tarneit

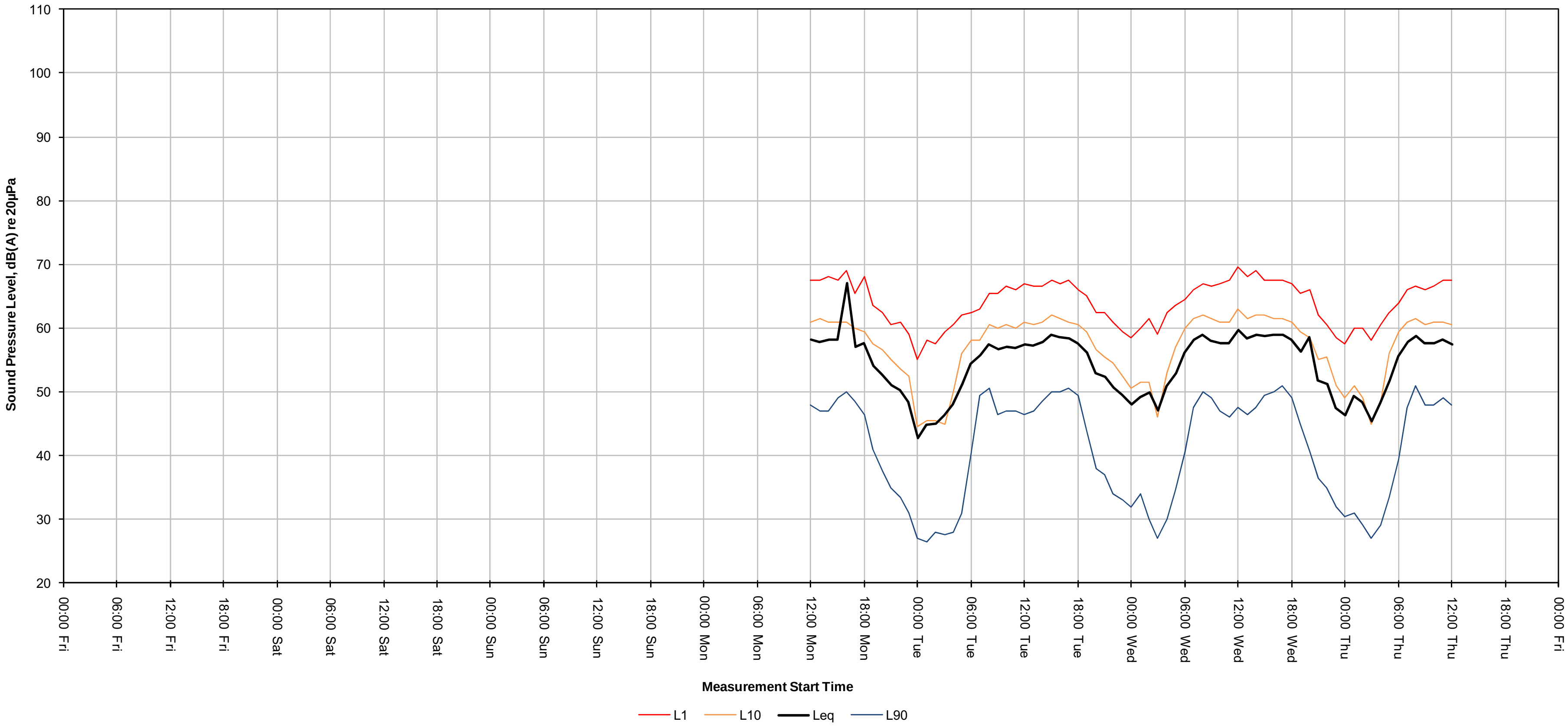


Figure 12 830 Leakes Road, Tarneit

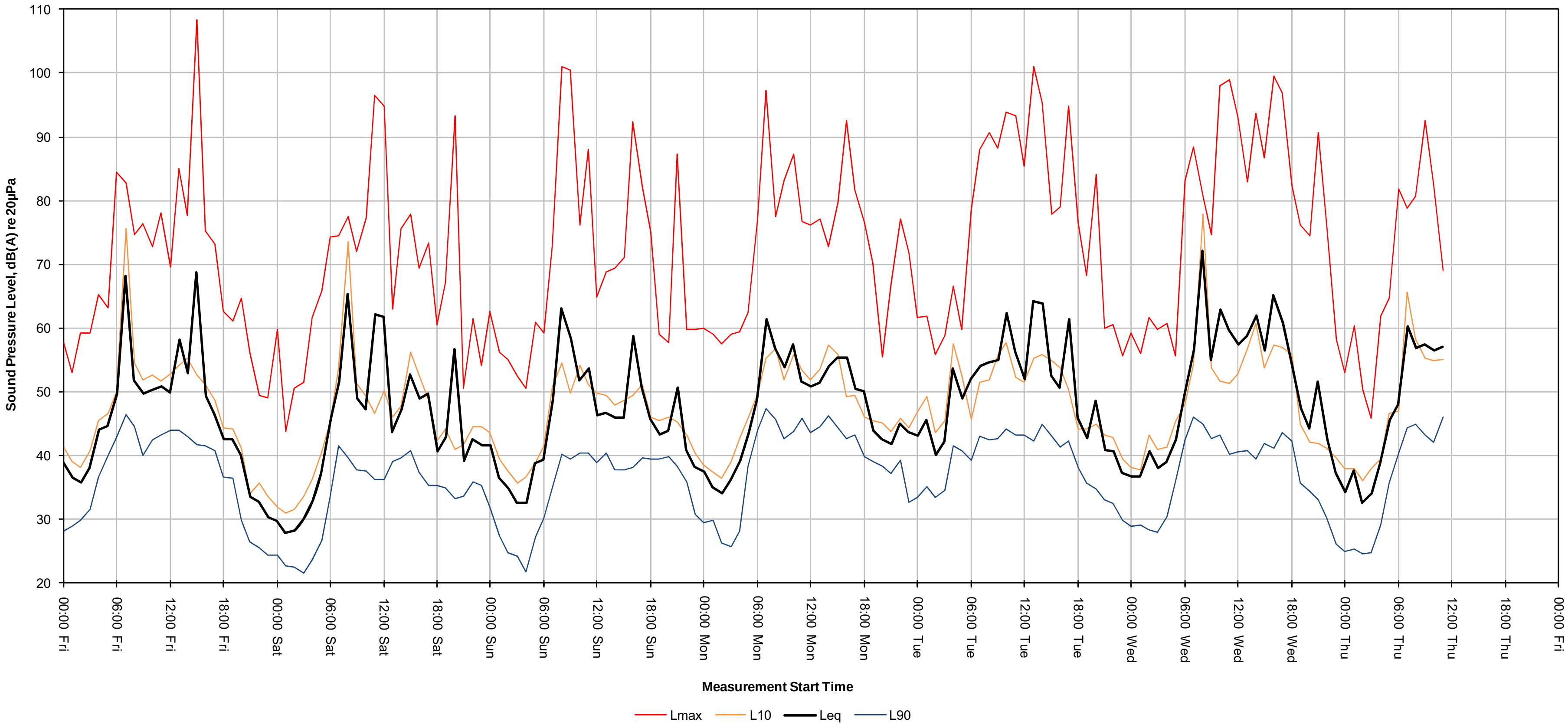


Figure 13 625 Derrimut Road, Tarneit

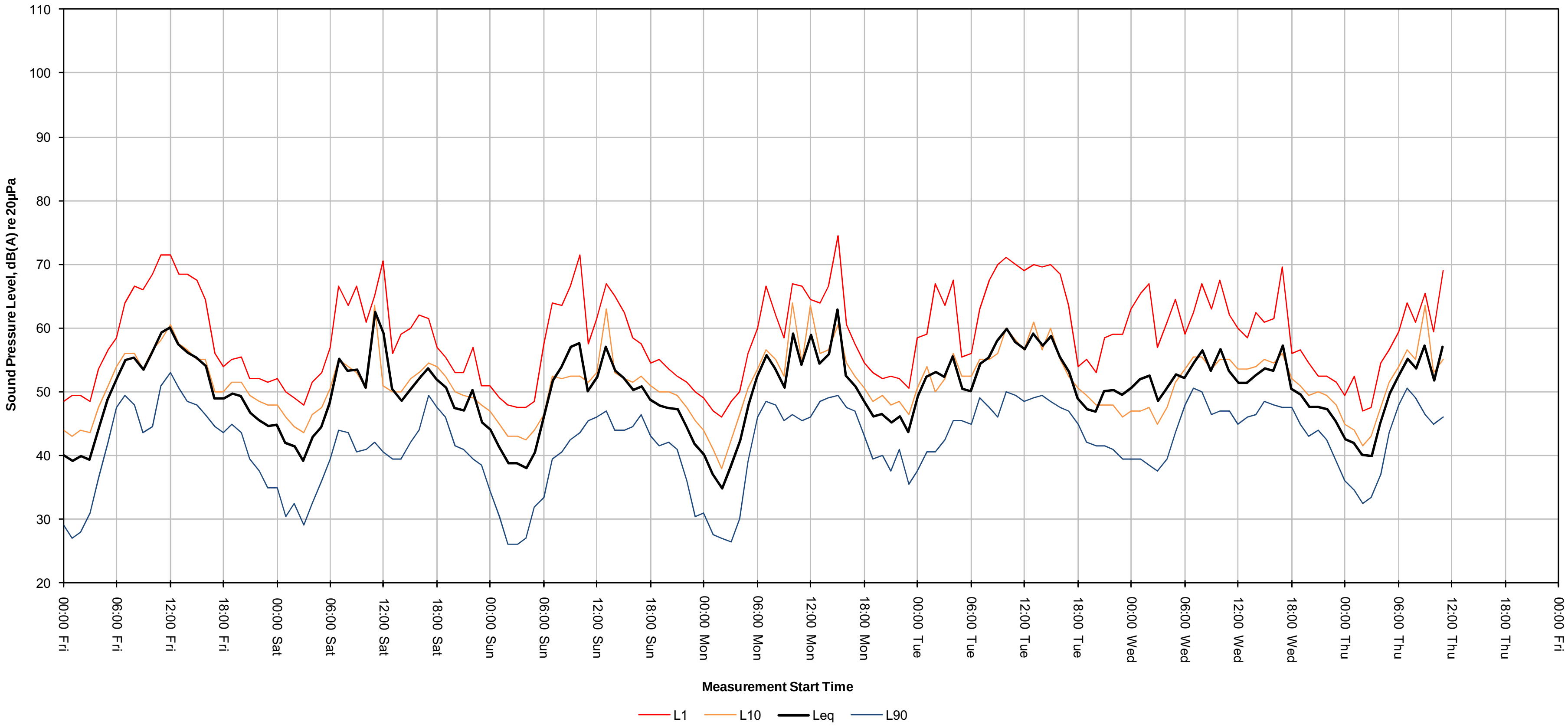


Figure 14 690 Derrimut Road, Tarneit

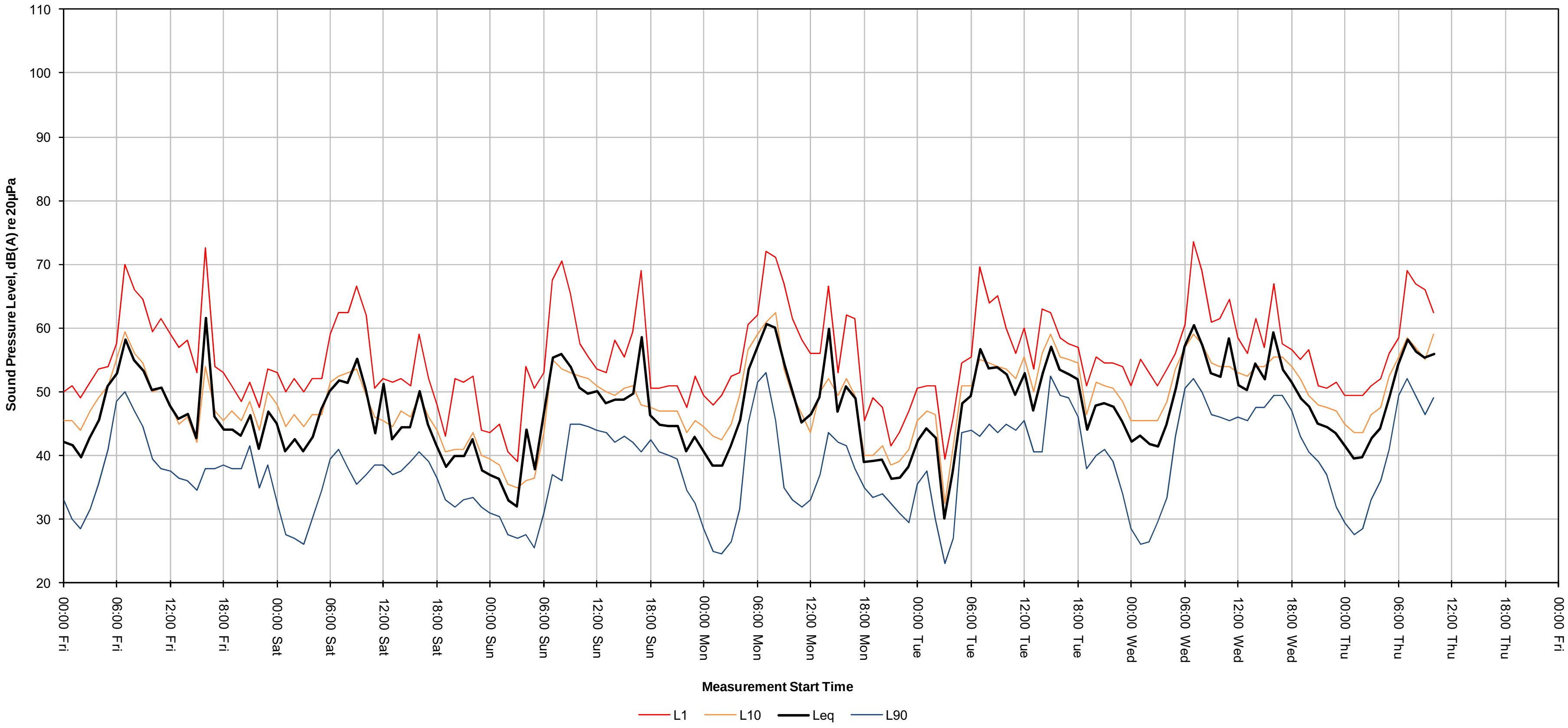


Figure 15 548 Hopkins Road, Truganina

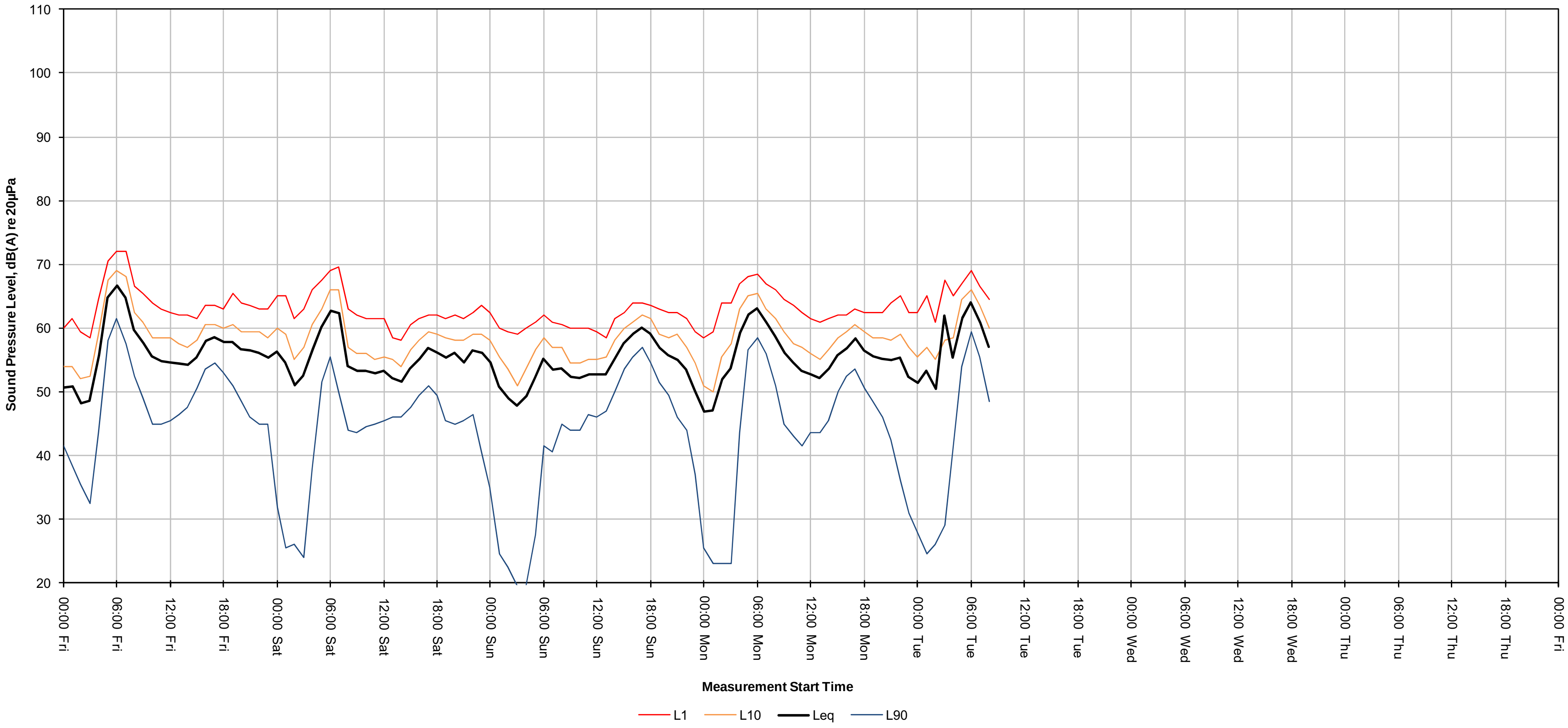
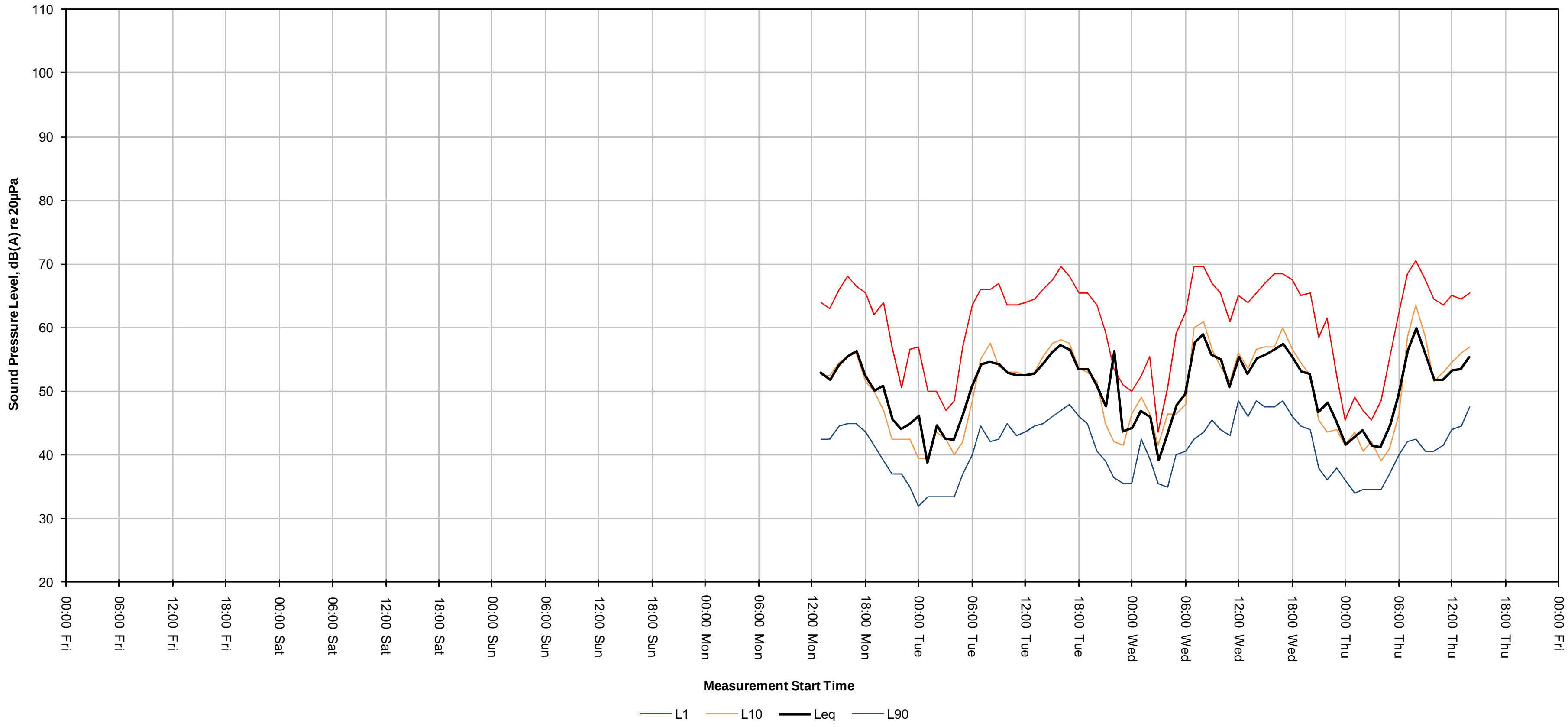


Figure 16 678 Boundary Road, Truganina



Appendix D

Design Inputs

D1 Design Inputs

Table D1 Design inputs used for the acoustic modelling

File	Date Received	Description
26534-lis--ph-01.dgn	27/11/09	Photogrammetry
26534-lis--ph-01.dgn	23/12/09	Photogrammetry
26521-lis--ph-01.dgn	23/12/09	Photogrammetry
26521-lis--ph-02.dgn	23/12/09	Photogrammetry
26521-lis--ph-03.dgn	23/12/09	Photogrammetry
26521-lis--ph-04.dgn	23/12/09	Photogrammetry
26521-lis--ph-05.dgn	23/12/09	Photogrammetry
Contours_1m_RRL_Study_Area.shp	18/11/09	Terrain contours
Melb_2009_35 cm_Cropped_090624.ecw	21/10/09	Aerial photograph
RRL-BR2000_R-Pway Design 3D-Earthworks.dgn	30/04/10	Existing terrain and RRL earthworks

Appendix E

Operational Railway Noise Prediction Figures

E1 Operational Railway Noise Predictions

E1.1 Key Map

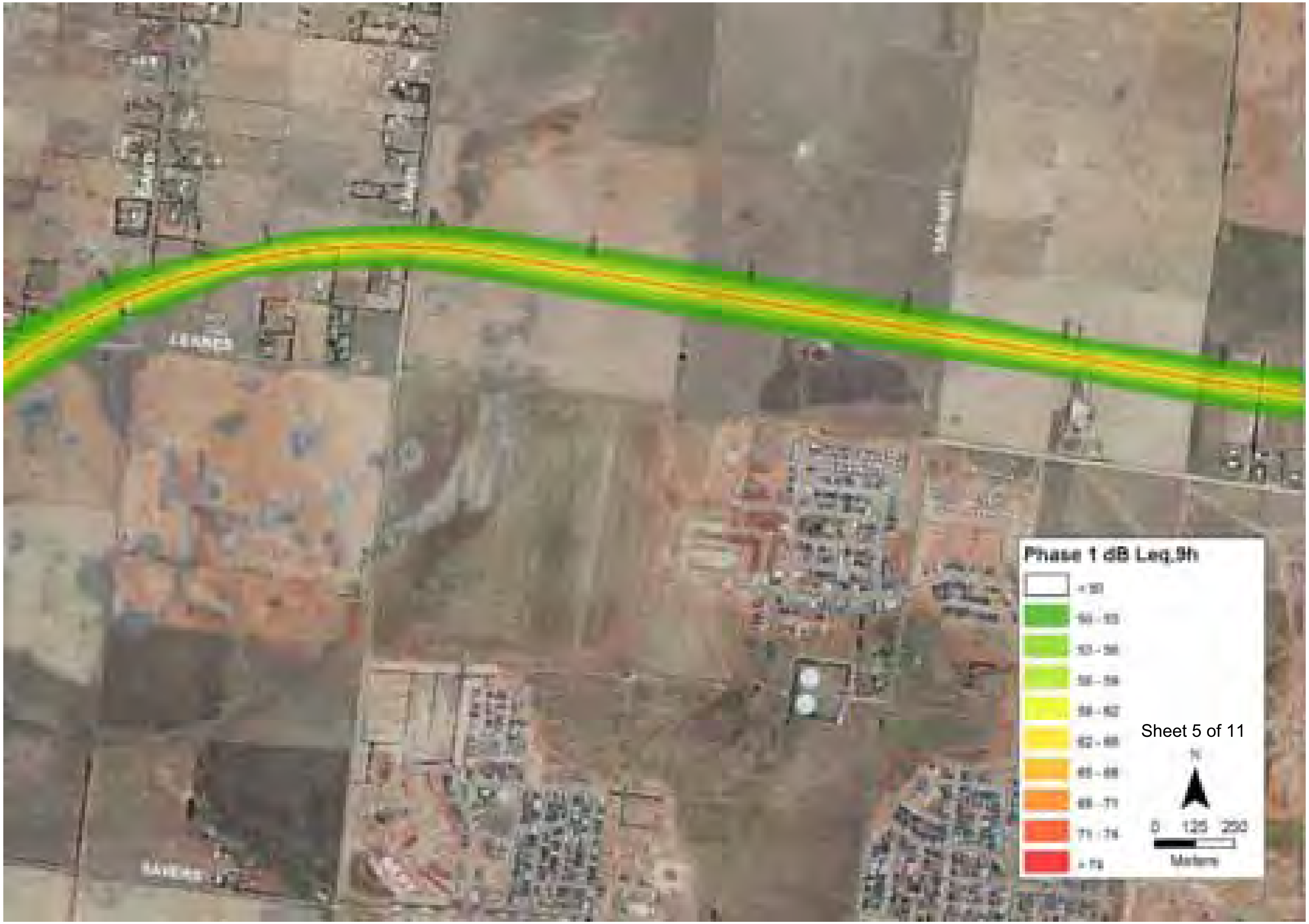
E1.2 Phase 1, Day 1 RRL (2014), night-time $L_{Aeq,\ 9hr}$


Phase 1 dB Leq,9h
Sheet 1 of 11


Phase 1 dB Leq,9h
Sheet 2 of 11


BOUNDARY
Phase 1 dB Leq,9h
Sheet 3 of 11


Phase 1 dB Leq,9h
Sheet 4 of 11
Meters


Phase 1 dB Leq,9h
Sheet 5 of 11
N
0 125 250
Meters


Phase 1 dB Leq,9h
Sheet 6 of 11
N
0 125 250


Phase 1 dB Leq,9h
Sheet 7 of 11
N
0 125 250
Meters

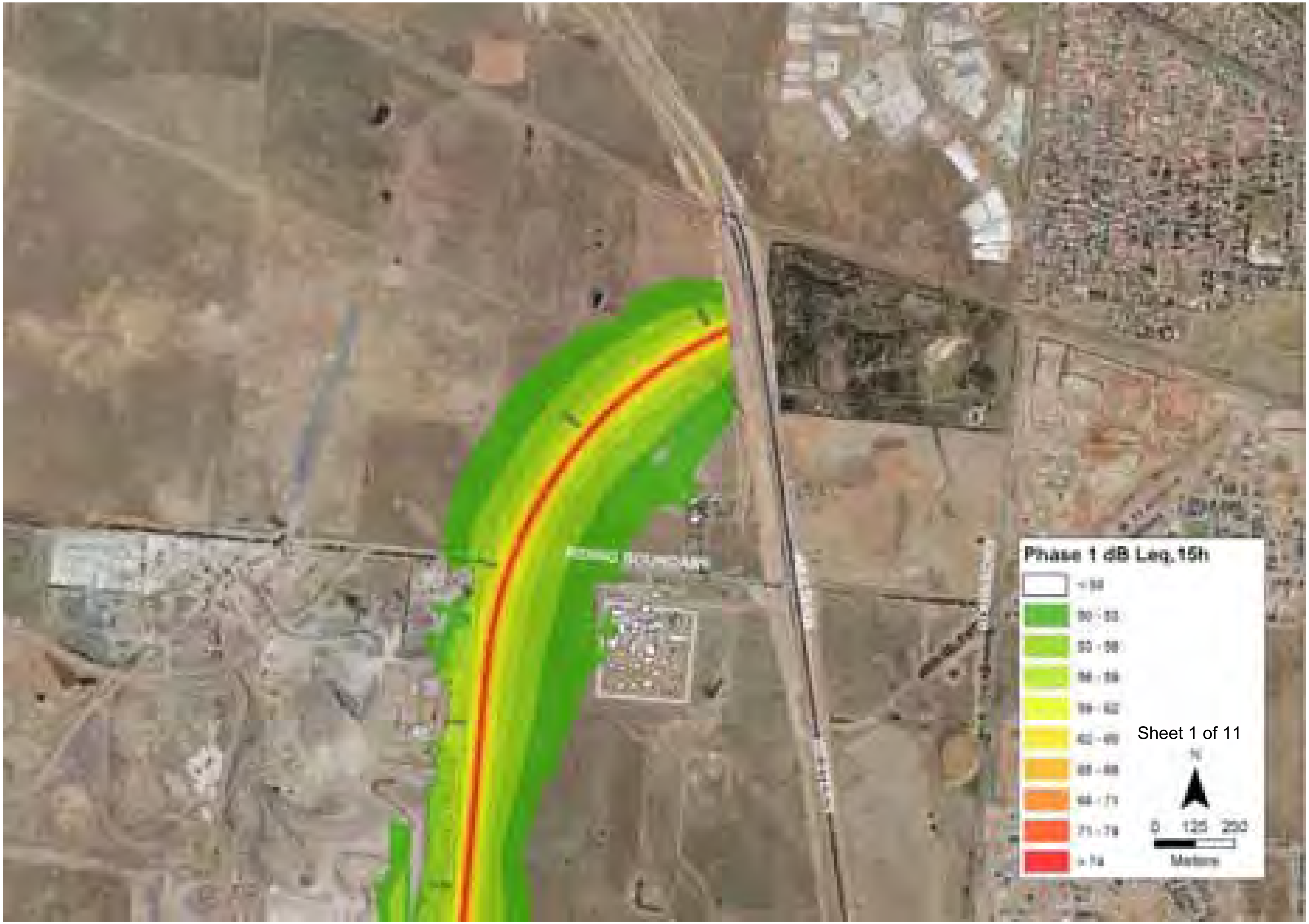

Phase 1 dB Leq,9h
Sheet 8 of 11
Meters

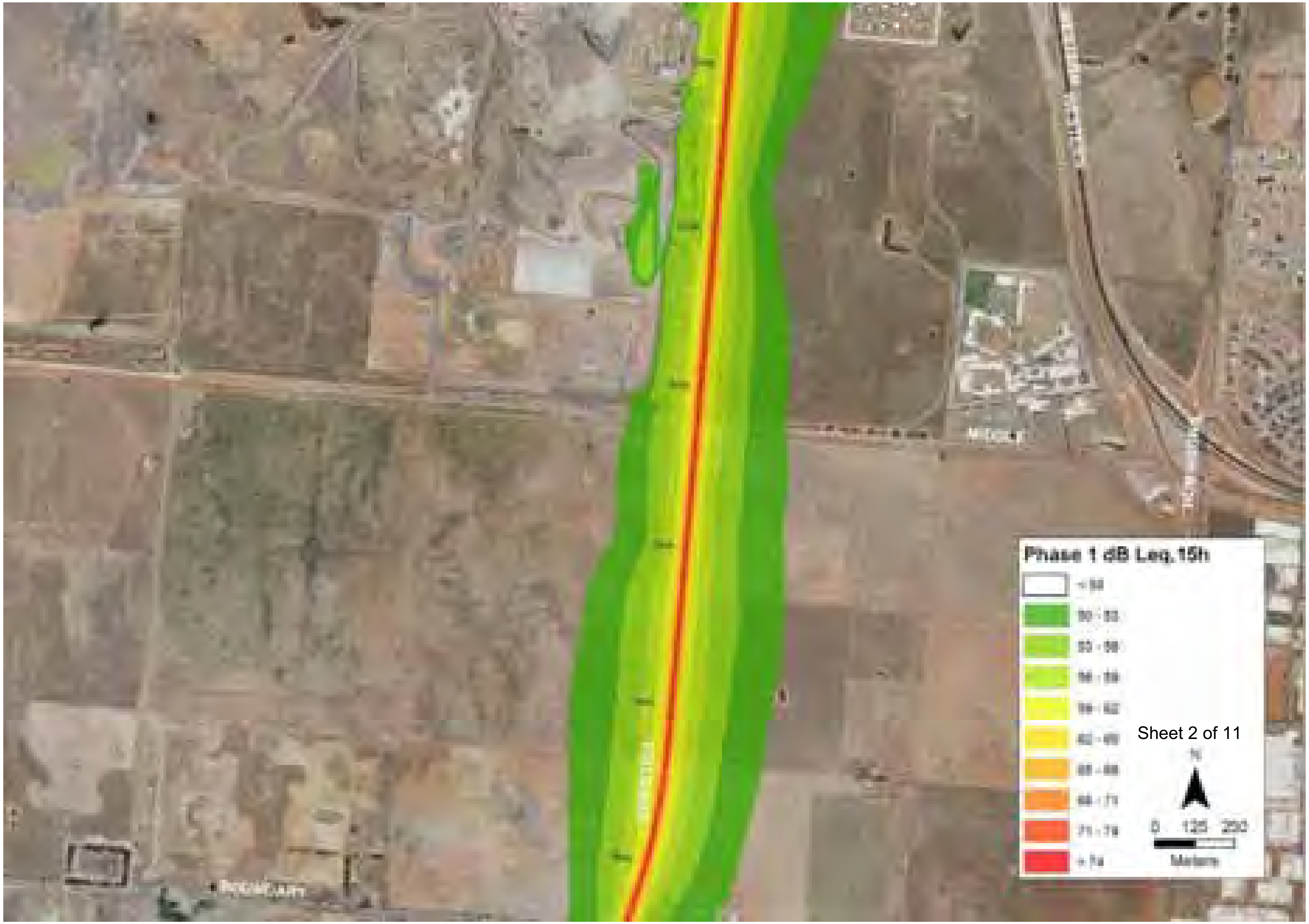

Phase 1 dB Leq,9h
Sheet 9 of 11
Meters


Phase 1 dB Leq,9h
< 50
50 - 53
53 - 56
56 - 59
59 - 62
62 - 65
65 - 68
68 - 71
71 - 74
> 74
Sheet 10 of 11
N
0 125 250
Meters


Phase 1 dB Leq,9h
Sheet 11 of 11
0 125 250

E1.3 Phase 1, Day 1 RRL (2014), day time $L_{Aeq, 15hr}$


Phase 1 dB Leq,15h
Sheet 1 of 11
0 125 250
Meters


Phase 1 dB Leq,15h
Sheet 2 of 11
N


Phase 1 dB Leq,15h
Sheet 3 of 11
Meters


Phase 1 dB Leq,15h
Sheet 4 of 11

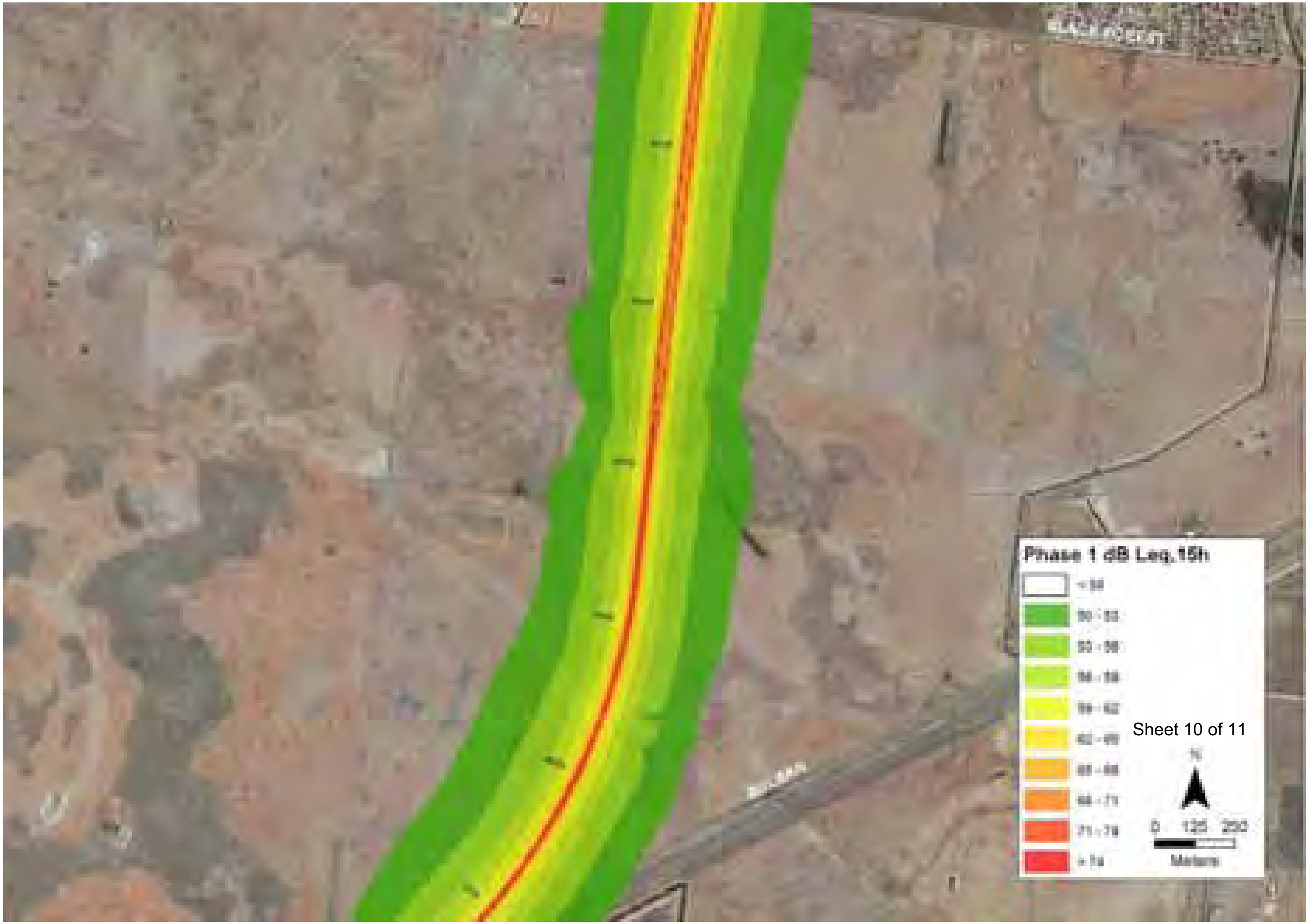

Phase 1 dB Leq,15h
Sheet 5 of 11


Phase 1 dB Leq,15h
Sheet 6 of 11


Phase 1 dB Leq,15h
Sheet 7 of 11
N
0 125 250

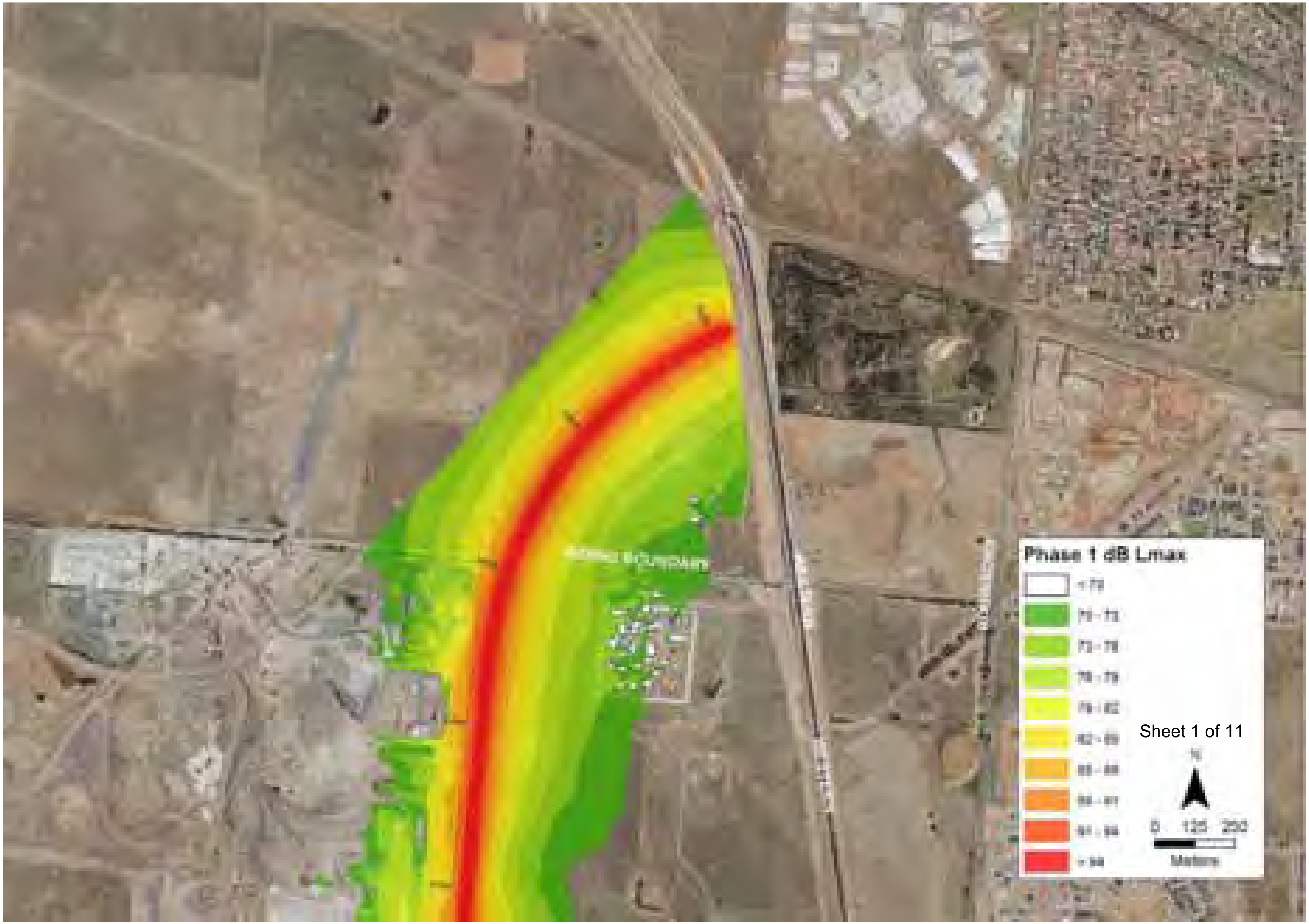

Phase 1 dB Leq,15h
Sheet 8 of 11

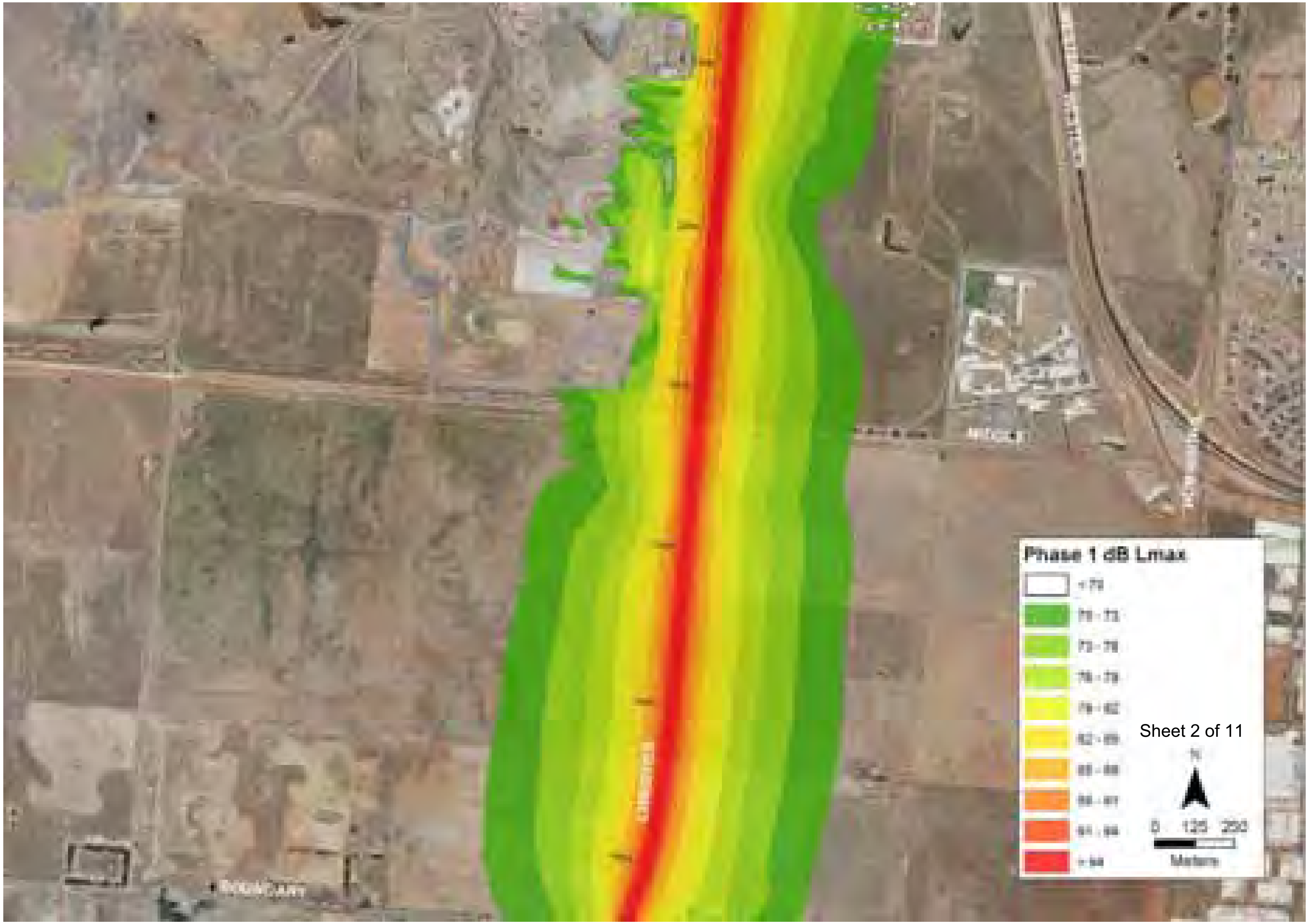

Phase 1 dB Leq,15h
Sheet 9 of 11
0 125 250
Meters

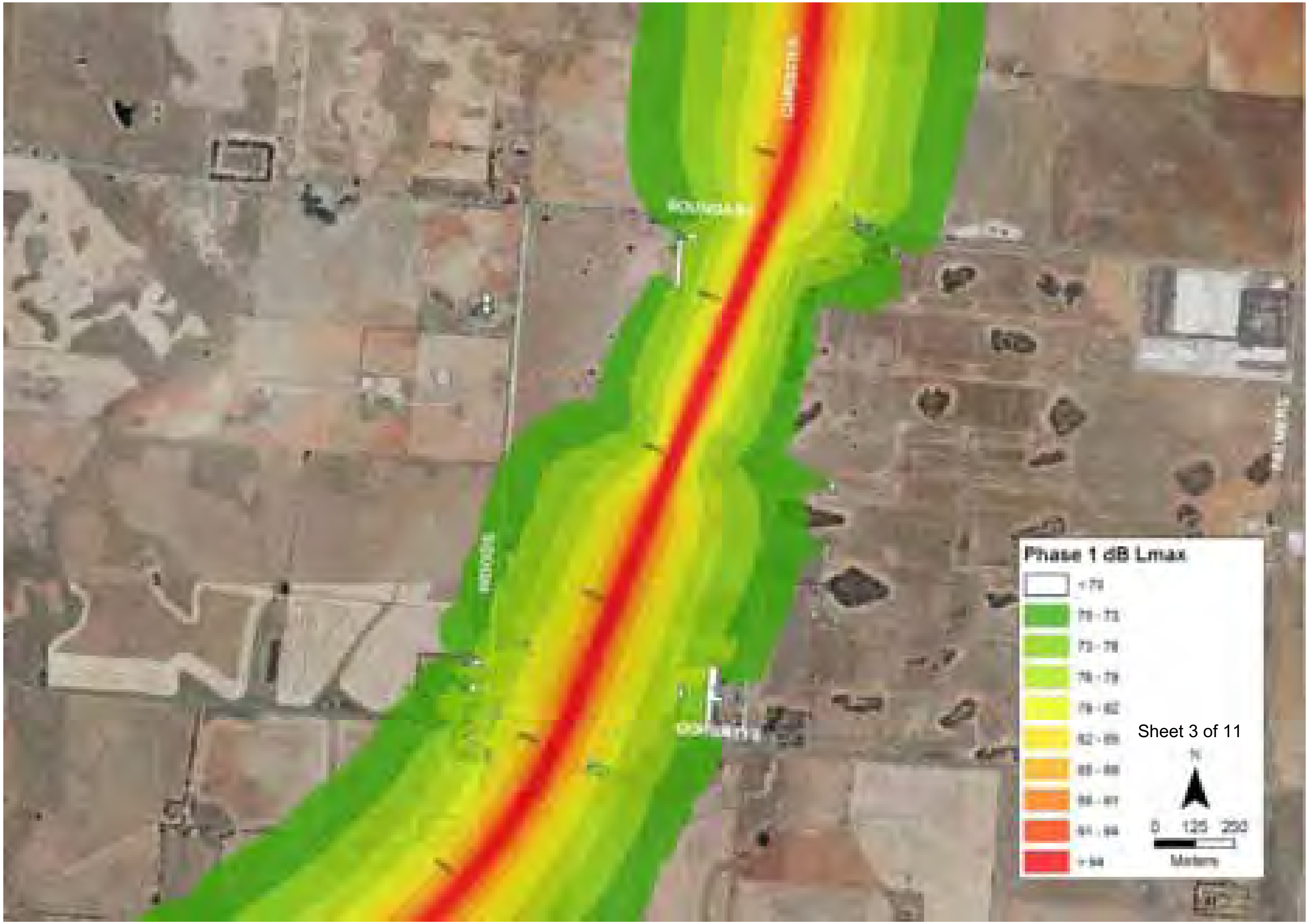

Phase 1 dB Leq,15h
Sheet 10 of 11
0 125 250

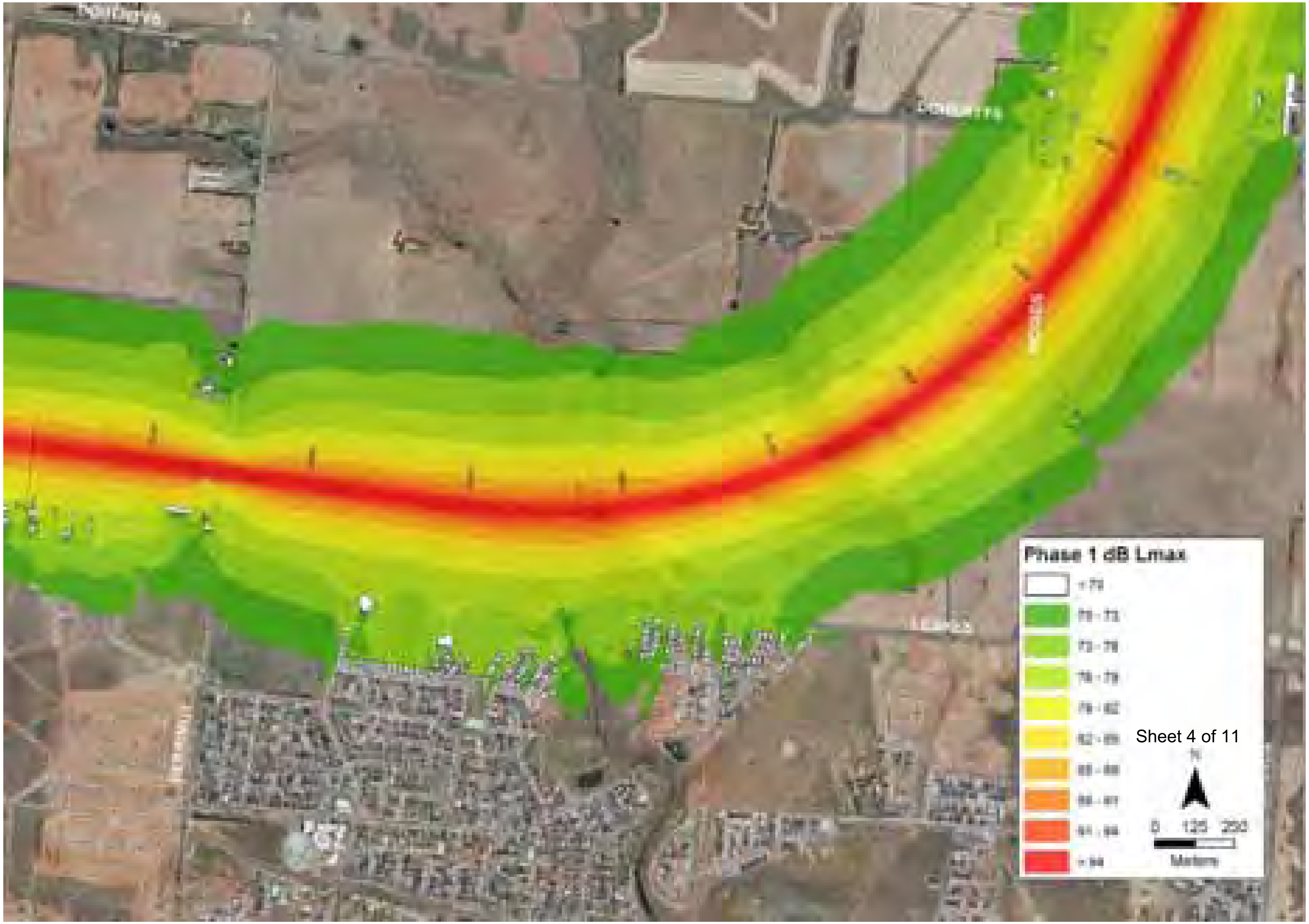

Phase 1 dB Leq,15h
Sheet 11 of 11
0 125 250
Meters

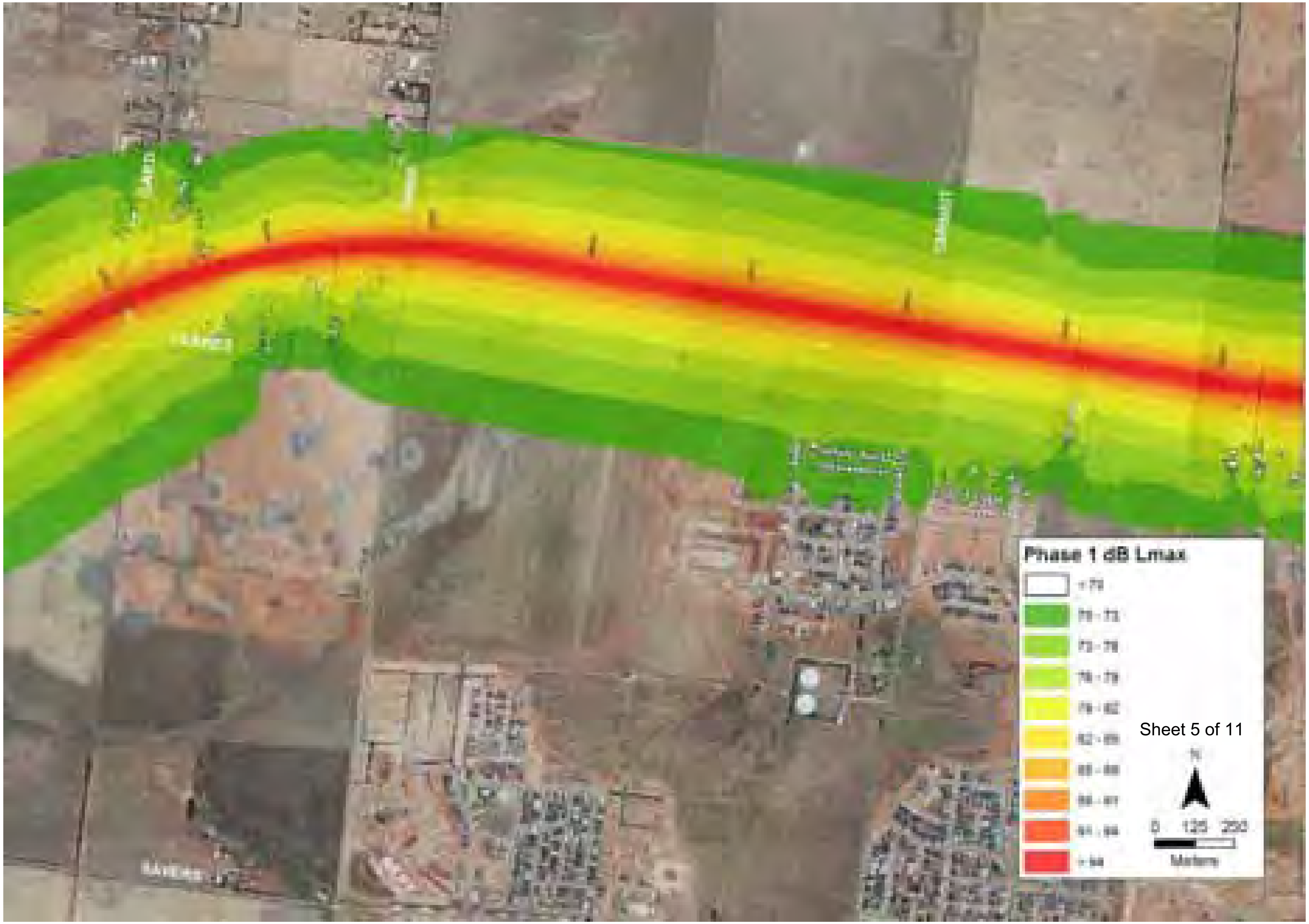
E1.4 Phase 1, Day 1 RRL (2014), L_{Amax}

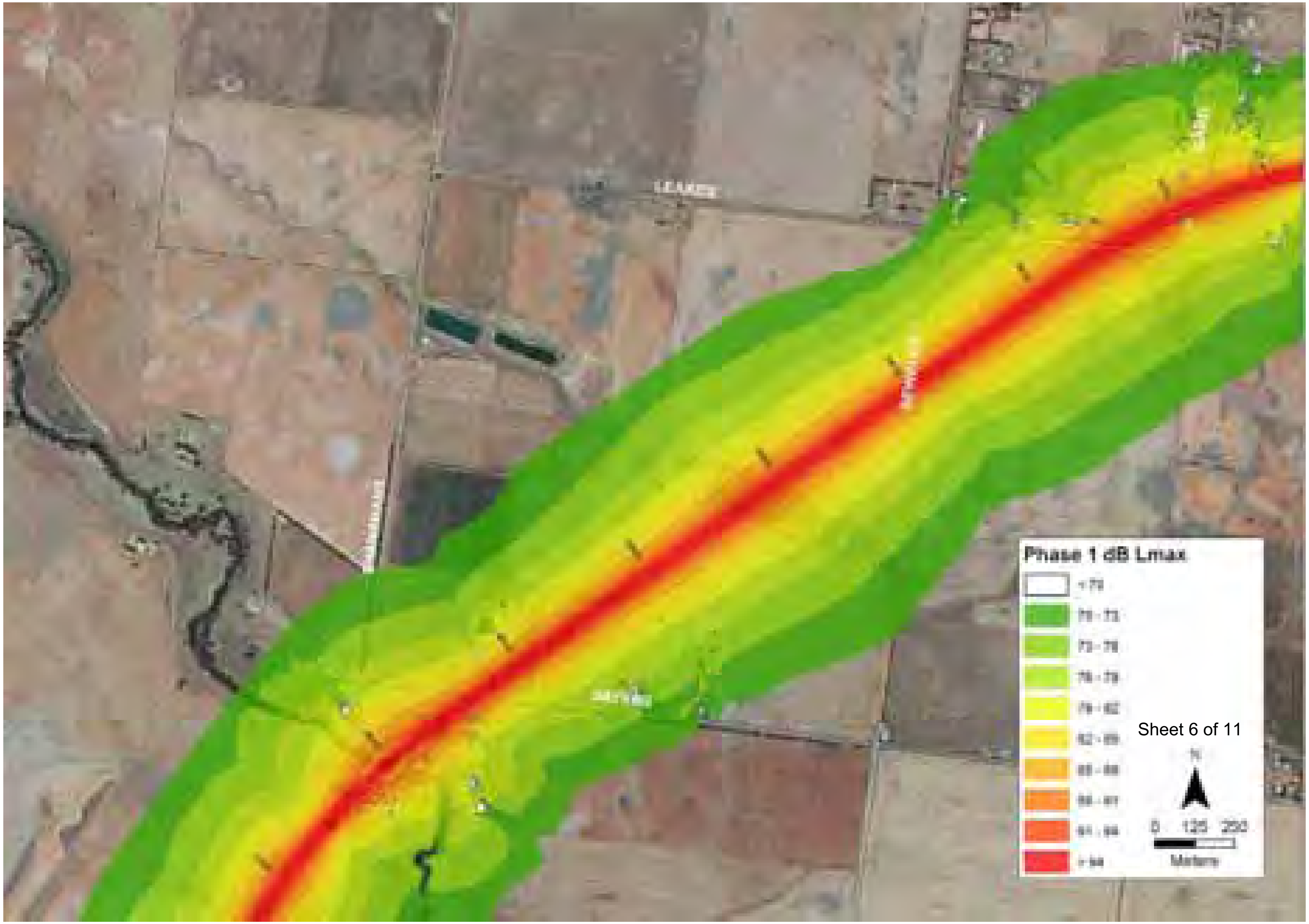

Phase 1 dB Lmax
Sheet 1 of 11
0 125 250

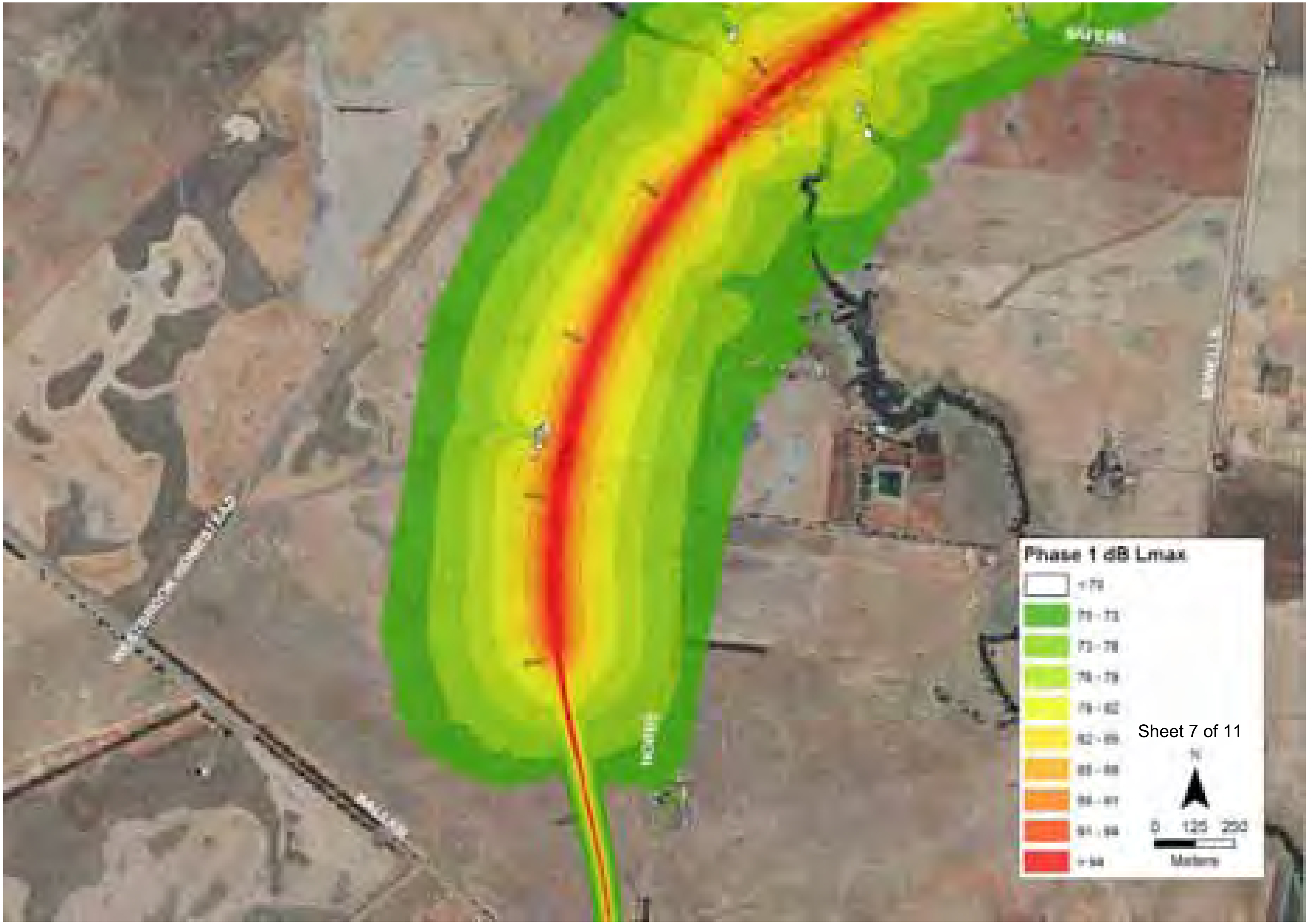

Phase 1 dB Lmax
Sheet 2 of 11
N
0 125 250
Meters


Phase 1 dB Lmax
Sheet 3 of 11
N
0 125 250
Meters

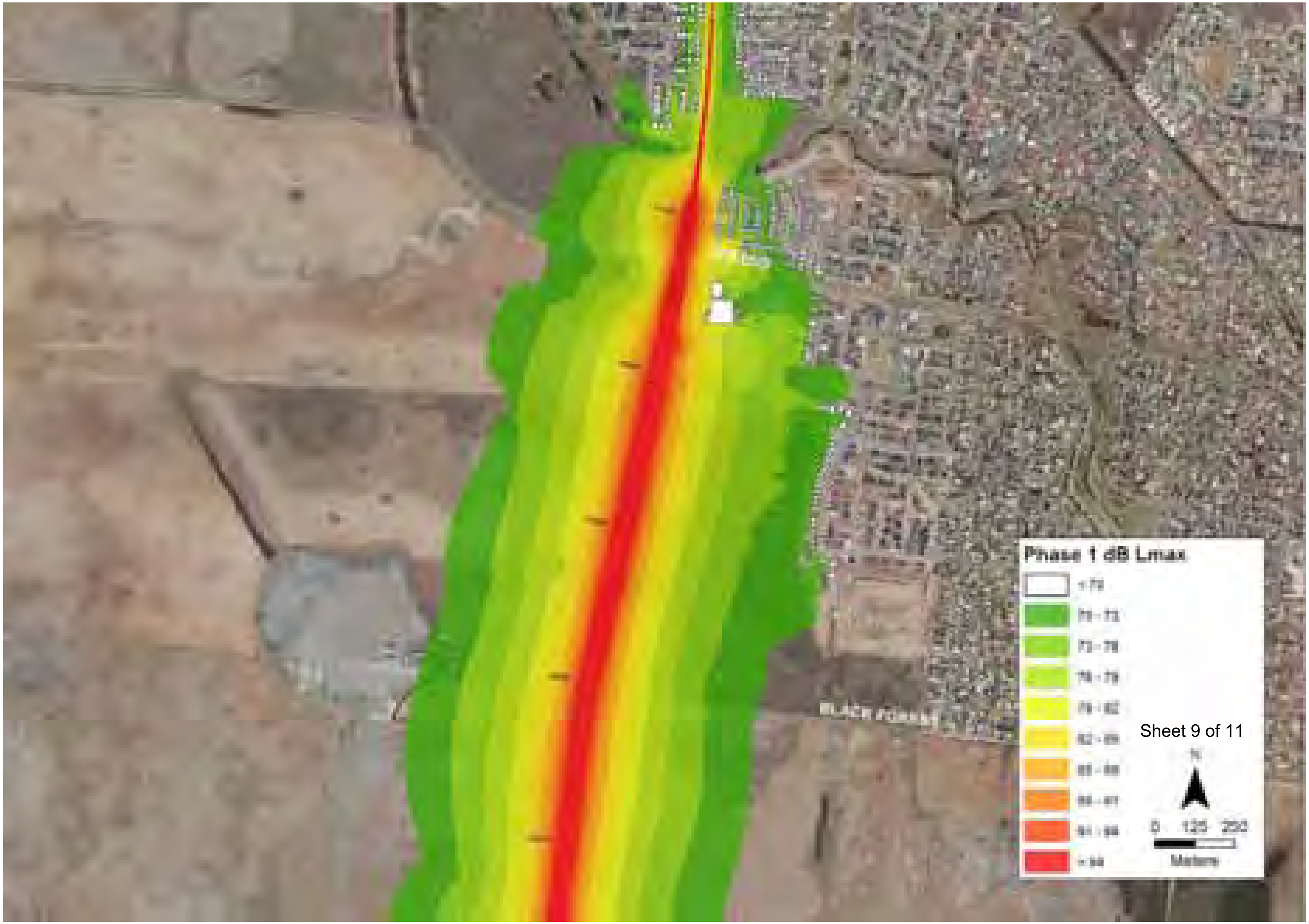

Phase 1 dB Lmax
Sheet 4 of 11

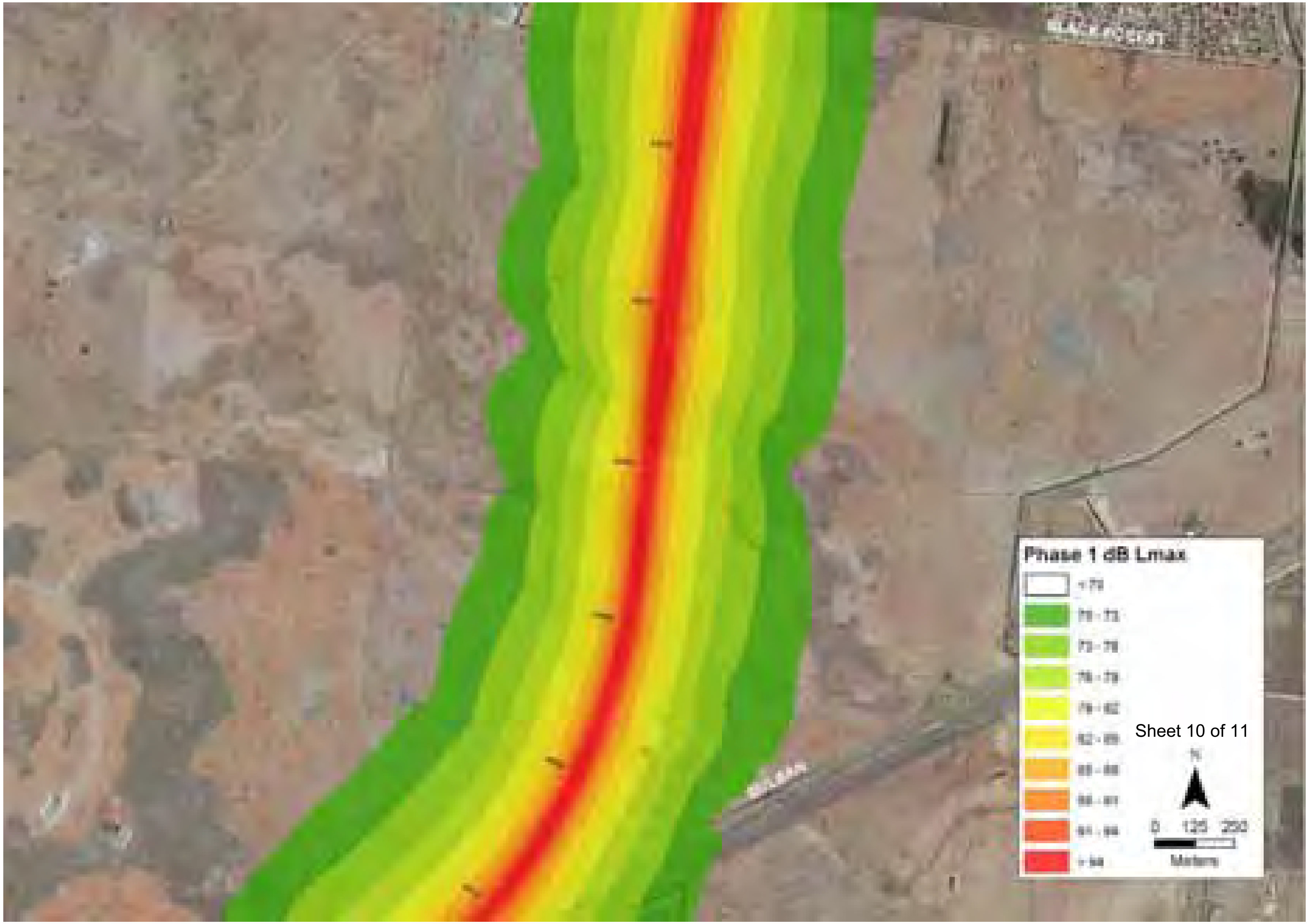

Phase 1 dB Lmax
Sheet 5 of 11
N
0
Meters

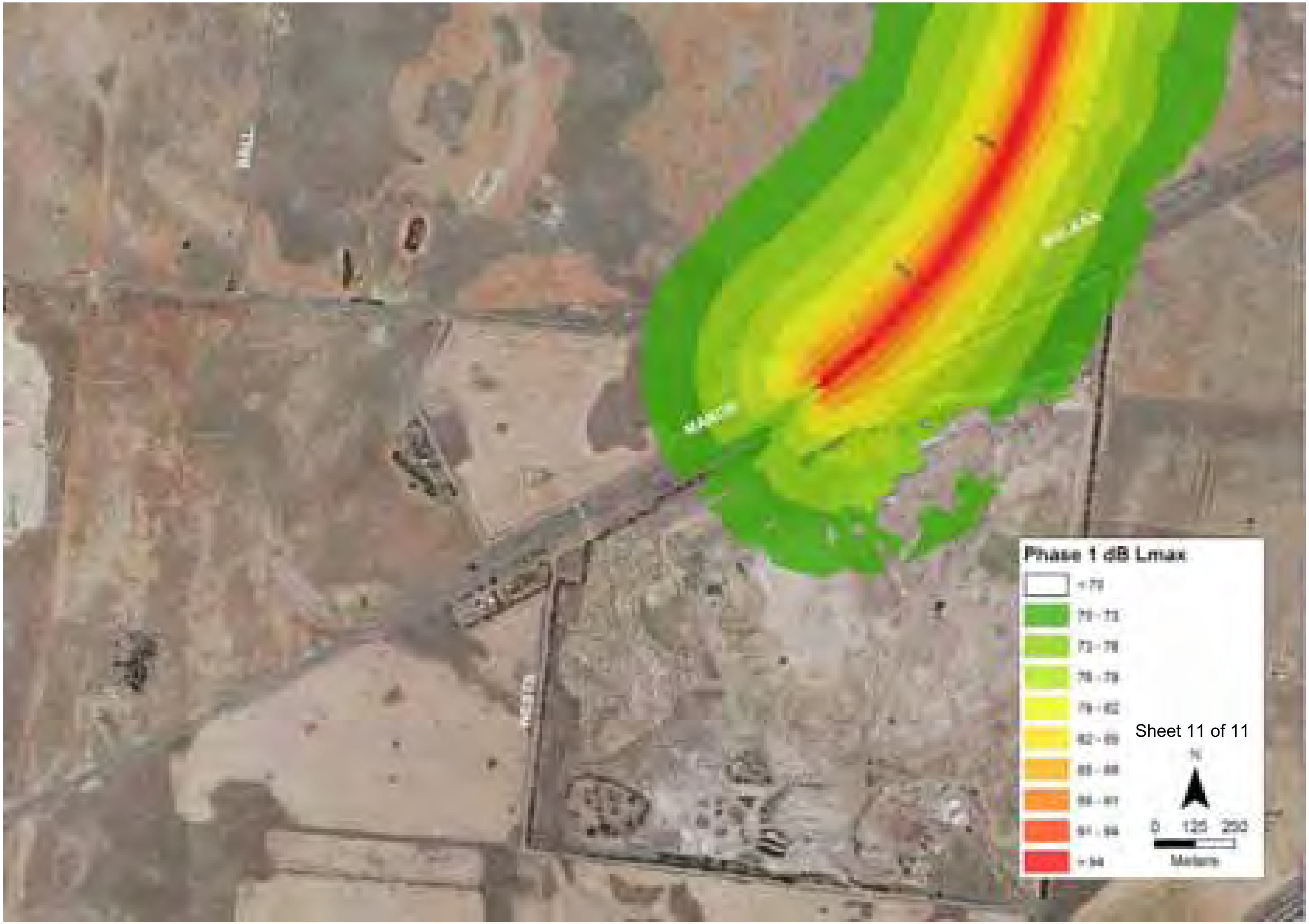

Phase 1 dB Lmax
Sheet 6 of 11


Phase 1 dB Lmax
Sheet 7 of 11


Phase 1 dB Lmax
Sheet 8 of 11
Meters


Phase 1 dB Lmax
Sheet 9 of 11


Phase 1 dB Lmax
Sheet 10 of 11
N
0 125 250
Meters


Phase 1 dB Lmax
Sheet 11 of 11
N
0 125 250
Meters

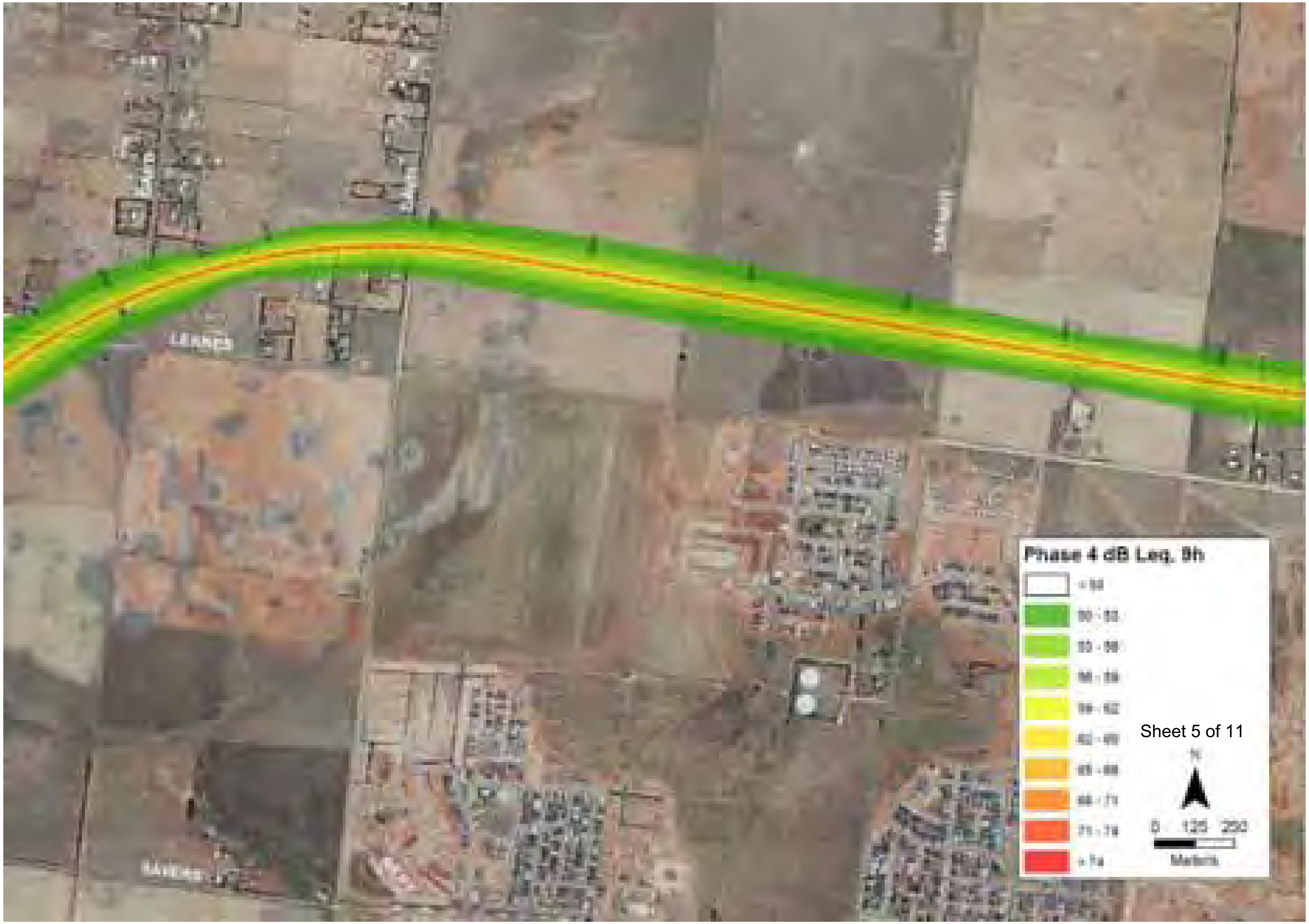
E1.5 Phase 4, Ultimate capacity (2030), night-time $L_{Aeq, 9hr}$


Phase 4 dB Leq, 9h
Sheet 1 of 11


Phase 4 dB Leq, 9h
Sheet 2 of 11
N


Phase 4 dB Leq, 9h
Sheet 3 of 11
N
Meters


Phase 4 dB Leq, 9h
Sheet 4 of 11
N
0 125 250


Phase 4 dB Leq, 9h
Sheet 5 of 11
N
0 125 250


Phase 4 dB Leq, 9h
Sheet 6 of 11
N


Phase 4 dB Leq, 9h
Sheet 7 of 11

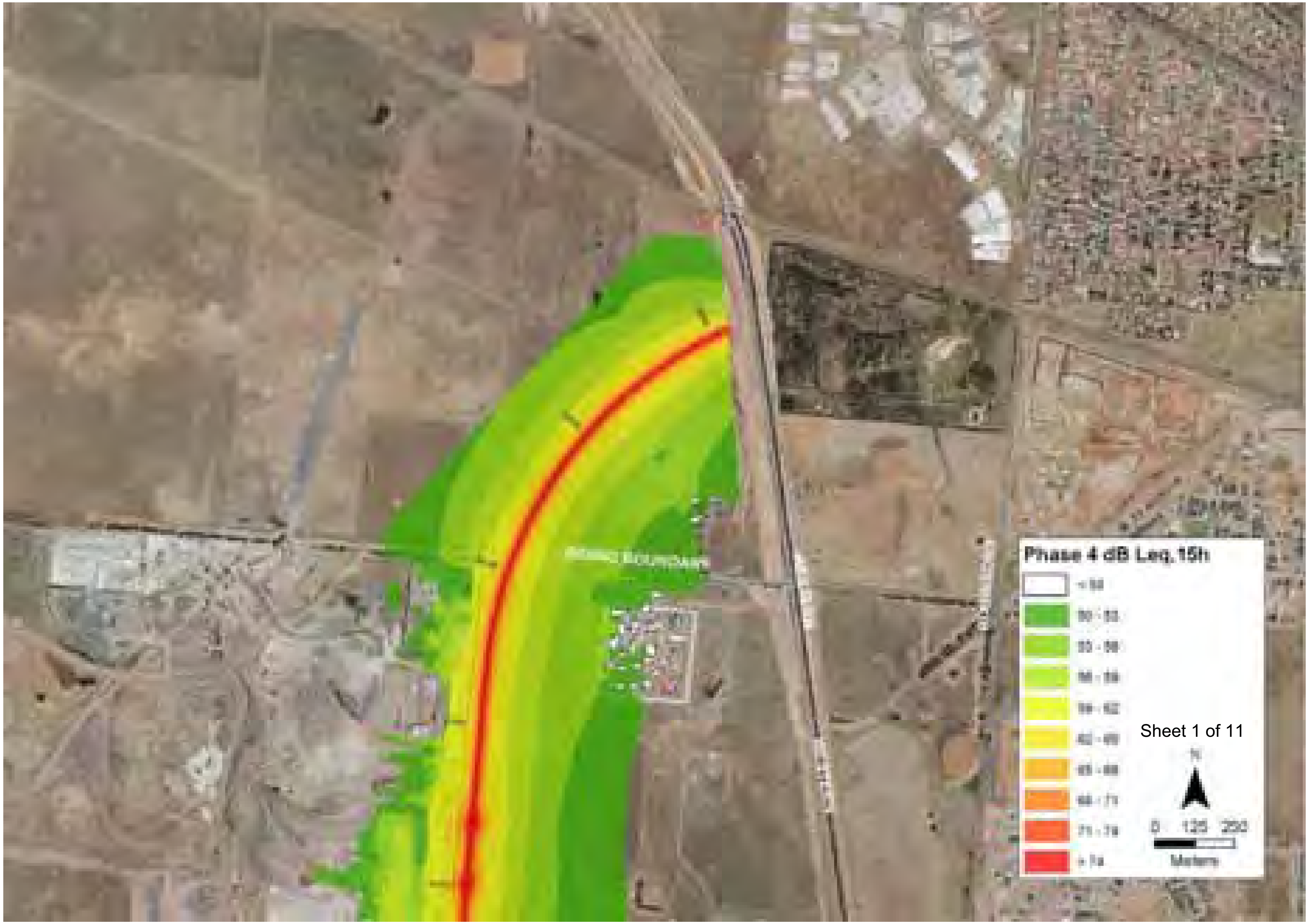

Phase 4 dB Leq, 9h
Sheet 8 of 11

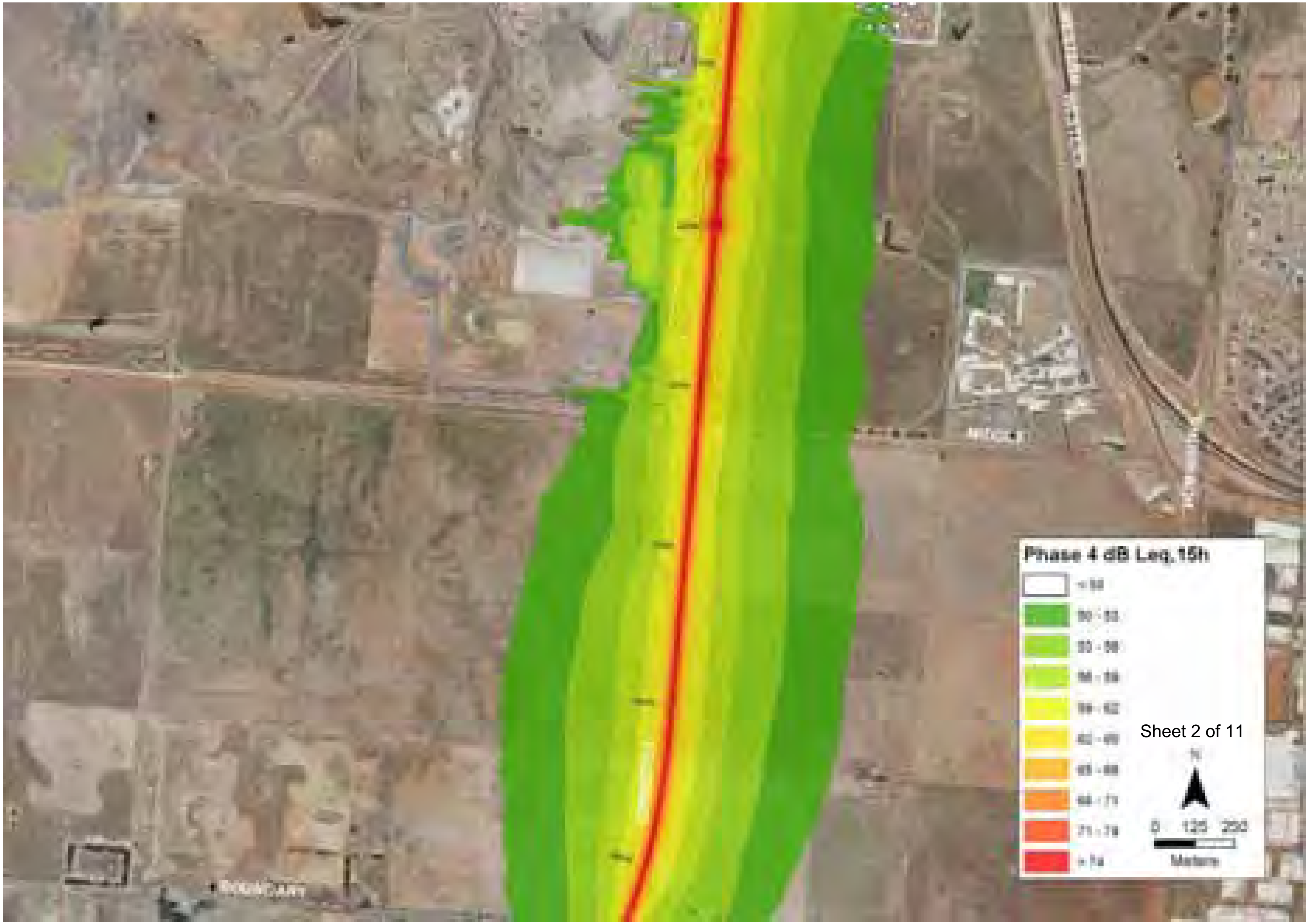

Phase 4 dB Leq, 9h
Sheet 9 of 11
Meters

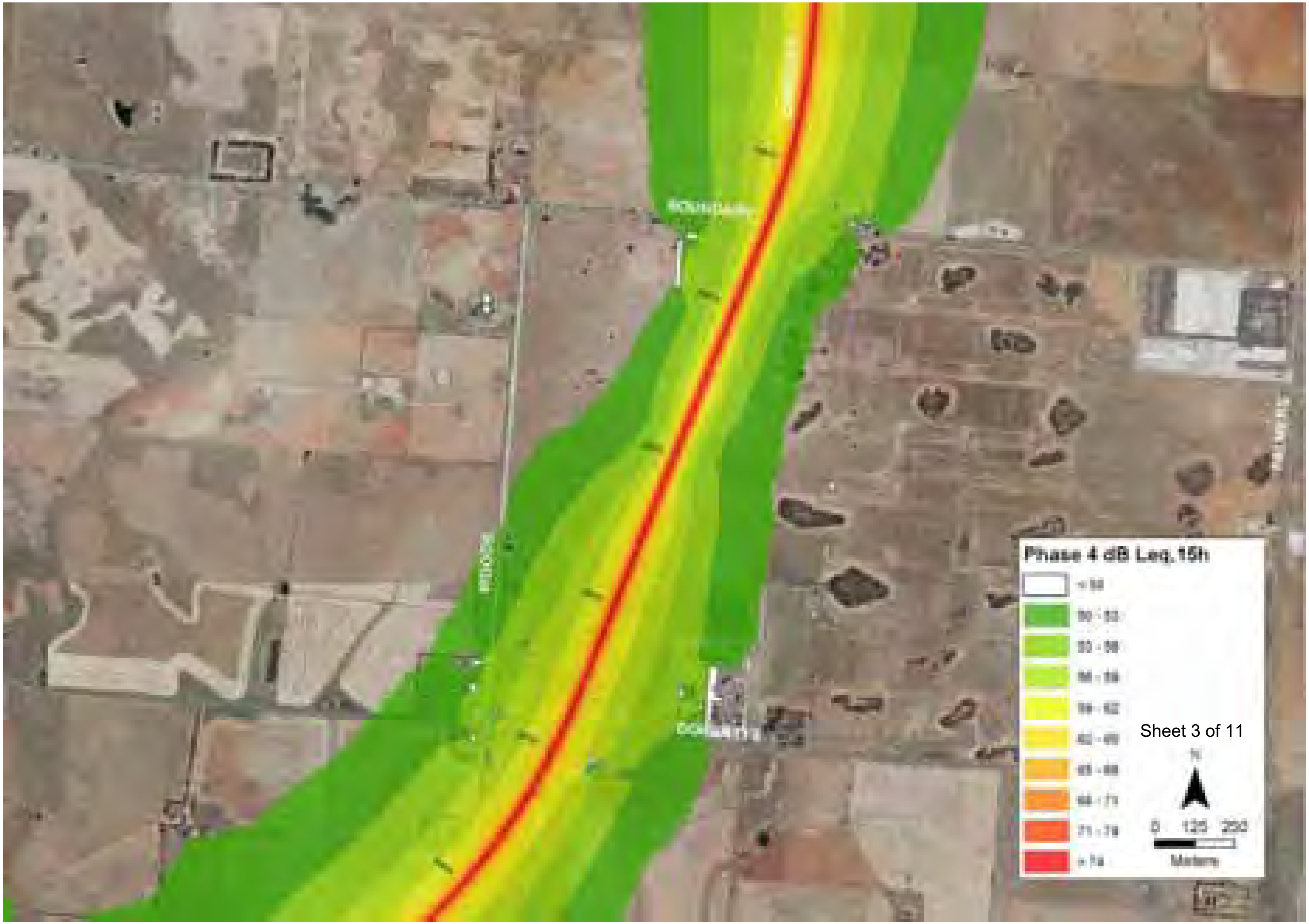

Phase 4 dB Leq, 9h
Sheet 10 of 11
0 125 250
Meters

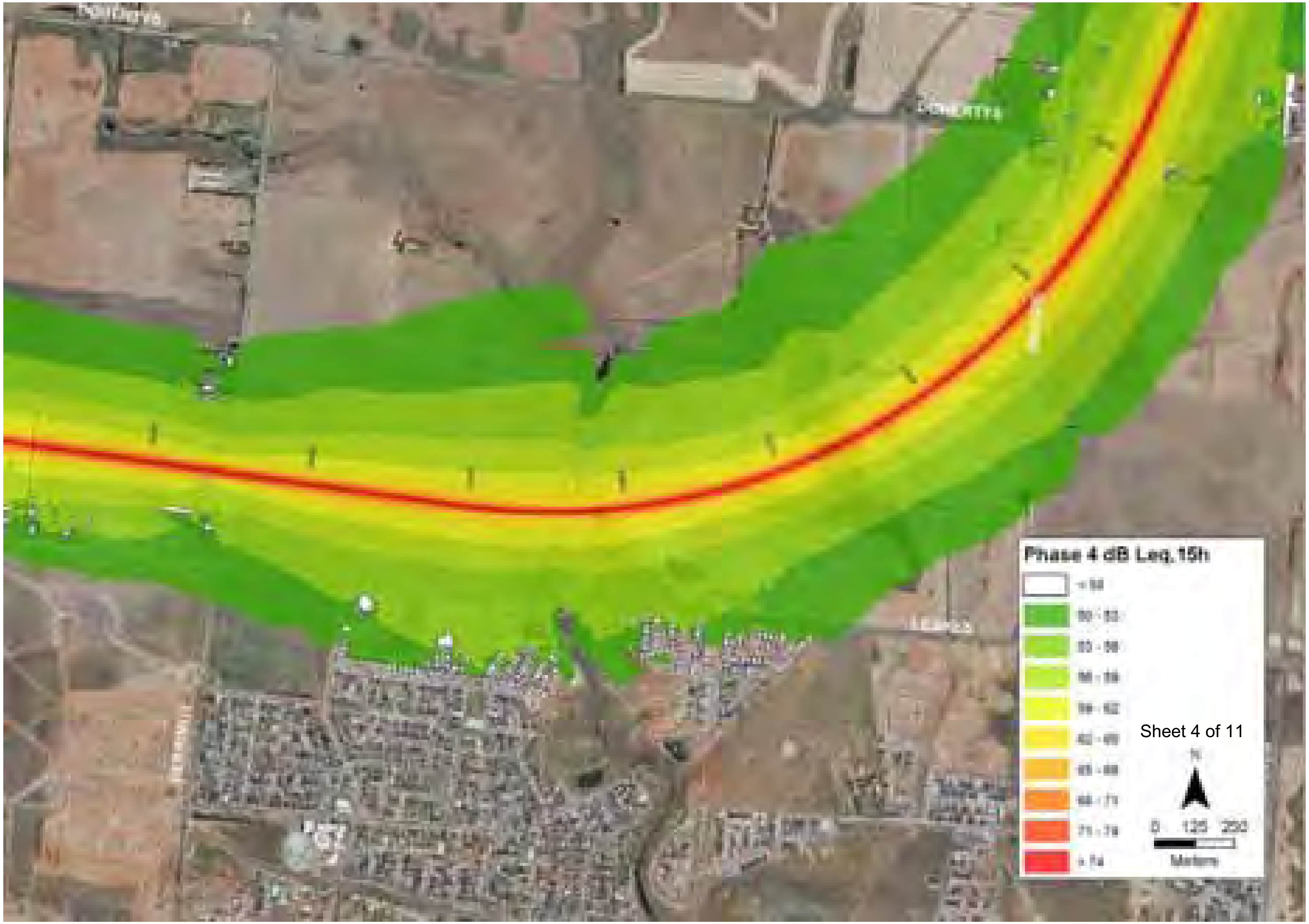

Phase 4 dB Leq, 9h
N
0 125 250
Metres

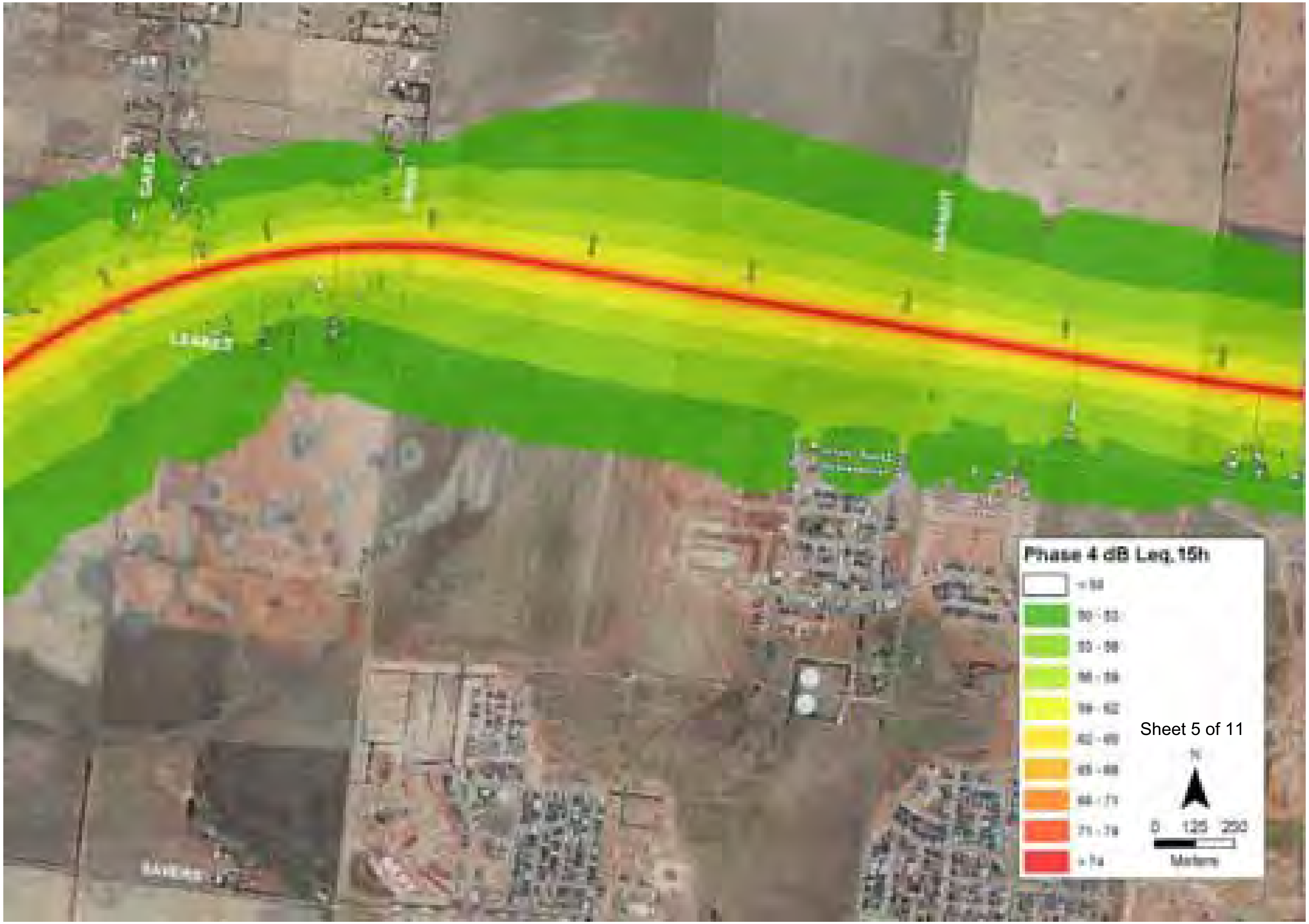
E1.6 Phase 4, Ultimate capacity (2030), day time $L_{Aeq, 15hr}$

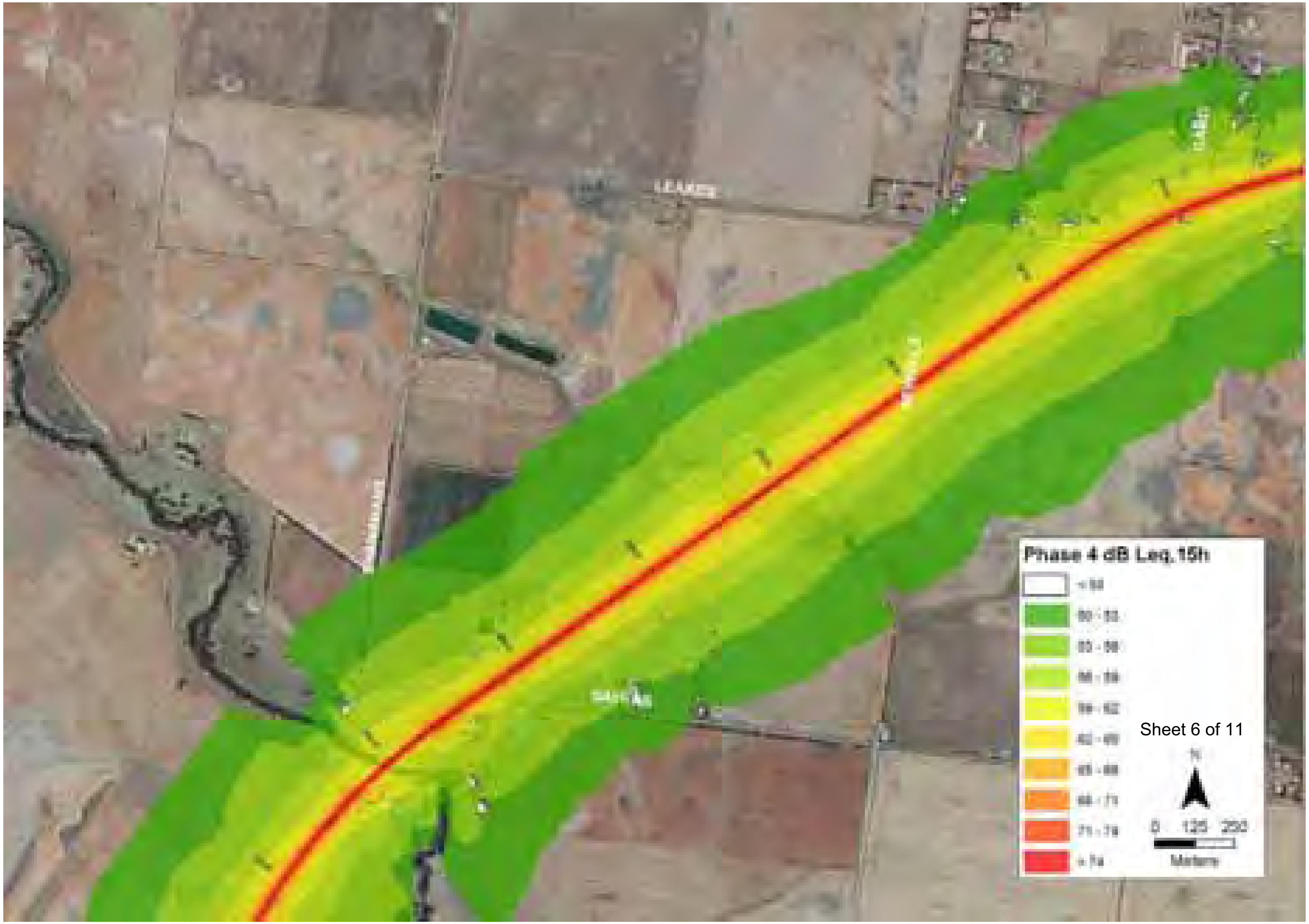

Phase 4 dB Leq,15h
Sheet 1 of 11
N
0 125 250
Meters

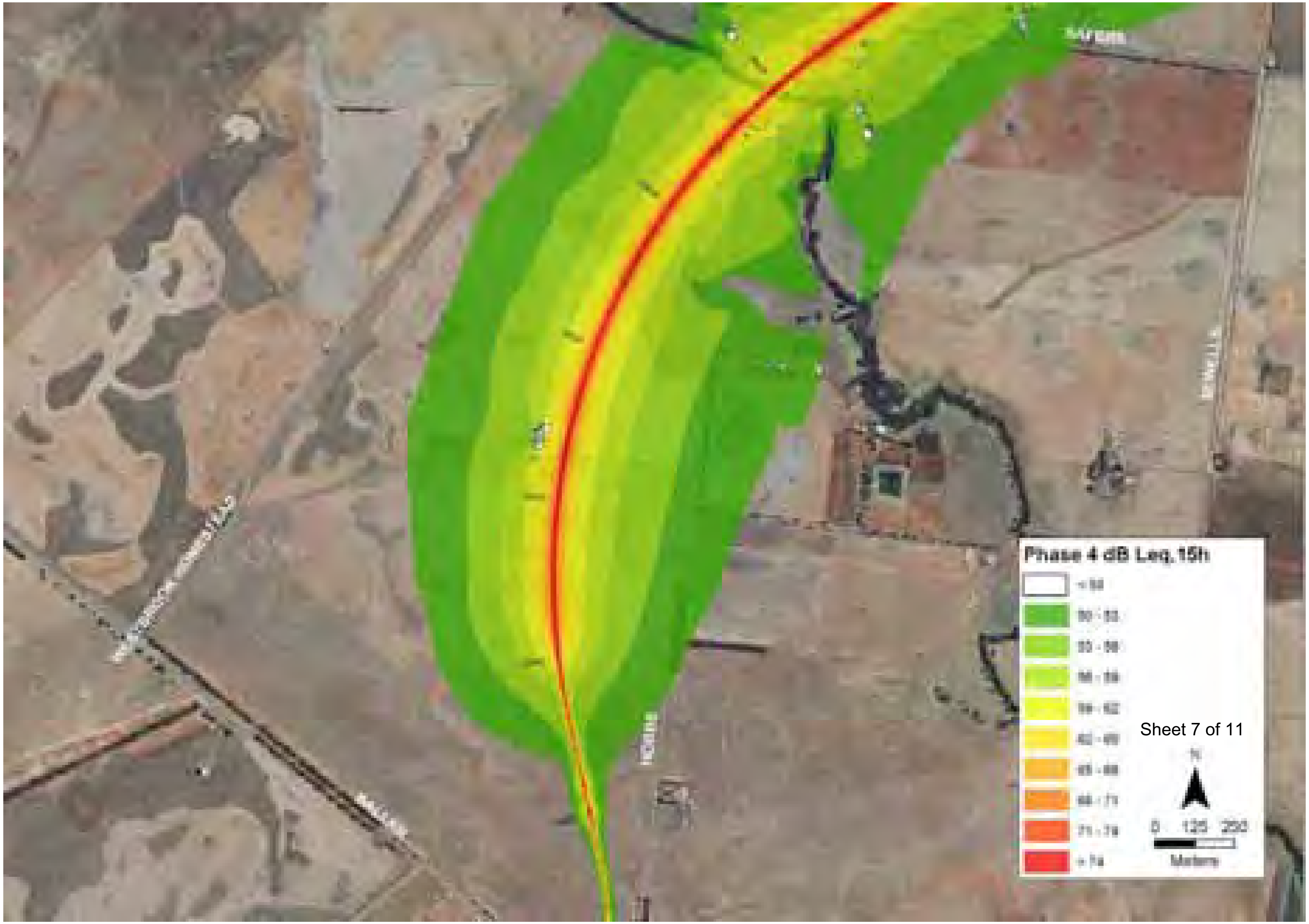

Phase 4 dB Leq,15h
Sheet 2 of 11
N
Meters


Phase 4 dB Leq,15h
Sheet 3 of 11

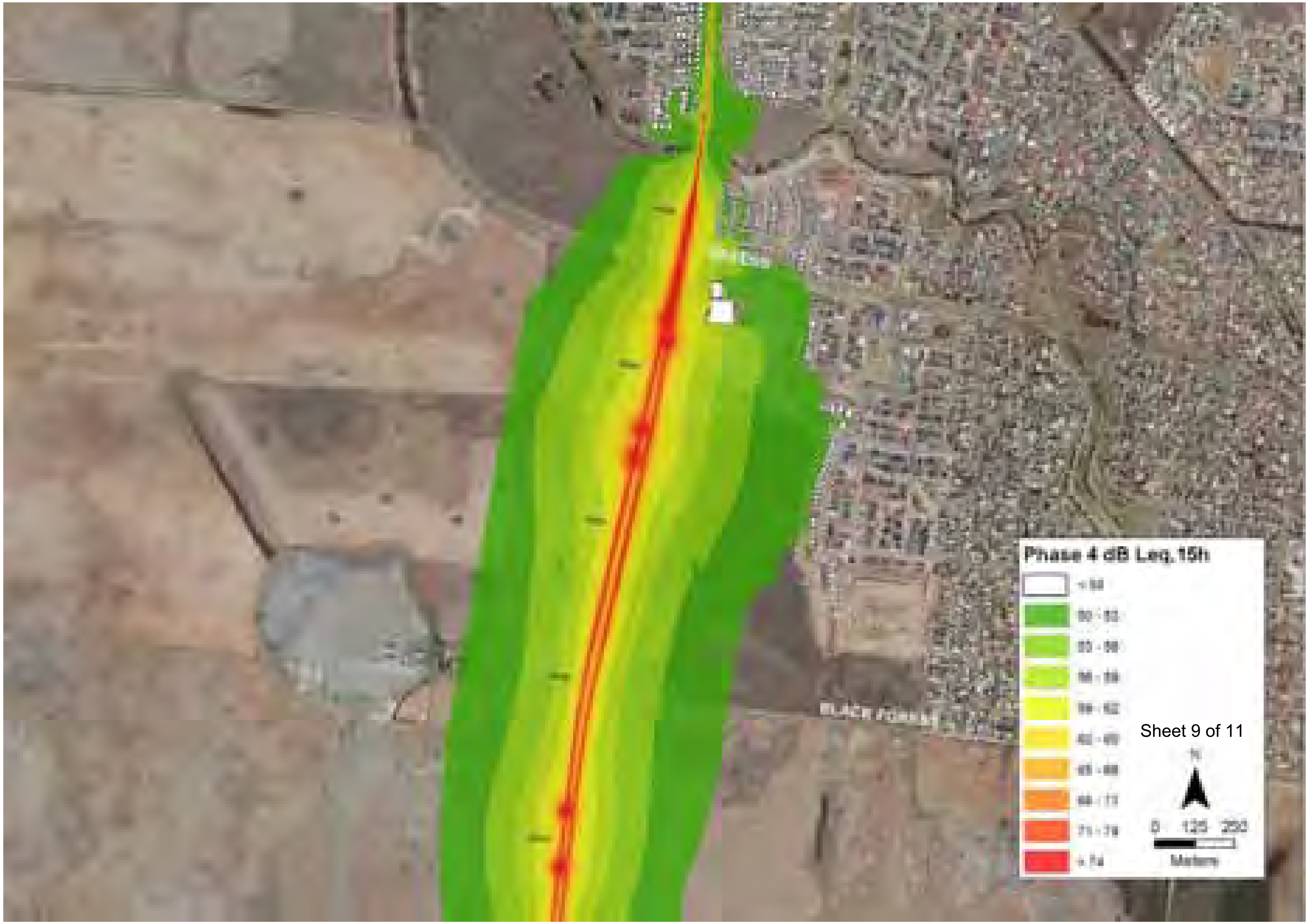

Phase 4 dB Leq,15h
Sheet 4 of 11

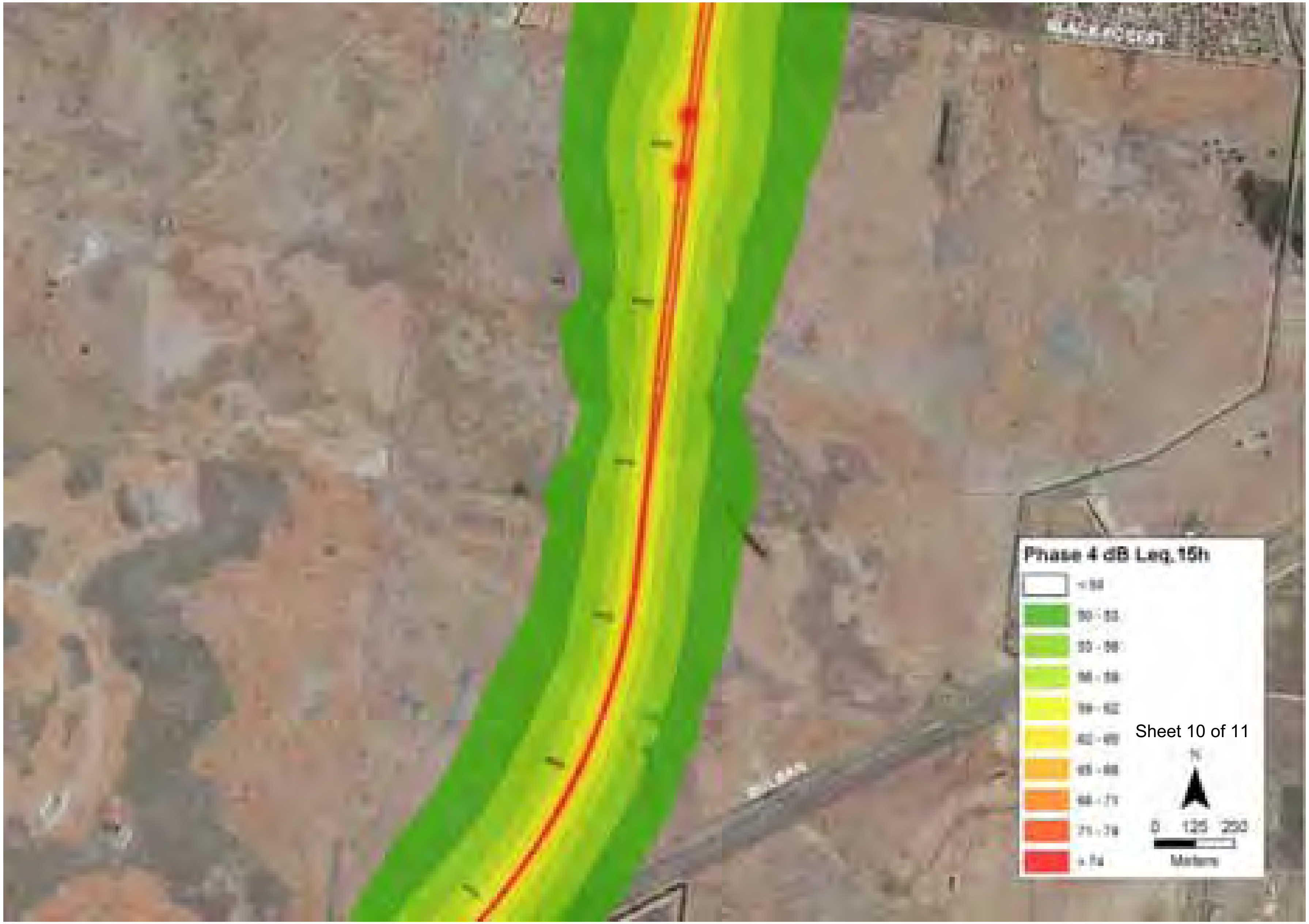

Phase 4 dB Leq,15h
Sheet 5 of 11


Phase 4 dB Leq,15h
Sheet 6 of 11
0 125 250


Phase 4 dB Leq,15h
Sheet 7 of 11
N
0 125 250
Meters

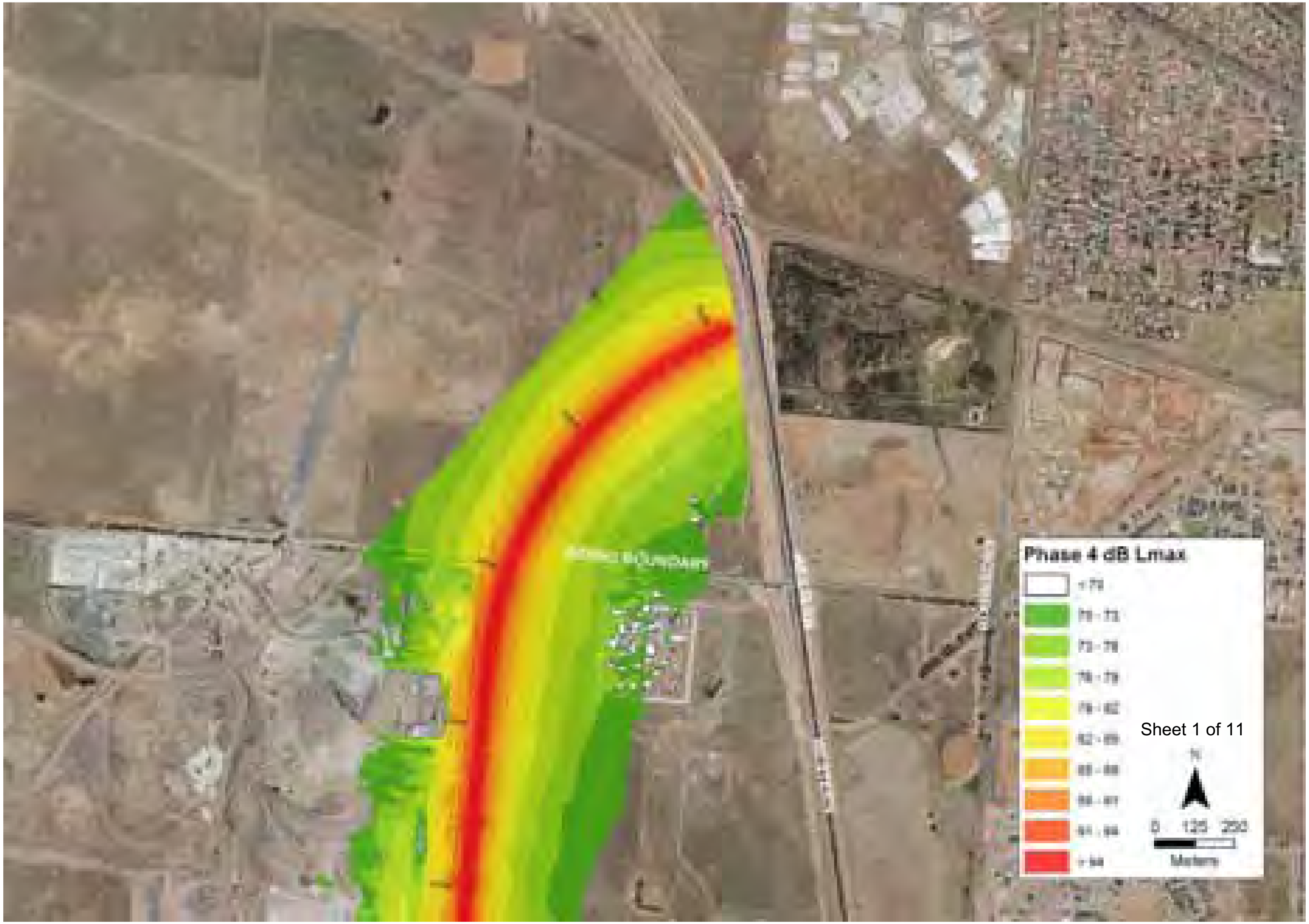

Phase 4 dB Leq,15h
Sheet 8 of 11

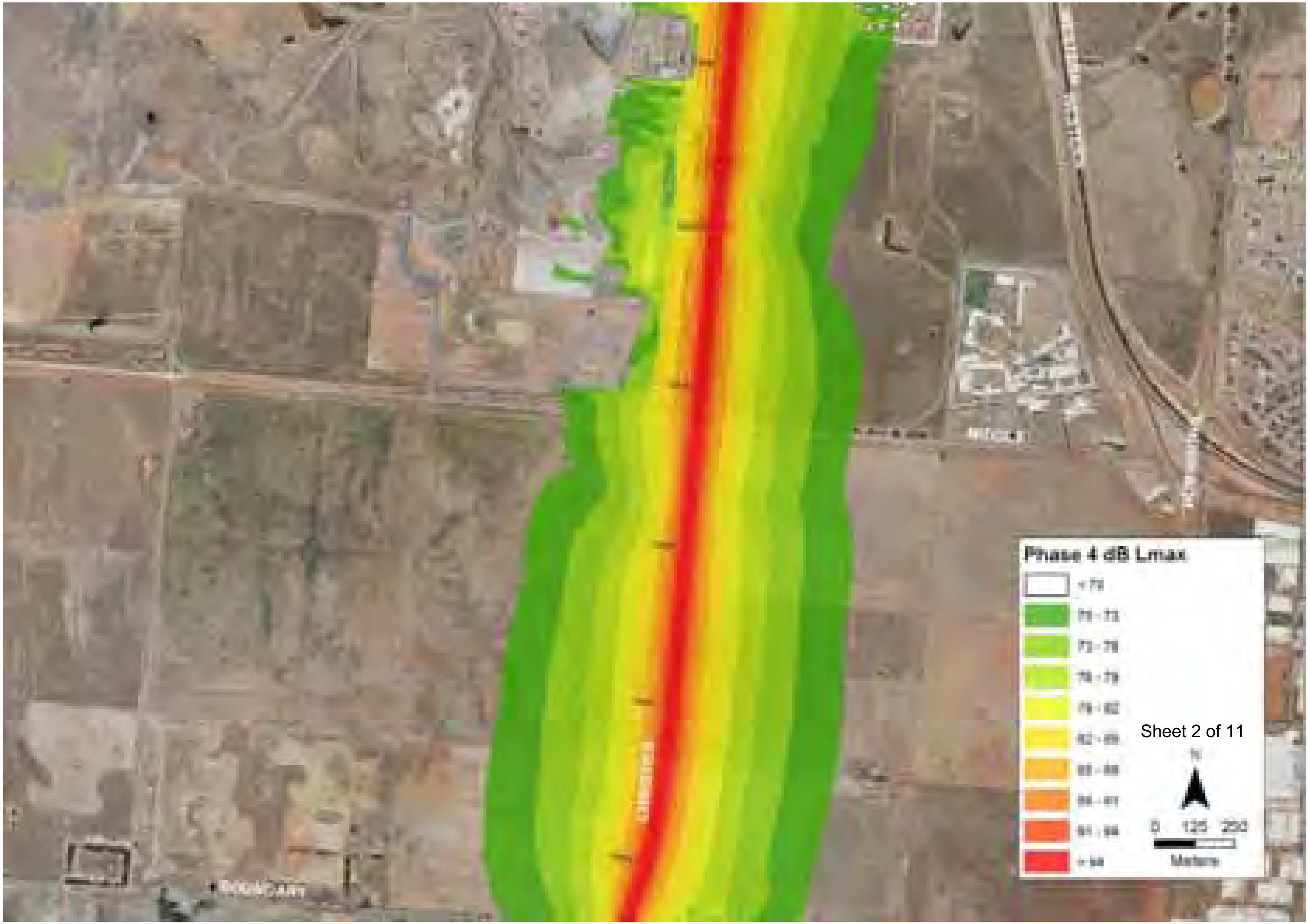

Phase 4 dB Leq,15h
Sheet 9 of 11
N
0 125 250
Meters

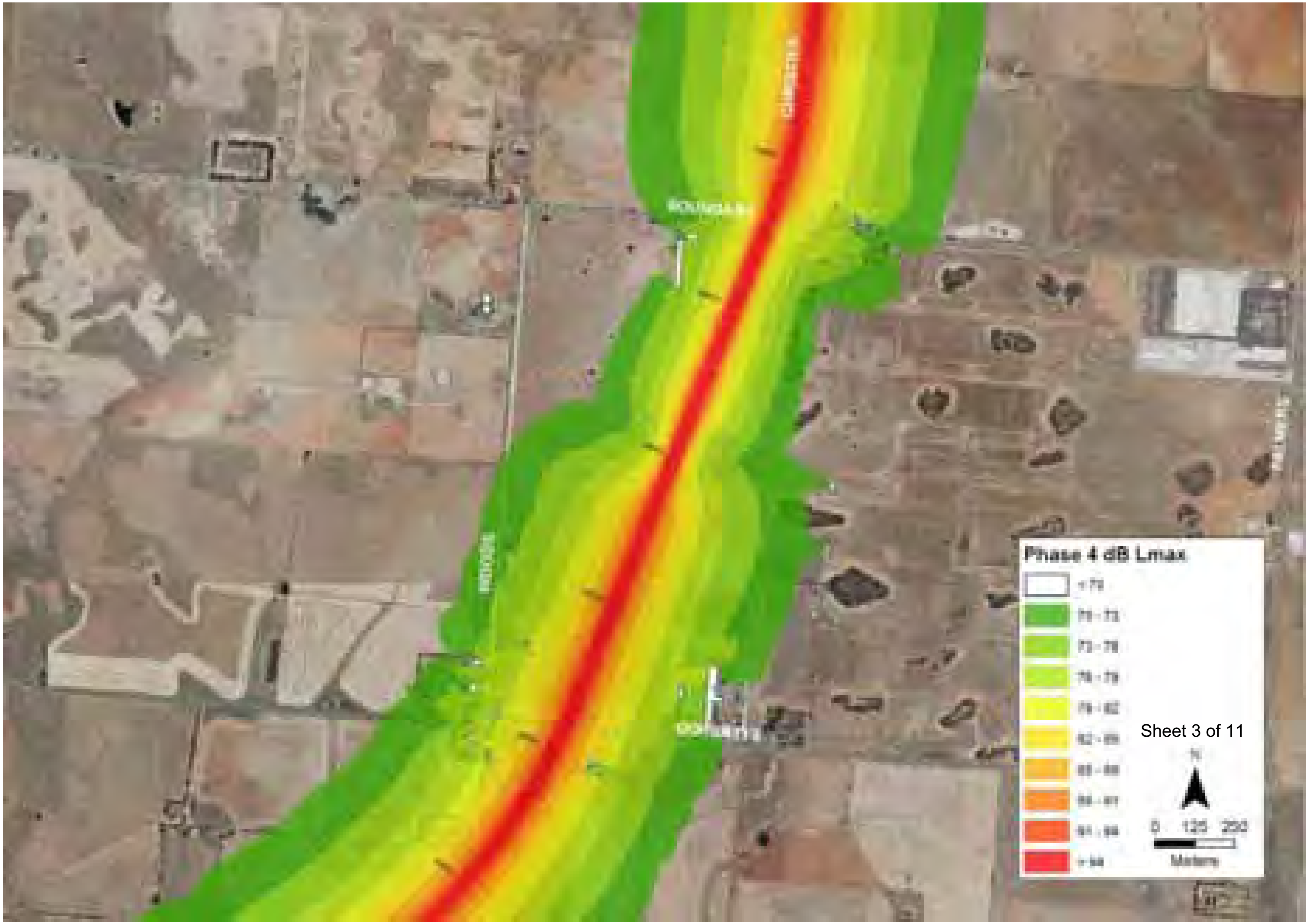

Phase 4 dB Leq,15h
< 50
50 - 53
53 - 56
56 - 59
59 - 62
62 - 65
65 - 68
68 - 71
71 - 74
> 74
Sheet 10 of 11
N
0 125 250
Meters

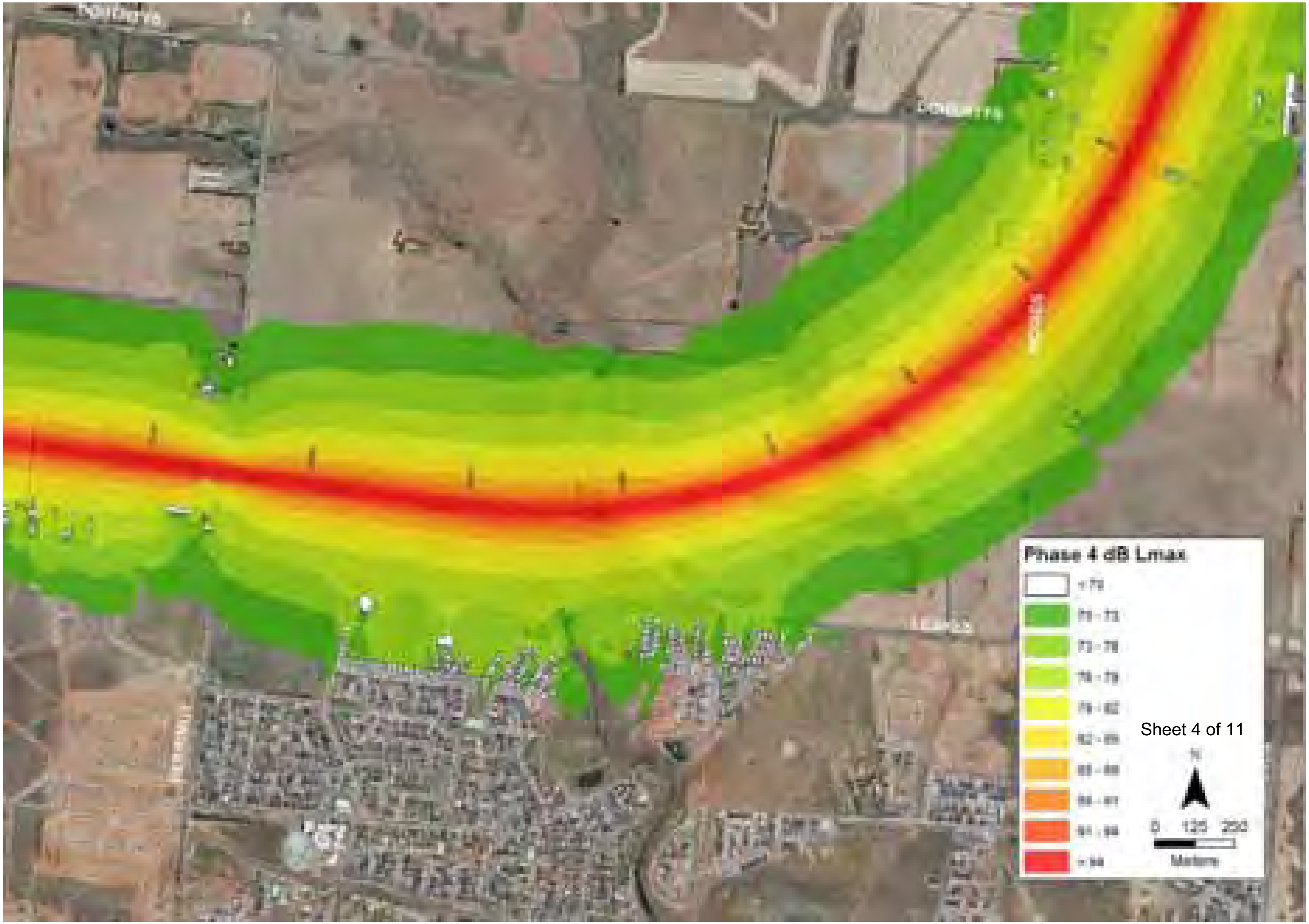

Phase 4 dB Leq,15h
Sheet 11 of 11
0 125 250

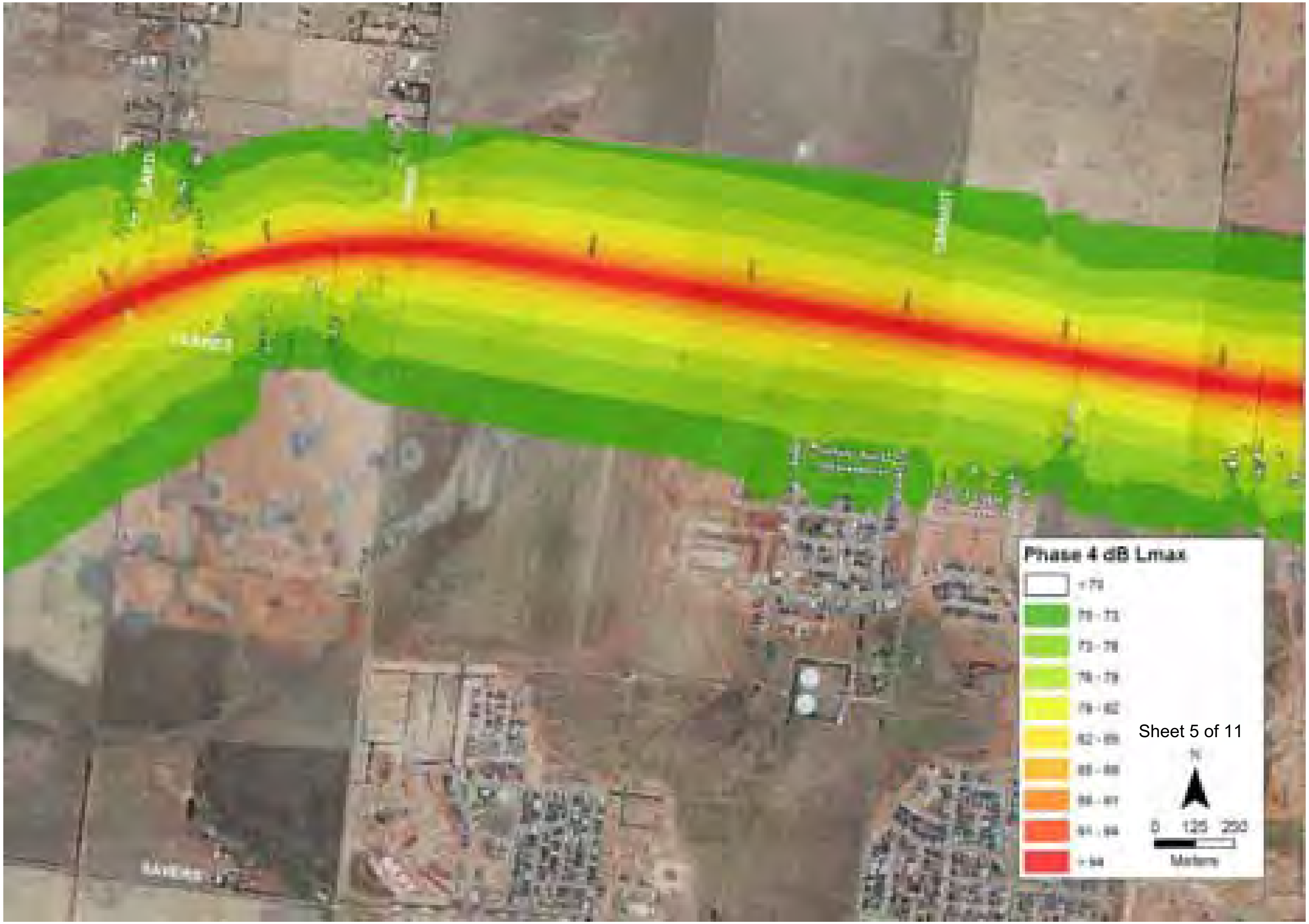
E1.7 Phase 4, Ultimate capacity (2030), L_{Amax}

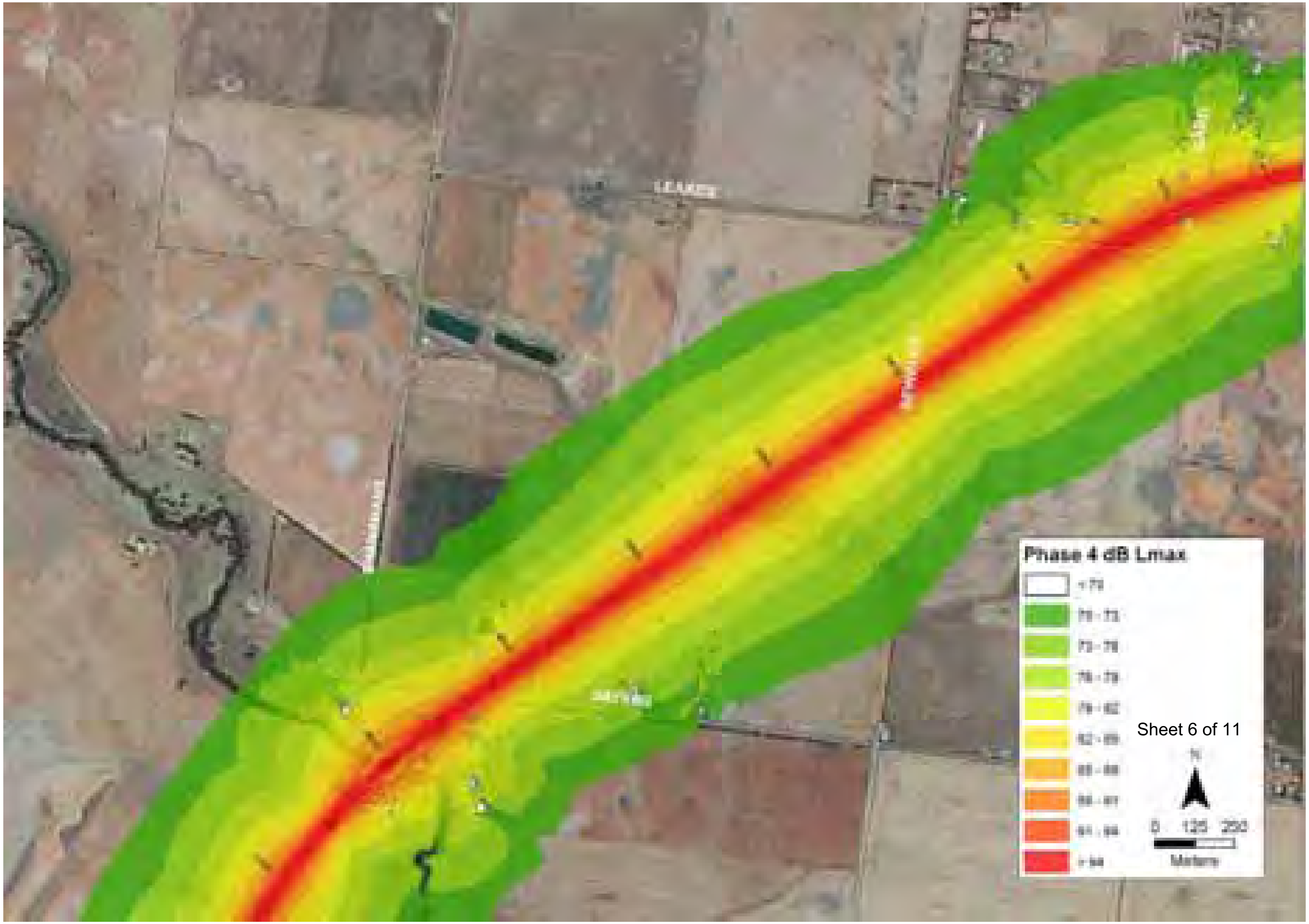

Phase 4 dB Lmax
Sheet 1 of 11

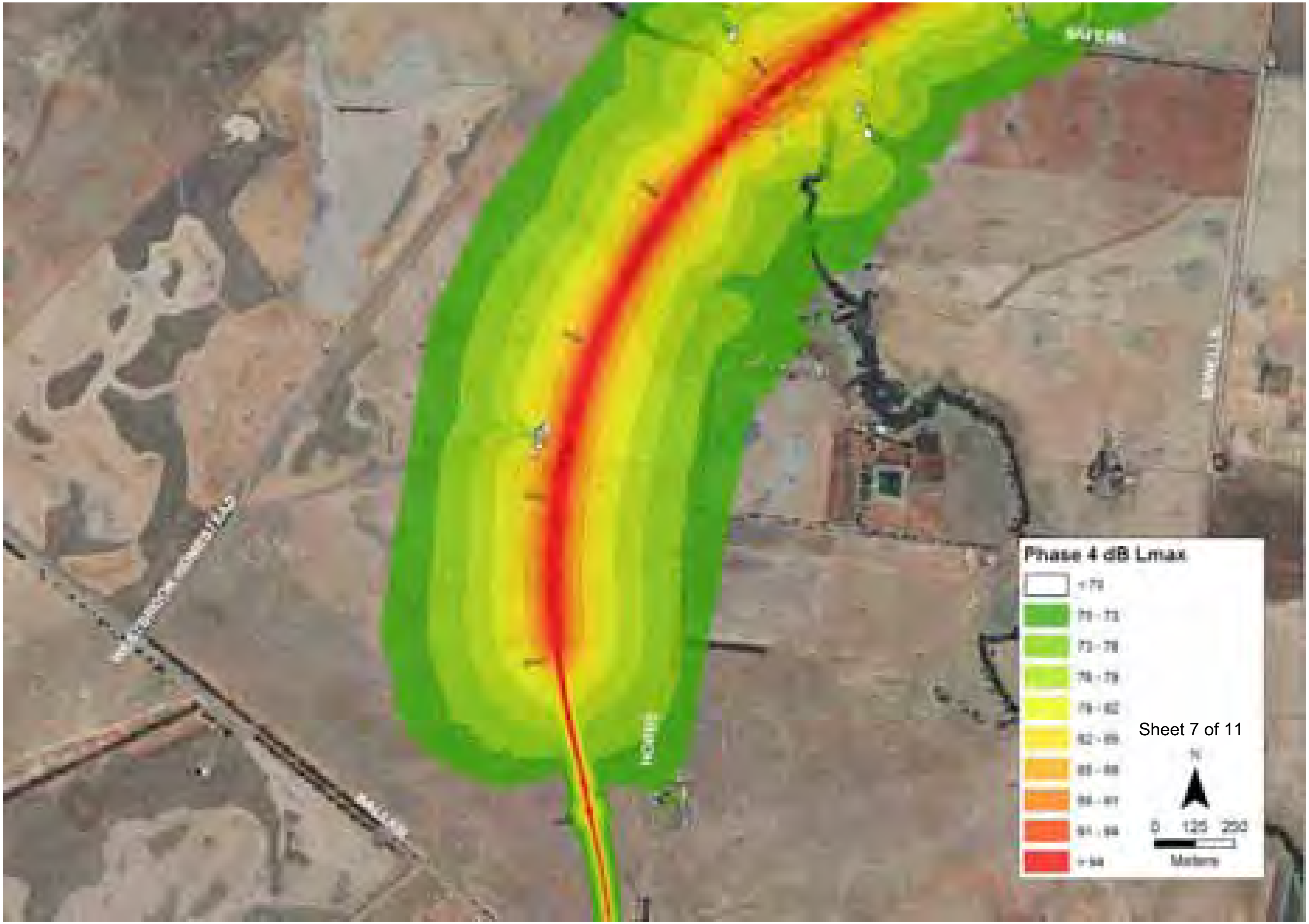

Phase 4 dB Lmax
Sheet 2 of 11
N
0 125 250
Meters


Phase 4 dB Lmax
Sheet 3 of 11
N

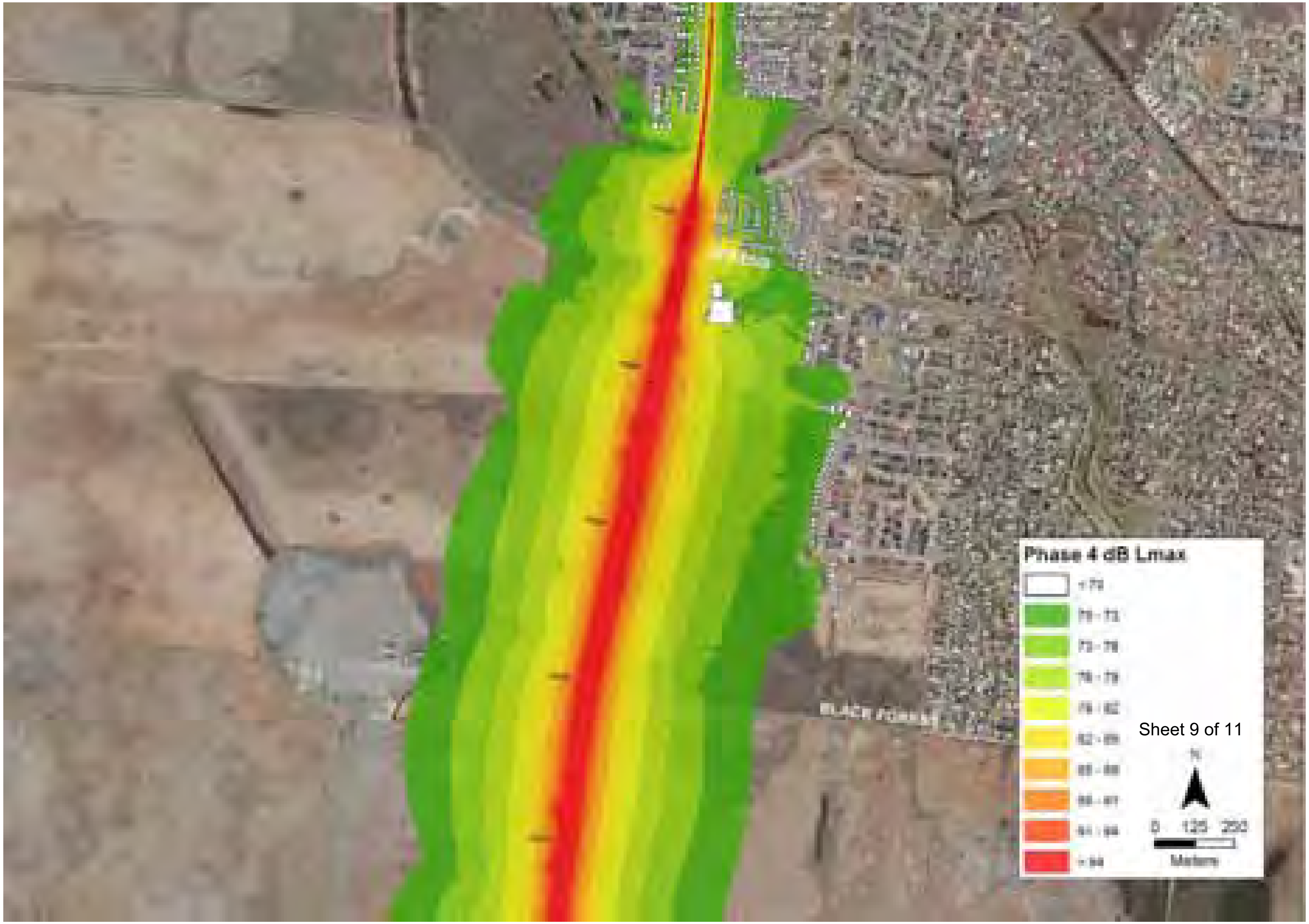

Phase 4 dB Lmax
Sheet 4 of 11

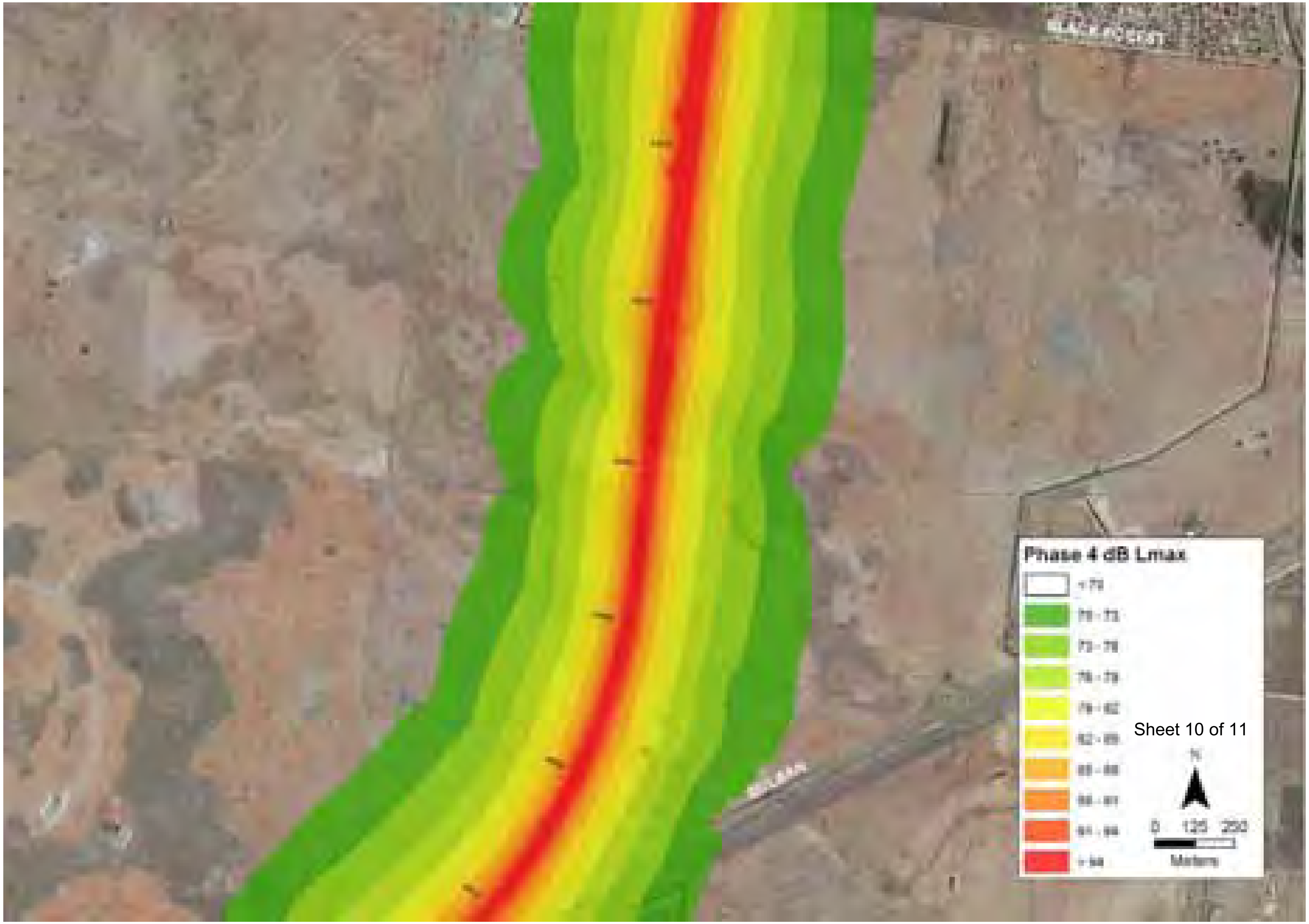

Phase 4 dB Lmax
Sheet 5 of 11
N
Meters

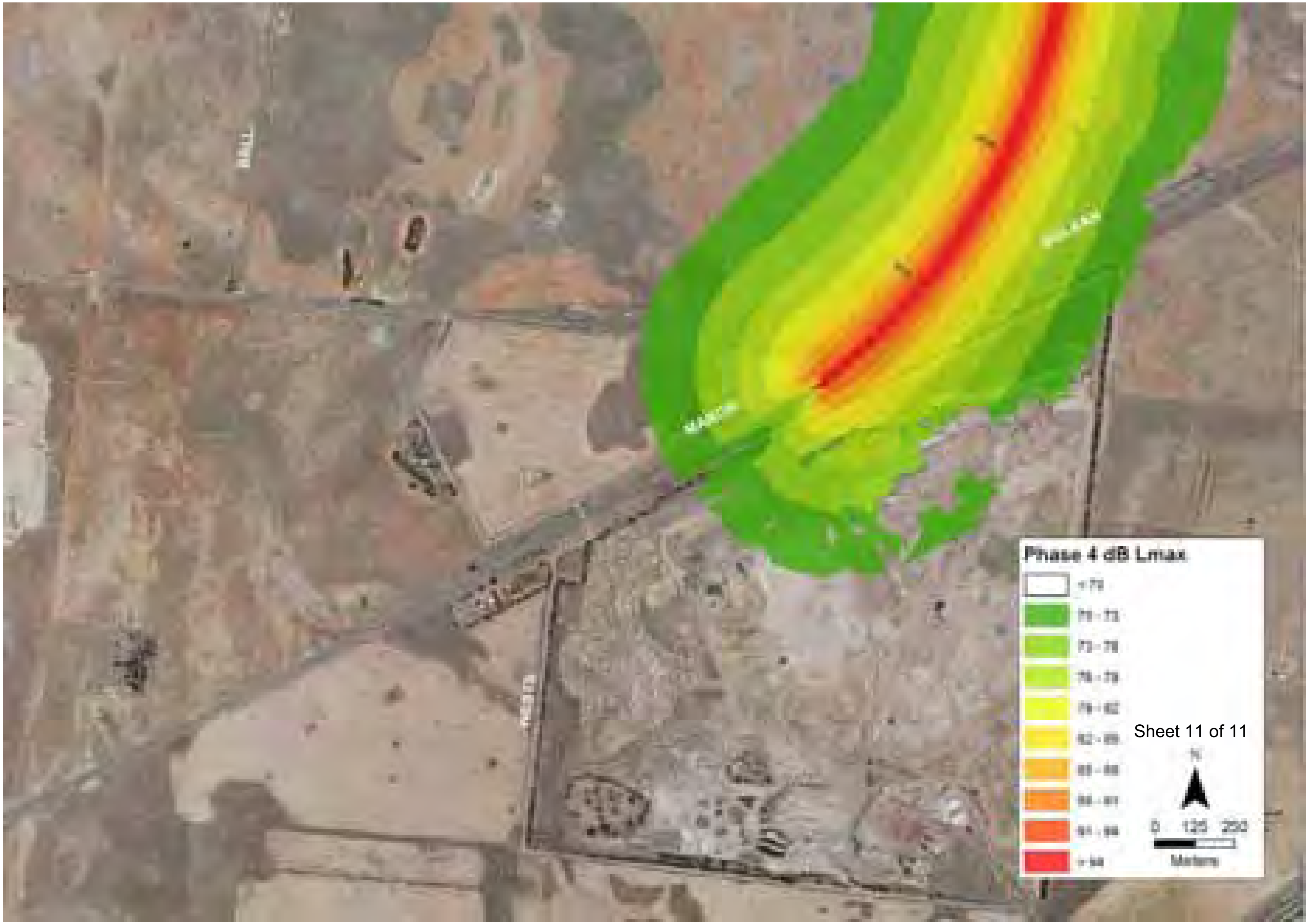

Phase 4 dB Lmax
Sheet 6 of 11
N
0 125 250
Meters


Phase 4 dB Lmax
Sheet 7 of 11
N
0 125 250
Meters

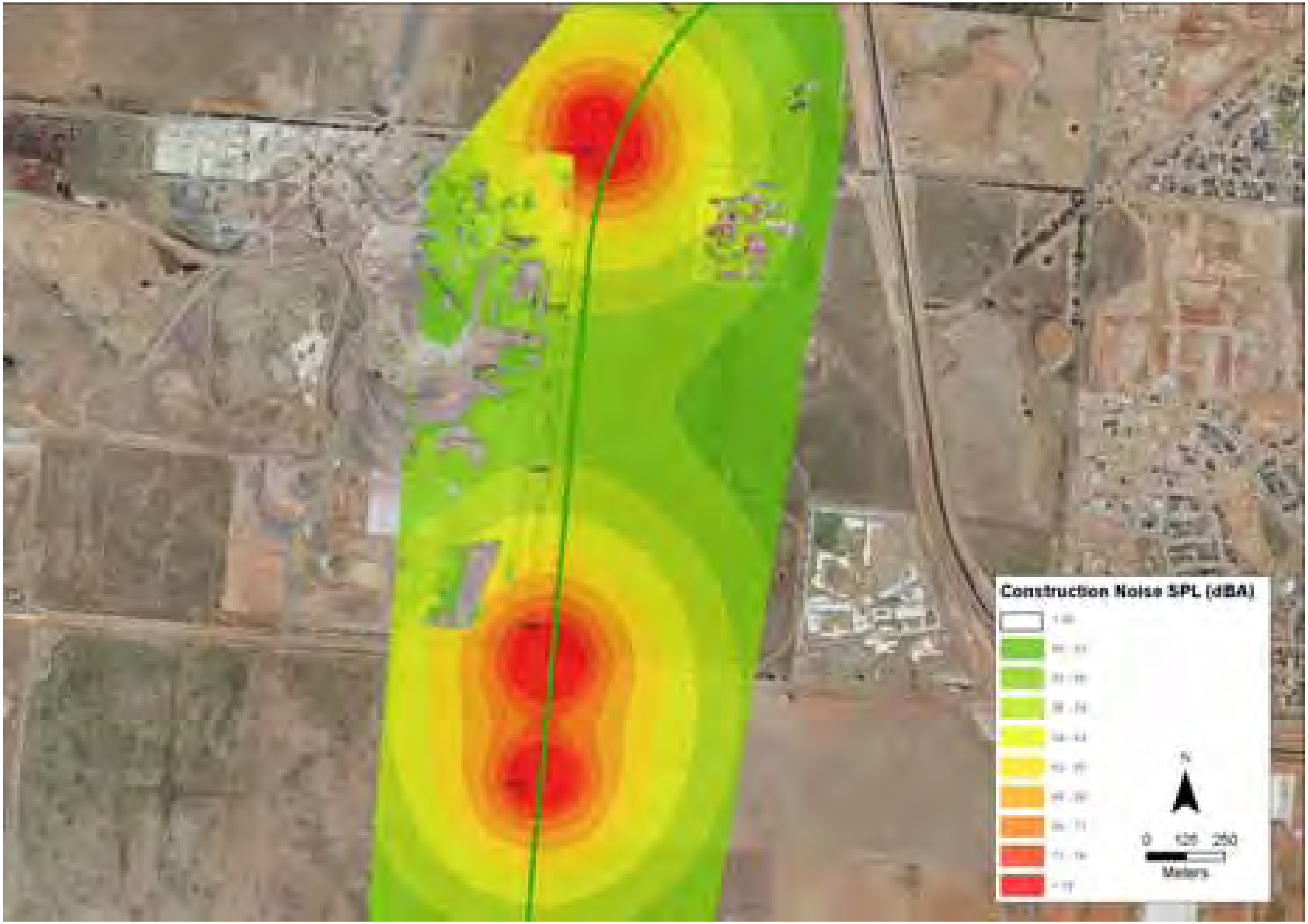

Phase 4 dB Lmax
Sheet 8 of 11
Meters

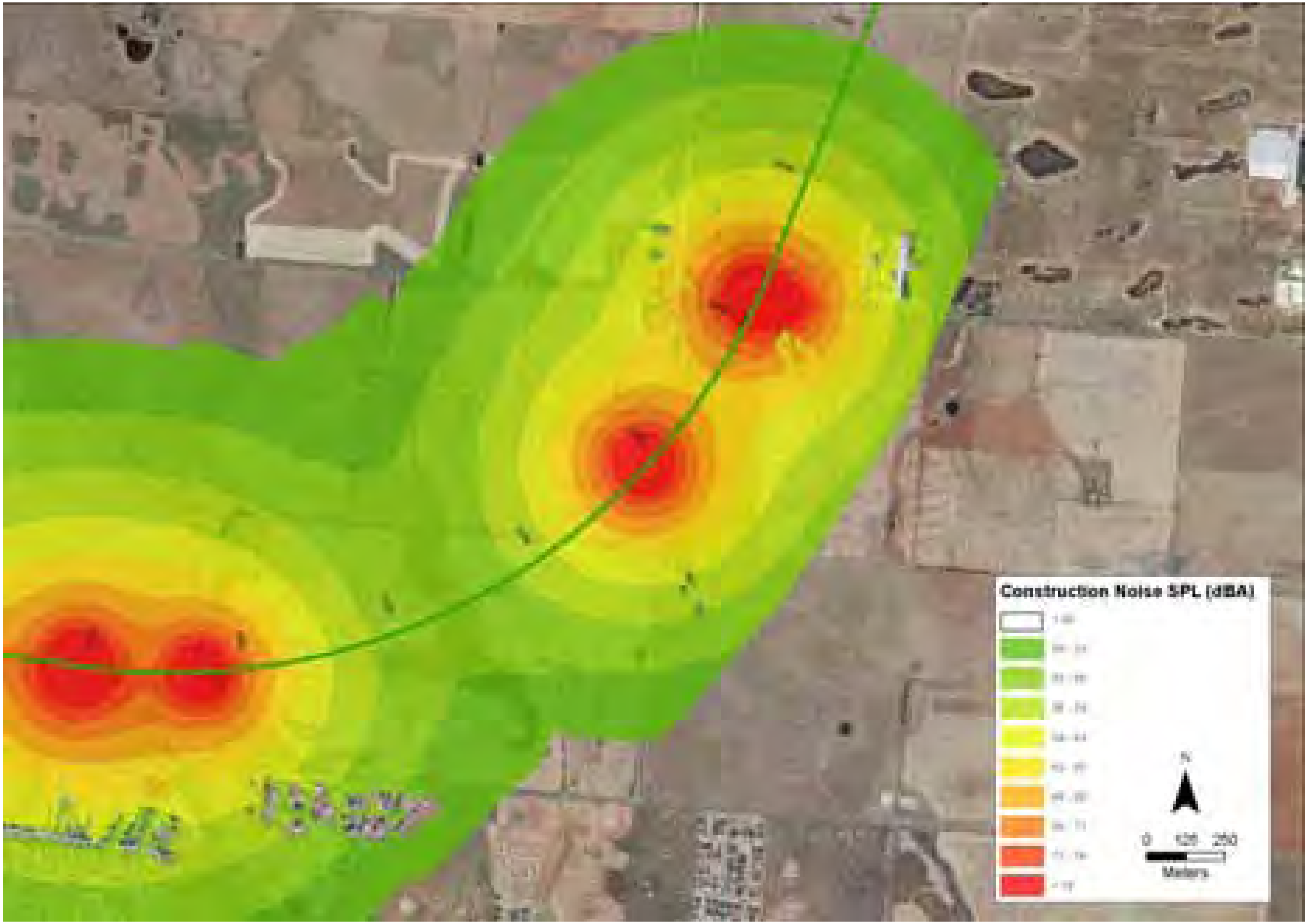

Phase 4 dB Lmax
Sheet 9 of 11
N
0 125 250

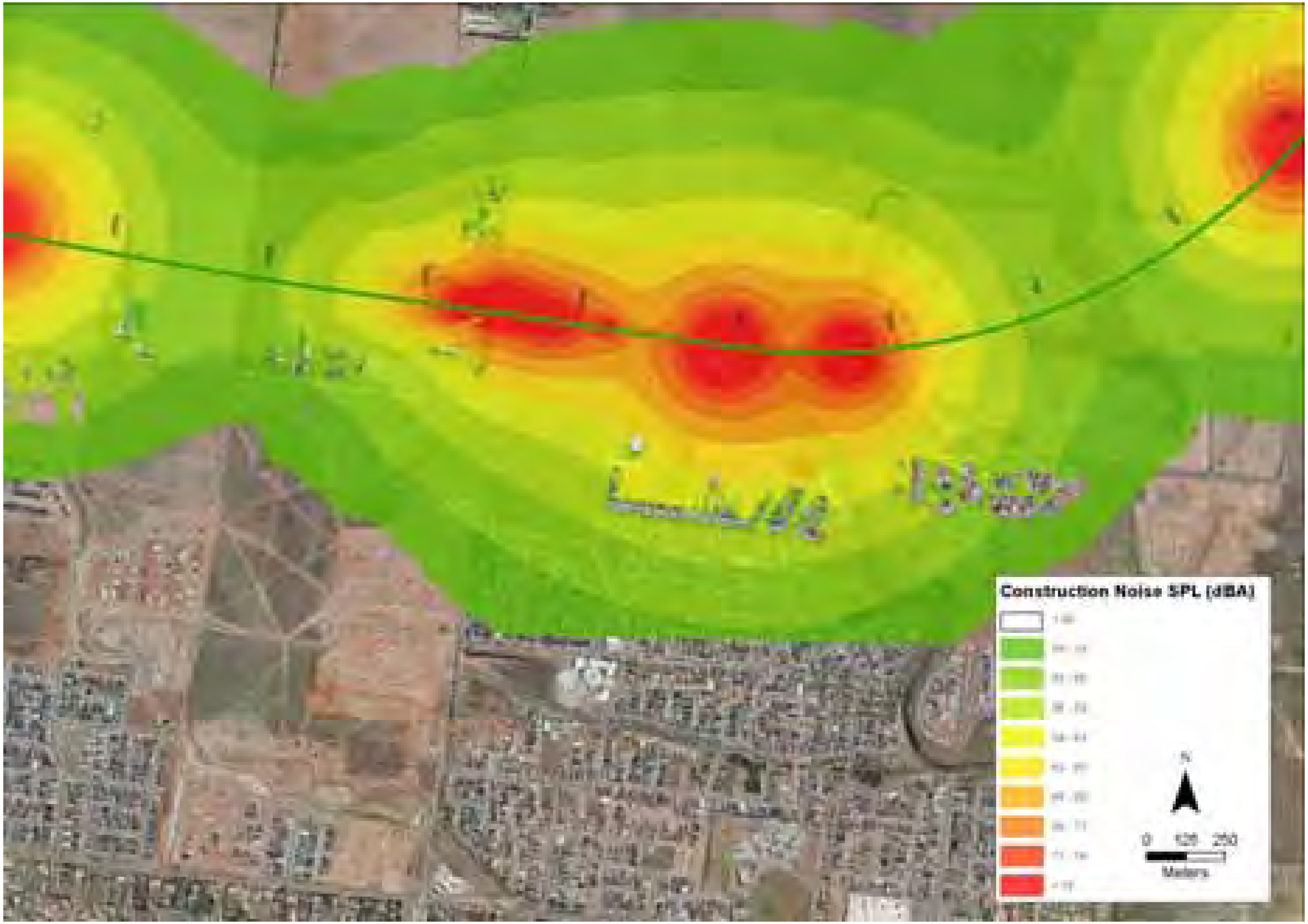

Phase 4 dB Lmax
Sheet 10 of 11
0 125 250
Meters

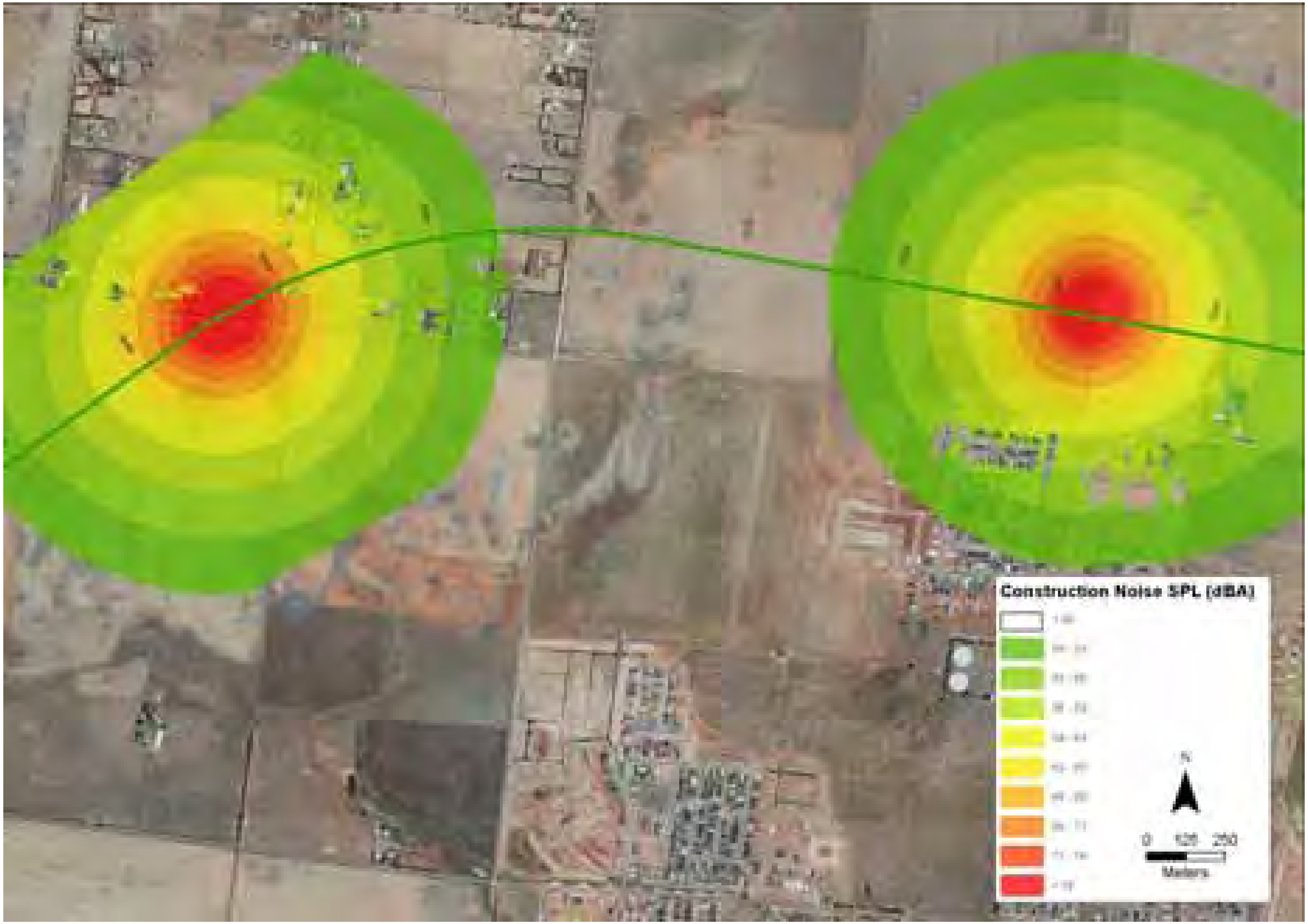

Phase 4 dB Lmax
Sheet 11 of 11
0 125 250

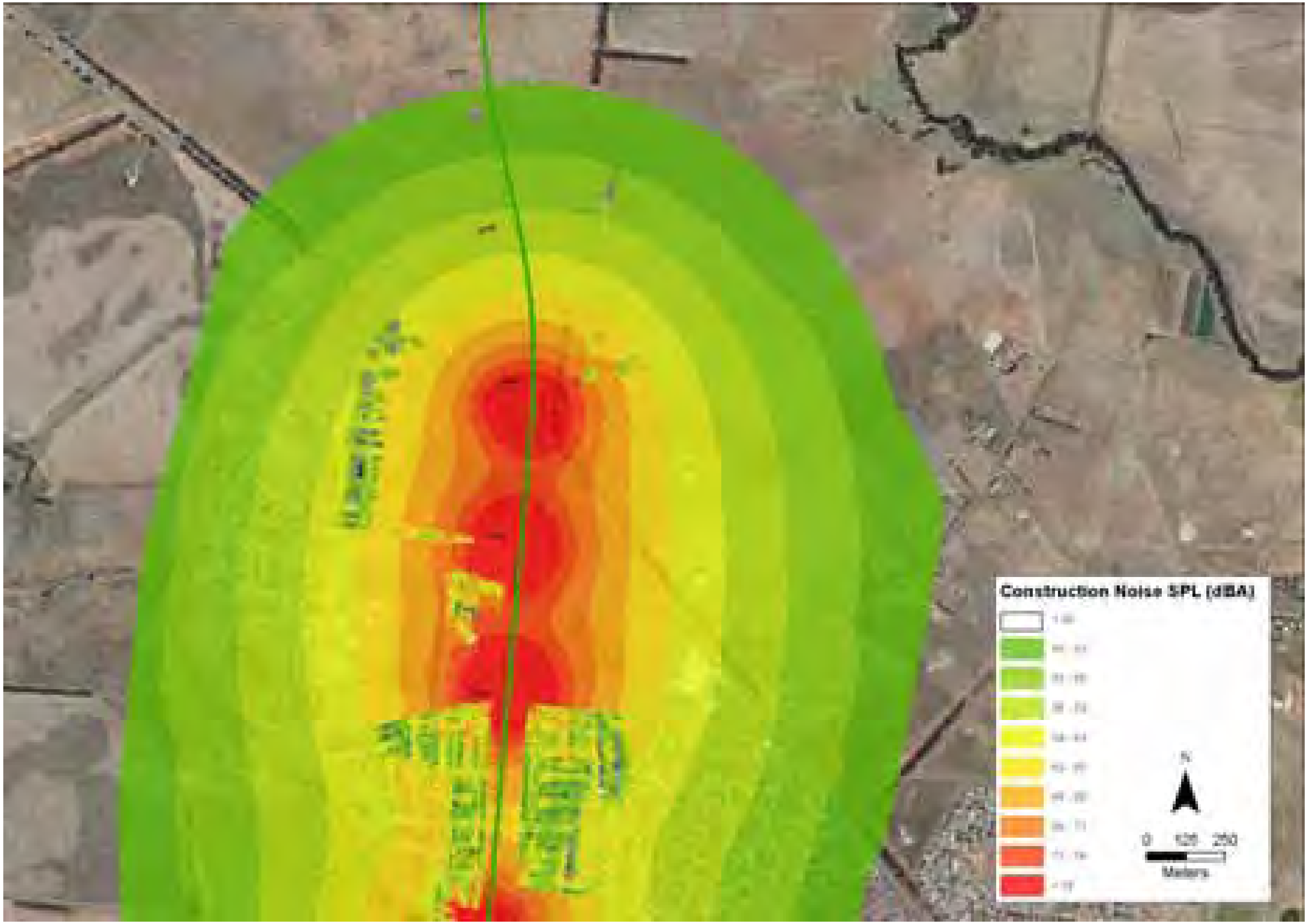
E2 Construction Noise Predictions

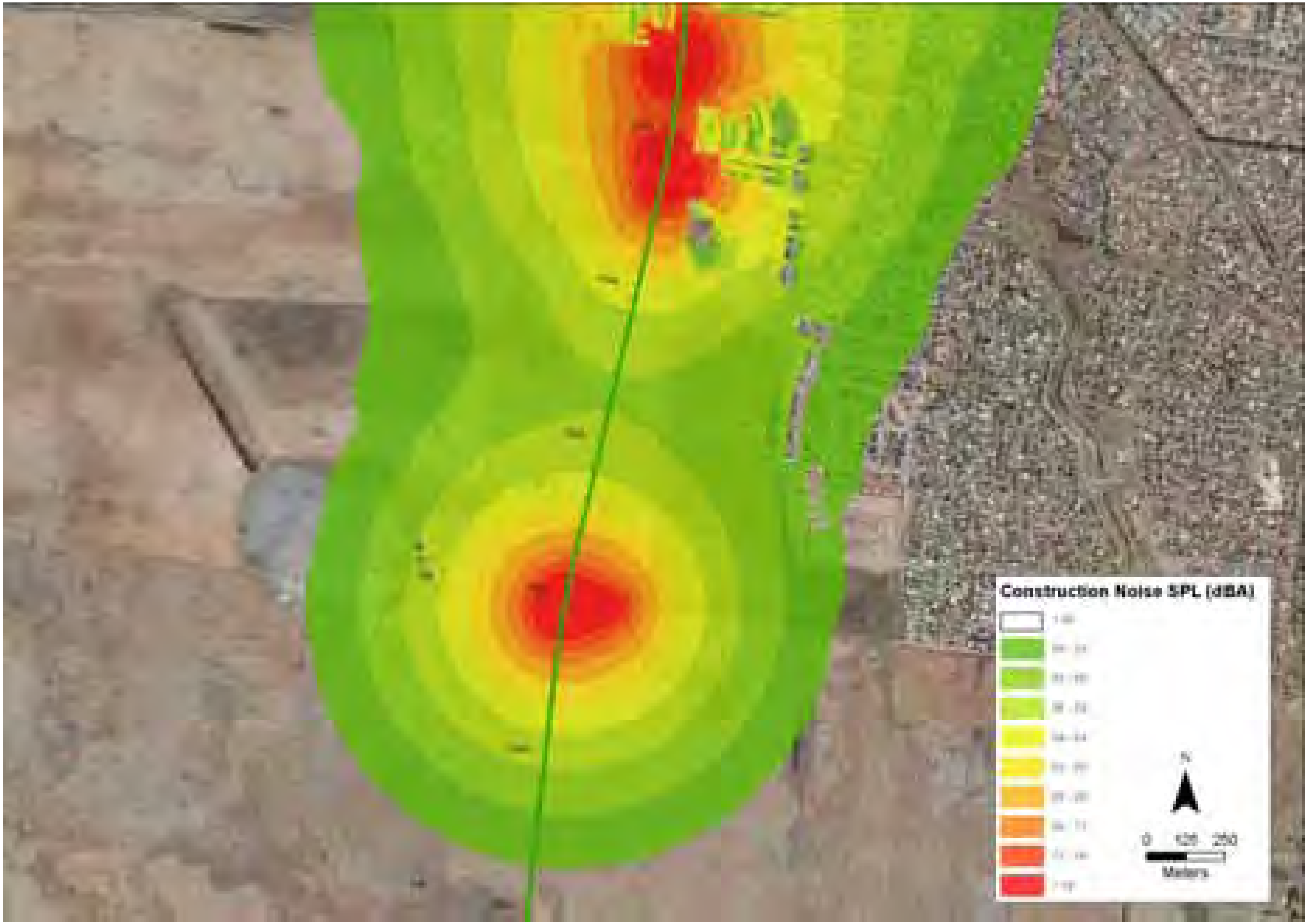

Construction Noise SPL (dBA)
N
0 125 250
Meters


Construction Noise SPL (dBA)
N
0 125 250
Meters


Construction Noise SPL (dBA)
0 125 250
Meters


Construction Noise SPL (dBA)
N
0 125 250
Meters


Construction Noise SPL (dBA)
N
0 125 250
Meters


Construction Noise SPL (dBA)
N
0 125 250
Meters