Noise and Vibration Report

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GROOTE EYLANDT MINING COMPANY PTY LTD

EASTERN LEASES PROJECT

NOISE AND VIBRATION IMPACT ASSESSMENT

REPORT J0130-85-R1
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GLOSSARY AND ABBREVIATIONS

Acoustical terms and abbreviations:

- Sound Pressure — Small air pressure variations above and below normal atmospheric pressure that are perceived by human ears as sound;
- Frequency — The rate of sound pressure fluctuations per second, expressed as cycles per second or hertz (Hz). Human ears in good condition can typically detect sound in the frequency range 20 Hz to 20,000 Hz, depending on sound level
- Octave — A frequency range covering a doubling of frequency from the lowest to the highest frequency in the band, for example from 1000 Hz to 2000 Hz. Standard octave bands for acoustic assessment are defined in Australian Standards and are referred to by their centre frequency in the approximate centre of lowest and highest frequencies in the range;
- Amplitude — The strength, intensity or loudness of a sound wave;
- RMS — Root-mean-squared, a mathematical method to determine the average amplitude of an acoustic or other time-varying signal;
- Decibels, dB — A noise level unit based on a logarithmic scale of pascals (Pa) of sound pressure above and below atmospheric pressure. Expressing a sound pressure level in decibels implies RMS sound pressure unless explicitly stated otherwise. Human ears in good condition can typically detect sound pressures from the threshold of perception at 0 dB (20 uPa) to the threshold of pain at 140 dB (200 Pa). An increase of 10 dB is perceived as an approximate doubling of sound level by an average human ear;
- dBL — Linear decibels, the same as dB but used to explicitly define a decibel scale in the absence of any frequency weighting;
- dBA — A-weighted decibels, where the A weighting means frequencies below 500 Hz and above 10 kHz are artificially reduced to approximate the frequency response of an average human ear. The ear is most sensitive to sound in the frequency range 1000 Hz to 6000 Hz, while sounds outside that range appear quieter. Most sound monitoring instruments include an A-weighting option, enabling direct measurement of noise levels in dBA;
- LAmax — The A-weighted maximum noise level over a defined measurement period, usually 15 minutes or 1 hour, which can be used to assess sleep disturbance;
- LA1 — The A-weighted noise level exceeded 1% of the time (which can be thought of as the loudest 1% of the time) over a defined measurement period, usually 1 minute or 15 minutes. LA1,1min is the average maximum noise level, is similar to the LAmax and is the recommended measure to assess sleep disturbance;
- LA90 — The A-weighted noise level exceeded 90% of the time (which can be thought of as the quietest 10% of the time) over a defined measurement period, usually 15 minutes or one hour, and widely accepted as the background noise level;
- LAeq — The A-weighted equivalent continuous, or logarithmic average, noise level over a defined time period of typically 15 minutes, either measured or predicted at a specific location;

- Sound Power — Sound energy emitted by a source, measured in watts (W) or expressed on a decibel scale with 0 dB representing 1 picowatt (1 pW) of sound power. While both sound pressure and sound power can be expressed on a decibel scale, the two are not interchangeable or directly comparable. Sound power levels are most commonly expressed as unweighted decibels (dBL) but can be expressed as A-weighted decibels (dBA);
- ABL — Assessment Background Level, the quietest 10% of the individual measured LA90,15min levels in a day, evening or night;
- RBL — Rating Background Level, the single background noise level used to determine relevant intrusive noise criteria and calculated as the median of the ABLs for each time period (day, evening and night);
- MIC — Maximum Instantaneous Charge, is a measure of the maximum weight of explosive material that is detonated at any instant in time in a blast event. The MIC is typically determined by multiplying the charge weight per blasthole, in kilograms, by the number of holes detonated simultaneously;
- Ground vibration — Earth movement or shaking caused by blasting, earthmoving equipment or heavy traffic;
- PPV — Peak particle velocity, the maximum vibration speed in mm/s of a ground particle in three dimensions due to a blasting or other event, typically measured by a blast monitor;
- Overpressure — A shockwave or pressure wave produced in the air by a blasting event. Overpressure is typically perceived as a low frequency rumble, similar to a thunderclap, to a distant observer; and
- dBL pk — Unweighted peak decibels for measuring overpressure, taking the peak or maximum instantaneous value rather than the RMS value.

Other terms and abbreviations:

- ALC — Anindilyakwa Land Council;
- ANZEC — Australian and New Zealand Environment Council;
- BoM — Bureau of Meteorology;
- CALMET — California Meteorological Model prepared as part of the EIS Air Quality Assessment to determine the variation of atmospheric conditions with time for a defined location, typically over a 12 month period;
- Concentrator — Ore processing plant which separates impurities from the manganese product;
- DoT — Department of Transport;
- ELR — Exploration Licence in Retention;
- ENM — Environmental Noise Model software developed by RTA Technology Pty Ltd and used to calculate noise levels at receptors or noise contours based on noise source details, terrain profile, ground surface covering and atmospheric conditions;
- EPA — Environment Protection Authority;
- INP — NSW Industrial Noise Policy;

- Mtpa — Million tonnes per annum;
- Ore — Manganese product in its as-mined, unprocessed form;
- Outstation — Small, rural Aboriginal settlement;
- Overburden — Soil, sand and other material that must be removed to uncover ore; and
- Wind Vector — A wind speed and direction can be divided into two perpendicular components or vectors, one component directly towards the receptor which affects noise propagation, and the other component perpendicular to the source-receptor direction which does not affect noise levels from the source. The wind vector of interest is typically the component from source to receptor and can be negative in the case of a wind blowing generally from the receptor to the source.

1 INTRODUCTION

Bridges Acoustics was commissioned by Hansen Bailey on behalf of BHP Billiton Manganese Australia Pty Ltd to complete an acoustics assessment as part of the Environmental Impact Statement (EIS) for the Eastern Leases Project (the project).

The project proponent is the Groote Eylandt Mining Company Pty Ltd (GEMCO) which has two shareholders, namely South32 Pty Ltd (60%) and Anglo Operations (Australia) Pty Ltd (40%). BHP Billiton Manganese Australia Pty Ltd was previously a shareholder in GEMCO, however its interest is now represented by South32.

The project involves the development of a number of open cut mining areas to the east of the existing GEMCO manganese mine on Groote Eylandt in the Gulf of Carpentaria, approximately 650 km south-east of Darwin as shown in Figure 1 in Appendix A. The proposed additional mining areas are located on the Eastern Leases, which are two Exploration Licences in Retention (ELRs). ELR28161 is termed the Northern Eastern Lease (Northern EL) and ELR28162 is termed the Southern Eastern Lease (Southern EL).

The Eastern Leases are located 2 km east of the existing GEMCO mine at the closest point. The township of Angurugu is located approximately 6 km to the north-west of the Eastern Leases, and is the closest residential community as shown in Figure 2. The Eastern Leases are located on Aboriginal land, scheduled under the *Aboriginal Land Rights (Northern Territory) Act 1976*. The Traditional Owners are represented by the Anindilyakwa Land Council (ALC). The land within the Eastern Leases comprises natural bushland, with the Emerald River and a small section of the Amagula River traversing the Northern EL and Southern EL respectively.

The project involves:

- Developing a number of open cut mining areas (termed “quarries”) within the Eastern Leases and mining manganese ore by the same mining methods that are in use at the existing GEMCO mine;
- Constructing limited mine related infrastructure in the Eastern Leases (dams, water fill points, crib hut, truck park up areas and laydown storage areas); and
- Transporting the ore by haul truck on a new haul road to be constructed between the existing GEMCO mine and the Eastern Leases.

Ore will be processed at the concentrator at the existing GEMCO mine and the concentrate would be transported to market via the existing port. No changes or upgrades to the existing GEMCO mine facilities are required as a result of the project. Ore mined from the Eastern Leases will supplement production from the existing GEMCO mine, however the project will not increase GEMCO’s annual production rate of approximately 5 Million tonnes per annum (Mtpa) of product manganese. The EIS does not include any assessment of operations within the existing GEMCO mine, given that these operations are subject to existing environmental approvals and will not be altered by the project.

The project site for the purposes of the EIS is the Northern and Southern ELs and the new section of haul road linking the Eastern Leases to the existing GEMCO mine. The project site covers an area of approximately 4,600 ha.

Mining in the Eastern Leases would take place concurrently with the operation of the existing GEMCO mine. According to current planning, construction in the Northern EL would commence in 2017 (termed Project Year 1). Construction in the Southern EL is scheduled to commence approximately 4 years later and mining would then take place in both of the tenements until approximately Project Year 15 (2031). This equates to a total of 13 years of mining operations (i.e. mining of ore).

This acoustic assessment considers noise from construction and mining, cumulative noise impacts with the existing GEMCO mine, potential impacts to sleep disturbance and low frequency noise, as well as ground vibration and overpressure from blasting.

The project will not increase total annual production of ore, therefore mine-related traffic on the Rowell Highway from the mine to the port at Alyangula will not change as a result of the project. Noise from construction related traffic has been assessed.

1.1 Environmental Noise Policies

The Northern Territory Environment Protection Authority (EPA) and the Northern Territory Department of Transport (DoT) have developed the following relevant guidelines:

- *Noise Guidelines for Development Sites in the Northern Territory* (Development Guideline) (EPA, 2013); and
- *Road Traffic Noise on NT Government Controlled Roads* (Traffic Noise Policy) (DoT, 2006).

The Development Guideline provides construction noise criteria but does not specifically address the issue of operating noise from extractive industries such as the project. The following additional policies and guidelines have been adopted for this assessment:

- *NSW Industrial Noise Policy* (INP) (NSW EPA, 2000) is a comprehensive policy addressing noise from industrial and mining developments to residential and other receptors;
- *Draft Ecoaccess Guideline for the Assessment of Low Frequency Noise* (Low Frequency Guideline) (Queensland EPA now the Department of Environment and Heritage Protection [EHP], 2004) recommends low frequency noise criteria for residences;
- *British Standard 7385-2:1993 Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration* (British Standards Institute, 1993);
- *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (Blasting Guideline) (Australian and New Zealand Environment Council [ANZEC], 1990) contains blasting criteria for residences that are accepted in most Australian states;
- *Australian Standard 2187.2-2006 Explosives – Storage and use, Part 2: Use of explosives* (SAI Global, 2006);

1.2 Sensitive Receptors

There are four sensitive receptors considered in the assessment as shown in Figures 2 and 3. These receptors are the nearest sensitive residences or recreation areas to the project site.

The township of Angurugu (receptor R1) is home to approximately 850 residents. The township is located inland from the western coast of Groote Eylandt adjacent to the Angurugu River approximately 6.5 km to the northwest of the Northern EL and is separated from closest proposed mining areas by a ridgeline approximately 50 m high. The existing GEMCO mine bounds the township on three sides with the Groote Eylandt Airport located directly to the north of the township. The closest Angurugu residence to the existing mining operations is located approximately 500 m to the north-east of current active mining operations including product stockpiles.

Yedikba (receptor R2) is an Aboriginal outstation located approximately 2.2 km to the west of the Southern EL and comprises three outstation buildings. Yedikba is not a permanently occupied outstation and is reported to have varying levels of use, from occasional visitation to sporadic residency. There were no occupants present in Yedikba during the noise survey in June 2014. Although Yedikba is located 400m from the tenement boundary of the existing mine, there are currently no mining activities occurring within the vicinity of this outstation, with the nearest operations at the existing mine taking place over 2 km from the outstation buildings. Although operations at the existing mine are currently located well over 2 km from Yedikba, GEMCO has approval to extend the mining operations further to the south within the mineral lease, and therefore operations may be in closer proximity to Yedikba in the future.

Wurrumenbumanja (receptor R3) is an Aboriginal outstation located approximately 3.5 km to the south of the Southern EL and comprises four outstation buildings. Wurrumenbumanja is not a permanently occupied outstation and is reported to have low levels of use, typically limited to occasional visitation. There were no occupants present in Wurrumenbumanja during the noise survey in June 2014. There are no mining activities occurring in the vicinity of this outstation, with the nearest operations at the existing mine taking place over 11 km from the outstation buildings.

A number of recreation areas are located on Groote Eylandt. The closest recreation area is located in the vicinity of the Amagula River south of the project site, with the Leske Pools swimming hole at the southern end of the recreation area approximately 2.4 km south of the project site. Leske Pools is used by Groote Eylandt residents and visitors to the island for swimming, camping and fishing activities. There are no mining activities occurring in the vicinity of this recreation area, with the nearest operations at the existing mine taking place over 11 km from this location.

Table 1 shows all potentially affected receptors in the vicinity of the project.

Table 1: Assessed Receptors

Number	Description	Location Relative to Project	Coordinates MGA Zone 53	
R1	Angurugu Township	6.5 km north-west	658061 mE	8453390 mN
R2	Yedikba Outstation	2.2 km west	657336 mE	8443030 mN
R3	Wurrumenbumanja Outstation	3.5 km south	663633 mE	8436591 mN
R4	Leske Pools Swimming Hole	2.4 km south	665871 mE	8437377 mN

2 EXISTING ENVIRONMENT

2.1 Noise Monitoring Program

The baseline noise monitoring program included long-term measurements using unattended noise monitors combined with short term operator-attended noise measurements to assist in identifying and quantifying dominant sources of background and ambient noise.

The long term survey occurred during the period 20 June to 1 July 2014 near the three residential receptor locations. The noise monitors were installed some distance from each receptor to minimise disturbance to residents during the operator-attended noise survey and to ensure the security of the noise monitoring equipment. The monitors were installed in the following locations as shown in Figure 3:

- M1 – In a wooded area approximately 870 m south-east of Receptor R1 and 30 m west of a light vehicle access road which carries limited local traffic;
- M2 – In a wooded area approximately 160 m north east of Receptor R2 and 30 m north of the receptor's access road; and
- M3 – In a wooded area approximately 100 m north west of Receptor R3 and 30 m west of the receptor's access road.

Noise monitors used during the survey consisted of Svantek 949 or 955 Type 1 sound level meters housed in weatherproof cases with the microphones and windshields attached via extension cables and mounted approximately 1.2m above the ground. The monitors were programmed to measure and store

1 second LAeq readings for the entire monitoring period, with recorded data subsequently converted to 15 minute percentile statistics to determine background and ambient noise levels. Data from the monitors is presented in chart form in Appendix A.

Short term operator attended noise measurements were also taken at each location during the day, evening and night at the beginning of the long term noise survey, with measurements taken over periods of nominally 15 minutes. Short term attended noise surveys were completed using a Svan 957 Type 1 sound level analyser fitted with a 12.7 mm polarised condenser microphone and a windshield. This instrument was mounted on a tripod with the microphone approximately 1.2 m above the ground. All instrument calibration levels were checked at the beginning and end of the survey using an 01dB Cal-01 Type 1 calibrator producing 94 dB at 1 kHz.

The short term noise survey included the following monitoring locations:

- S1 – Approximately 200 m south of Angurugu township on a GEMCO mine road located east of the premium concentrate stockpile area;
- S2 – Approximately 140 m east of Receptor R2 on the access road at the closest point to M2;
- S3 – Approximately 100 m north of Receptor R3 on the access road at the closest point to M3; and
- S4 – Adjacent to Receptor R4 on the access road approximately 40 m from the Amagula River.

2.2 Measured Noise Levels

Calculated ABLs and measured ambient (LAeq) noise levels at each long term monitoring location are shown in Tables 2, 3 and 4 for Receptors R1, R2 and R3 respectively.

Table 2: Measured Noise Levels at M1, June - July 2014, dBA

Day, Date	Background Levels, LA90 (ABL)			Ambient Levels, LAeq		
	Day 7am – 6pm	Evening 6 – 10pm	Night 10pm – 7am	Day 7am – 6pm	Evening 6 – 10pm	Night 10pm – 7am
Fri 20 – Sat 21 June	-	-	-	-	-	-
Sat 21 – Sun 22 June	26.4 [1]	24.3	18.5	40.1 [1]	46.4	33.4
Sun 22 – Mon 23 June	27.5	23.0	22.7	43.1	34.7	36.5
Mon 23 – Tue 24 June	29.9	19.2	20.8	42.3	32.6	35.3
Tue 24 – Wed 25 June	28.1	20.9	19.4	43.2	42.4	35.1
Wed 25 – Thu 26 June	32.8	25.1	19.7	42.7	39.9	34.4
Thu 26 – Fri 27 June	29.6	27.0	22.0	40.3	43.6	34.9
Fri 27 – Sat 28 June	25.0	23.6	18.9	38.3	43.0	30.7
Sat 28 – Sun 29 June	24.2	20.1	18.6	38.2	31.9	34.6
Sun 29 – Mon 30 June	28.8	22.9	20.1	43.3	32.4	32.4
Mon 30 – Tue 1 July	29.0	18.9	19.7	44.4	34.2	31.7
Tue 1 – Wed 2 July	30.1 [1]	-	-	43.5 [1]	-	-
RBL [2]	30	30	30	-	-	-

1 Data at the beginning and end of the survey were collected for less than an entire day, evening or night time period.

2 A minimum Rating Background Level (RBL) of 30 LA90,15min has been adopted in each time period.

Table 3: Measured Noise Levels at M2, June - July 2014, dBA

Day, Date	Background Levels, LA90 (ABL)			Ambient Levels, LAeq		
	Day 7am – 6pm	Evening 6 – 10pm	Night 10pm – 7am	Day 7am – 6pm	Evening 6 – 10pm	Night 10pm – 7am
Fri 20 – Sat 21 June	-	27.0 [1]	25.2	-	34.9 [1]	32.0
Sat 21 – Sun 22 June	27.7	27.4	24.9	39.6	40.8	31.2
Sun 22 – Mon 23 June	27.0	25.3	22.3	44.0	31.4	30.5
Mon 23 – Tue 24 June	26.4	25.1	23.5	40.9	31.0	30.8
Tue 24 – Wed 25 June	26.0	25.9	22.1	44.3	36.7	31.6
Wed 25 – Thu 26 June	27.6	25.7	22.9	44.2	39.8	29.8
Thu 26 – Fri 27 June	26.3	26.4	23.8	38.4	40.0	31.3
Fri 27 – Sat 28 June	26.7	27.5	24.7	40.0	39.1	33.1
Sat 28 – Sun 29 June	26.5	26.0	24.7	38.0	34.9	31.4
Sun 29 – Mon 30 June	27.9	25.2	24.8	45.4	30.9	31.5
Mon 30 – Tue 1 July	28.6	25.3	25.3	45.9	34.5	32.0
Tue 1 – Wed 2 July	29.4 [1]	-	-	43.5 [1]	-	-
RBL [2]	30	30	30	-	-	-

1 Data at the beginning and end of the survey were collected for less than an entire day, evening or night time period.

2 A minimum Rating Background Level (RBL) of 30 LA90,15min has been adopted in each time period.

Table 4: Measured Noise Levels at M3, June - July 2014, dBA

Day, Date	Background Levels, LA90 (ABL)			Ambient Levels, LAeq		
	Day 7am – 6pm	Evening 6 – 10pm	Night 10pm – 7am	Day 7am – 6pm	Evening 6 – 10pm	Night 10pm – 7am
Fri 20 – Sat 21 June	-	33.8 [1]	19.1	-	35.8 [1]	28.1
Sat 21 – Sun 22 June	30.1	30.5	18.1	36.0	37.0	27.9
Sun 22 – Mon 23 June	29.7	30.8	16.8	37.9	34.6	26.8
Mon 23 – Tue 24 June	27.5	29.2	19.0	34.4	33.3	28.5
Tue 24 – Wed 25 June	30.1	33.4	18.2	36.8	37.5	27.0
Wed 25 – Thu 26 June	30.7	32.3	17.3	37.9	37.8	26.7
Thu 26 – Fri 27 June	28.0	29.8	15.8	33.1	35.5	25.9
Fri 27 – Sat 28 June	27.9	30.6	16.8	32.6	36.9	29.5
Sat 28 – Sun 29 June	29.5	32.1	18.2	34.2	36.3	28.5
Sun 29 – Mon 30 June	29.3	29.7	15.6	38.8	33.0	25.0
Mon 30 – Tue 1 July	29.0	31.2	20.4 [1]	38.2	35.5	25.5 [1]
RBL [2]	30	31	30	-	-	-

1 Data at the beginning and end of the survey were collected for less than an entire day, evening or night time period.

2 A minimum Rating Background Level (RBL) of 30 LA90,15min has been adopted in each time period.

Background noise levels at the three long term monitoring locations were determined according to the following procedure as recommended in the INP:

- Remove any noise data affected by wind speeds over 5 m/s or rain as required by Section 3.4 of the INP;

- Separate data into day (7 am to 6 pm), evening (6 pm to 10 pm) and night (10 pm to 7 am) periods and calculate the L90 of the individual 15 minute LA90s to determine the background noise level per period (known as the Assessment Background Levels [ABLs]); and
- Adopt the median of the ABLs for the day, evening and night, with a lower limit of 30 LA90 where the median is lower than 30 LA90, as the Rating Background Levels (RBLs) for use in the assessment.

A summary of short term operator attended noise measurements and observations, which are primarily intended to identify and quantify audible sources of noise at each location, is presented in Table 5. Measured noise levels have been rounded to the nearest dBA.

Table 5: Summary of Short Term Measurements and Observations, dBA

Location, Date, Time, Period	Measured Levels			Audible Sources and Measured dBA Levels
	LA1	LAeq	LA90	
S4, 20/6, 6:56pm, Evening	48	46	39	insects 45-48, water in river 35
S3, 20/6, 7:24pm, Evening	41	38	36	insects 36-40, intermittent animals 42
S2, 20/6, 8:24pm, Evening	37	31	26	insects 32-36, water in river 26
S1, 20/6, 8:47pm, Evening	51	44	33	party 40-50, mine 38-45, insects 46, dogs 42
S4, 20/6, 11:34pm, Night	36	32	31	water in river 33, intermittent insects 32
S3, 21/6, 0:05am, Night	24	21	19	water in river 20, intermittent animals audible
S2, 21/6, 0:40am, Night	28	25	22	water in river 22-24, intermittent insects
S1, 21/6, 1:05am, Night	41	34	31	horn 47, dozer 33-42, reverse alarm 0-39, mine vehicle engines 40, dog 33, car 28, music 25
S1, 21/6, 12:50pm, Day	-	-	-	(high wind prevented noise measurement)
S4, 21/6, 1:32pm, Day	53	44	39	wind 54, birds 50, water in river audible
S3, 21/6, 2:03pm, Day	44	37	32	wind 35-45, birds 42
S2, 21/6, 2:30pm, Day	52	46	40	wind 40-50, birds 52

Data presented in Table 5 indicate noise from existing mining operations can reach 45 dBA at S1 which is located approximately 200 m south of Angurugu. A noise level of 45 dBA at S1 would equate to approximately 43 dBA at the closest residences when mining machines operate within approximately 750 m from R1. As the majority of mining areas are located at significantly greater distances, mining noise levels are typically less than 40 dBA. Other sources of noise at S1 include intermittent wind, insects, dogs barking and traffic.

Existing audible noise sources at S2, S3 and S4 are primarily natural sources such as wind, insects and water flowing in the nearby rivers. Noise from vehicle movements would also be intermittently audible at these locations, however no vehicle movements were noted during the short term noise survey. Mining activity currently occurs at some distance from S2, S3 and S4 and is not currently audible.

3 CRITERIA

3.1 Mining Noise

The Development Guideline published by the Northern Territory EPA recommends noise levels and work hours for construction, excavation and demolition work on land within or near commercial or residential areas. The guideline recommends a construction noise level not exceeding 5 dBA above the existing ambient noise, with both ambient and construction noise levels measured as an equivalent continuous LAeq level. However, the Development Guideline does not apply to mining activity.

In the absence of a defined policy dealing with mining noise to residential and other receptors, this assessment has adopted the *NSW Industrial Noise Policy* (INP) developed by the NSW Environment Protection Authority in 2000. The INP has successfully regulated noise from mining and industrial development in NSW for over 14 years and is considered a conservative policy. It is broadly consistent with or more conservative than equivalent noise policies adopted in other Australian states and by the World Health Organisation. The stated aim of the INP is *to allow the need for industrial activity to be balanced with the desire for quiet in the community*, with noise criteria *selected to protect at least 90 percent of the population living in the vicinity of industrial noise sources from the adverse effects of noise for at least 90 percent of the time*.

The INP recommends two sets of noise criteria for residential receptors. Intrusive criteria are set 5 dBA above the adopted RBL in each time period and are assessed as a LAeq,15min level to limit the relative audibility of mining or industrial operations to residential receptors. The intrusive criteria apply to noise from the project in isolation and exclude noise from existing GEMCO operations, wind, birds, insects and other sources not directly related to the project.

Amenity limits recommended in the INP depend on existing industrial noise levels and the nature of the receptor area. The amenity limits are designed to control the total level of industrial noise at a sensitive receptor such as a residence or recreation area. The amenity criteria therefore apply to the cumulative level of noise from all industrial sources, excluding other non-industrial sources such as traffic, birds and insects. Where noise from other industrial sources is insignificant, the cumulative noise level is effectively identical to the project noise level.

The INP defines the following receptor categories for permanent residences to determine appropriate amenity criteria:

- Rural means an area with an acoustical environment that is dominated by natural sounds, having little or no road traffic. Such areas may include:
  - an agricultural area, except those used for intensive agricultural activities;
  - a rural recreational area such as resort areas;
  - a wilderness area or national park; and
  - an area generally characterised by low background noise levels (except in the immediate vicinity of industrial noise sources).
- Suburban an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristics:
  - decreasing noise levels in the evening period (1800–2200); and/or
  - evening ambient noise levels defined by the natural environment and infrequent human activity.
- Urban an area with an acoustical environment that:
  - is dominated by ‘urban hum’ or industrial source noise;
  - has through traffic with characteristically heavy and continuous traffic flows during peak periods;
  - is near commercial districts or industrial districts; or
  - has any combination of the above, where ‘urban hum’ means the aggregate sound of many unidentifiable, mostly traffic-related sound sources.

A passive recreation area is not defined in the INP, however the INP distinguishes between a passive recreation area such as a National Park and an active recreation area such as school playground or a golf course. Passive recreation areas are therefore areas used for relatively quiet activities such as camping or walking while an active recreation area is used for potentially louder activities such as exercise or sport.

For the purposes of determining appropriate noise amenity criteria, Receptor R1 has been assigned the 'suburban' category while Receptors R2 and R3 have been assigned the 'rural' category. Receptor R4 is most accurately classified as a passive recreation area and has been assigned relevant criteria from Table 2.1 of the INP. Intrusive criteria are only applied to residences and therefore do not apply to Receptor R4.

The INP therefore recommends the following situations and criteria be assessed:

- Noise from the project should meet the intrusive criteria at residential receptors R1, R2 and R3;
- Cumulative noise from the project plus other industrial sources should comply with the amenity criteria at residential receptors R1, R2 and R3; and
- Cumulative noise from the project plus other industrial sources should meet the amenity criteria at the recreation area receptor R4.

Table 6 shows the intrusive and amenity criteria determined according to the INP.

Table 6: NSW Industrial Noise Policy Noise Criteria.

Receptor	Background Level and Noise Criteria, Day/Evening/Night			
	R1	R2	R3	R4
Intrusive (Project Alone) Criteria, LAeq,15min				
Background level LA90,15min	30/30/30	30/30/30	30/31/30	-
Intrusive criteria	35/35/35	35/35/35	35/36/35	-
Amenity (Cumulative) Criteria, LAeq,period				
Suburban Residence	55/45/40	-	-	-
Rural Residence	-	50/45/40	50/45/40	-
Passive Recreation Area	-	-	-	50/50/50

1 Day (7am to 6pm), Evening (6pm to 10pm), Night (10pm to 7am). Night ends, and day begins, at 8am on Sundays and public holidays.

3.2 Sleep Disturbance

Disturbance to sleep can occur when a short, sharp noise is significantly louder than the average ambient noise level. While research in Australia and overseas has partly quantified the effects of noise on sleep, research results remain uncertain and a clear relationship between noise levels and sleep quality has not yet been established to allow firm noise criteria to be developed. Nevertheless, the World Health Organisation and various Australian state governments have developed conservative criteria to minimise the risk of sleep disturbance until further research can lead to more robust criteria.

The INP does not recommend maximum noise level criteria to minimise sleep disturbance, however the NSW EPA recommends a sleep disturbance criterion set 15 LA1,1min above the adopted background noise level during the night. An adopted minimum background noise level of 30 LA90 implies a sleep disturbance criterion of 45 LA1,1min, which is approximately equal to 45 LAmax.

3.3 Low Frequency Noise

The INP recommends low frequency noise be assessed by applying a correction factor to normal industrial or mining noise levels, however this aspect of the policy is currently subject to revision. The *Draft Ecoaccess Guideline for the Assessment of Low Frequency Noise* (Low Frequency

Guideline) published by the Queensland EPA suggests a criterion of 50 dBL for the frequency range 10 Hz to 200 Hz to minimise the potential for impacts on noise sensitive receivers such as residences. dBL means unweighted decibels, without the usual A-weighting correction that is normally applied to approximate the frequency response of an average human ear. There is no dBA equivalent to the suggested criterion of 50 dBL.

The Low Frequency Guideline requires assessment of low frequency noise inside a residence with windows and doors closed to reduce background noise levels and to avoid contamination of the noise measurement with wind noise or other extraneous external noise sources. This approach is adopted because low frequency noise inside a residence is more audible when windows and doors are closed, thereby lowering background noise levels in the residence. A typical difference of 20 dBA is encountered between noise levels outside and inside a residence where windows and doors are closed, however a lower attenuation of 10 dBA has been conservatively adopted for the low frequency assessment as the walls and roof of most residences provide less attenuation of low frequency noise compared to typical audible noise. The 50 dBL criterion inside a residence would be approximately equivalent to a criterion of 60 dBL outside a residence.

3.4 Road Traffic Noise

The Northern Territory Department of Transport has developed a road traffic noise policy which is available online at http://www.transport.nt.gov.au/ntroads/nt-roads-policies/traffic-noise. The policy recommends a noise criterion of 68 LA10,18hr for existing roads and residences, with a lower criterion of 63 LA10,18hr for noise from future roads to existing residences.

3.5 Blasting

Blasting is proposed within the project site to loosen sections of ore for removal by excavator. Blast effects include ground vibration which can sometimes be perceptible as a brief shaking of the ground surface, typically expressed in mm/s Peak Particle Velocity (PPV), and low frequency noise known as overpressure which is typically expressed as dBL Peak and is subjectively similar to distant thunder. Overpressure levels measured in dBL Peak are quite different and cannot be compared to more common noise levels expressed in dBA.

3.5.1 Residential Disturbance Criteria

The *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (Blasting Guideline) recommends residential ground vibration and overpressure limits and time restrictions for blasting and has been adopted in the majority of Australian states. Recommended residential overpressure and vibration limits in the Blasting Guideline, which are designed to minimise disturbance to occupants, are listed below.

Overpressure	115 dBLpk for 95% of blast events in a 12 month period;
	120 dBLpk for all blasts;
Ground vibration	5 mm/s PPV for 95% of blast events in a 12 month period; and
	10 mm/s PPV for all blast events.

The Blasting Guideline recommends blasting criteria apply during the hours 9am to 5pm Monday to Saturday, with no blasting on Sundays or public holidays. With mining activity occurring 7 days per week it may be appropriate to also allow blasting during the hours 9am to 5pm on Sundays and public holidays, subject to negotiation with the community. Blasting at the existing GEMCO mine currently takes place 7 days per week.

3.5.2 Building Damage Criteria

The overpressure and ground vibration limits in the Blasting Guideline, although designed to minimise disturbance to occupants, would also prevent any damage to structures. The majority of occupied buildings such as residences can withstand much greater vibration levels, typically well over 20 mm/s, before the onset of superficial or cosmetic damage. Vibration levels over 25 mm/s would typically be required to cause structural damage to these buildings. Appendix J4 of *Australian Standard 2187.2-2006 Explosives – Storage and use, Part 2: Use of explosives* suggests a vibration criterion of 15 mm/s at 4 Hz, rising to 50 mm/s at 40 Hz and above, would protect occupied buildings constructed of lightweight materials such as timber frames and plasterboard lining. AS2187 also recommends a vibration criterion of 50 mm/s for industrial and heavy commercial buildings. The residential disturbance vibration criterion of 5 mm/s and upper limit of 10 mm/s for occupied buildings is therefore adequate to protect these buildings from even superficial or cosmetic damage.

Similarly, occupied buildings routinely withstand wind pressures, including strong wind gusts, so are not particularly sensitive to overpressure. Appendix J5 of AS2187 states *"From Australian and overseas research, damage (even of a cosmetic nature) has not been found to occur at airblast levels below 133 dBL. Windows are the building element currently regarded as most sensitive to airblast, and damage to windows is considered improbable below 140 dBL"*. The recommended criterion of 115 dBL, and upper limit of 120 dBL, is therefore adequate to protect buildings from damage due to overpressure.

4 ASSESSMENT

4.1 Calculation Procedure

Environmental noise levels from the project have been predicted using RTA Technology's Environmental Noise Model (ENM) software. ENM is a general purpose noise modelling package that combines terrain and noise source information with other input parameters such as weather conditions to predict noise levels at specific receptor locations or as contours over a defined area. It is recognised as one of the most appropriate choices for situations involving complex topography and a large number of individual noise sources, and where a detailed assessment of the effects of atmospheric conditions on noise propagation is required.

The standard ENM package includes data input modules to allow terrain and noise source information to be entered and amended, plus an initial setup page containing terrain and source lists and modelled weather conditions for each scenario. All terrain and source files were prepared for this assessment using a combination of AutoCad and Excel based data then converted to ENM format terrain and source files. All outputs were obtained using algorithms equivalent to ENM's standard sectioning and contouring functions and are presented on a base plan after minor tidying such as closing gaps in the contour lines. Noise contours are presented in Figures 3 to 9.

The assessment considers three operating years:

- Project Year 3 with mining occurring only in the Northern EL, represents the closest mining activity to receptor R1. The Project Year 3 mine plan shows a number of active mining and overburden emplacement areas, however the assessment considers a conservative worst case situation with the majority of mining equipment located at the closest point to R1;
- Project Year 9 with mining occurring in both the Northern EL and Southern EL, represents the closest mining activity to receptors R3 and R4. The mine plan for Project Year 9 shows a number of active mining and overburden emplacement areas, however the assessment considers a conservative worst case situation with the majority of mining equipment located at the closest point to R3 and R4; and
- Project Year 13 with mining occurring in both the Northern EL and Southern EL represents the closest mining activity to receptor R2. The assessment considers a conservative worst case situation with the majority of mining equipment located at the closest point to R2.

The operating years that were selected for modelling are worst case years, both in terms of the intensity of mining activity defined by production rate, volume of overburden moved and the proximity to sensitive receptors. Project noise levels over the remainder of the project life would be no higher than during these worst case years, and for much of the time would be significantly lower.

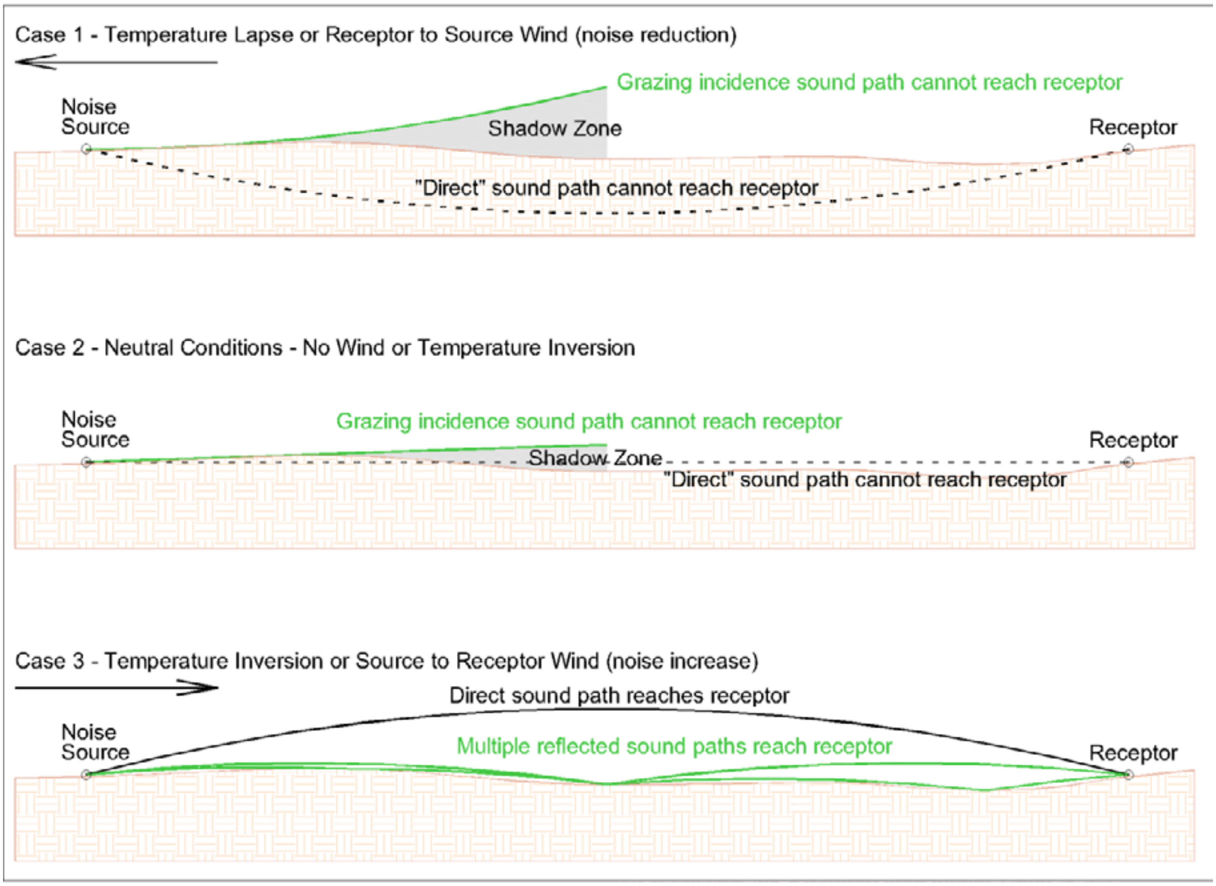
4.2 Atmospheric Conditions

4.2.1 General Discussion

A review of atmospheric conditions that occur in the region has been carried out to assist in determining the effect of such conditions on noise propagation from the project. Parameters such as air temperature, relative humidity, wind speed profile and vertical temperature gradient can influence noise levels at some distance from a source, while such effects are rarely significant at much shorter distances.

It is commonly understood that winds tend to 'blow' noise and increase received levels downwind from a source. The actual noise enhancement mechanism is related to bending or refraction of sound rays as they pass from one wind speed zone to another or, in real cases, as they pass through a gradually changing wind speed profile. Sound rays travelling against the wind tend to be refracted away from the ground (Case 1) while sound rays in calm conditions travel in straight lines (Case 2). Sound rays travelling in the same direction as the wind tend to be refracted towards the ground (Case 3) as shown in the following sketch.

Sketch 1: Sound Ray Refraction



Where all sound paths intersect the ground or other structures rather than reaching the receptor, the receptor is considered to be in the shadow of a noise barrier and the received noise level is significantly reduced.

Where a direct sound path and one or more reflected sound paths reach a receptor, received noise levels are the sum of noise from all paths and can increase significantly.

Wind speeds tend to increase with height above the ground in a non-linear fashion, requiring all important wind speed measurements to be taken at a standardised height of 10m above the ground. The wind speed profile, or the variation of wind speed with height, varies depending on the average roughness of the ground surface and near major changes in ground elevation such as hills and valleys. The actual wind speed and direction varies in a complex way over undulating and forested areas and it would be very difficult to accurately measure or model this situation for a single point in time. This complexity is further increased when variations in wind conditions over time are considered.

A less complex approach to wind effects is adopted for noise assessment purposes. The approach assumes a standard wind speed profile occurs over the study area, resulting in a more easily determined radius of curvature for sound rays that only depends on the wind speed and whether the sound rays are travelling downwind, upwind or at an angle to the wind direction.

It is also commonly understood that temperature inversions tend to increase noise levels at some distance from a source. A temperature inversion is formed when air near the ground is cooler than the air above, which primarily occurs during the late evening and night. Sunny days allow the sun to heat the ground surface which disperses an inversion and creates the opposite effect, known as a temperature lapse, where air near the ground is warmer than air at a greater height above the ground.

As cool air is more dense than warm air and sound travels slower in dense air, sound rays are refracted towards the cooler air which is away from the ground for a lapse (Case 1) or towards the ground for an inversion (Case 3) as shown in the sketch above.

Cool air, being heavier than warmer air, tends to run down hills and will form a pool in valleys. The depth of cool air settling in a valley tends to increase during the night, particularly in winter. In most cases the cold air mass moves down the valley towards the ocean, creating a ‘drainage flow’. While water is much heavier than air and follows the lowest path along the valley, cool air is only marginally heavier than warm air and the moving cool air mass tends to spill out over the width of the valley floor. The speed of this movement depends on site conditions but is typically in the range 1 to 2 m/s.

The wind speed and direction during a calm night therefore varies depending on the direction of the main valleys in the area and can be vastly different over a large area such as the project site. The depth of any cool air flows vary depending on terrain conditions. As for gradient winds discussed above, it would be very difficult to measure and model air temperatures and flows over the entire modelled area for a particular point in time and it would be more difficult to model the situation as it changes with time.

A simpler situation is considered for noise modelling, in which a constant temperature gradient above ground level is assumed over the entire project area and surrounds. A constant temperature gradient allows an average radius of curvature for sound rays to be determined and, in this case, the radius of curvature is assumed to apply in all directions from the source. Any drainage flows associated with temperature inversions are modelled as a wind speed and direction at a height of 10m above the ground.

Currently available noise model software assumes the separate radii of curvature due to winds and inversions have a similar effect on noise propagation and can sum or cancel each other depending on wind direction and relative strength. For the noise model software, sound ray curvature due to an inversion is the same as curvature downwind from a source, provided the radii of curvature are the same. Greatest sound ray curvature occurs downwind from a source during inversion conditions, as these effects are cumulative.

The INP recognises the complex nature of weather effects and recommends a general assessment procedure for the purpose of noise modelling which is intended to represent most real situations for most of the time. Essentially, in cases where noise enhancing weather effects occur for 30% of the time or more in any season or time period, the INP recommends the following default weather conditions should be modelled:

- A 3°C/100m inversion during the night plus a 2m/s drainage flow from source to receiver where the source is on higher ground than the receiver with no intervening hills; or
- A 3m/s gradient wind from source to receiver where such a wind direction occurs for at least 30% of the time in any season or time period.

Alternatives to the default weather conditions can be adopted where justified by site-specific weather data.

Weather conditions occurring in the vicinity of the project have been assessed in detail based on:

- Data from the Groote Eylandt Weather Station which is located near the southern boundary of Groote Eylandt Airport as shown in Figure 2, supplied by the Bureau of Meteorology (BoM) for calendar year 2013; and
- A California Meteorological (CALMET) output file prepared as part of the EIS Air Quality Assessment.

Further detail on atmospheric conditions, as relevant to the acoustic assessment, is provided in the following sections.

4.2.2 Temperature Inversions

Direct measurement of temperature inversion strength requires at least two temperature sensors mounted at different heights above the ground, generally with one sensor at 10 m above the ground and a second sensor at a height in the range 50 m to 80 m above the ground. In the absence of direct inversion measurements, stability class data included in the CALMET file were used to estimate the occurrence of temperature inversions. A CALMET model estimates the occurrence of A to F classes as described in Table 7 while G class, representing a strong inversion, is not considered by the CALMET model. The CALMET data were analysed using the following method:

- Separate the data into day (7 am to 6 pm) and evening/night (6 pm to 7 am) periods and discard data for the day;
- Separate the evening/night data by season; and
- Count the percentage occurrence of class F which indicates a moderate temperature inversion.

Table 7 shows the results of this analysis.

Table 7: Occurrence of Temperature Inversions, 2013 CALMET

Stability Class	Occurrence of Temperature Inversions by Season, 6 pm to 7 am			
	Summer	Autumn	Winter	Spring
A – very unstable B – unstable C – slightly unstable D – neutral E – slightly stable	18%	19%	13%	21%
F – stable (G – very stable)	82%	81%	87%	79%

Table 7 indicates mild F class inversions (which includes stronger G class inversions not calculated by the CALMET model) occur for more than 30 % of the time in all seasons and should therefore be considered by the noise model. Combined F and G class inversions have been modelled using an inversion strength of 3 °/100 m which is recommended in the INP and lies at the upper end of the F class range, while the combined inversion and drainage flow included in the model is equivalent to a stronger G class inversion for downwind receptors.

4.2.3 Wind Analysis

Weather data supplied by the BoM in half hour intervals for the year 2013 have been analysed to determine the occurrence of gradient winds that may enhance noise levels at receptors. For the purposes of this assessment, a noise enhancing wind is defined as wind from 0.5 m/s to 3 m/s blowing from the project site generally towards a noise sensitive receptor, or causing a significant wind vector component in the direction of a receptor. Higher wind speeds tend to cause turbulence and increased background noise levels so do not increase the relative audibility of a distant source, while lower wind speeds do not significantly affect received noise levels.

The analysis was completed using the method recommended in the INP using the Noise Enhancement Wind Analysis software provided by the NSW EPA. Wind analysis results are shown in Table 8 with shaded values highlighting wind vector components that occur at least 30% of the time.

Table 8: Prevailing Winds, Groote Eylandt Weather Station, BoM 2013.

Wind Vector Direction	Occurrence of Noise Enhancing Winds, % of Season and Time Period											
	Summer			Autumn			Winter			Spring		
	Day	Even.	Night	Day	Even.	Night	Day	Even.	Night	Day	Even.	Night
N	14	22	13	8	4	5	2	1	0	10	19	14
NNE	17	41	21	13	15	9	6	5	4	14	45	23
NE	18	51	29	18	26	16	13	17	15	15	55	35
ENE	18	51	32	21	41	24	17	38	27	14	58	39
E	17	52	32	20	50	29	21	64	41	11	59	38
ESE	17	47	30	20	54	31	20	69	43	11	52	35
SE	15	32	25	24	53	29	20	66	39	11	39	29
SSE	13	18	13	29	43	23	27	60	33	12	24	16
S	11	4	3	13	18	9	15	32	17	8	4	4
SSW	15	3	2	14	8	5	9	6	5	13	2	3
SW	18	2	3	14	4	4	6	1	1	15	2	3
WSW	17	3	3	10	2	3	3	1	0	14	1	2
W	13	3	3	7	2	3	3	1	0	10	1	3
WNW	15	7	9	10	3	5	3	1	0	13	2	5
NW	17	8	10	11	4	6	4	1	0	16	5	6
NNW	18	11	11	9	4	5	3	1	0	14	8	8

Winds during the day tend to occur from any direction and are often over 3 m/s, therefore do not significantly enhance noise. The noise model will consider only calm conditions during the day.

Winds during the evening and night occur from similar directions, therefore the evening and night time periods will be combined in the noise model.

Evening winds during the summer and spring seasons are significant from the NNE to the SE directions. Winds from the NE direction have been modelled to cover the northern end of this range and are highlighted in Table 8 in red font. As the noise model calculates noise levels in each direction based on the vector component of wind speed, modelling a NE wind will also increase calculated noise levels in adjacent directions.

Evening winds during the autumn and winter seasons are significant from the ENE to SSE or S directions, with SE winds selected to cover the southern end of this range and highlighted in red font in Table 8. The NE and SE winds selected for the evening period cover all seasons adequately, and are also appropriate for the night period which includes similar significant wind directions as the evening period as shown by the shaded cells in Table 8.

The noise model will therefore consider winds from the north-east and from the south-east as representative directions for assessment during the evening and night.

It is considered likely that the dominant easterly winds measured at the BoM weather station are strongly affected by drainage flows during the evening and night and therefore do not represent gradient winds that apply over the region. Measured weather data would be required at another location, preferably in a valley that does not drain to the west, to determine the separate influence from gradient winds and drainage flows. In the absence of available data from another location, the measured data from the BoM weather station are conservatively assumed to represent gradient winds and to occur over the region.

4.2.4 Drainage Flows

Temperature inversions tend to be accompanied by cold air drainage flows which, being more dense than warmer air, run downhill towards river valleys then along the valley floor. Rather than remain within a narrow channel, the cold air tends to spill over the entire valley width as it travels downhill. Drainage flows can enhance noise for downwind receptors and have therefore been considered in the assessment. Measured weather data do not reliably indicate drainage flows over the entire project site because such flows vary considerably from one location to the next depending on local terrain, while weather data are measured at a single location.

A detailed inspection of terrain within and around the project area indicates the following drainage flow directions are likely to occur:

- Mining areas in the Northern EL are within the Emerald River catchment, therefore drainage flows associated with temperature inversions over the Northern EL are expected to flow in the same direction as the Emerald River generally from the north-east. Calculated noise levels for Project Year 3, which is the worst case year for noise levels to R1, would therefore include a north-east drainage flow;
- The mining area within the Southern EL closest to Receptors R3 and R4 is within the Amagula River catchment, adjacent to a tributary that flows generally north to south. A northerly drainage flow associated with a temperature inversion will therefore be considered in Project Year 9, which is the worst case year to R3 and R4; and
- The mining area within the Southern EL closest to Receptor R2 is adjacent to tributaries of the Emerald River, with the land generally falling from the east to the west in that area. An easterly drainage flow associated with a temperature inversion will therefore be considered in Project Year 13 which is the worst case year to R2.

The Groote Eylandt Weather Station is located near the airport approximately 400 m north of the Angurugu River on RL 14 m land as shown in Figure 2, which is the same elevation as much of Angurugu township. Any drainage flows noted during the evening and night at the Groote Eylandt Weather Station would be similar to the flows that occur in Angurugu and over the Angurugu River floodplain. Table 9 presents results from a detailed analysis of measured wind speeds during the night period, based on BoM weather data with wind speeds reported in 0.5 m/s intervals.

Table 9: Occurrence of Drainage Flows, 2013 BoM Data, Night

Wind Speed Count	Occurrence of Wind Speed m/s, Night							
Wind Speed, m/s	0	0.5	1.0	1.5	2.0	2.5	3.0	>3.0
Count, Percent	46	5	7	15	12	5	4	6
Cumulative, Percent	46	51	58	73	85	90	94	100

The weather data in Table 8 further indicate winds generally from the east are the most common at night, which is consistent with the east to west flow of the Angurugu River near the weather station. Table 9 shows 1.5 m/s represents the highest 30% of wind speeds at night and is therefore appropriate for use in the assessment in conjunction with a temperature inversion. The same drainage flow speed is assumed to apply to all other receptors in the absence of site specific data.

4.2.5 Weather Conditions Summary

The analysis of weather conditions described in the sections above resulted in the weather parameters shown in Table 10 being considered in this assessment. Representative parameters for air temperature and relative humidity have been selected based on weather station data although calculated noise levels are not significantly affected by these parameters.

The 'effective inversion' row of Table 10 indicates the total level of atmospheric noise enhancement, based on the following relationship between winds and temperature inversions adopted in the noise model software for the 'rural' terrain category:

Equivalent Inversion °/100m = Inversion °/100m + 2.5 x Wind speed m/s. *Equation 1.*

Table 10: Modelled Weather Conditions

Atmospheric Parameter	Day	Evening/Night					
	All Years	All Years	All Years	All Years	Project Year 3	Project Year 9	Project Year 13
Temperature, °C	35	25	25	25	25	25	25
Relative Humidity, %	80	90	90	90	90	90	90
Wind Speed, m/s	0	0	3	3	1.5	1.5	1.5
Wind Direction	-	-	NE	SE	NE	N	E
Temp Gradient, °C/100 m	-2	3	0	0	3	3	3
Effective Inversion, °C/100 m	-2	3	7.5	7.5	6.8	6.8	6.8

Table 10 indicates an equivalent inversion of 6.8 °/100m to 7.5 °/100m would be considered to down-wind receivers during the evening and night, therefore an equivalent to strong G class inversions will be implicitly considered in the noise model and a separate assessment of strong temperature inversions is not required.

One noise contour figure has been produced for each assessed year for the day period, based on a single set of weather conditions shown in Table 10 for the day. Four sets of noise contours would be produced for the combined evening and night period for each assessed year, based on the following weather conditions from Table 10:

- 3 °C/100m inversion with no wind;
- 3 m/s NE wind;
- 3 m/s SE wind; and

- 3 °C/100m inversion plus a 1.5 m/s drainage flow in the relevant direction for each assessed year (NE for Project Year 3, N for Project Year 9 and E for Project Year 13).

The final noise contours presented for the combined evening and night period for each assessed year have been produced by taking the maximum, or worst case, of the four evening/night contours listed above. The maximum contours can be produced by superimposing the four individual sets of contours on the same figure and tracing around the outer contours, although the maximum contours presented in this report have been prepared using software based on alternative and equivalent methods.

4.3 Modelled Noise Sources

Sound power levels produced by proposed mining equipment associated with the project have been adopted based on noise levels currently produced by similar equipment at other open cut mines in Australia. Sound power levels and spectra for proposed equipment are shown in Table 11.

The listed sound power levels represent reasonable worst case noise levels produced by each machine or noise source operating continuously. The assumed situation reflected in the noise model is therefore likely to overstate average noise levels produced by the project and to provide a measure of conservatism.

Table 11: Modelled Sound Power Levels, Leq.

Noise Source Code and Description	Octave Band, Hz									Total	
	31.5	63	125	250	500	1000	2000	4000	8000	dBL	dBA
	Sound Power Level, Leq										
E, Excavator 250t	124	125	121	116	115	116	113	110	103	129.2	120.2
e, Excavator 30t	122	123	119	114	113	114	111	108	101	127.2	118.2
L, Loader	121	122	124	122	117	106	107	104	96	128.8	118.2
t, Truck 777G	116	119	119	117	117	112	111	103	100	125.1	118.1
d, Drill	104	106	111	114	116	107	107	97	93	119.8	115.5
Z, Dozer D11, D10	108	105	108	117	119	121	119	115	96	125.8	125.0
Z7, Dozer D7	105	102	105	114	116	118	116	112	93	122.8	122.0
z, Wheel dozer	121	122	124	122	117	106	107	104	96	128.8	118.2
g, Grader	115	116	118	116	111	100	101	98	90	122.8	112.2
w, Water cart	115	118	118	116	116	111	110	102	98	124.1	117.1

Other noise sources associated with GEMCO's operations, such as the concentrator or light vehicles, are either part of the existing operation rather than part of the Eastern Leases Project or produce insignificant noise compared to the modelled sources and have not been included in the model.

Table 12 shows the modelled project equipment fleet in each assessed year, with the location of each source shown for each assessed year in Figures 10 to 12 in Appendix A.

Table 12: Modelled Fleet and Total Sound Power Level, LAeq,15min

		Assessed Year	Project Year 3	Project Year 9	Project Year 13
Noise Source Code	Description	Modelled Height (m)	Modelled Fleet Size		
E	Excavator 250t	5	-	-	1
e	Excavator 30t	3	1	1	1
L	Loader	3	-	1	-
t	Truck 777G	3	3	7.5	7.5
d	Drill	2.5	-	1	1

		Assessed Year	Project Year 3	Project Year 9	Project Year 13
Noise Source Code	Description	Modelled Height (m)	Modelled Fleet Size		
Z	Dozer D11, D10	1.5	12	13	12
Z7	Dozer D7	1.5	-	1	-
z	Wheel dozer	3	-	1	1
g	Grader	2	1	1	1
w	Water cart	2	0.5	1	0.5
		Total Modelled Fleet Size	17.5	27.5	25
		Total Modelled Sound Power Level, dBA	136	137	137

The modelled equipment fleet is significantly smaller in Project Year 3 compared to subsequent assessed years, however the total site sound power level is only 1 dBA lower as the Project Year 3 fleet includes a large number of dozers (the loudest noise sources) stripping overburden.

Noise from mobile machines is generally modelled at a single representative location per machine, however noise from highly mobile machines such as ore haulage trucks has been distributed over a number of locations along the haul route. For example a single truck source is represented by the code 't' in the model, whereas a truck source that has been distributed into 4 parts over 4 representative sections of haul road has been indicated by the code 't/4'at each location.

In all assessed years, three ore haulage trucks are assumed to operate on an extended length of haul road within the project site. One-quarter of a truck source modelled at each of 12 representative locations along the haul road sums to three trucks operating continuously within the project area. The noise model therefore represents a reasonable worst case situation as there would be times when fewer ore trucks, or no ore trucks, are operating. In addition, GEMCO has the ability to control the fleet operating in sensitive areas of the project site to control environmental noise levels, in that event that such control is required.

4.4 Mining Noise Levels

4.4.1 Calculated Noise Levels

Noise levels from the project have been calculated with all noise sources operating continuously to represent a reasonable worst case situation. Table 13 shows predicted received noise levels and relevant noise criteria for each assessed year and time period.

Table 13: Predicted Project Noise Levels and Noise Criteria, LAeq,15min

Time Period, Weather Conditions	Day Neutral				Evening/Night Prevailing			
Receptor	R1	R2	R3	R4	R1	R2	R3	R4
Predicted Noise Level, Project Year 3	<25	<25	<25	<25	34	32	<25	<25
Predicted Noise Level, Project Year 9	<25	<25	<25	28	30	33	41	46
Predicted Noise Level, Project Year 13	<25	<25	<25	<25	31	35	35	30
Intrusive Criteria – Day	35	35	35	-	-	-	-	-
Intrusive Criteria – Evening	-	-	-	-	35	35	36	-
Intrusive Criteria - Night	-	-	-	-	35	35	35	-
Amenity Criteria – All Time Periods	-	-	-	50	-	-	-	50

Predicted noise levels in Table 13 indicate compliance with relevant noise criteria with the exception of Receptor R3 in Project Year 9 during the evening and night period. Noise levels at R3 are predicted to reach 41 LAeq,15min with mining activity at the closest point within the project site, under reasonable worst case noise enhancing conditions during the evening and night. Noise levels would be significantly lower in the absence of a large dozer fleet stripping overburden or when mining activity occurs at a greater distance from R3. As noted in Section 1.2, R3 is only intermittently occupied and the proponent has committed to discussions with the ALC (the authority responsible for R3) to resolve any issues that may arise from predicted noise levels at R3. Further discussion regarding noise mitigation measures is provided in Section 5.

4.5 Sleep Disturbance

An assessment of sleep disturbance requires sources of maximum noise level to be considered and noise levels from these sources to be calculated to residential receptors. The loudest noise sources proposed for the project are tracked dozers, with track noise producing a maximum sound power level of approximately 132 dBA as a dozer operates in reverse.

The operational noise model includes simultaneous operation of 12 dozers stripping overburden in each assessed year, with an average sound power level of 125 dBA per dozer shown in Table 11 and a combined sound power level of 136 LAeq,15min from the project site shown in Table 12. Maximum noise from one dozer producing a sound power of 132 dBA would therefore be approximately 4 dBA lower than average noise levels from the project produced by an average sound power of 136 dBA.

Further calculations indicate average noise from 12 dozers plus simultaneous maximum noise from one dozer would result in a combined noise level 2 dBA above the average noise levels shown in Table 13.

Calculated maximum noise levels are shown in Table 14, including only the night period as sleep disturbance is not considered during the day. Sleep disturbance criteria only apply to residential receptors and therefore do not apply to R4.

Table 14: Predicted Noise Levels and Sleep Disturbance Criteria, LAmax

Time Period, Weather Conditions	Evening/Night Prevailing			
Receptor	R1	R2	R3	R4
Predicted Noise Level, Project Year 3	36	34	<27	<27
Predicted Noise Level, Project Year 9	32	35	43	48
Predicted Noise Level, Project Year 13	33	37	37	32
Residential Sleep Disturbance Criteria - Night	45	45	45	-

Calculated maximum noise levels shown in Table 14 would meet the adopted conservative sleep disturbance criterion of 45 LAmax at all residential receptors. Based on the predicted maximum noise levels, sleep disturbance is unlikely to occur at any residential receptor as a result of the project operating during the night.

4.6 Low Frequency Noise

Low frequency noise levels, in the range 10 Hz to 200 Hz, have been assessed by the project noise model at each receptor location under reasonable worst case evening and night prevailing weather conditions.

The model calculates received noise levels in octave bands from 31.5 Hz to 16 kHz, therefore the frequency bands used in the noise model do not precisely match the low frequency range recommended in the Low Frequency Guideline. A reasonable approximation to the low frequency range 10 Hz to 200 Hz recommended in the Low Frequency Guideline is obtained by taking the sum of the lowest three frequency bands (31.5 Hz to 125 Hz) from the noise model results.

Table 15 presents a summary of calculated noise levels to each residential receptor in octave bands. Total noise levels in the three lowest frequency bands for comparison with the external 60 dBL low frequency criterion, along with total dBL and dBA noise levels, are also shown in the table.

Results in Table 15 indicate predicted low frequency noise levels in the 31.5 to 125 Hz octave bands would remain at least 10 decibels lower than the criterion, therefore low frequency noise impacts are not expected to occur at any residential receptor.

Total dBA noise levels for corresponding situations in Tables 13 and 15 are not identical due to significant differences in the method used by the noise model software to calculate noise contours and noise levels at receptor points. For example, a predicted noise level of 40.5 dBA at R3 in Project Year 9 has been calculated by the model in noise contour mode and has been rounded up to 41 dBA in Table 13, compared to a predicted noise level of 40.1 dBA calculated to R3 in point mode as presented in Table 15. This 0.4 dBA difference between contour mode and point mode is typical for noise model software and is within the accepted tolerance for received noise level calculations.

Table 15: Predicted Project Noise Levels, LAeq,15min

Receptor	Assessed Year	Octave Band, Hz									Total		
		31.5	63	125	250	500	1000	2000	4000	8000	31.5 to 125 Hz Bands	dBL	dBA
		Predicted Noise Level, Leq											
R1	3	41	37	37	37	36	13	-30	-84	-85	43.5	45.0	34.6
R2	13	48	44	31	31	37	23	-6	-42	-84	49.5	49.8	34.7
R3	9	44	39	43	42	42	27	-2	-43	-84	47.2	49.3	40.1
Low Frequency Criterion, 10 – 200 Hz											60	-	-

According to the Low Frequency Guideline, low frequency noise criteria only apply to residential receptors. Low frequency noise levels have therefore not been calculated to R4.

4.7 Cumulative Noise Impacts

Receptors would be potentially exposed to cumulative noise impacts from the following simultaneous noise sources:

- The project; and
- The currently approved GEMCO mining operation.

No other significant industrial developments with the potential to generate cumulative noise impacts exist or have been proposed in the vicinity of the project.

Reasonable worst case noise levels from the project are shown in Table 13, while noise levels produced by existing mining operations depend on a number of factors including:

- Noise levels produced by mining equipment;
- Areas to be mined; and
- Weather conditions.

Mining near Receptor R1 has already occurred at a minimum distance of approximately 500 m, although mining typically occurs more than 700 m from R1. Short term measurements at S1 indicated noise levels produced by mining machines can reach 42 dBA for periods of a few seconds, while an average level of 34 LAeq,15min was measured during the night as shown in Table 5. More intense mining activity close to R1 is likely to produce a higher noise level of closer to 40 LAeq,15min.

Considering the typical variation in mining activity and noise levels during a night period, a worst case noise level of 40 LAeq,15min is approximately equivalent to an average night noise level of 37 LAeq,9hr.

Short term noise measurements at R2 indicated no mining noise was audible in June 2014, with no mining activity occurring close to the receptor. However, the currently approved mining area extends to within approximately 380 m from R2 which would result in similar noise level at R2 as was measured at R1. A noise level of 37 LAeq,9hr has therefore been adopted for possible future mining noise levels at R2.

Receptors R3 and R4 are located a minimum distance of 8 km and typically over 9 km from currently approved mining areas and would therefore receive a noise level significantly below 30 LAeq,9hr during the night from currently approved mining activities.

Cumulative noise levels under worst case weather conditions during the night which is the most sensitive time period, from both the project and approved mining areas, are shown in Table 16. Project noise levels averaged over an entire 9 hour night have been estimated by subtracting 3 dBA from the predicted LAeq,15min noise levels shown in Table 13 to allow for variations in mining intensity and weather conditions during a reasonable worst case night period.

Table 16 indicates cumulative noise levels would remain within relevant criteria at all assessed receptors. Predicted noise levels from the project would not significantly increase noise levels from currently approved mining areas at R1 and R2, given the significantly greater setback distance to the project compared to currently approved mining areas. Conversely, noise levels from currently approved mining areas are insignificant at R3 and R4 and would not noticeably affect cumulative noise levels at these receptors.

Table 16: Predicted Cumulative Noise Levels, Night, LAeq,9hr

Receptor, Assessed Year	Predicted Noise Level, LAeq,9hr			Amenity Criterion, Night, LAeq,9hr
	Project	Approved GEMCO Mine	Cumulative Noise Level	
R1, Project Year 3	31	37	38	40
R2, Project Year 13	32	37	38	
R3, Project Year 9	38	<30	38	
R4, Project Year 9	43	<30	43	50

4.8 Construction Noise

Construction work associated with the project would include the following tasks:

- Clearing, grading, capping and compacting the haul road from the existing GEMCO mine to the project site, including culvert and overpass construction, drainage and other work associated with the road;
- Excavation and compaction of dams; and
- Clearing, levelling , installation of gravel, grading and compacting hardstand areas for vehicle parking and portable amenities buildings within the Northern EL and Southern EL.

All other work required to establish the project areas, including vegetation clearing, is considered mining activity and has been assessed above.

Haul road construction work would require a number of earthmoving machines such as a dozer, excavator, trucks, grader and roller, however these machines would typically operate individually or in small groups and would produce less noise than the proposed 12 dozers stripping overburden included in the worst case operating scenario.

Construction noise levels would therefore remain at least 5 dBA below worst case operational noise levels and would be below the relevant noise criteria shown in Table 6 at all receptors. Given a straightforward comparison can be made between noise levels produced by the construction and operational phases, a more detailed construction noise assessment is not warranted for this project.

4.9 Traffic Noise

Traffic on the Rowell Highway associated with the project construction phase is assumed to include:

- An estimated 20 light vehicle and 4 bus movements per day to transport personnel; and
- An estimated 20 light vehicle and 16 heavy vehicle movements per day to transport tools and materials.

Nearest residential receptors are located approximately 110 m west of the Rowell Highway. Calculations indicate a construction traffic noise level of 36 LA10,18hr which is insignificant compared to the criterion of 68 LA10,18hr recommended in the Northern Territory Traffic Noise Policy and would only marginally increase existing traffic noise levels by less than 1 dBA. No traffic noise mitigation measures are therefore recommended.

The main volume of the EIS provides further details regarding traffic flows, indicating the project will not generate additional traffic during the project operational phase on the Rowell Highway or other roads. An operational traffic noise assessment is therefore not required.

4.10 Blasting

Blasting is currently undertaken to loosen sections of ore for removal by excavator and is proposed to be undertaken within the project site. An average of 80 and a maximum of 140 blast events per year are proposed to occur within the project site. Blast effects include ground vibration, typically expressed in mm/s peak particle velocity, and low frequency noise known as overpressure which is typically expressed as dBL Peak. Blast effects depend on the following factors:

- Ground conditions including rock types and layers;
- Groundwater conditions including extent and depth;
- Distance from the blast site to a receptor;
- How well the explosive charges are confined in the holes with stemming material;
- Maximum Instantaneous Charge (MIC) for the blast event, which is the weight of explosive mixture per hole multiplied by the number of holes detonated simultaneously in the blast pattern;
- Topography between the blast site and receptors; and
- Atmospheric conditions including wind speed, wind direction and vertical temperature gradient.

Blasts during the wet season are detonated on the same day as the holes are loaded to minimise water contamination and risks associated with lightning strike. An average of 250 blastholes can be loaded per day with an average of 7.5 kg of explosive material per hole, resulting in a typical blast during the wet season with a MIC of 1,900 kg assuming all holes are detonated simultaneously.

Blasts in the dry season with low risk of rain and storms can include 3 to 5 days of hole loading and can result in an MIC of 5,600 to 11,300 kg if all holes are detonated simultaneously.

Blast effects have been calculated using the equations in Appendix J of AS 2187.2:2006. Anticipated values of K = 500 and B = 1.6 for the wet season and K = 250 and B = 1.6 for the dry season have been adopted for the ground vibration coefficients required by the equations in the Standard, as wet ground transmits vibration more effectively than dry ground, based on the generally sandy nature of the ground between the project site and receptors. These parameters can be adjusted if site specific blast monitoring results are available.

Predicted blast effects have been calculated from the closest mining areas to residential receptors and are shown in Table 17, assuming a well confined charge in each hole with effective stemming material. Calculations include an overpressure correction factor of -5 dB to R1 and R3 where a significant ridgeline exists between the closest blast site and the receptor.

Predicted blast effects in Table 17 are well below relevant residential criteria, primarily due to the large setback distances from closest blast sites to each receptor, and are significantly below the building damage criteria recommended in AS 2187 and BS 7385. Blast management measures and blast monitoring are not recommended or considered warranted for residential receptors. However, it may be necessary to implement a ground vibration management and monitoring program for blasting in close proximity to other sensitive features such as rock shelters with archaeological significance. Archaeological sites are discussed in the EIS Archaeology Report.

Table 17: Predicted Blast Impacts to Residential Receptors

Receptor	Closest Distance, m	MIC, kg						Residential Criteria, mm/s, dBL
		1,900	5,600	11,300	1,900	5,600	11,300	
		Ground Vibration mm/s			Overpressure dBLpk			
R1	6.4 km	0.2	0.2	0.4	91 [1]	96 [1]	99 [1]	5, 115
R2	5.4 km	0.2	0.3	0.5	98	103	106	5, 115
R3	4.2 km	0.3	0.4	0.7	96 [1]	101 [1]	104 [1]	5, 115

1 Overpressure levels at R1 and R3 have been reduced by 5 dBL to account for topographical shielding.

Rock shelters are not sensitive to overpressure, therefore no overpressure management measures would be required. Available options to control ground vibration, if required to protect rock shelters, include:

- For blasts in the dry season, detonate the shot on a daily basis to reduce the MIC rather than accumulate charged holes over multiple days; and
- Divide the blastholes into a number of groups and introduce detonation delays between groups to reduce the MIC.

5 MITIGATION MEASURES

Predicted noise levels are expected to meet relevant noise criteria at all sensitive receptors, with the exception of an exceedance of the evening and night noise criteria at R3 during Project Year 9. R3 is an intermittently occupied outstation.

The proponent has committed to discussions with the ALC (the representative agency for Groote Eylandt Traditional Owners) in order to resolve any community related issues that may arise from predicted noise levels at R3. The following additional information is intended to place predicted noise levels into perspective to assist the discussion:

- Existing approved mining activity occurs approximately 500 m from R1 Angurugu, compared to proposed mining activity a minimum distance of 4.2 km from R3. Assuming a similar intensity of mining activity, proposed noise levels at R3 are significantly lower due to the increased setback distance compared to currently approved mining operations at R1;
- The predicted noise levels at R3 consider simultaneous operation of 12 dozers stripping overburden at the closest point to the receptor. More typical mining activity, for example

including overburden or ore removal using an excavator and a fleet of haul trucks, would be at least 6 dBA lower and would comply with the adopted noise criteria. Therefore predicted exceedances of the noise criteria would occur intermittently, for occasional periods of a few weeks, with significantly lower noise levels at other times; and

- Noise levels at R3 will be lower as the mining area progresses further from the receptor. Predicted noise levels in Project Year 13, for example, are predicted to comply with the criteria with the dozers operating approximately 6.3 km from R3. Short periods of noise above the criteria would therefore be limited to a few years either side of Project Year 9 as mining activity passes the closest point to R3.

6 CONCLUSION

This noise and vibration assessment shows the GEMCO Eastern Leases Project is expected to produce environmental noise and vibration levels that are below the applicable criteria at all sensitive receptors, except at R3 during the evening and night. Mining noise levels at Receptor R3, which is an intermittently occupied group of residential buildings, are predicted to reach 41 LAeq,15min under a reasonable worst case combination of operating and weather conditions in the evening and night, compared to a criterion of 35 LAeq,15min. Noise levels above the criterion are predicted to occur intermittently for periods of a few weeks at a time, as a fleet of dozers strip overburden from the ore body in the closest areas of the project site to the receptor.

At all other times, with less intense mining activity such as ore extraction with an excavator and fleet of haul trucks, mining noise levels are expected to be below the relevant criteria at this receptor. Nevertheless, the proponent has committed to consultation with the ALC on behalf of the Traditional Owners to resolve any issues that may arise from predicted noise levels at R3.

Maximum noise levels are predicted to remain at least 8 dBA below the conservative sleep disturbance criterion at R1 and R2 and at least 2 dBA below the criterion at R3, under reasonable worst case operating and weather conditions during the night. Maximum levels at other times would be significantly lower. No sleep disturbance impacts are therefore predicted to occur at any residential receptor. Low frequency, cumulative and construction noise levels are also predicted to remain below relevant criteria at all receptors.

With the low potential for noise impacts at all permanently occupied residences, a regular noise monitoring program is not required or considered warranted.

Blasting impacts are predicted to remain well within relevant criteria, with proposed blasts occurring at a significantly greater distance from residences than currently approved blasts. Given the low predicted impacts, blast mitigation measures or blast monitoring are not required for the purpose of minimising impacts on residential amenity. Additional management of blasts in close proximity to rock shelters with archaeological significance may be necessary and there are a number of measures that could be adopted to reduce ground vibration levels.

Notwithstanding predicted compliance with all relevant criteria, the proponent will continue to maintain an effective complaints handling procedure.

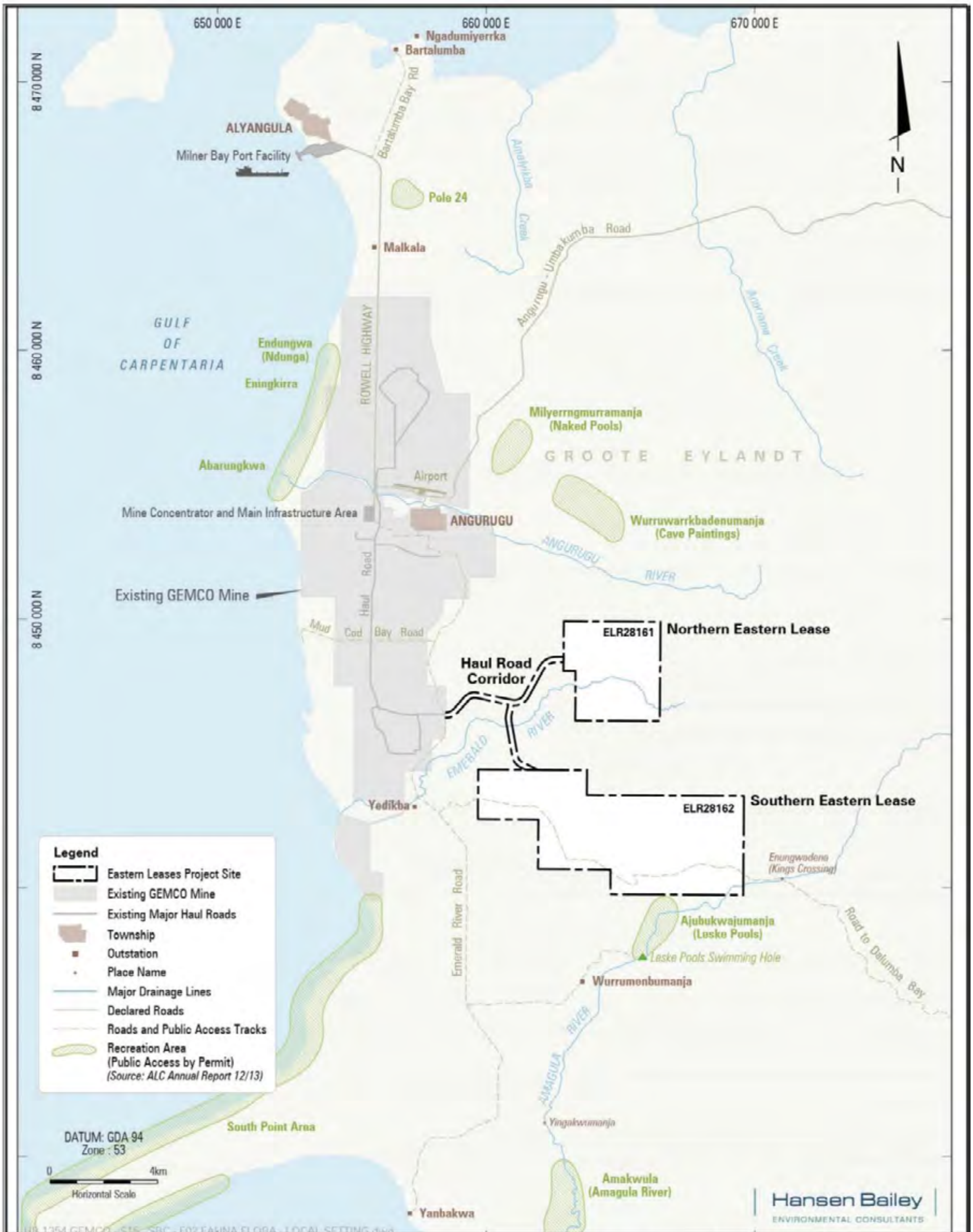
7 REFERENCES

- *Noise Guidelines for Development Sites in the Northern Territory* (Development Guideline) (EPA, 2013); and
- *Road Traffic Noise on NT Government Controlled Roads* (Traffic Noise Policy) (DoT, 2006).
- *NSW Industrial Noise Policy* (INP) (NSW EPA, 2000);

- *Draft Ecoaccess Guideline for the Assessment of Low Frequency Noise* (Low Frequency Guideline) (Queensland EPA now the Department of Environment and Heritage Protection [EHP], 2004);
- *British Standard 7385-2:1993 Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration* (British Standards Institute, 1993);
- *Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (Blasting Guideline) (Australian and New Zealand Environment Council [ANZEC], 1990); and
- *Australian Standard 2187.2-2006 Explosives – Storage and use, Part 2: Use of explosives* (SAI Global, 2006).

FIGURES

Eastern Leases Project	
Location Plan	Figure 1
	24 October 2014

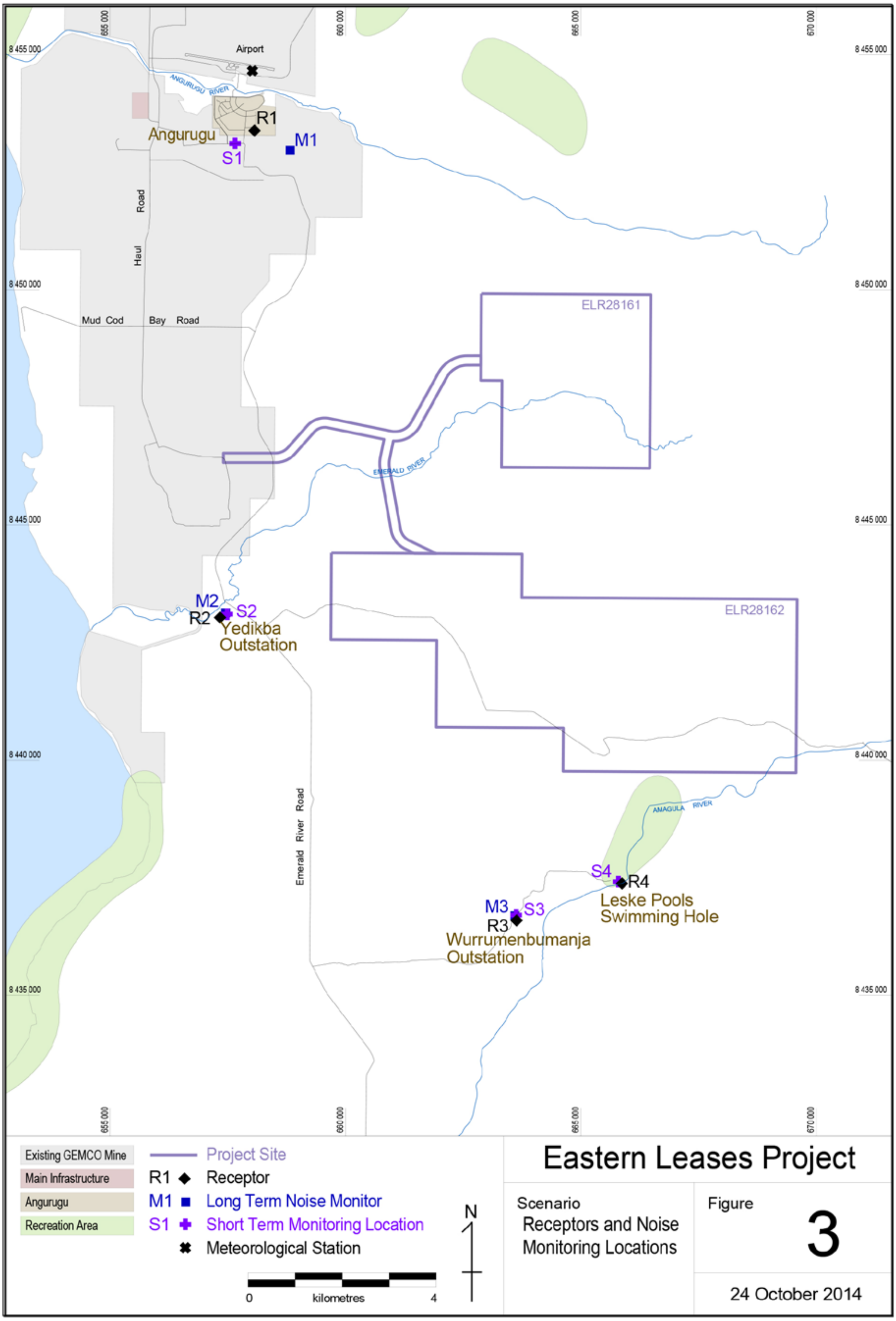


Eastern Leases Project

Local Setting

Figure 2

24 October 2014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S1 Short Term Monitoring Location
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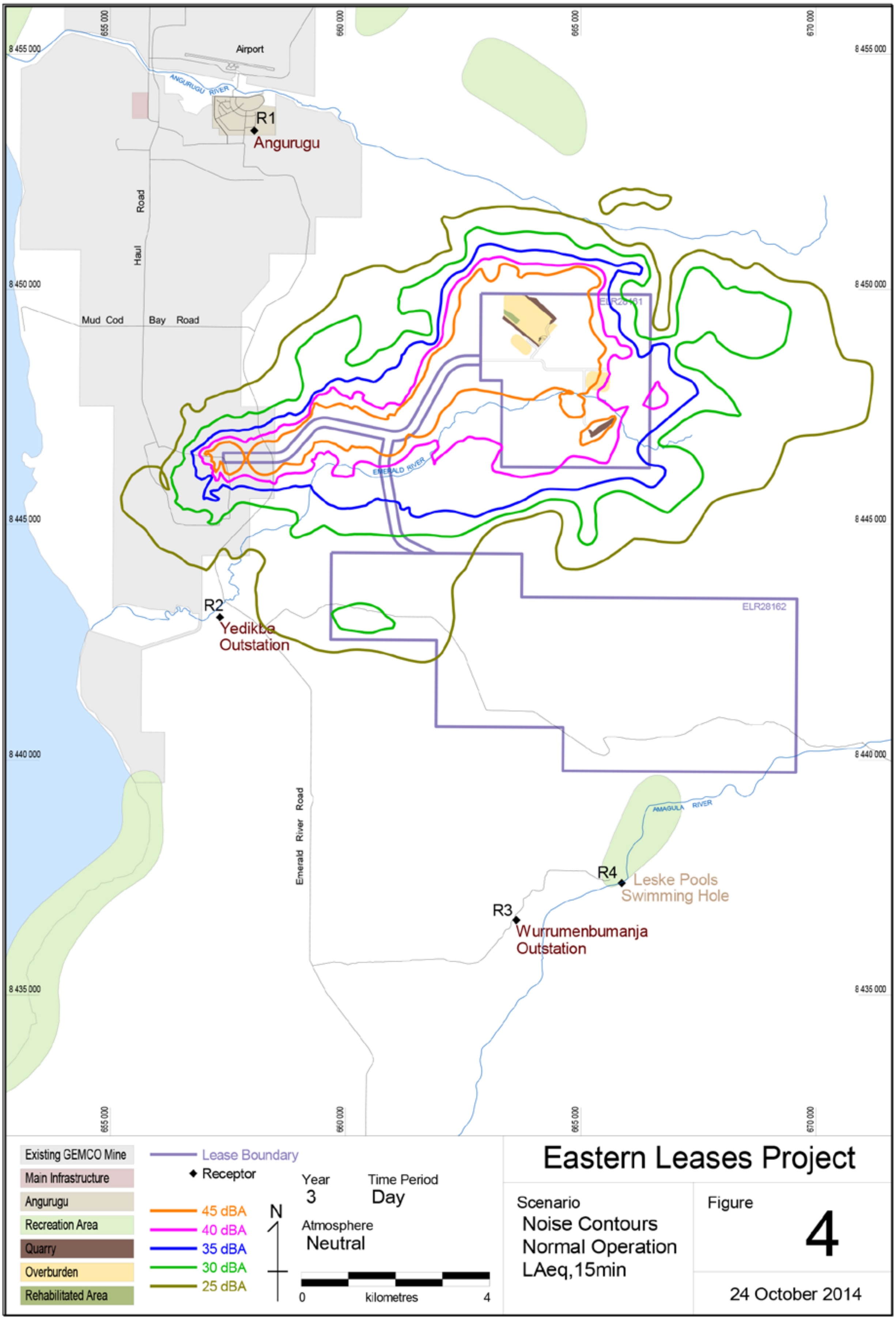
Eastern Leases Project
Scenario
Receptors and Noise Monitoring Locations
Figure
3
24 October 2014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Scenario
Noise Contours
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Figure
4
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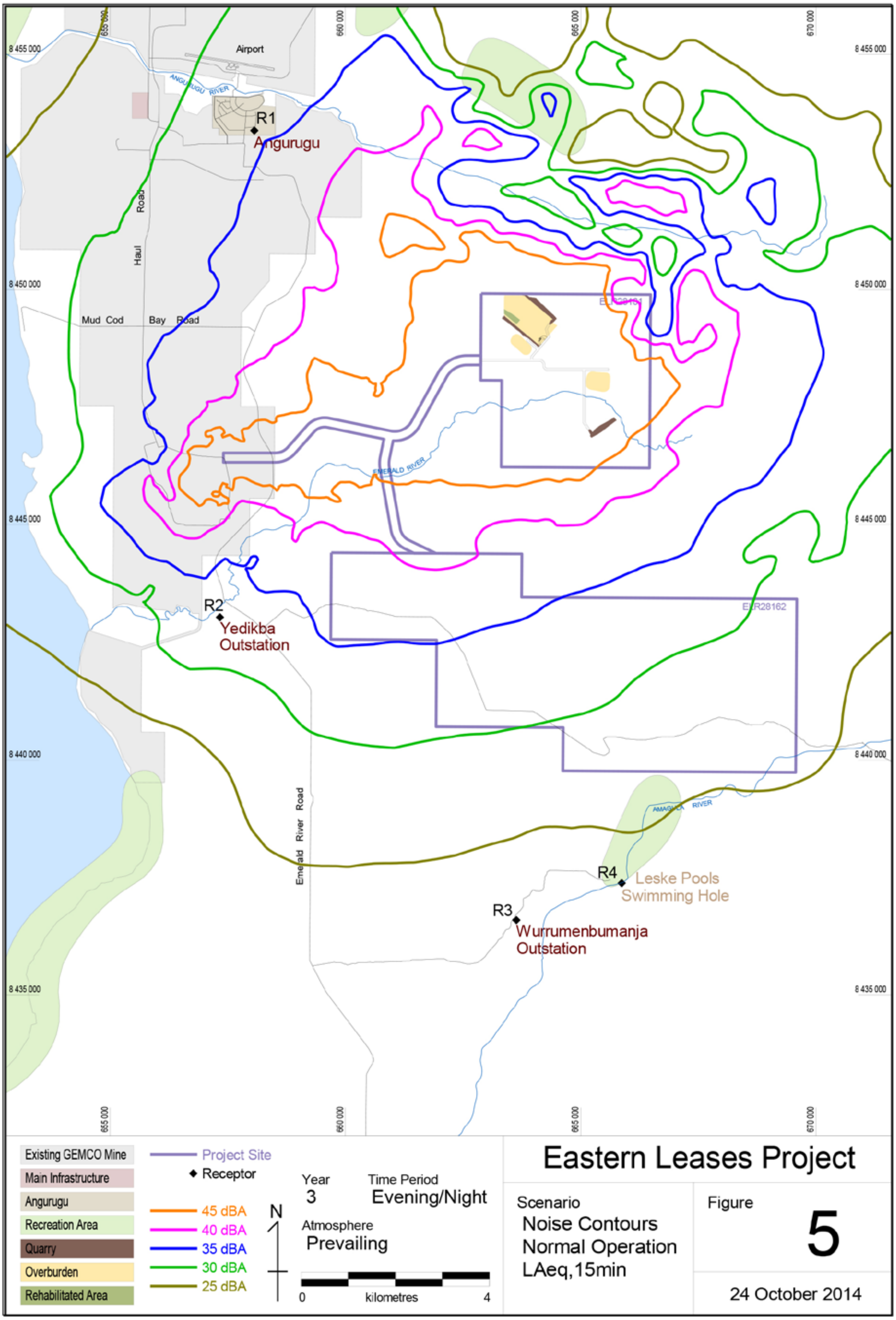
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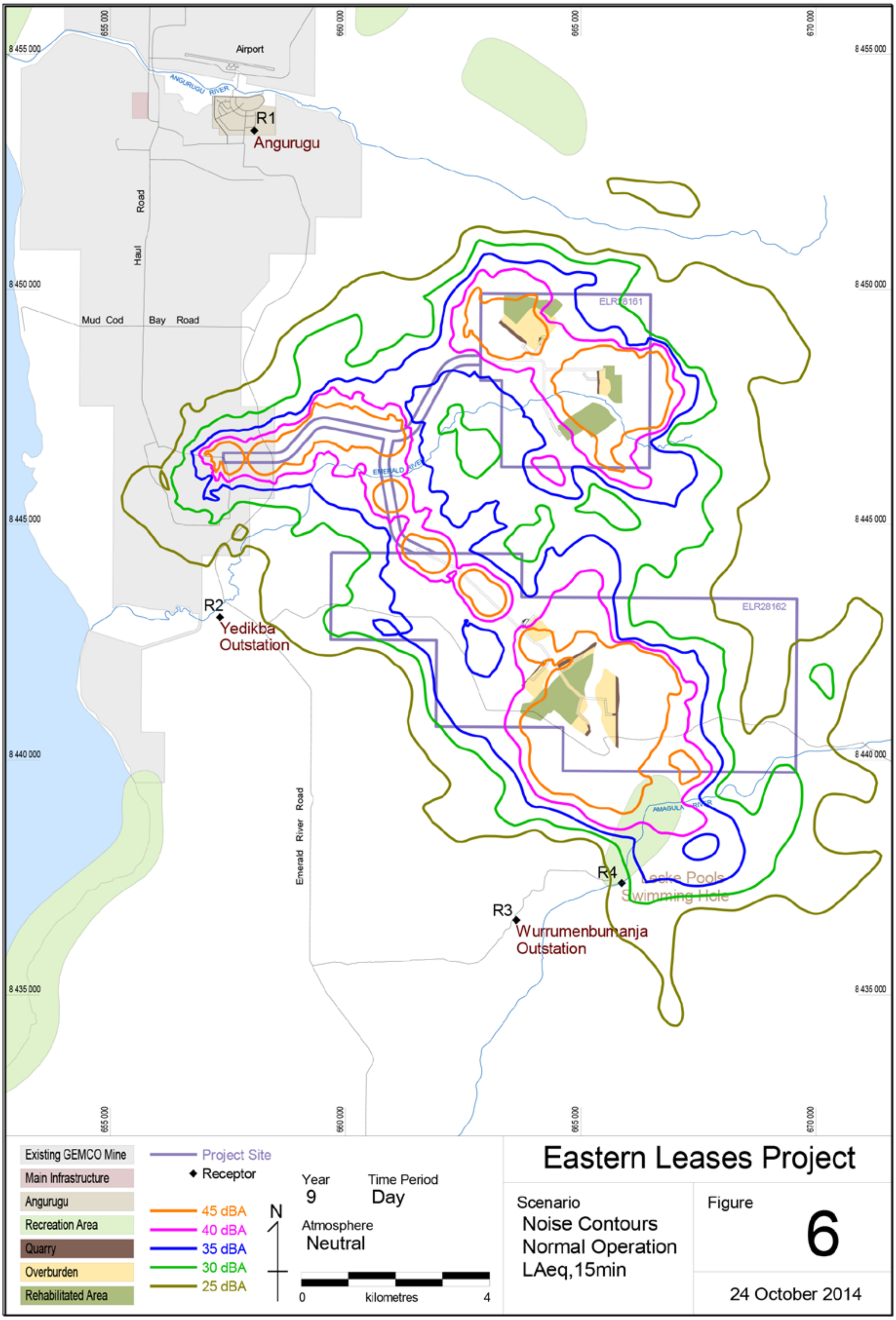
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LAeq,15min
Figure
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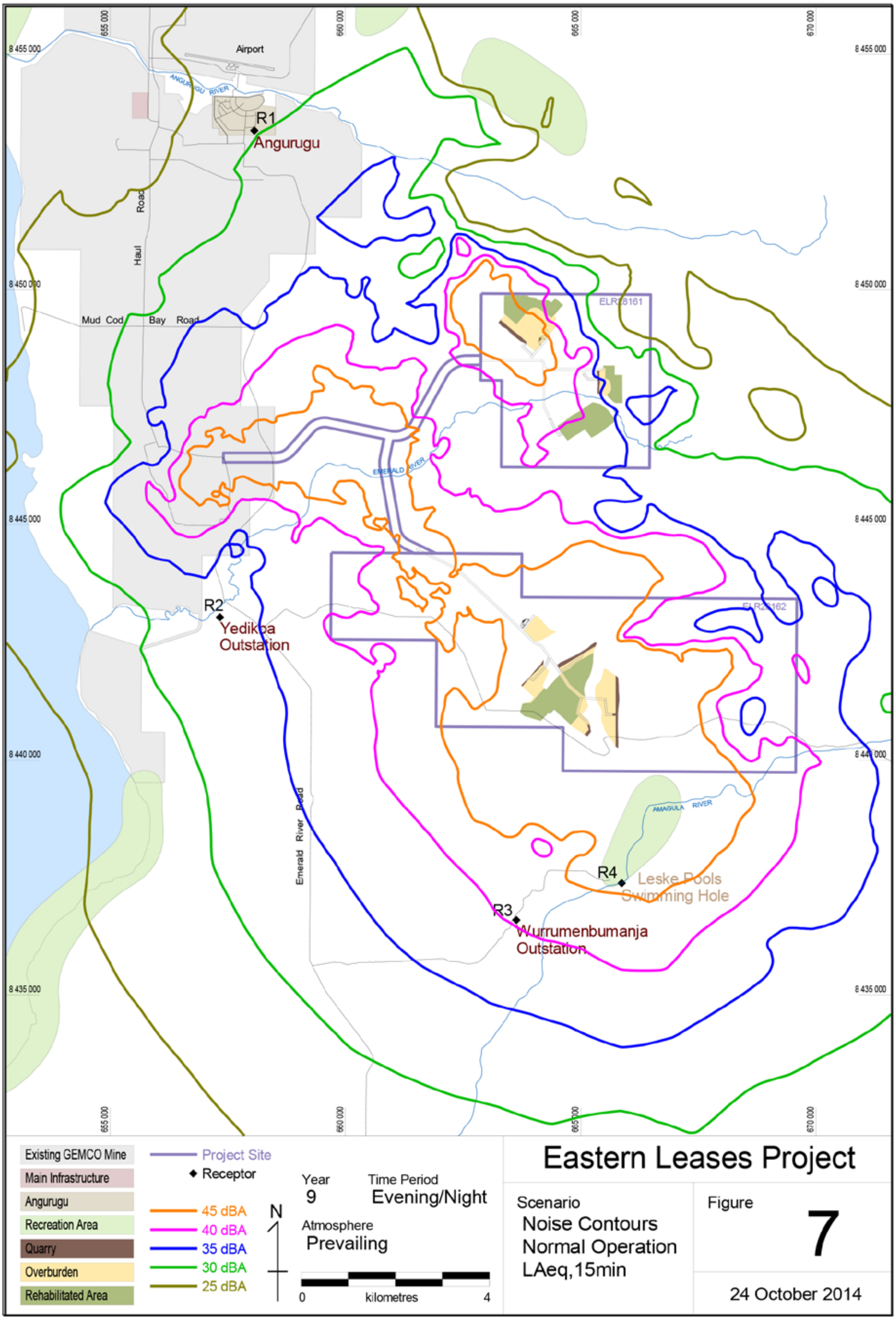
24 October 2014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Noise Contours
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LAeq,15min
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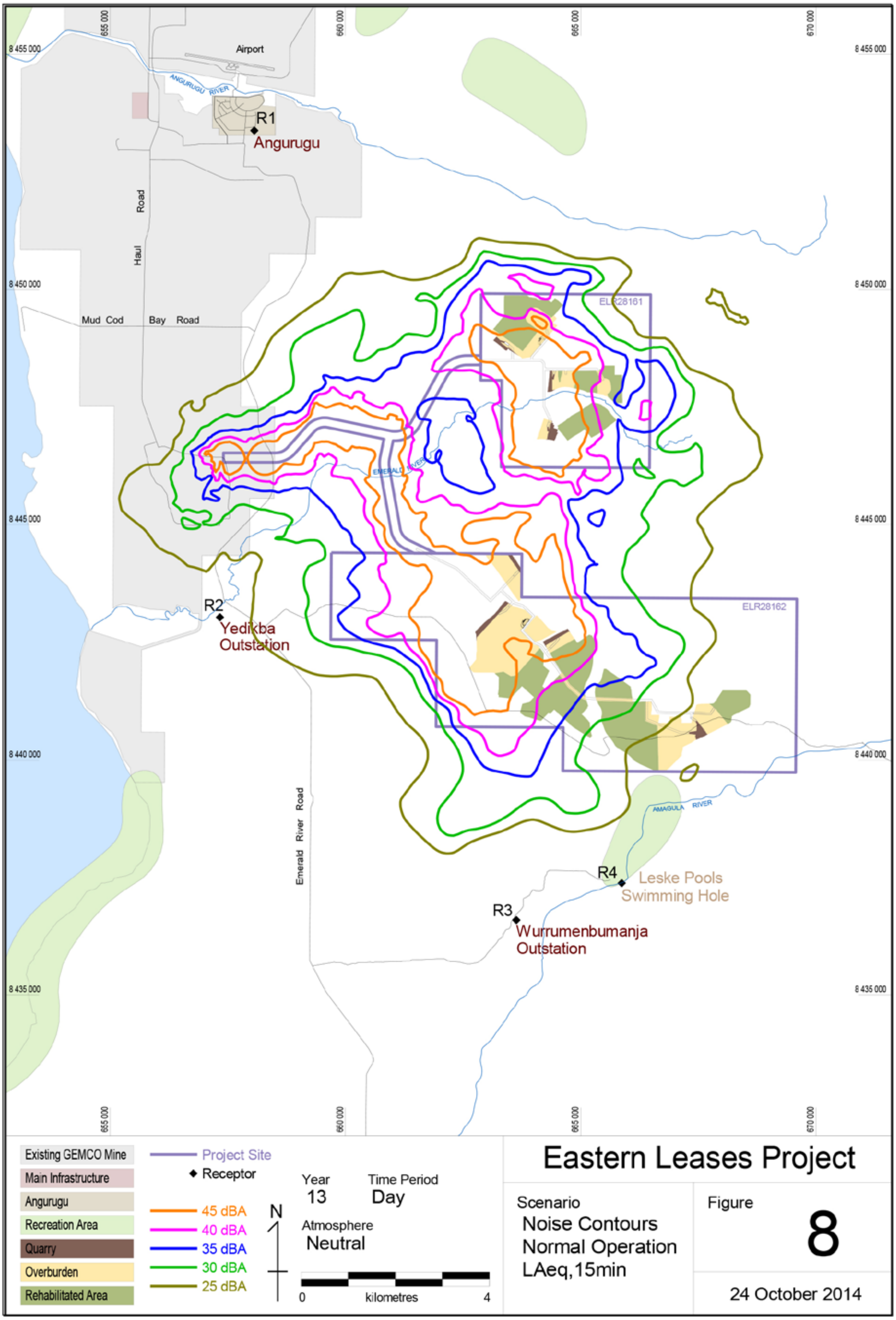
24 October 2014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LAeq,15min
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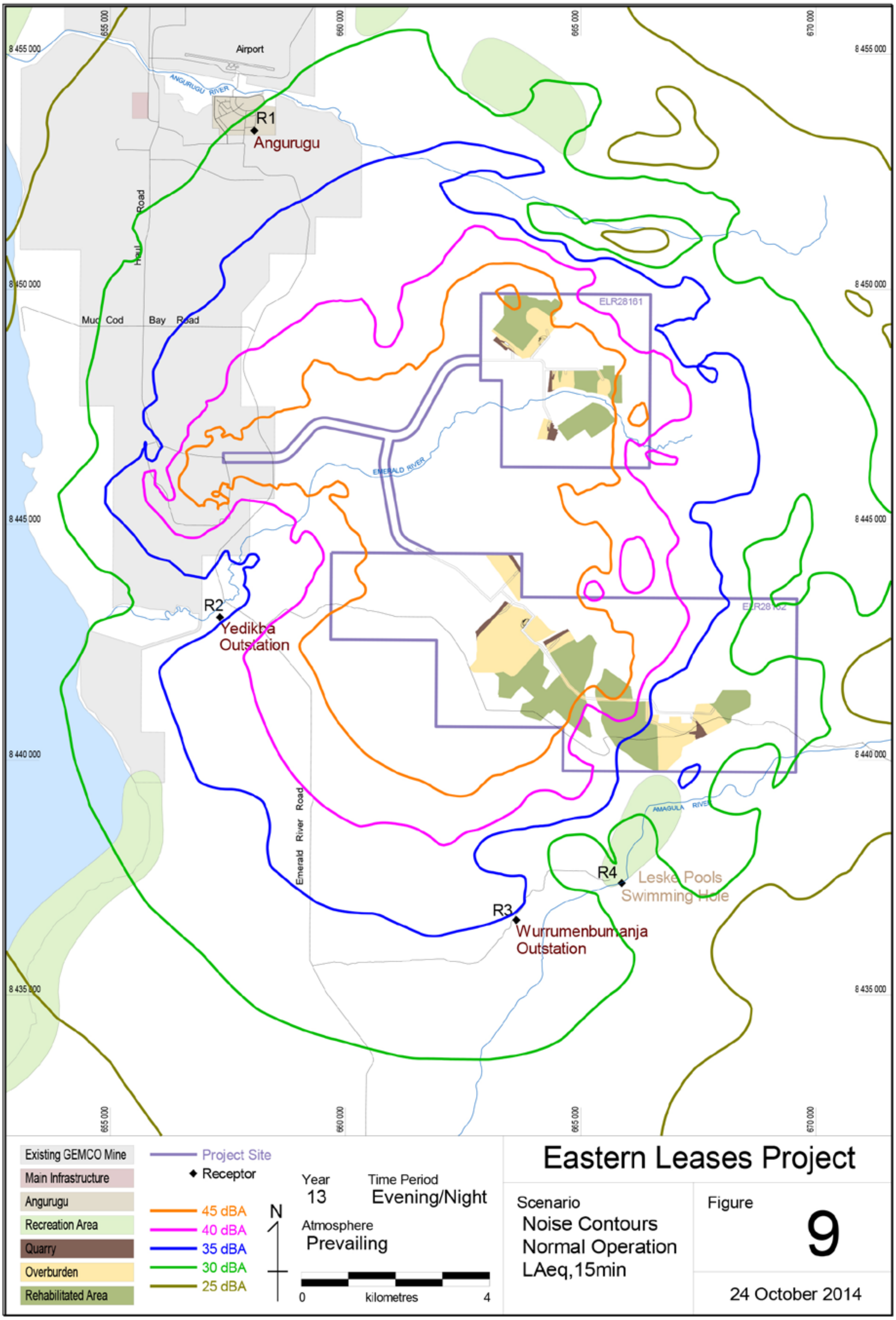
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Normal Operation
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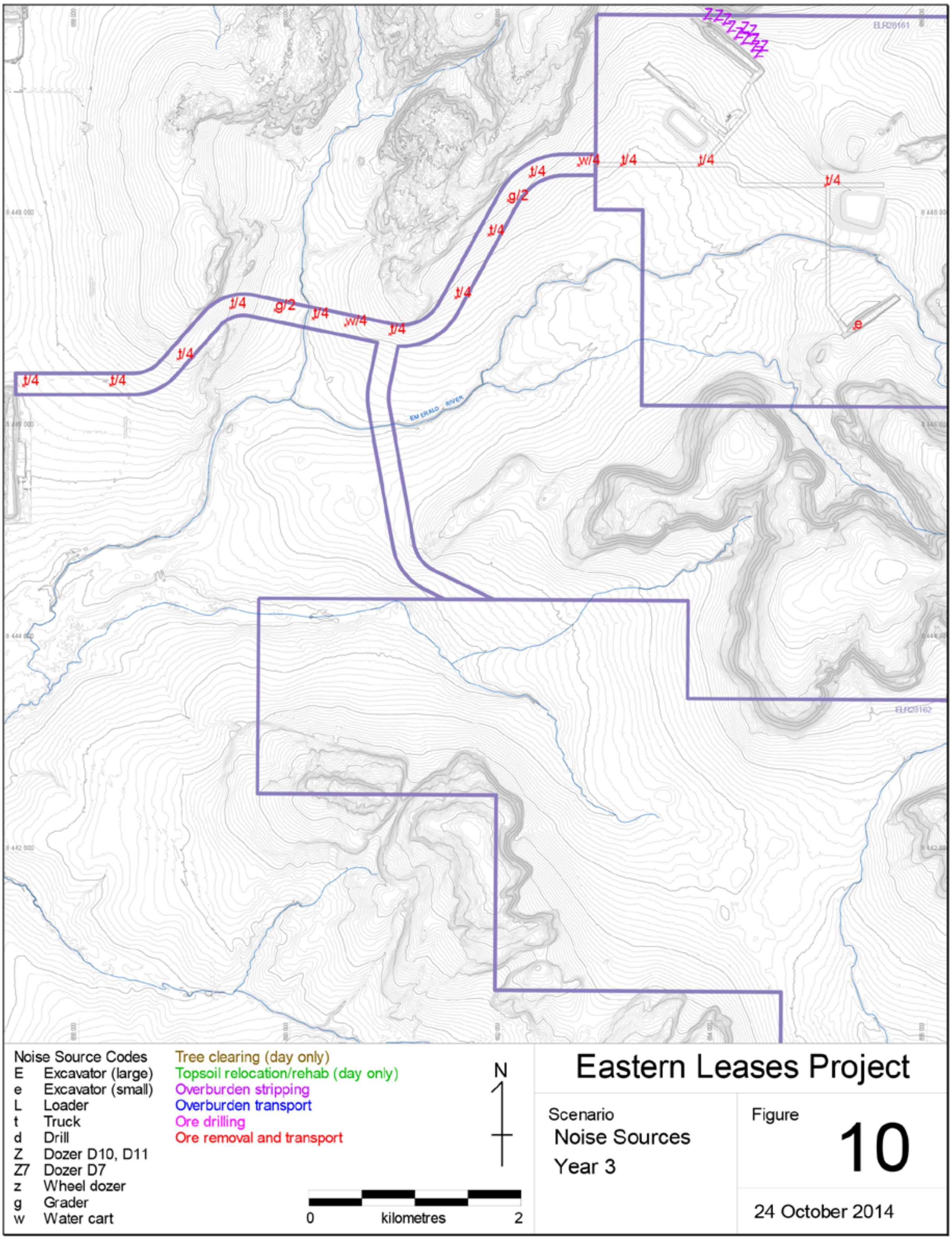
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Noise Source Codes
E Excavator (large)
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L Loader
t Truck
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Z7 Dozer D7
z Wheel dozer
g Grader
w Water cart
Tree clearing (day only)
Topsoil relocation/rehab (day only)
Overburden stripping
Overburden transport
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Noise Sources
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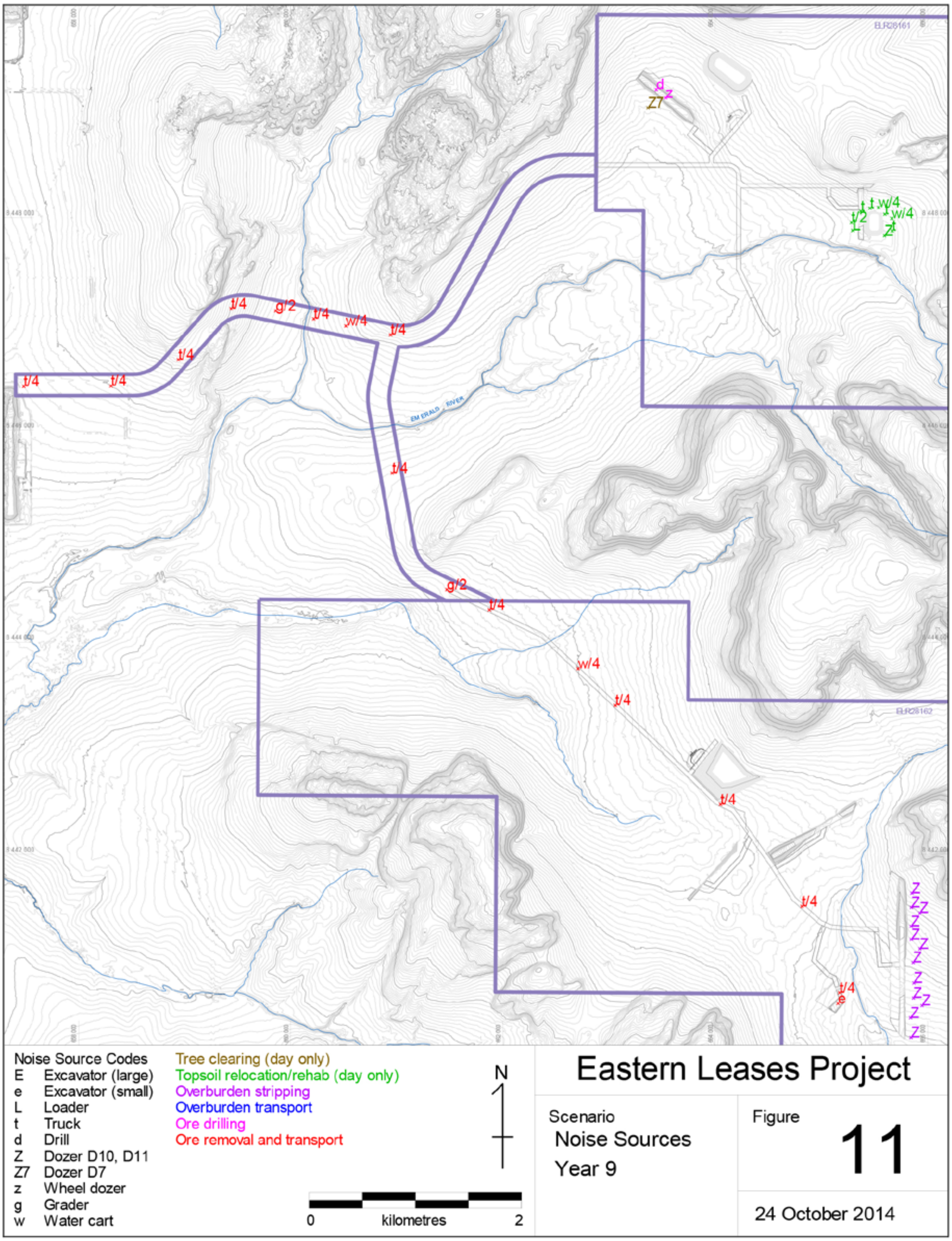
24 October 2014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Overburden stripping
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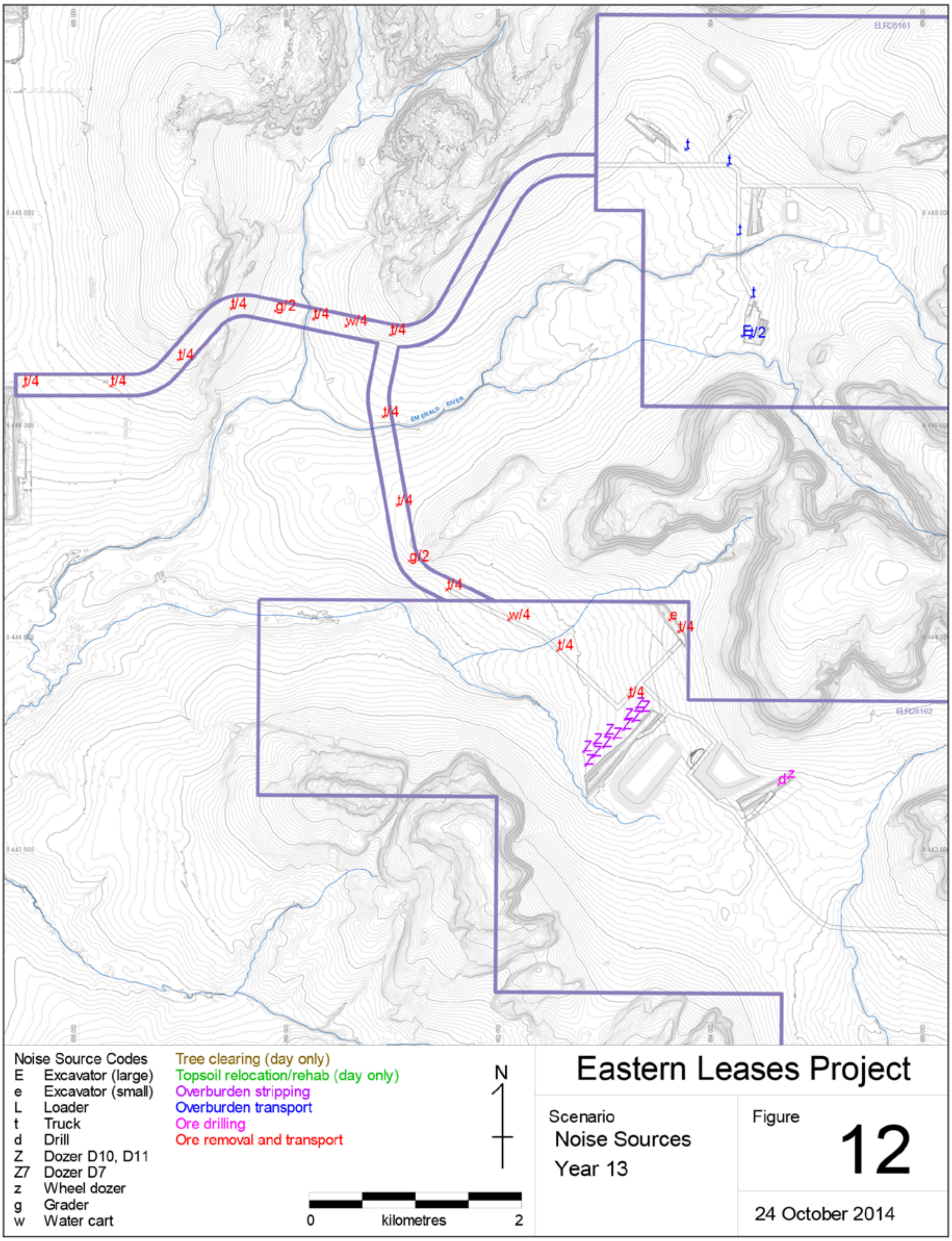
24 October 2014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Overburden stripping
Overburden transport
Ore drilling
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Eastern Leases Project
Scenario
Noise Sources
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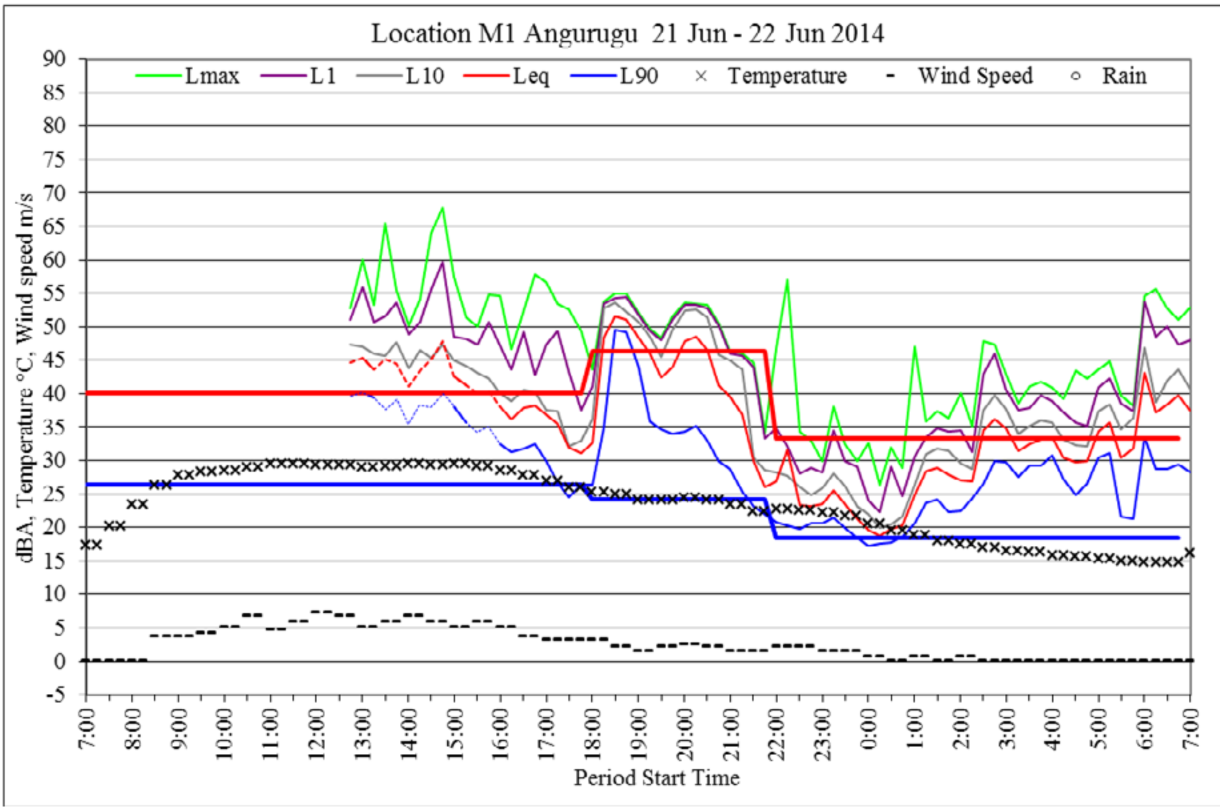
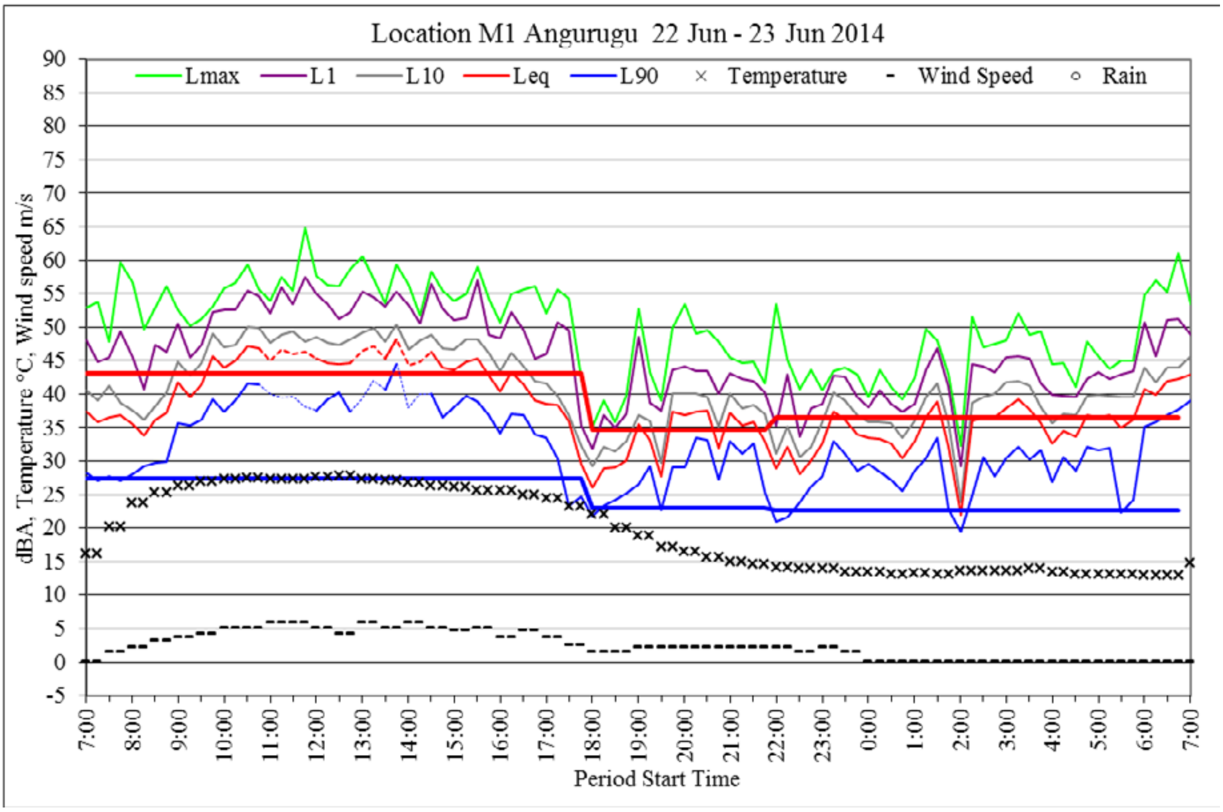
12
24 October 2014

APPENDIX A – LONG TERM NOISE MONITORING RESULTS

Environmental noise level charts on the following pages show 15 minute percentile statistics from noise loggers installed at two representative receiver locations in the area in June and early July 2014, with each chart showing a 24 hour period beginning at 7:00am. Each chart includes:

Lmax -	The highest line on the chart, shown with a light green line. The Lmax is the maximum dBA noise level measured in each 15 minute period.
L1 -	The second highest line on the chart, shown with a violet line and representing the loudest 1 percent of the time (9 seconds) in each 15 minute period.
L10 -	The third highest line on each chart without data markers, shown as a grey line and representing the loudest 10% of the time (90 seconds) during each 15 minute period.
Leq -	the equivalent continuous (acoustic average) noise level in each 15 minute period, shown as a red line. The Leq can be above or below the L10 line and can, in extreme cases, extend above the L1 line.
Period Leq -	the equivalent continuous (acoustic average) noise level in each day, evening or night period, calculated from the average of all 15 minute Leq values in that time period excluding those affected by wind over 5m/s or rain. The Period Leq line is shown as a heavy red line.
L90 -	the lowest line on the chart, shown by a blue line, representing the quietest 10 percent of the time in each 15 minute period and accepted as the background noise level. Sections of line shown dotted indicate periods affected by wind over 5m/s or rain.
Period L90 -	The 'L90 of the 15 minute L90s' for each day, evening and night period, representing the Assessment Background Levels (ABLs) for each period according to the INP. The Period L90 represents the lowest 10% of all 15 minute L90 values in that time period, excluding those affected by wind or rain, and is shown as a heavy blue line.


Location M1 Angurugu 21 Jun - 22 Jun 2014
Lmax
L1
L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M1 Angurugu 22 Jun - 23 Jun 2014
Lmax
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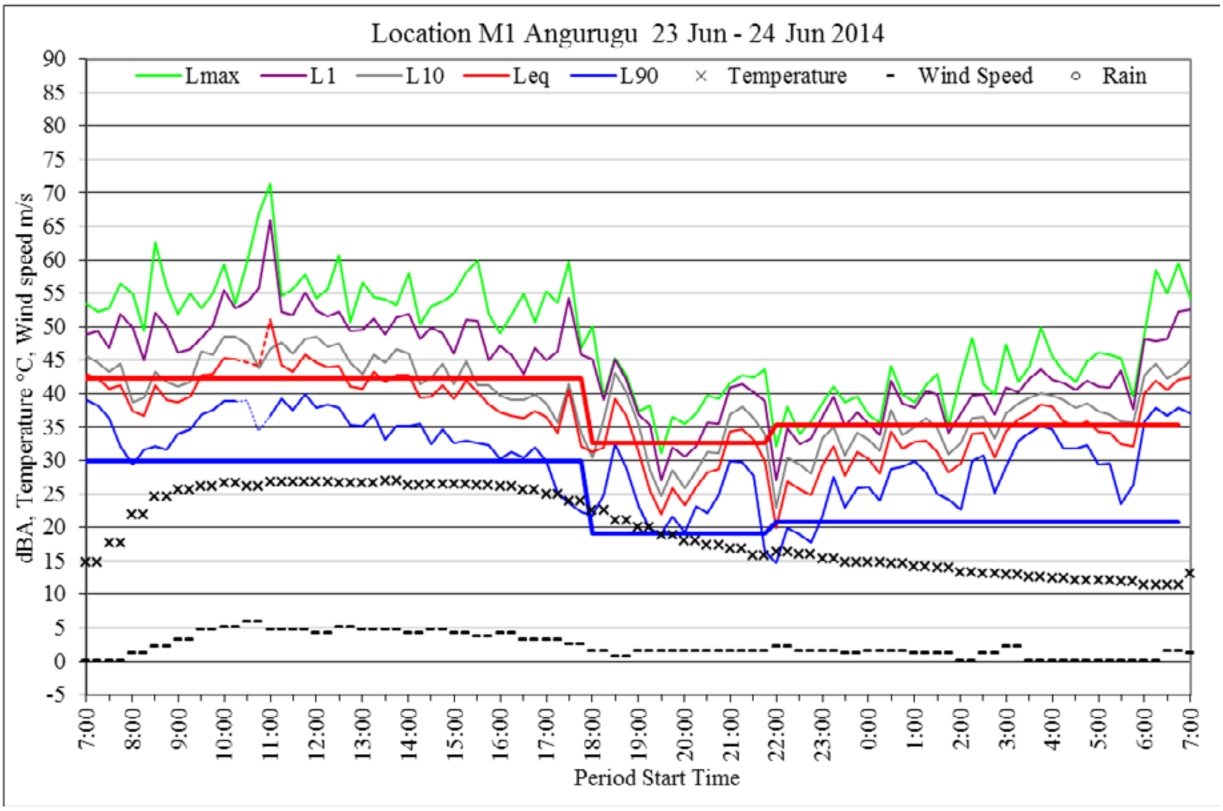
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M1 Angurugu 23 Jun - 24 Jun 2014
Lmax
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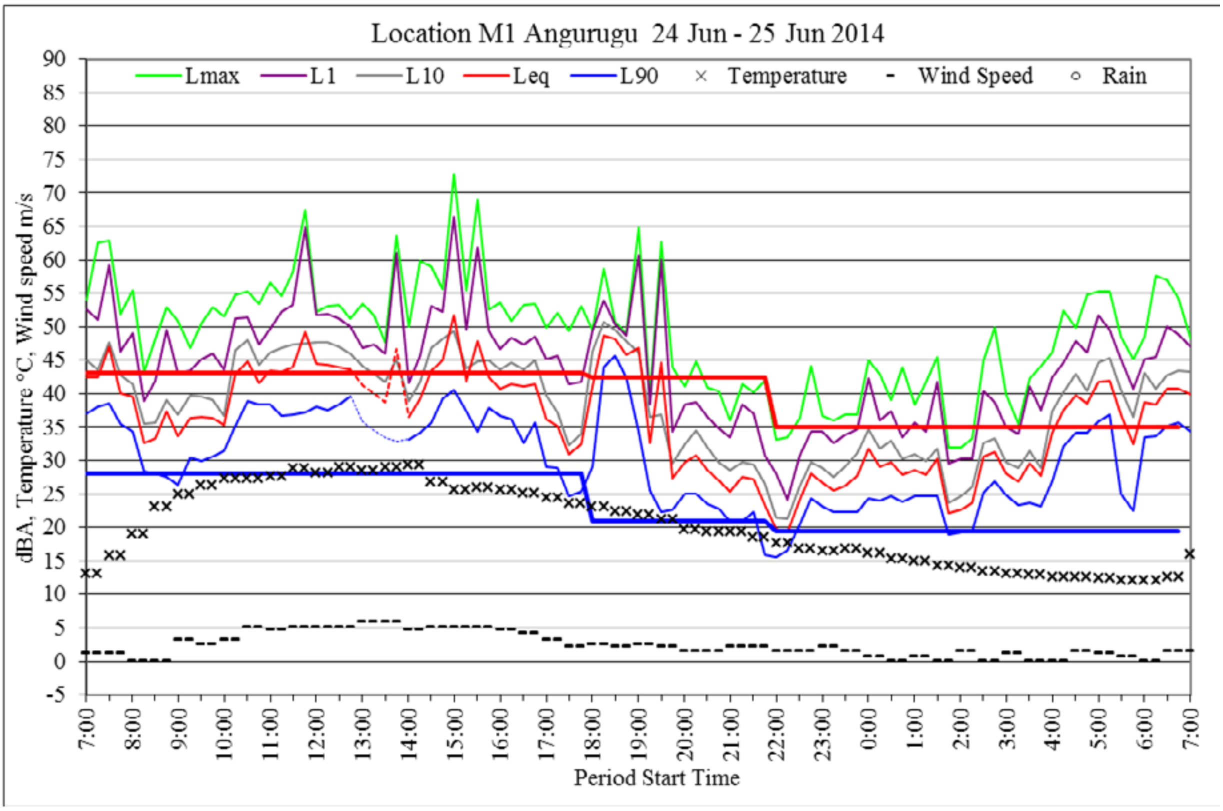
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M1 Angurugu 24 Jun - 25 Jun 2014
Lmax
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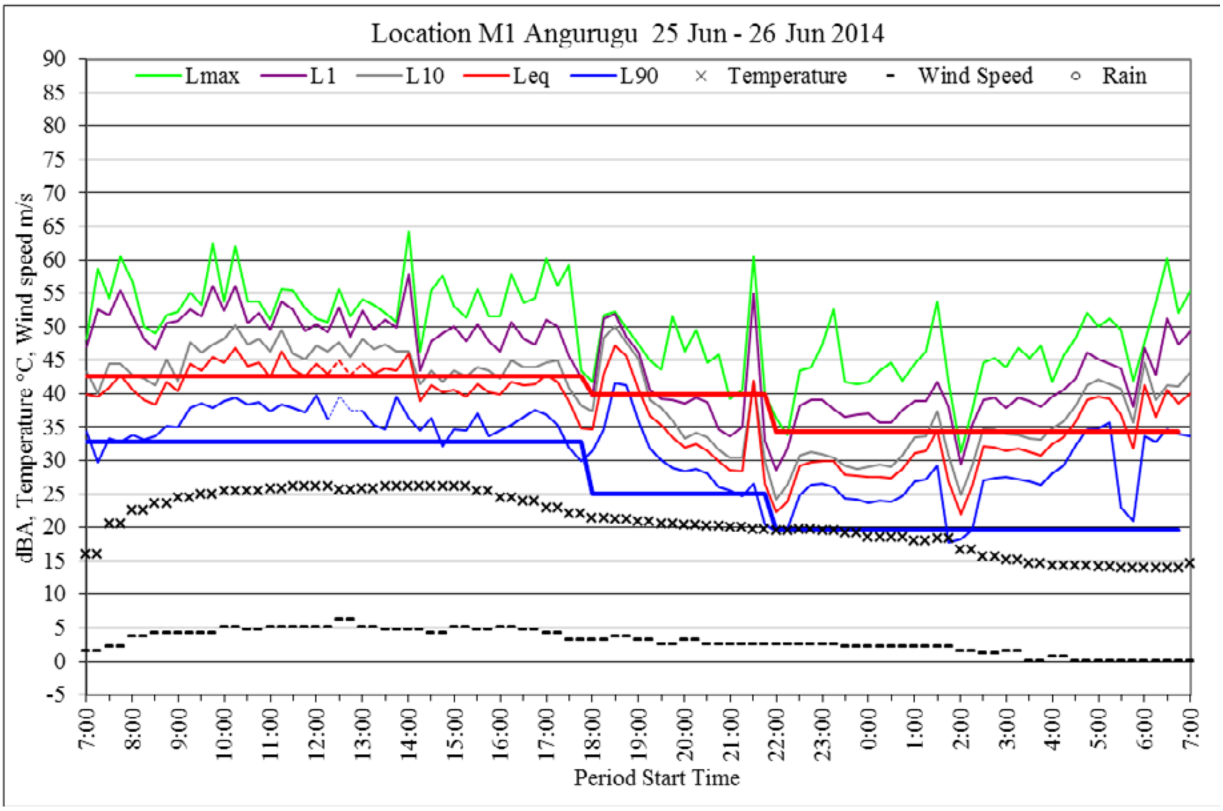
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M1 Angurugu 25 Jun - 26 Jun 2014
Lmax
L1
L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time
7:00
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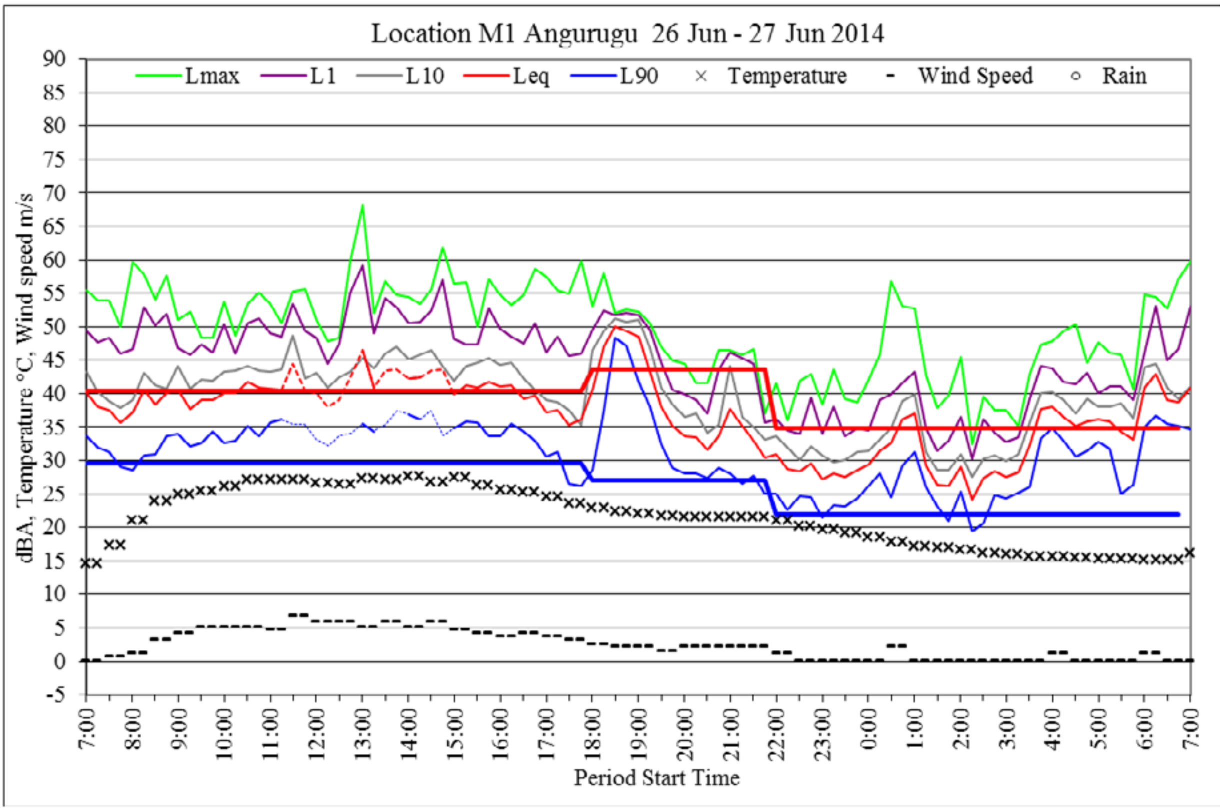
Location M1 Angurugu 26 Jun - 27 Jun 2014
Lmax
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Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time
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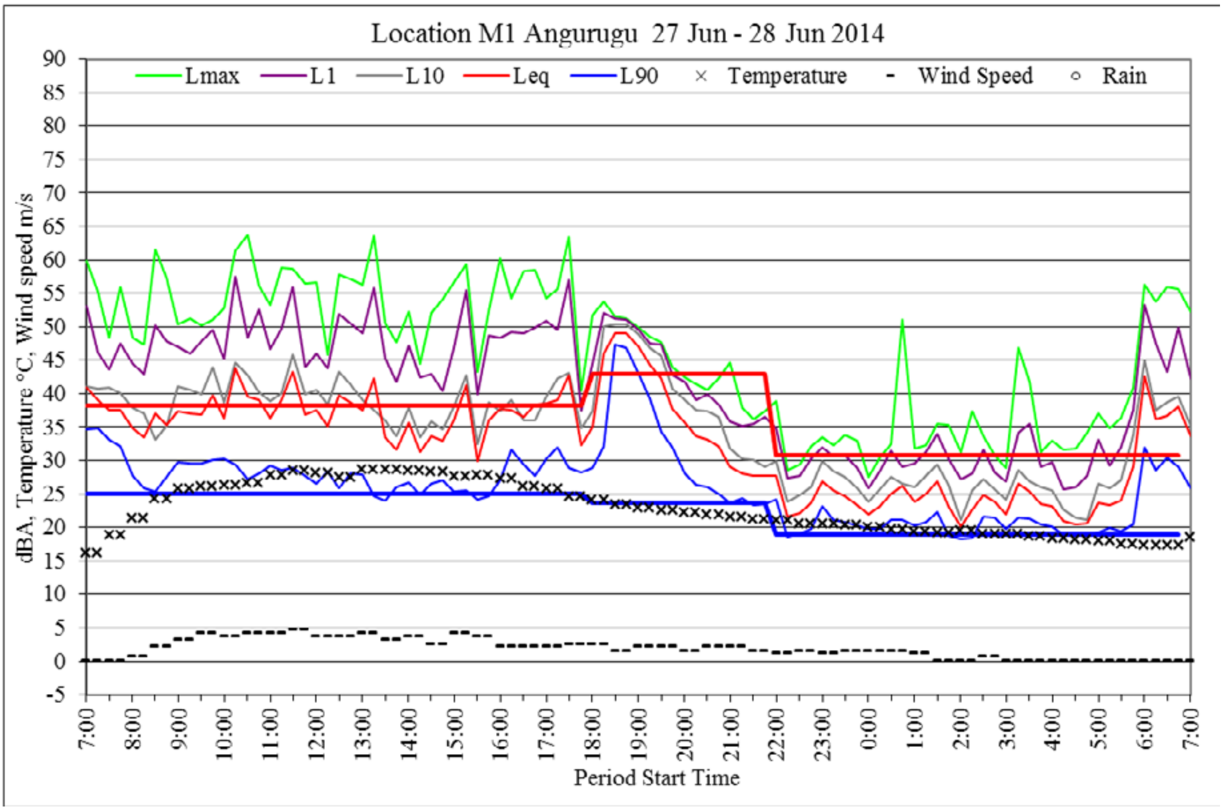
Location M1 Angurugu 27 Jun - 28 Jun 2014
Lmax
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Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time
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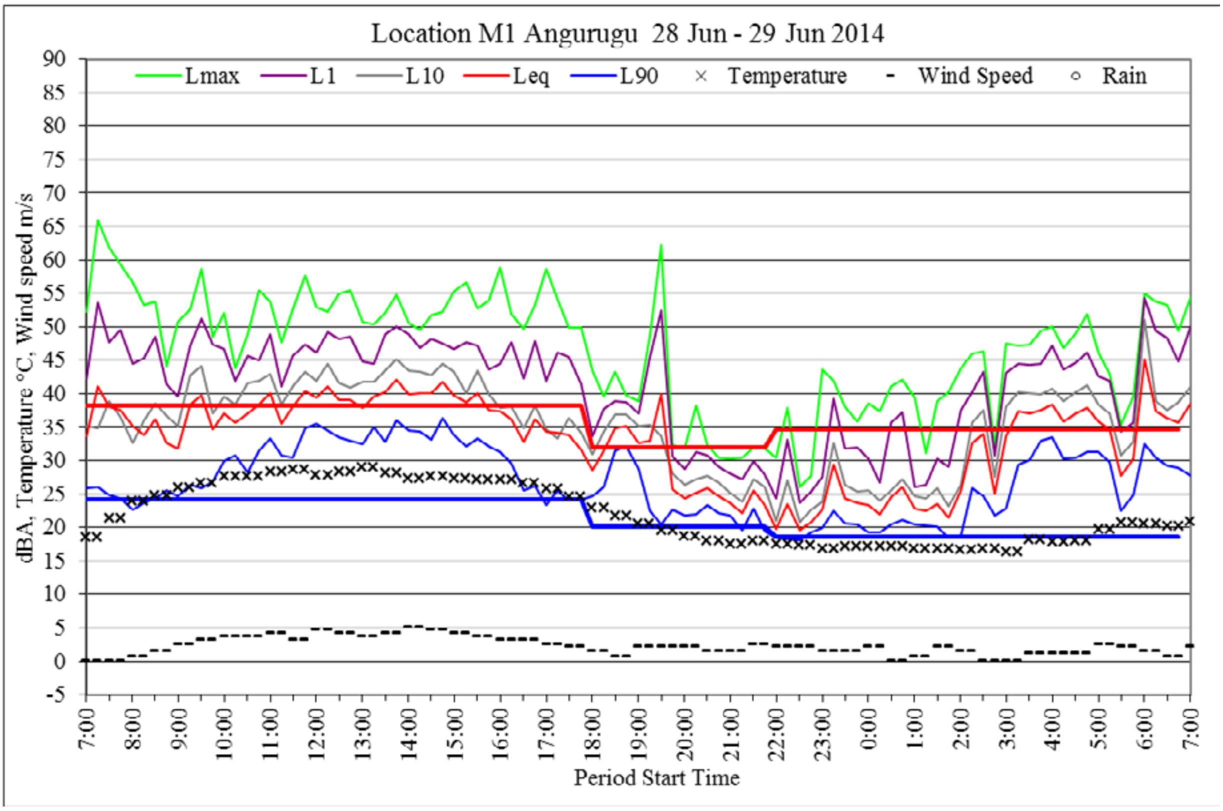
Location M1 Angurugu 28 Jun - 29 Jun 2014
Lmax
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Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time
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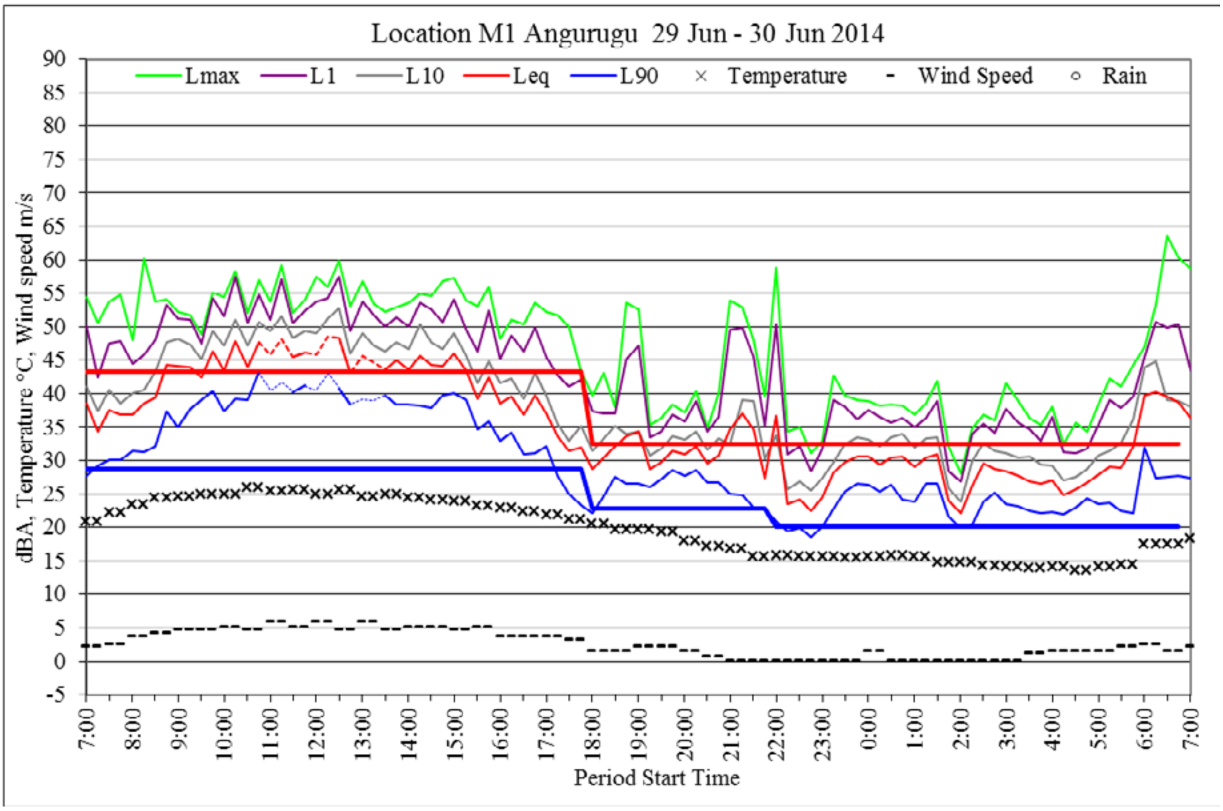
Location M1 Angurugu 29 Jun - 30 Jun 2014
Lmax
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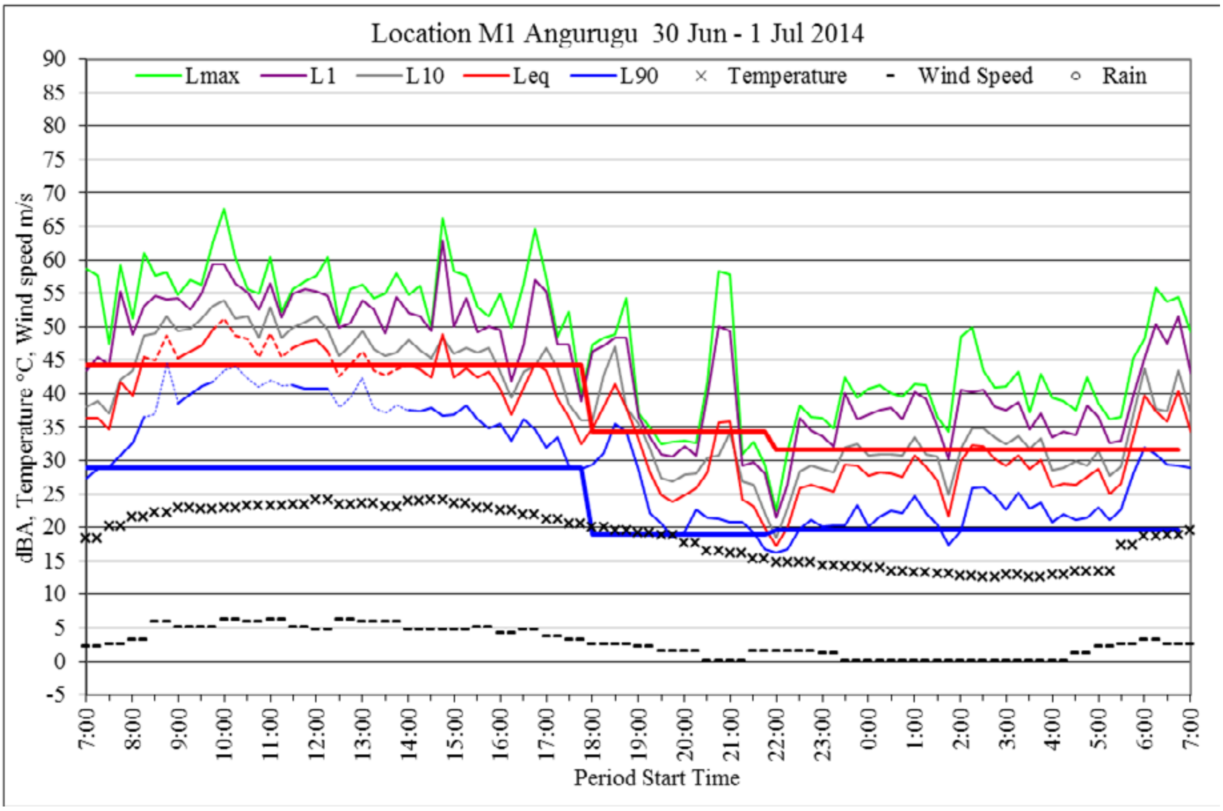
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M1 Angurugu 30 Jun - 1 Jul 2014
Lmax
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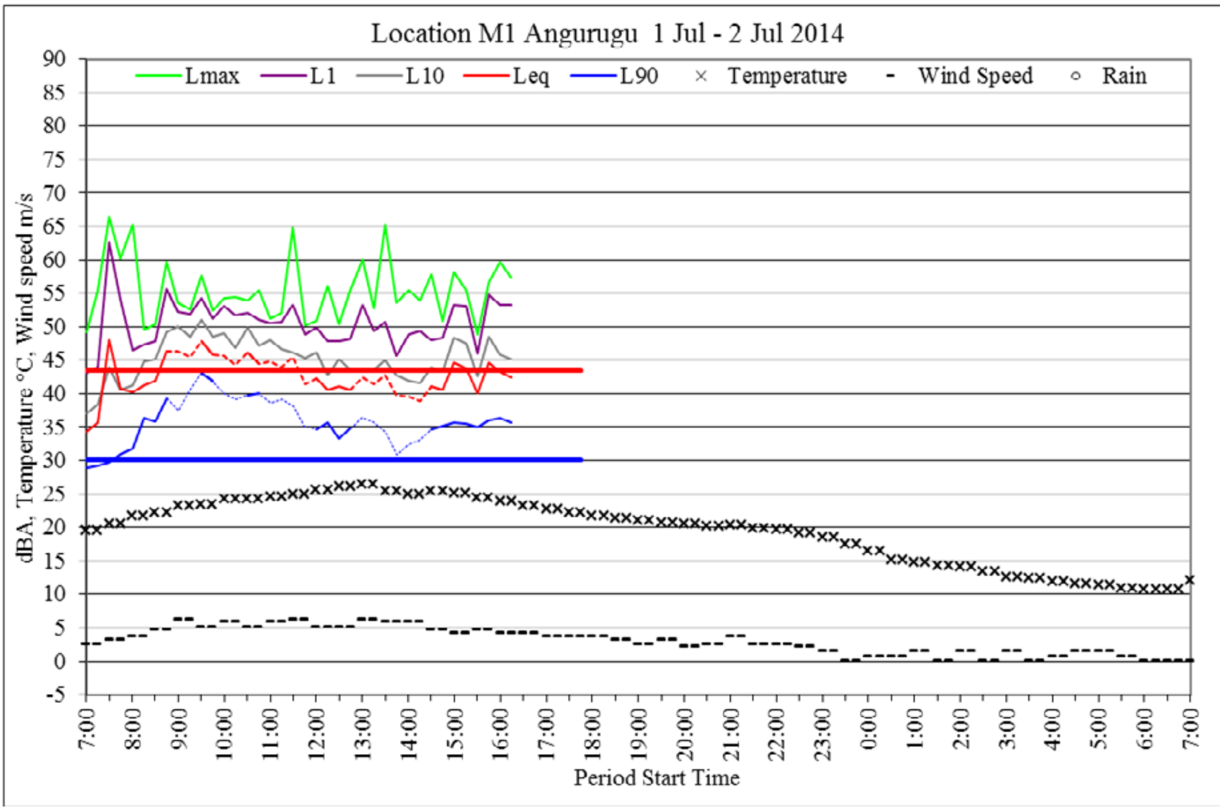
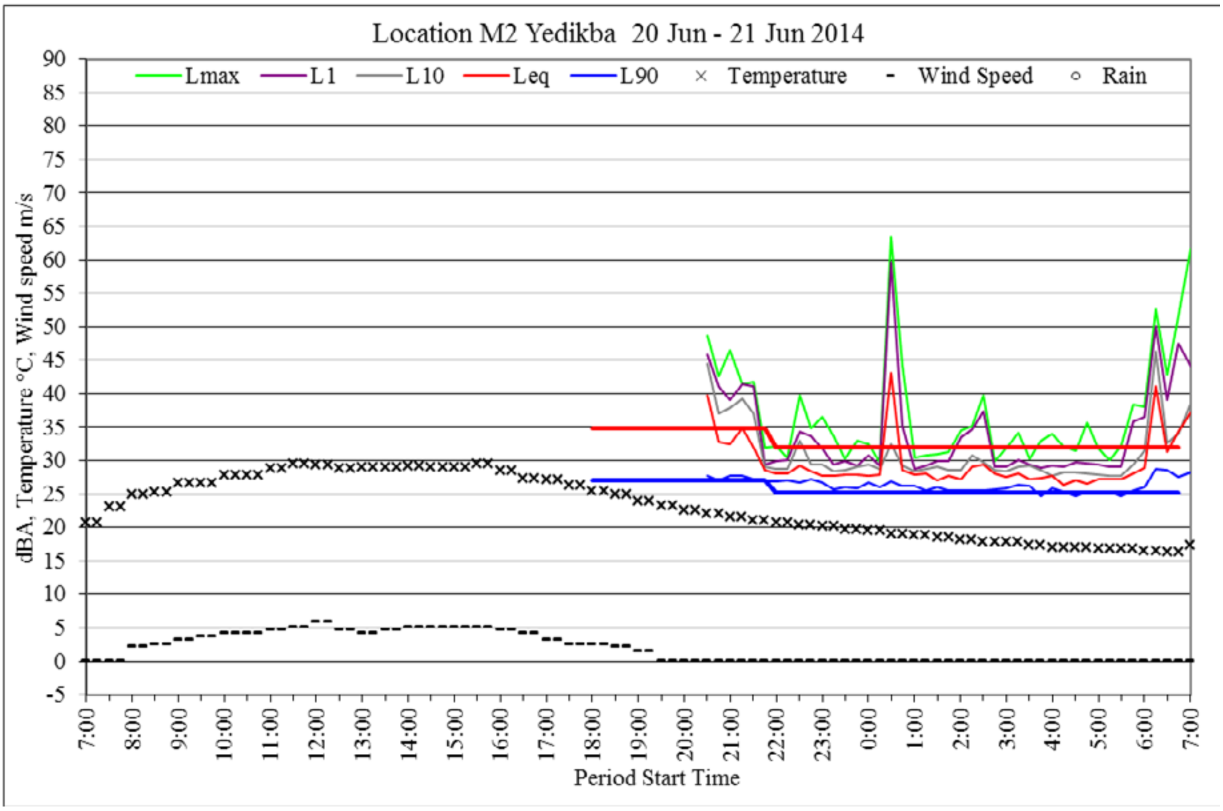
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M1 Angurugu 1 Jul - 2 Jul 2014
Lmax
L1
L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M2 Yedikba 20 Jun - 21 Jun 2014
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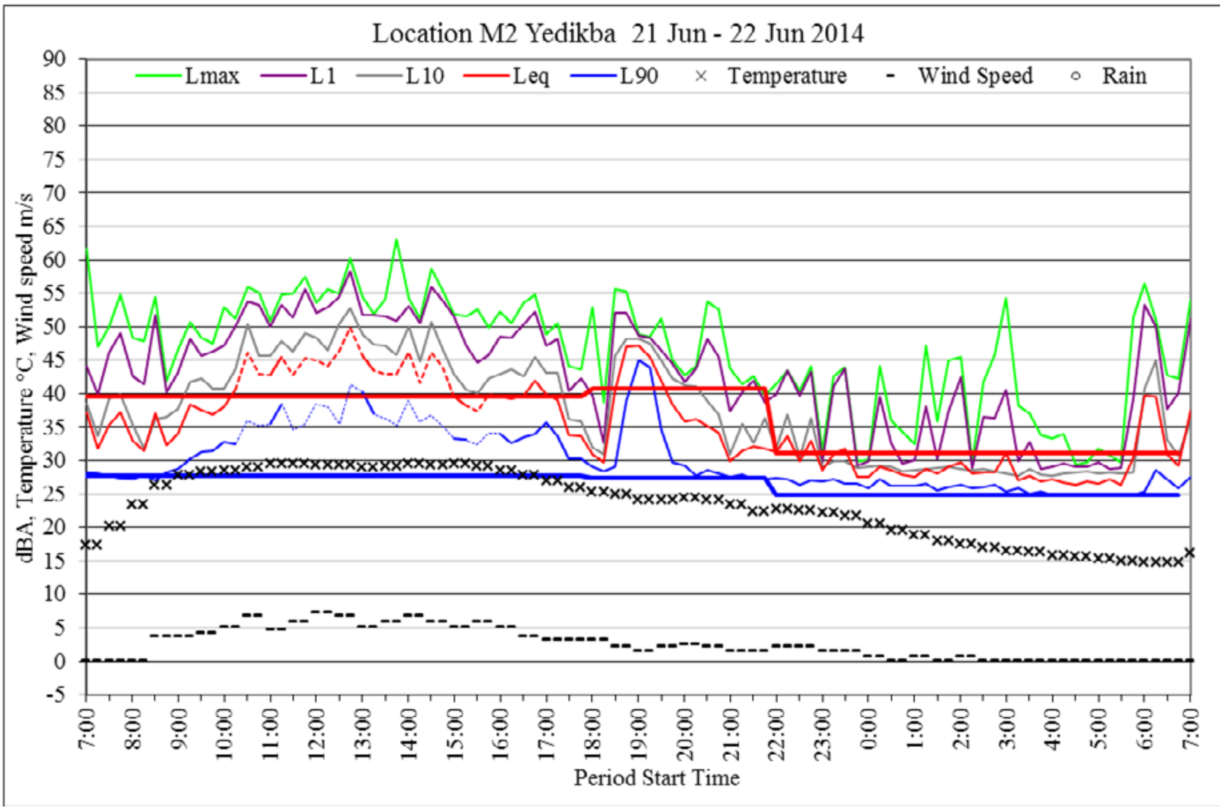
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M2 Yedikba 21 Jun - 22 Jun 2014
Lmax
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Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
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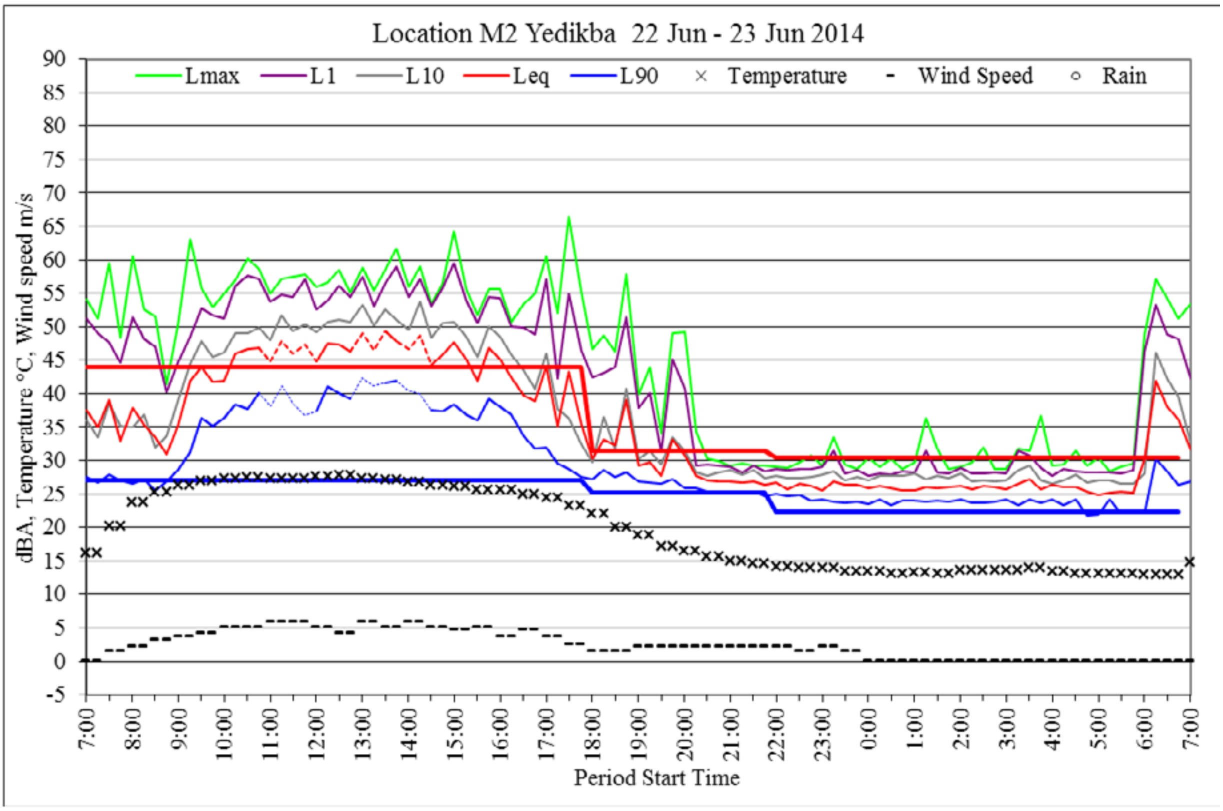
Period Start Time


Location M2 Yedikba 22 Jun - 23 Jun 2014
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Temperature
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dBA, Temperature °C, Wind speed m/s
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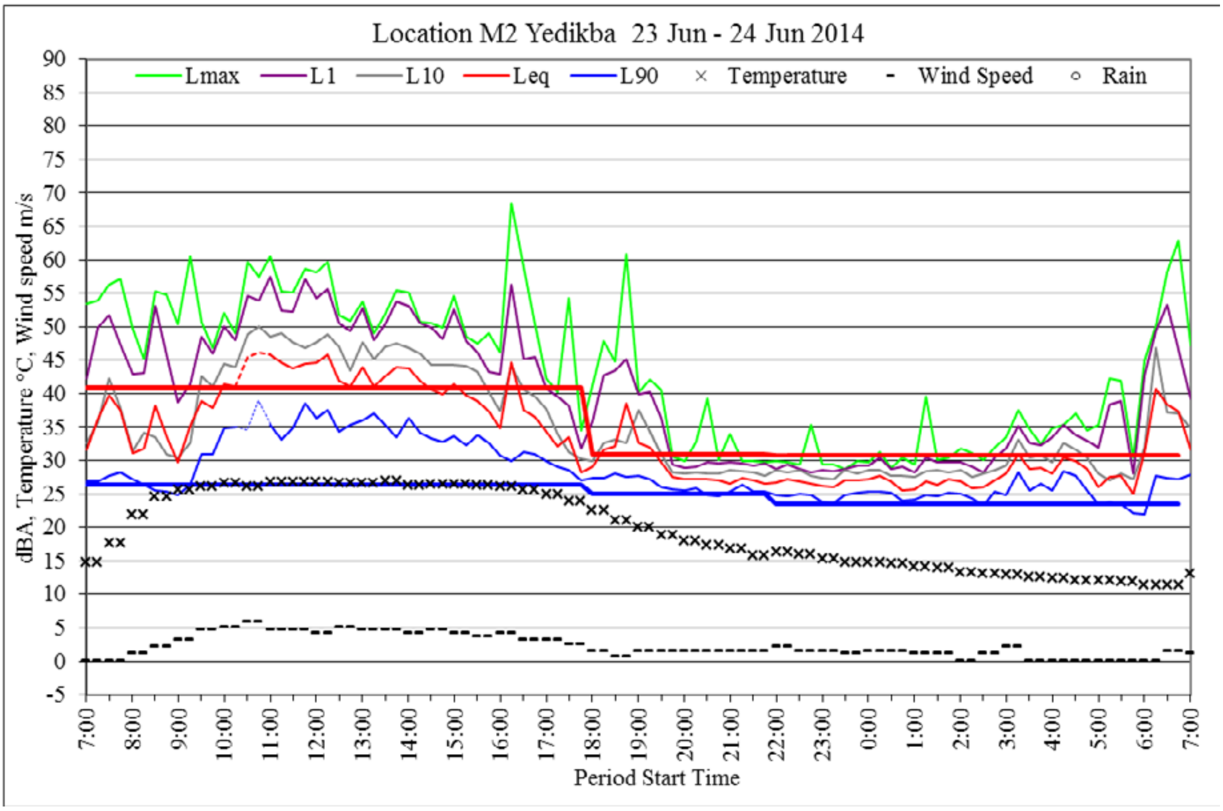
Location M2 Yedikba 23 Jun - 24 Jun 2014
Lmax
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Temperature
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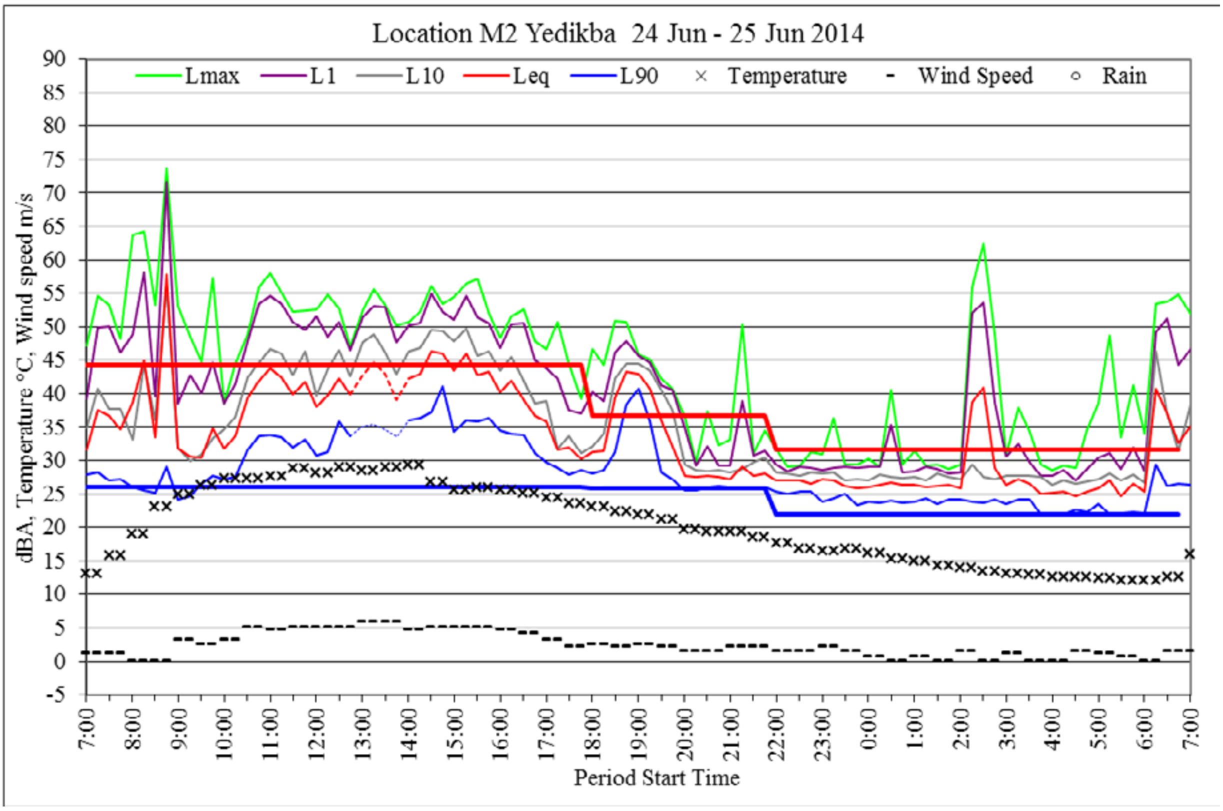
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M2 Yedikba 24 Jun - 25 Jun 2014
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Temperature
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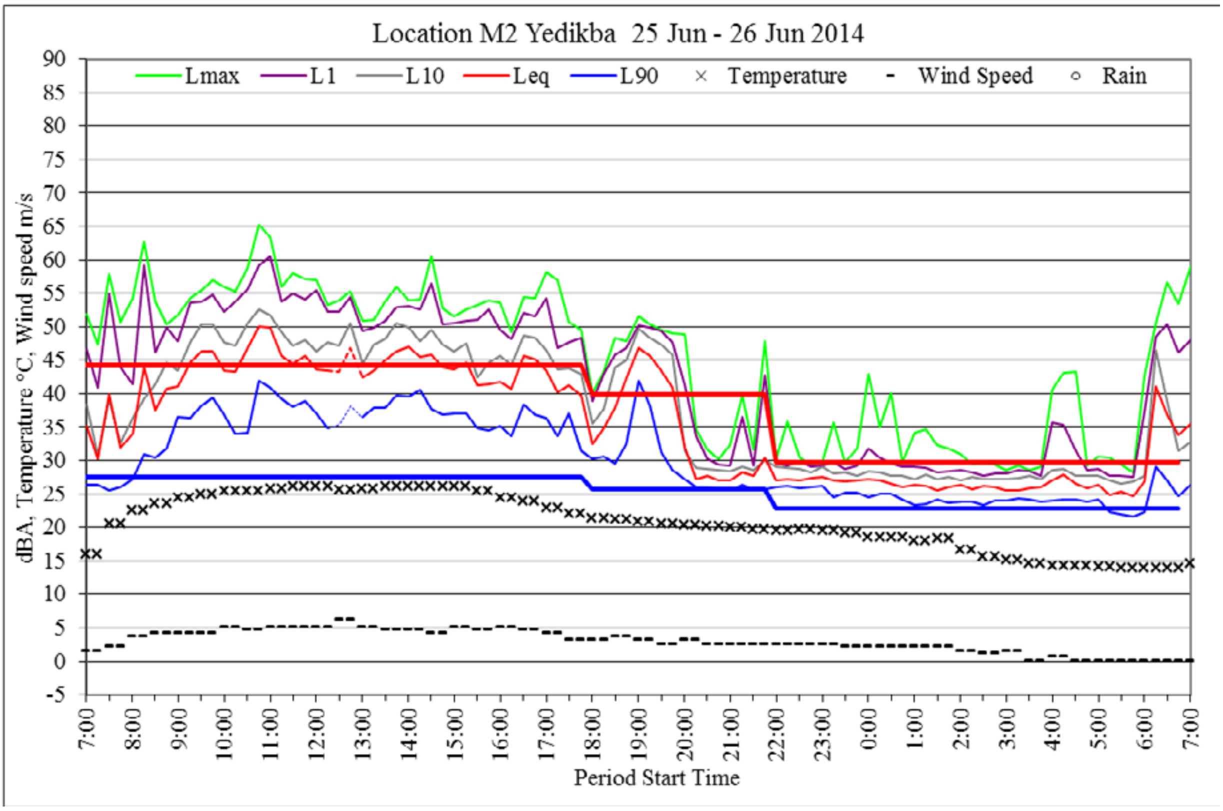
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M2 Yedikba 25 Jun - 26 Jun 2014
Lmax
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Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
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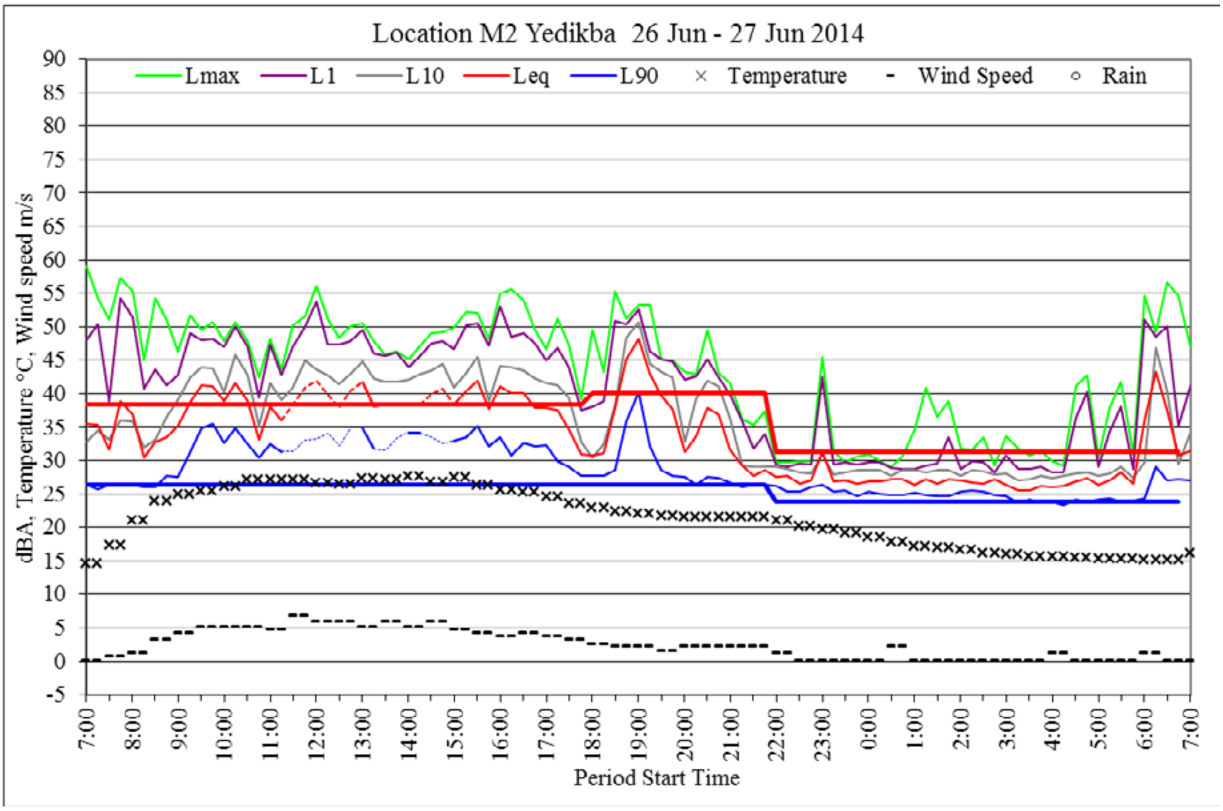
Period Start Time


Location M2 Yedikba 26 Jun - 27 Jun 2014
Lmax
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Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
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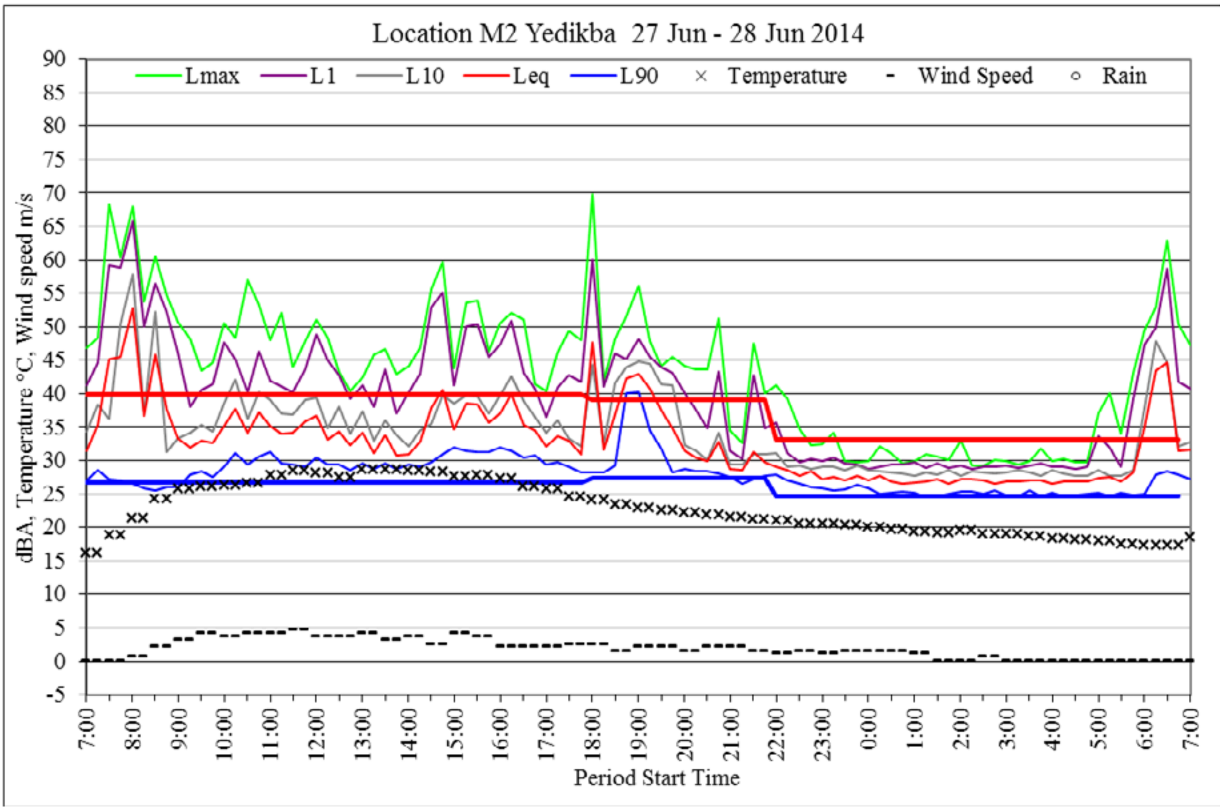
Period Start Time


Location M2 Yedikba 27 Jun - 28 Jun 2014
Lmax
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Temperature
Wind Speed
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dBA, Temperature °C, Wind speed m/s
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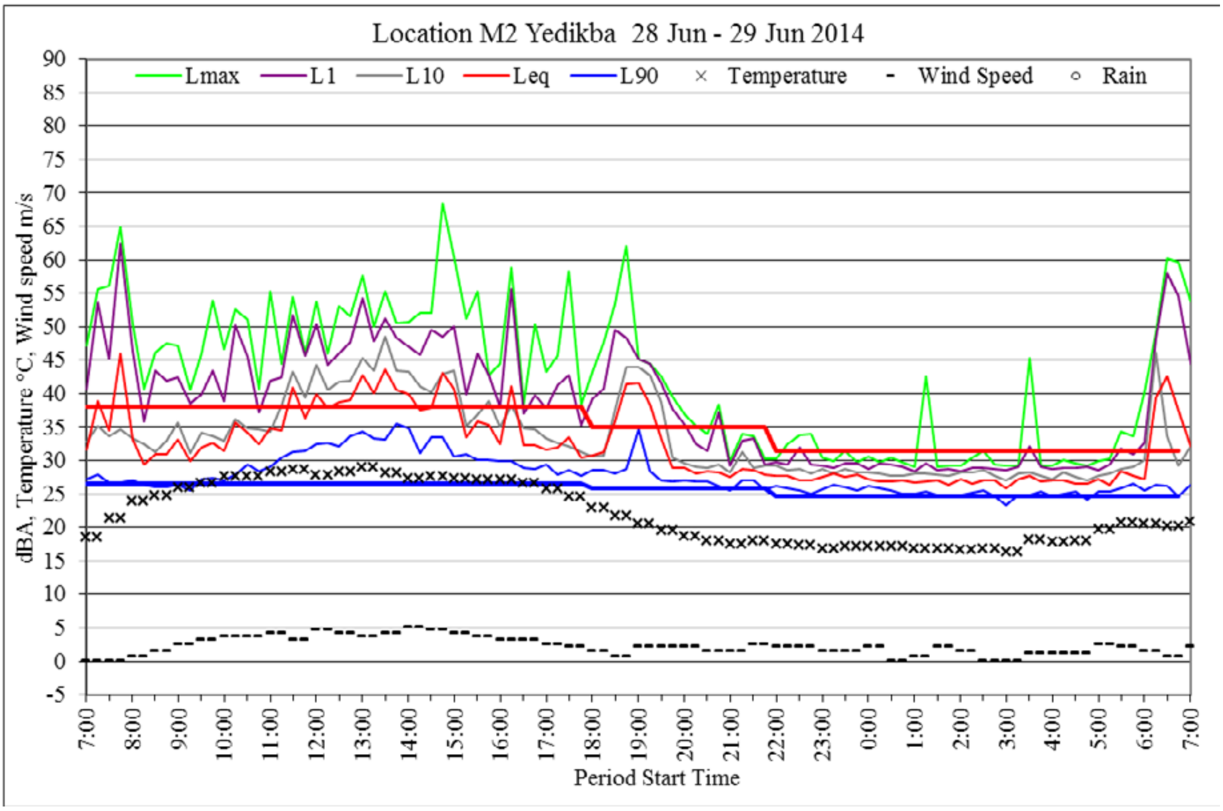
Period Start Time


Location M2 Yedikba 28 Jun - 29 Jun 2014
Lmax
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Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
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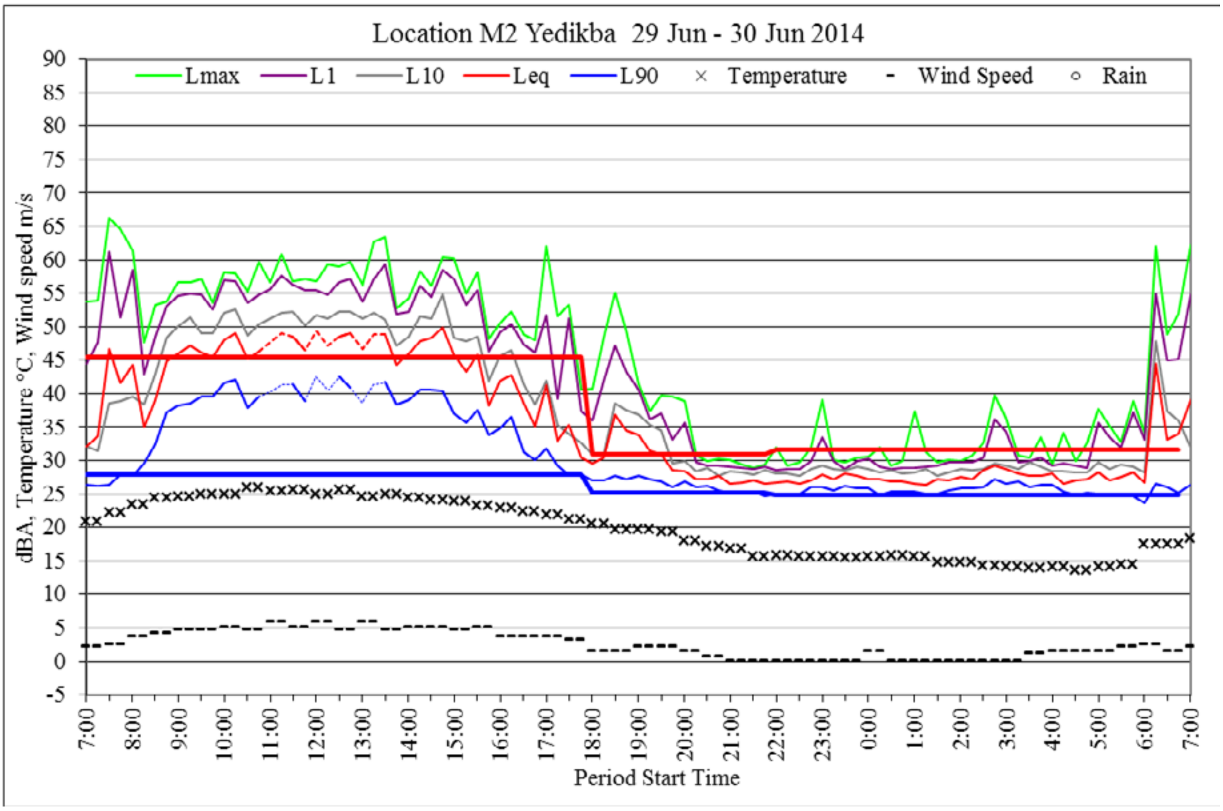
Period Start Time


Location M2 Yedikba 29 Jun - 30 Jun 2014
Lmax
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L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
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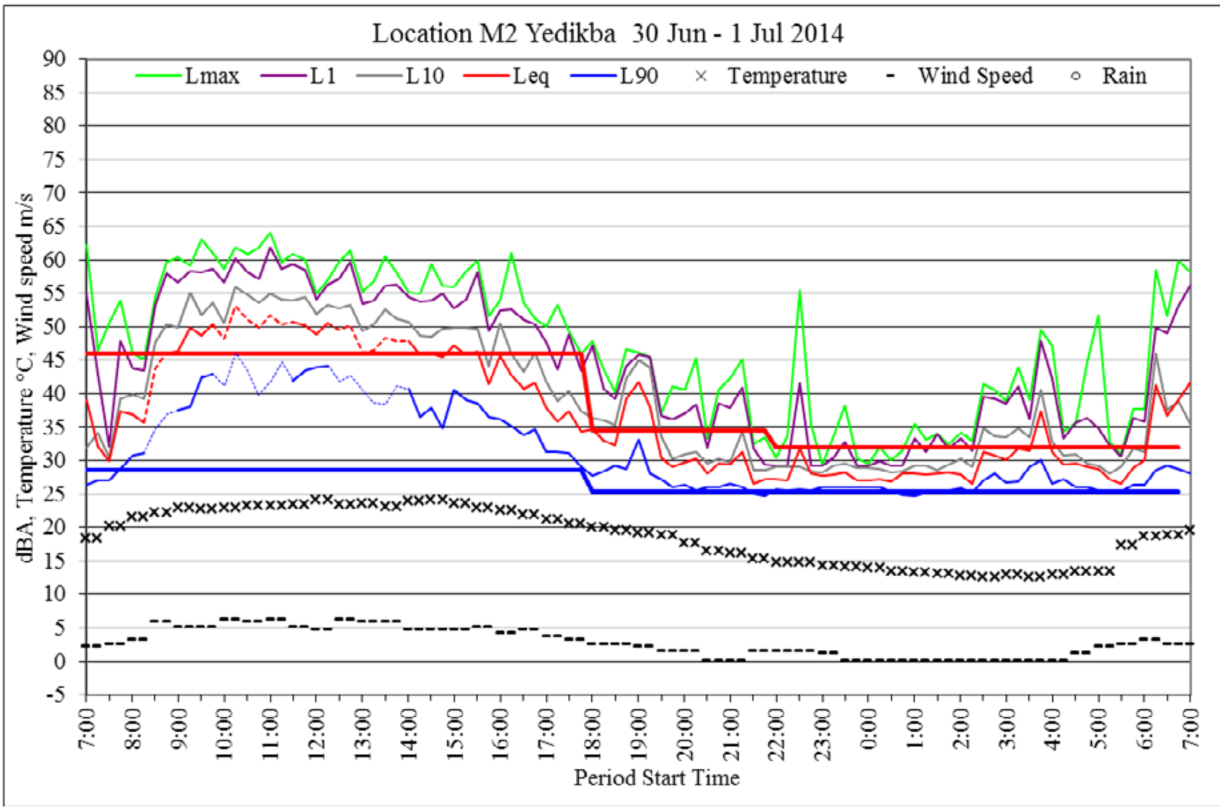
Period Start Time


Location M2 Yedikba 30 Jun - 1 Jul 2014
Lmax
L1
L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
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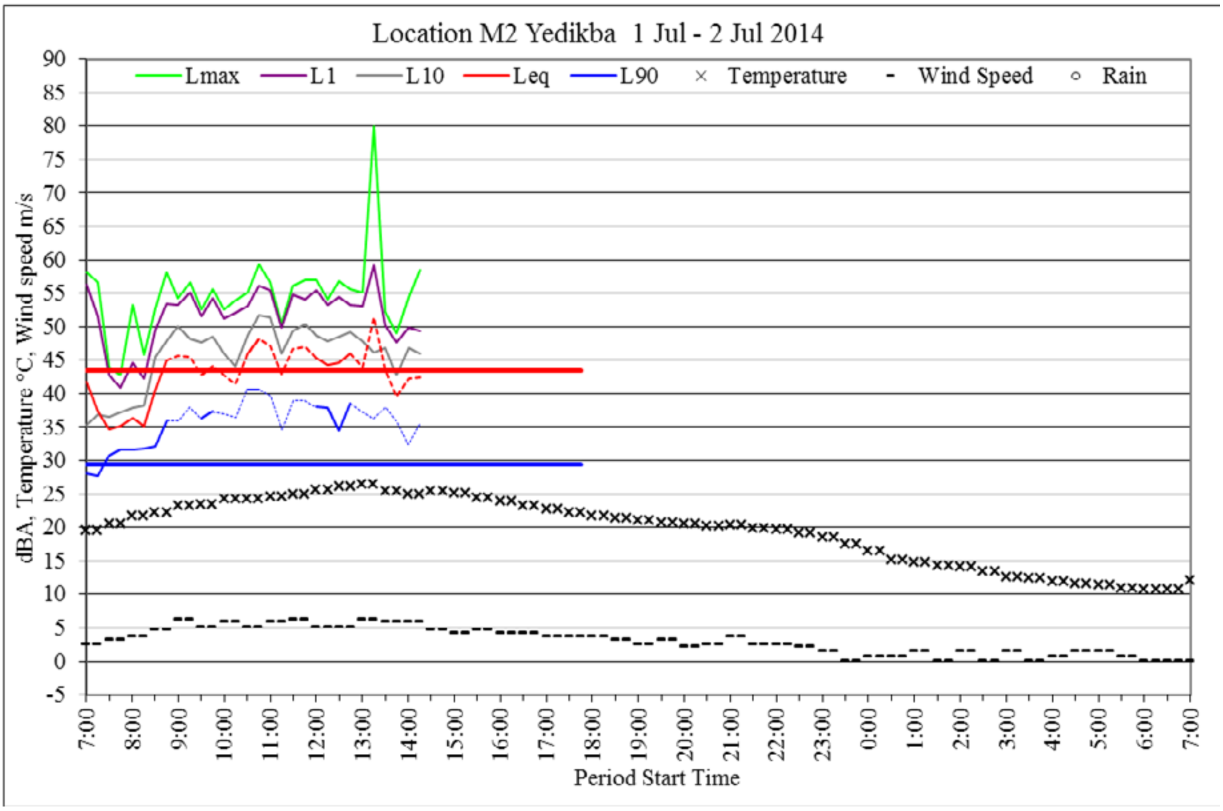
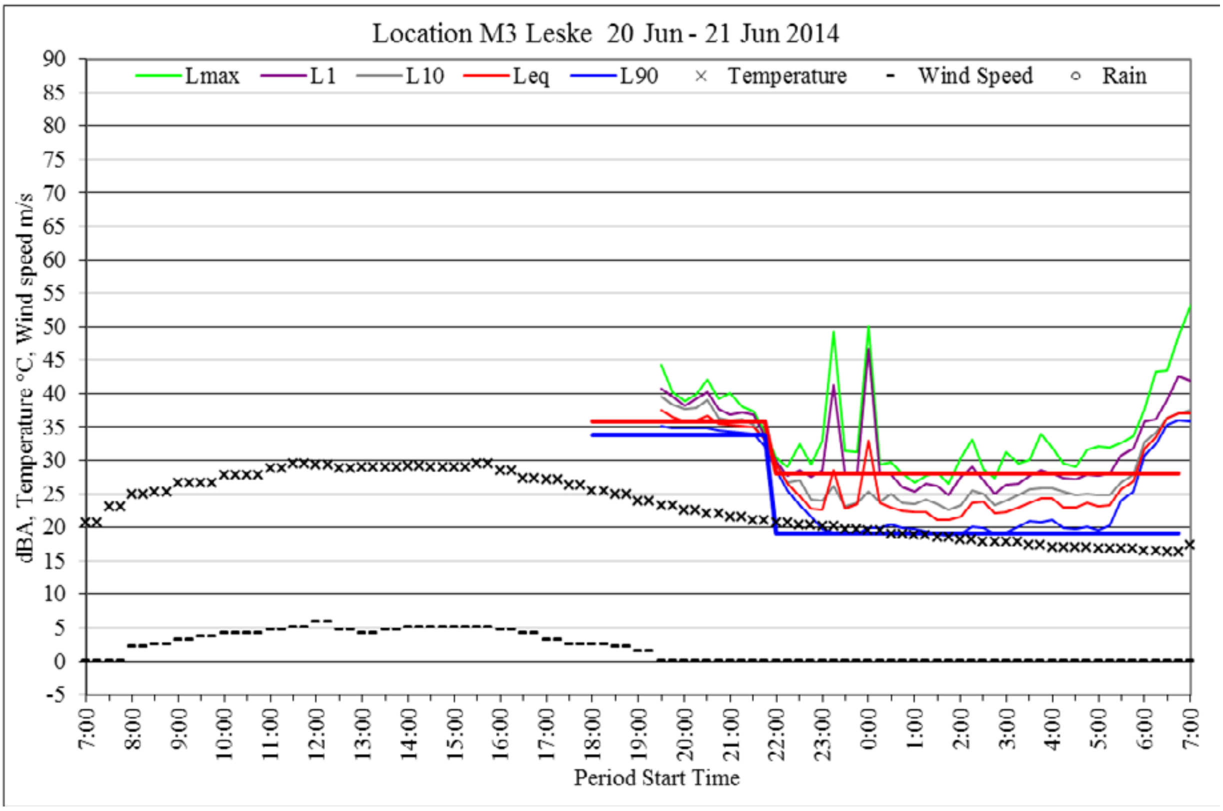
Period Start Time


Location M2 Yedikba 1 Jul - 2 Jul 2014
Lmax
L1
L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M3 Leske 20 Jun - 21 Jun 2014
Lmax
L1
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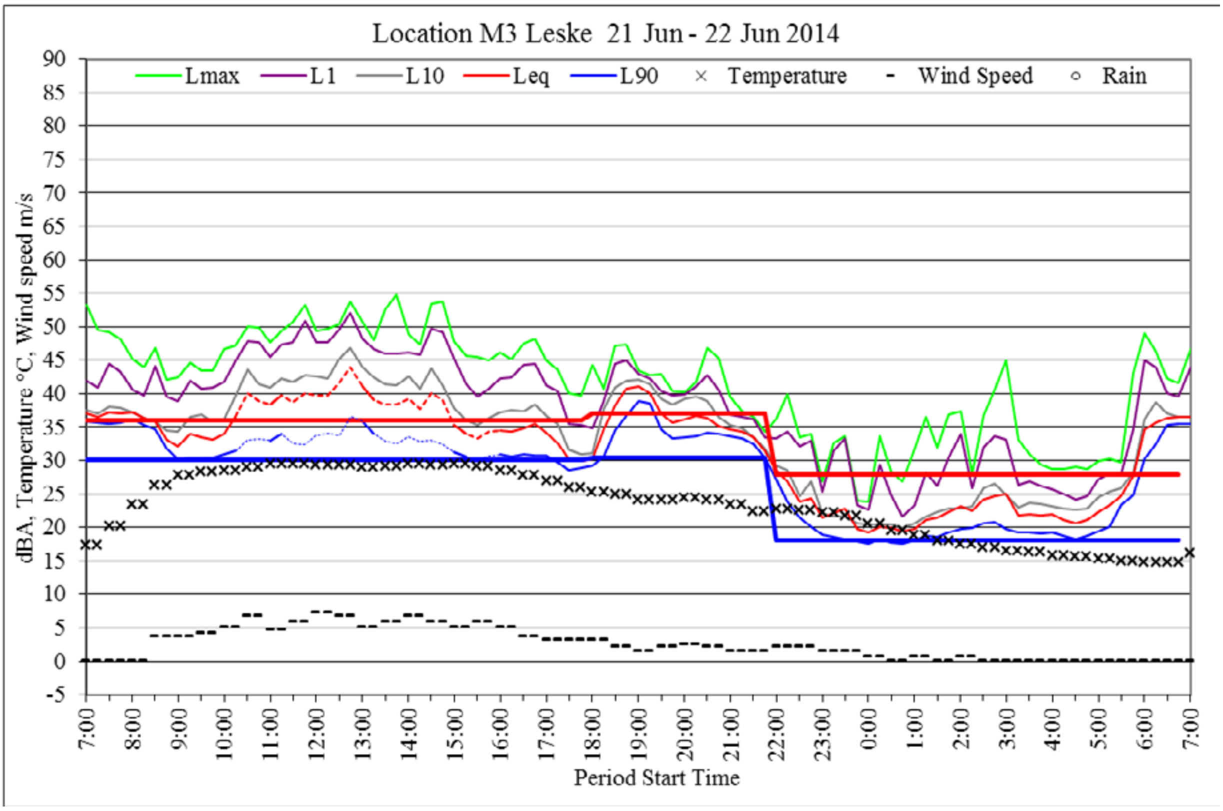
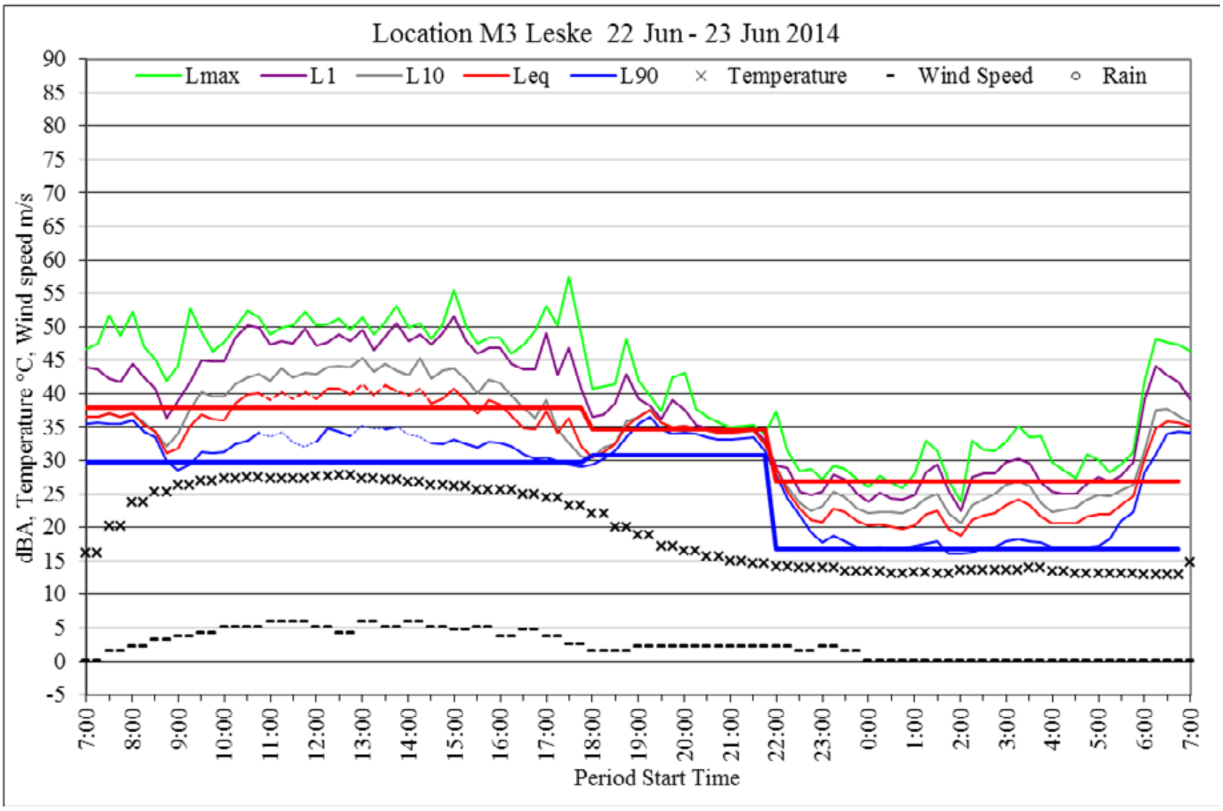
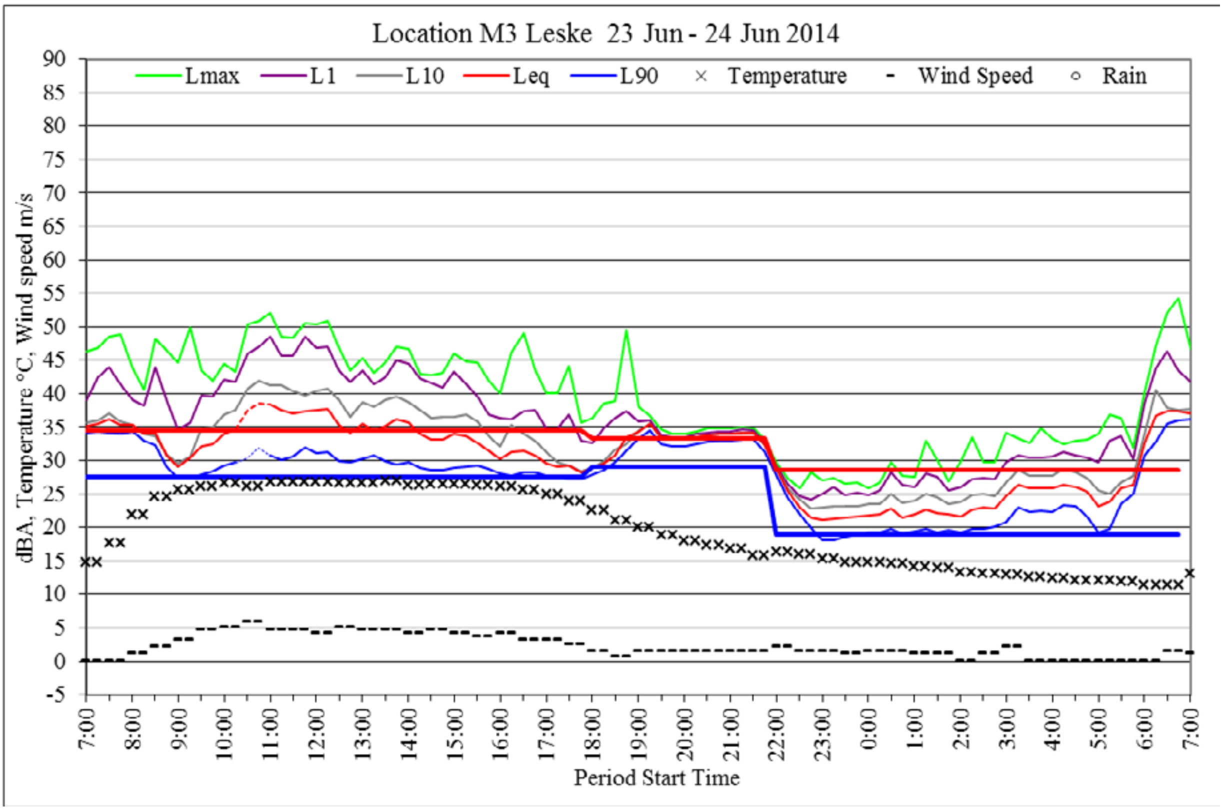
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M3 Leske 21 Jun - 22 Jun 2014
Lmax
L1
L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M3 Leske 22 Jun - 23 Jun 2014
Lmax
L1
L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M3 Leske 23 Jun - 24 Jun 2014
Lmax
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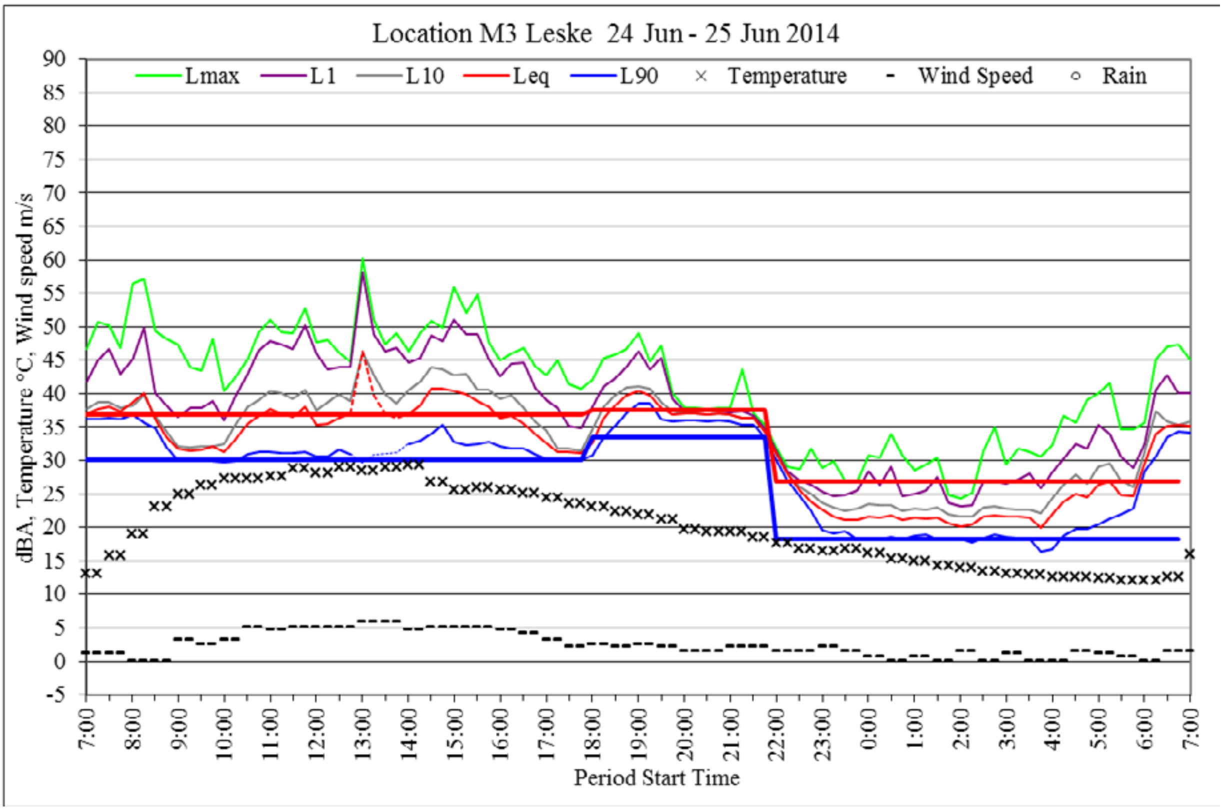
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M3 Leske 24 Jun - 25 Jun 2014
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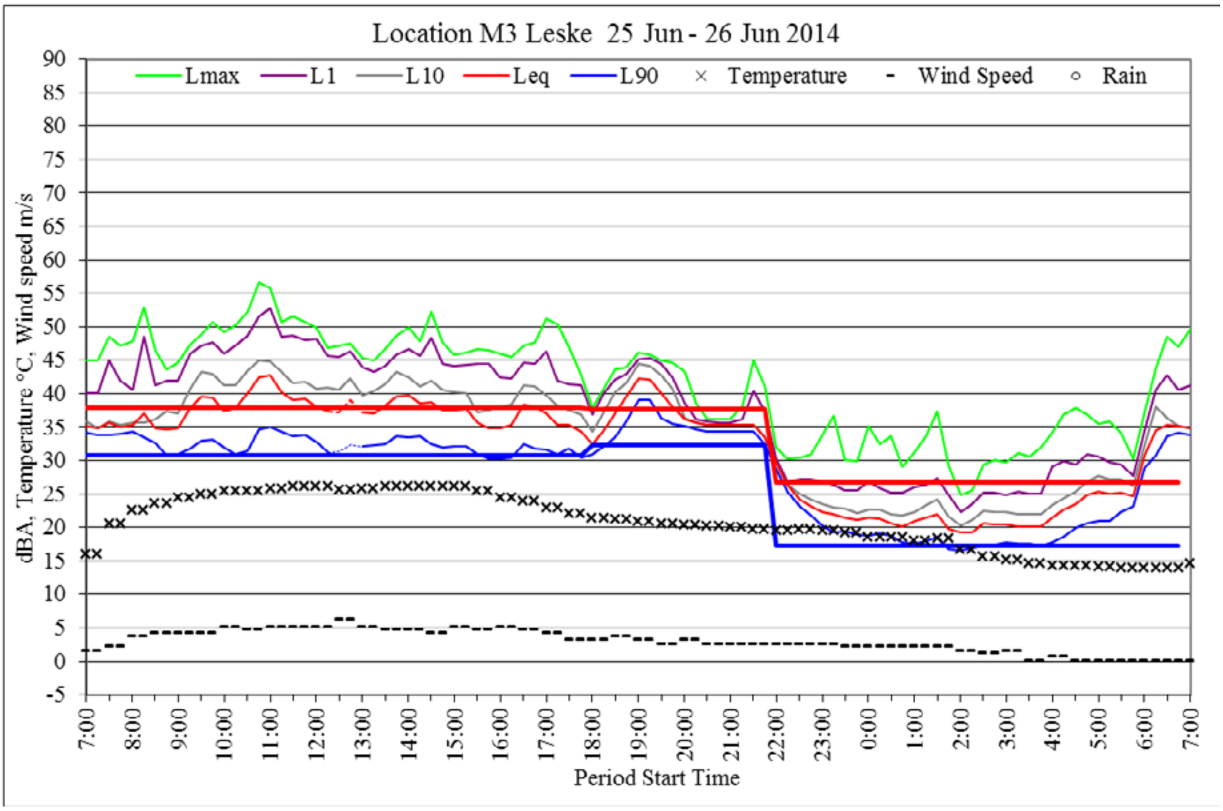
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M3 Leske 25 Jun - 26 Jun 2014
Lmax
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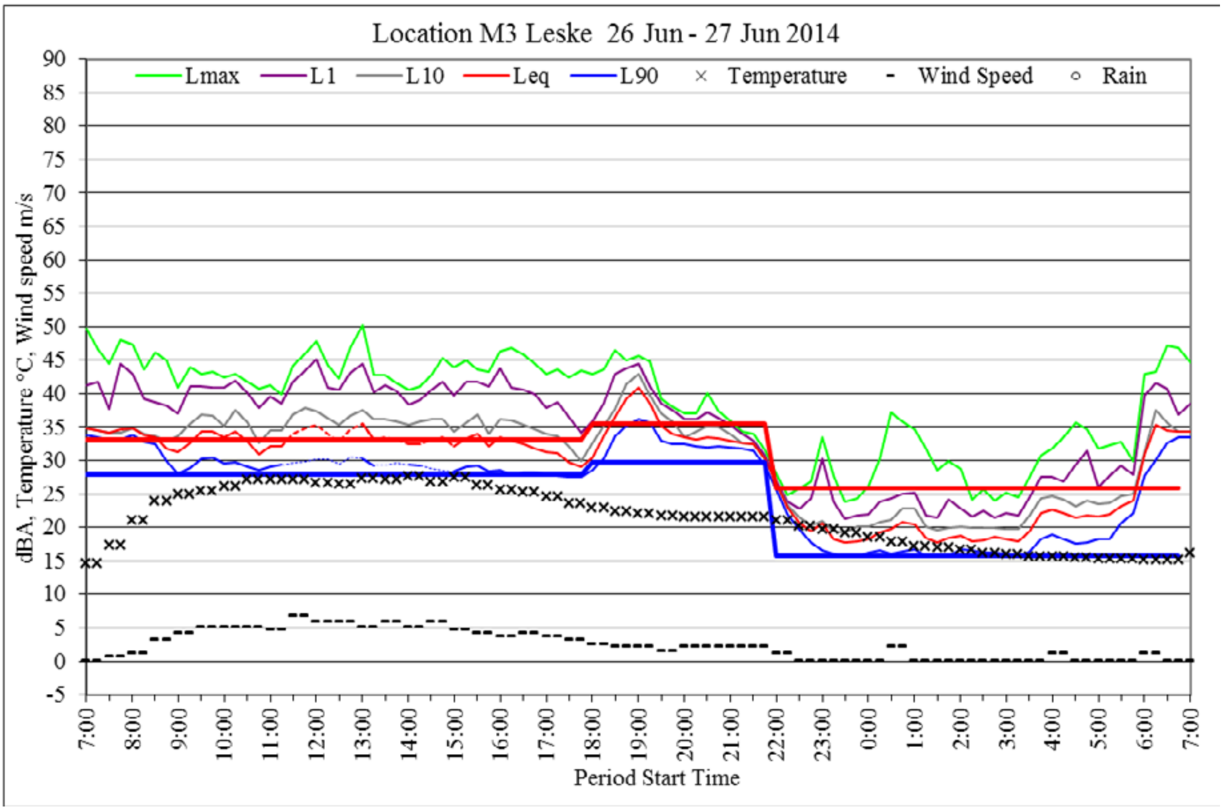
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M3 Leske 26 Jun - 27 Jun 2014
Lmax
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Leq
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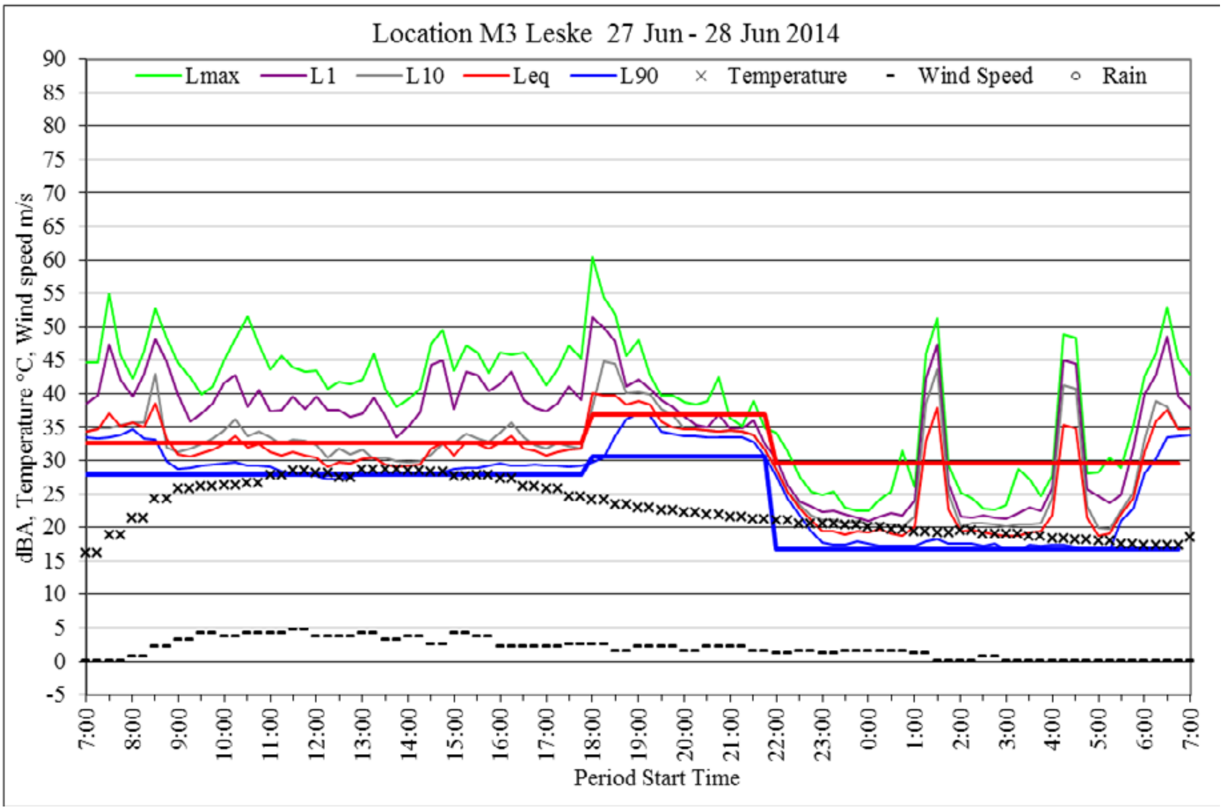
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
Period Start Time


Location M3 Leske 27 Jun - 28 Jun 2014
Lmax
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Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
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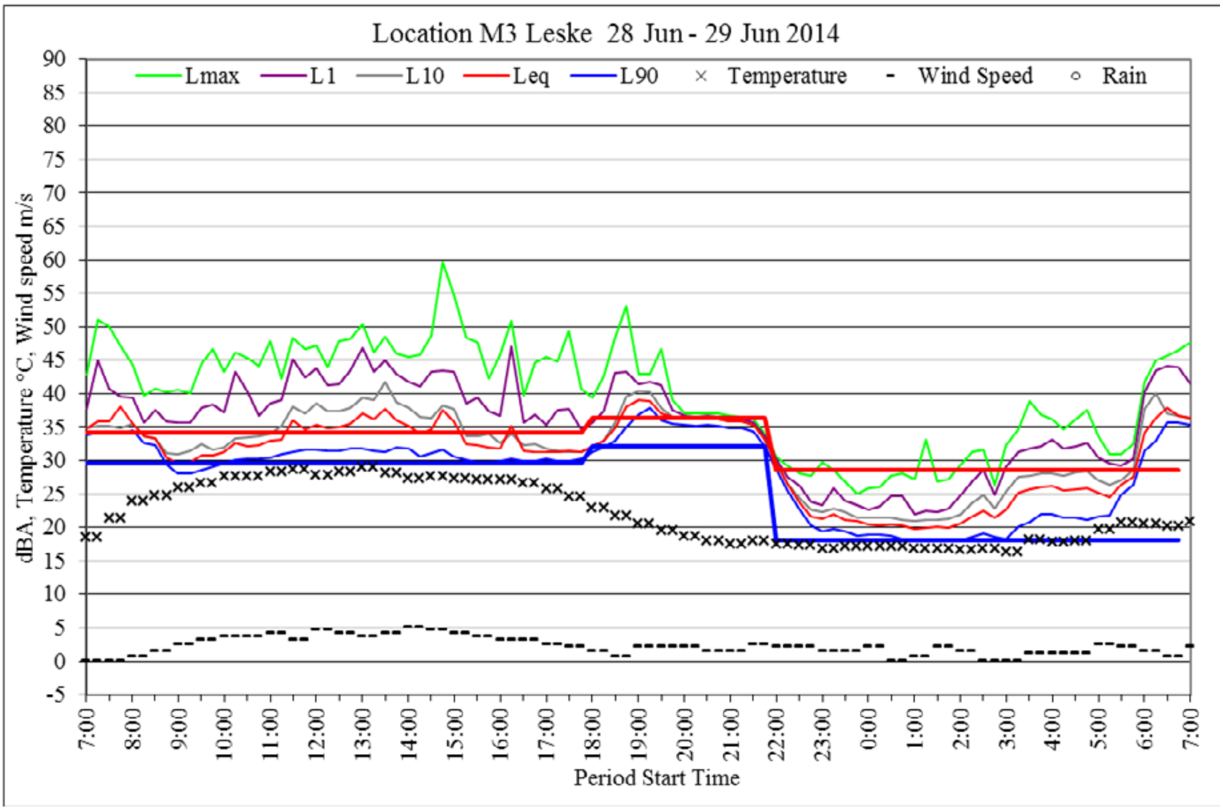
Period Start Time


Location M3 Leske 28 Jun - 29 Jun 2014
Lmax
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Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
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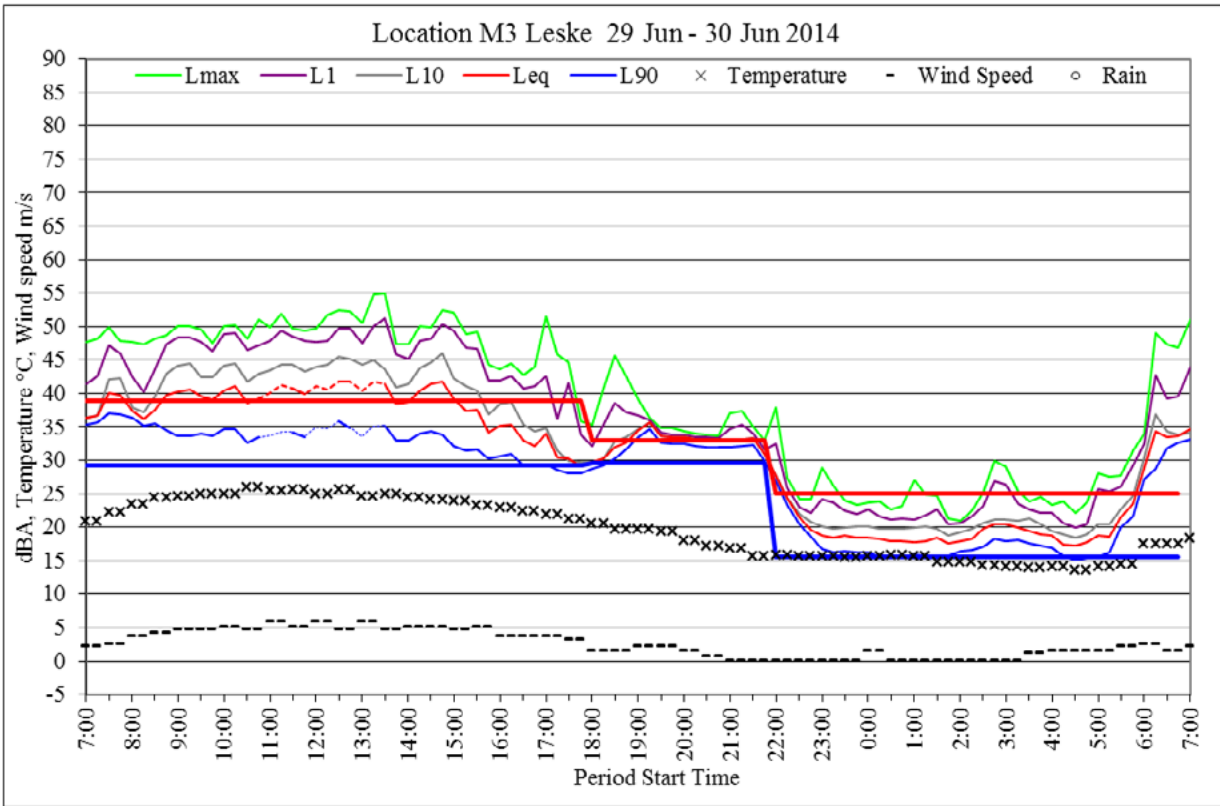
7:00
Period Start Time


Location M3 Leske 29 Jun - 30 Jun 2014
Lmax
L1
L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
7:00
8:00
9:00
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11:00
12:00
13:00
14:00
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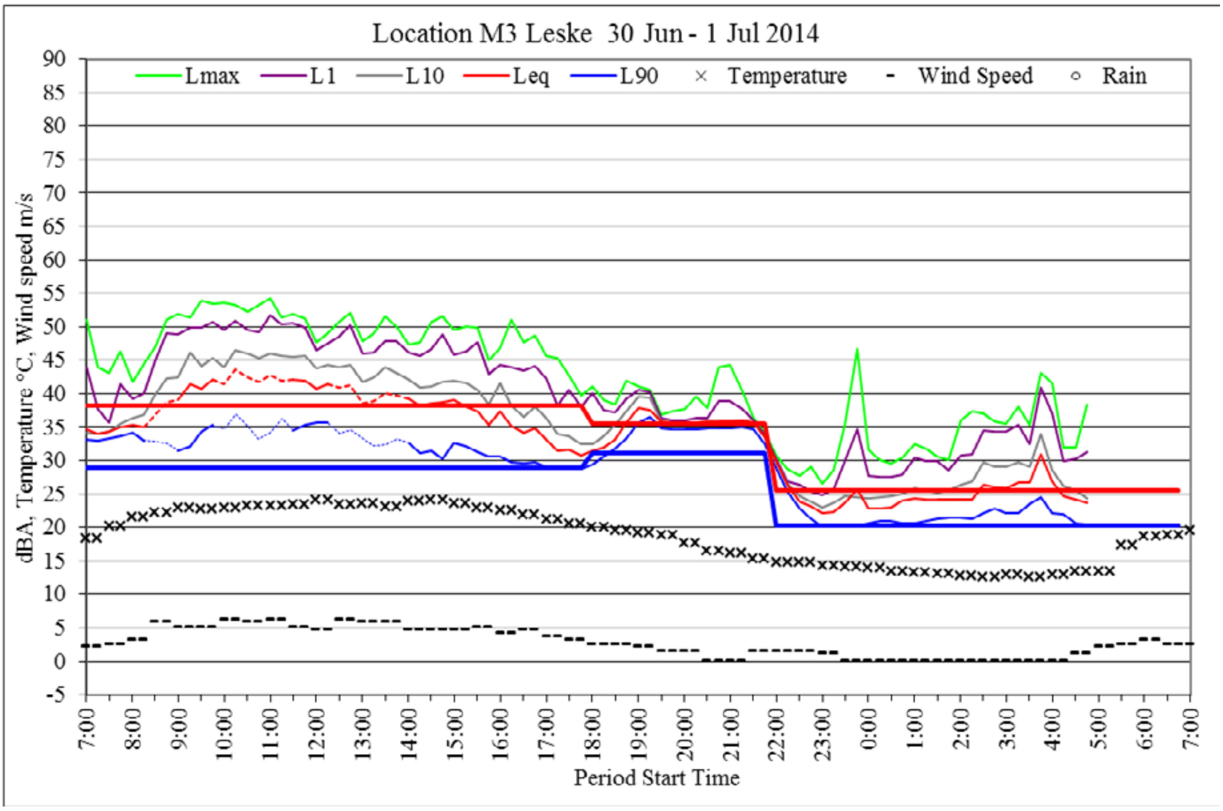
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
Period Start Time


Location M3 Leske 30 Jun - 1 Jul 2014
Lmax
L1
L10
Leq
L90
Temperature
Wind Speed
Rain
dBA, Temperature °C, Wind speed m/s
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
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10
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0
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Period Start Time