April 2025

Taronga Zoo Sky Safari

Appendix T
Noise and Vibration Impact Assessment (NVIA)
RTS Revision 2

PREPARED BY

ACOUSTICS

PREPARED FOR

TARONGA
CONSERVATION SOCIETY AUSTRALIA
For the Wild

TARONGA ZOO SKY SAFARI

ACOUSTIC REPORT FOR STATE SIGNIFICANT DEVELOPMENT APPLICATION

Issued

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Attachment(s)	Appendices as listed in the Table of Contents

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This report takes into account the particular instructions and requirements of our Client.
It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Table of Contents

1 Executive Summary

This Acoustic Impact Assessment has been prepared by Acoustic Studio to accompany a detailed State Significant Development Application (SSDA) for the redevelopment of the Sky Safari at Taronga Zoo. The site is legally described as Lot 22 on Deposited Plan 843294 and is Crown Land managed by the Taronga Conservation Society Australia (TCSA).

This report has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) issued for the project (SSD-46807958). Revision B issued in February 2025 incorporates concept design updates which have occurred since September 2024.

This report concludes that the proposed Sky Safari development is suitable and warrants approval subject to the implementation of the following mitigation measures:

- Construction noise and vibration methods are selected to manage impacts on surrounding sensitive receivers within the Zoo, which will also result in compliance with applicable environmental noise and vibration management requirements;
- The design incorporates noise and vibration mitigation measures to ensure that sensitive receivers within Zoo premises are not adversely affected by operational noise, resulting in full compliance with applicable operational noise emissions targets to receivers located outside the Zoo.

Following the implementation of the above mitigation measures, the remaining impacts are appropriate.

2 Introduction

Acoustic Studio has been commissioned to provide an environmental acoustic assessment for the proposed construction and operation of the new Taronga Sky Safari at Taronga Zoo, Mosman.

The Sky Safari Project has been categorised as a "State Significant Development". This acoustic assessment report has been prepared in support of the EIS for the proposed project.

This report has been prepared to accompany an SSDA for the redevelopment of the Sky Safari at Taronga Zoo, which is legally described as Lot 22 on Deposited Plan 843294.

Taronga Conservation Society Australia (TCSA) is a statutory body representing the Crown. The Minister for Planning and Environment, or their delegate, is the consent authority for the SSDA and this application is lodged with the NSW Department of Planning, Housing, and Infrastructure (DPHI) for assessment as the works are located within the Taronga Zoo site and have an estimated development cost that exceeds the $10 million threshold pursuant to Clause 2(h) of Schedule 2 of the *State Environmental Planning Policy (Planning Systems) 2021*.

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 11 August 2022 and issued for the SSD- 46807958. Specifically, this report has been prepared to respond to the SEARs requirement issued below.

Item	Description of requirement	Section reference
12. Noise and Vibration	Provide a noise and vibration assessment prepared in accordance with the relevant NSW Environment Protection Authority (EPA) guidelines. The assessment must detail construction and operational noise and vibration impacts on nearby sensitive receivers and structures and outline the proposed management and mitigation measures that would be implemented.	This report

An operational and construction acoustic assessment has been carried out for the proposal, and is detailed in this report along with the findings and recommendations. It has been prepared as part of the State Significant Development Application (SSDA) to be submitted to NSW Department of Planning and Environment for the proposed Sky Safari. The acoustic assessment report addresses the acoustic requirements in the Secretary's Environmental Assessment Requirements (SEARs) for application SSD-46807958.

The SSDA was placed on public exhibition for 28 days between 24 September to 22 October 2024. Since lodgement, the project team have refined the proposal to address

comments from public agencies and the public as well as ongoing design development. The proposed refinements include updates to the Top and Lower Stations to improve queuing and visitor experience and the pylon design to reflect inputs from the cable car contractor.

This Revision B of the Acoustic Report issued in February 2025 incorporates concept design updates which have occurred since the 2024.

The objectives of this assessment are to:

- Identify noise sensitive receivers that will potentially be affected by the construction and operation of the proposed Sky Safari.
- Determine existing ambient and background noise levels at the nearest noise sensitive receivers that surround the site.
- Establish the appropriate noise assessment criteria in accordance with the relevant standards and guidelines.
- Carry out an assessment to determine whether the relevant criteria can be achieved based on proposed operations and likely construction methods. Where applicable, provide recommendations for any necessary acoustic control measures that will need to be incorporated into the development or use in order to ensure compliance with the assessment criteria.

3 Project Description

3.1 Taronga Zoo local context

Taronga Zoo is located at Bradleys Head Road, Mosman and is situated in the Mosman Local Government area (LGA). The site is bounded by Bradleys Head Road to the east, Athol Wharf Road and Sydney Harbour to the south, Little Sirius Cove to the west and Whiting Beach Road to the north. Taronga Zoo is legally described as Lot 22 on DP843294 and is Crown Land managed by the TCSA (the Zoological Park Board). Taronga Zoo has been subject to numerous upgrades and redevelopment schemes over time, to stay compliant with contemporary regulations, meet contemporary animal welfare and contemporary visitor experience expectations.

Taronga Zoo has evolved over time from a Zoo that simply provides the traditional visitor experience of viewing animals in exhibits, to a Zoo that focusses on wildlife conservation, animal welfare and providing a range of visitor learning experiences. Taronga Zoo is one of Australia's most popular attractions, and together with Taronga Western Plains Zoo hosts more than 1.8 million visitors annually.

3.2 Project Description

Taronga Zoo, located in Mosman, Sydney, has long been served by a cable car system known as the Sky Safari. This ran roughly along a north-south route, connecting the ferry terminal to the south with the main entry to the north. This original Sky Safari has been decommissioned, and is to be replaced by a new Sky Safari.

The former Sky Safari was an ageing asset within the Zoo and was retired on 31 January 2023. The former Sky Safari route is a lineal 450 metres with each one-way journey taking approximately 4 minutes. The retired Sky Safari route utilised 9 pylons.

Access to the retired Sky Safari was open to all Zoo visitors generally between the hours of 9:30am to 4:15pm as well as on special occasions such as VIVID or to transport guests to conference facilities. The majority of trips were one way from the Lower Station near the Taronga Zoo Ferry Wharf as they entered the Zoo or from the Top Station near the Top Plaza (main entrance) as they exited the Zoo.

The former Sky Safari cable cars had a maximum capacity of six guests and could accommodate wheelchairs up to a width of 610mm but prams or wheelchairs which did not fold could not be transported given the size restraints.

Taronga Zoo is one of Australia's most popular attractions, and together with Taronga Western Plains Zoo hosts more than 2 million visitors annually and contributes an estimated $249 million per annum to the NSW economy. The Zoo has evolved over time

from a Zoo that simply provides the traditional visitor experience of viewing animals in exhibits, to a Zoo that focusses on wildlife conservation, animal welfare and providing a range of visitor learning experiences.

Within Taronga Zoo, the Sky Safari is one of Taronga's most loved experiences and has transported more than 20 million passengers since it was first installed in 1987 and upgraded in 2000. The current Sky Safari was an ageing asset and was formally retired in January 2023. The redevelopment of the existing Sky Safari will allow the Zoo to update the now obsolete infrastructure on site and provide new facilities which improve accessibility, ease increased demand and assist the public in moving around the Zoo.

Development consent is specifically sought for:

- Site establishment works including removal of the existing Sky Safari;
- Installation of a new 916m Sky Safari cable car system including:
    - Construction of six (6) new pylons and associated infrastructure within pylon zones within the Zoo ranging in height between 5.9m (P1) to 36.5m (P5)
    - Construction of two new stations at both the upper and lower entrances within the Zoo grounds.
    - Public facilities including accessible queueing areas, ticket booths and public amenities.
    - Associated mechanical plant, servicing and storage areas for ongoing maintenance.
- Landscaping works, including new accessible pathways, planting, shade structures and seating areas, and wayfinding signage. Taronga has implemented a tree replacement ratio of 2:1 for all trees removed as part of this development.
- Excavation, site preparation works and tree removal/pruning to allow the works to occur.
- Increased hours of operation.

Overall, the revitalised Sky Safari will:

- Feature additional, larger cable cars that are more accessible, dramatically improving the guest experience journey for all visitors.
- Connect to recent upgrades underway to the Taronga Zoo Wharf under the NSW Government’s Transport Access Program.

- Increase the Sky Safari's former capacity, allowing for a more seamless flow of guests around the Zoo, while also enhancing opportunities for educating guests on Taronga's conservation efforts.
- Encourage guests off the roads and onto public transport as they explore the harbour en route to the Zoo.
- Provide unique, affordable, family-focused sightseeing tourism infrastructure that provides comfortable all-season experiences to support year-round growth in visitation to the Zoo. This will assist in securing the financial future of the Zoo to ensure that it can continue to undertake a range of conservation and education projects.
- Consider the heritage significance of local heritage items within the Zoo grounds and the strong historical presence of Taronga.
- Enhance opportunities for educating the community on TCSA's conservation efforts.

3.3 Detailed project description

Taronga Zoo is one of Australia's most popular attractions, and together with Taronga Western Plains Zoo hosts more than 1.8 million visitors annually. The Zoo has evolved over time from a Zoo that simply provides the traditional visitor experience of viewing animals in exhibits, to a Zoo that focusses on wildlife conservation, animal welfare and providing a range of visitor learning experiences.

Within Taronga Zoo, the Sky Safari is one of Taronga's most loved experiences and has transported more than 20 million passengers since it was first installed in 1987 and upgraded in 2000. The former Sky Safari was an ageing asset and was formally retired in January 2023. The redevelopment of the existing Sky Safari will allow the Zoo to update the now obsolete infrastructure on site and provide new facilities which improve accessibility, ease increased demand and assist the public in moving around the Zoo.

3.3.1 Upgraded Experience

The reimagined cable car experience introduces approximately 20 - 25 new cable cars that are accessible to visitors with prams, larger wheelchairs and mobility challenges, to ensure all visitors to the zoo have a safe and dignified experience in utilising the Sky Safari. The new cable cars are also larger in capacity than existing cable cars to meet current and future visitor demand to visit the Zoo.

The infrastructure associated with the cable cars will incorporate approximately 6 pylon towers (previously 9 pylon towers with the retired Sky Safari), ranging in height from 5.9m to 36.5m. The route itself has been carefully located to minimise impact on remnant

bushland, existing trees and the archaeological and built heritage as well as scenic values of the Zoo.

Overall, the route of the upgraded Sky Safari maintains the existing footprint of the Sky Safari, however, will require the cable car corridor to increase from 9m to 12.5m.

3.3.2 Cable Car Stations

A new station is proposed at each end of the new cable car route allowing for visitors to enter and exit at both the top and bottom of the Zoo site.

Top Station is proposed to replace the existing storage facility adjacent to the Main Entrance Plaza. The new station will provide Zoo guests with direct access to the Sky Safari via the existing Main Entrance plaza. The station provides covered queuing within the heritage building and associated landscaping and shading provided in the plaza space.

Lower Station is proposed to replace the existing lower station near the Taronga Ferry Wharf. The station aims to improve existing queuing on site by incorporating fully equitable queuing areas with shade and amenity in order to enhance the visitor's arrival experience. The Lower Station will have improved accessibility through the new ramping system up to the station which will make the station easily accessible for those in wheelchairs and with prams. In addition, level access into the station when re-queuing to use the cable car to go back to the Top Station, removing the existing stairs. A lift will also be provided to access the platform if required by guests. The station will also be supplemented with toilet amenities and a ticketing booth.

There are six pylons, one located at each station (top and lower) and four within zoo. There are no pylons outside of the Zoo grounds.

- Pylon 1 (5.9m) – located in close proximity to the existing and proposed Lower station;
- Pylon 2 (10.12m) – located by existing Pylon 2;
- Pylon 3 (26.2m) – located by the Food Court;
- Pylon 4 (35.7m) – in front of the Savannah toilet facilities;
- Pylon 5 (36.5m) – located to the north of the Helmore lawns; and
- Pylon 6 (6.5m) – located in close proximity to the existing and proposed Top station.

The Sky Safari will generally operate during normal zoo opening hours, however may have some extended use periods up to 10pm for special events such as Vivid, New Year's Eve, Cinemas, events held at the Function Centre, and Summer Concert Series.

The proposed upgraded Sky Safari will follow the same route from the now-decommissioned north-south Sky Safari. Therefore the location and type of construction activities, and the location of operational noise sources, will be similar to the former Sky Safari.

The proposal is shown in Figure 1 below.

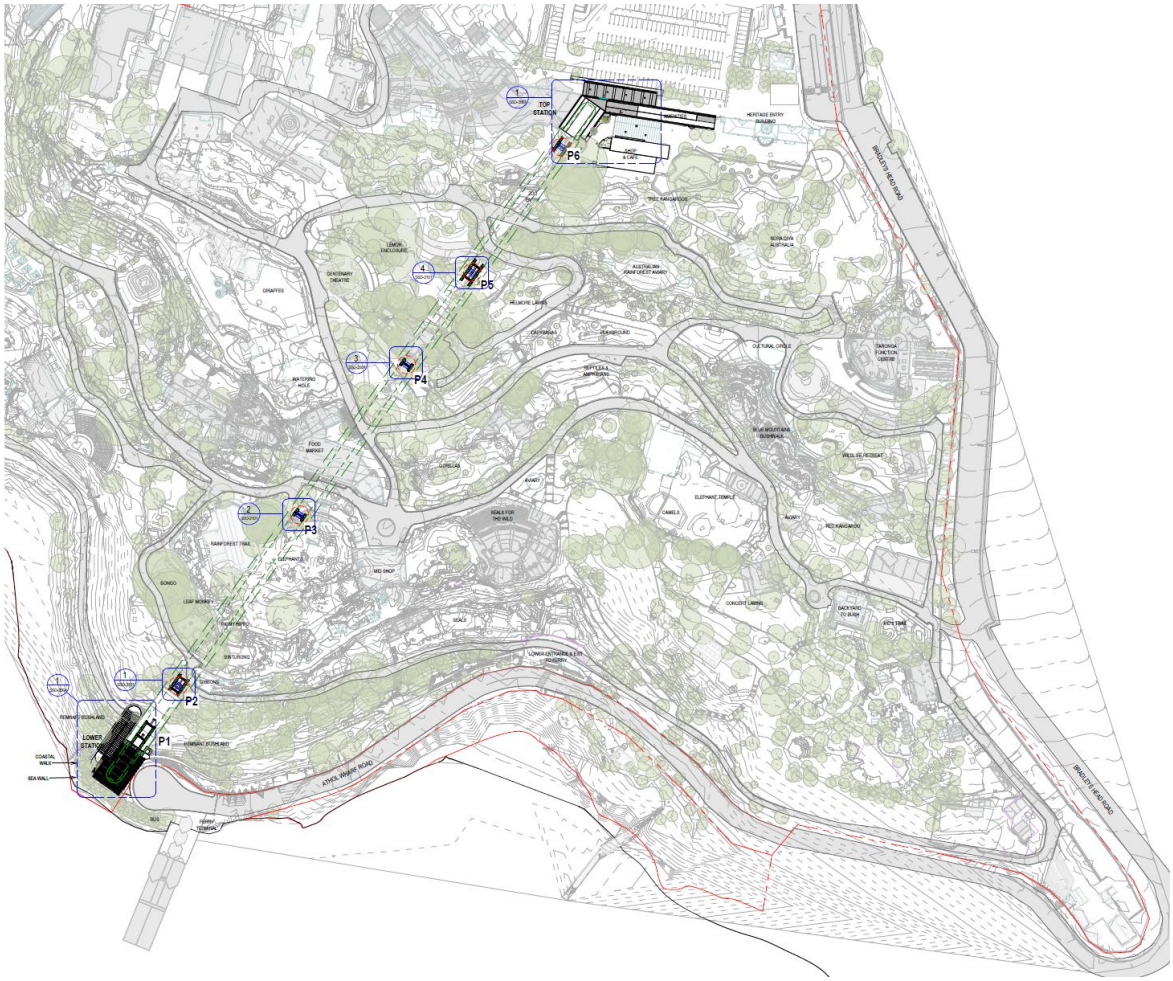


Figure 1: Plan view of the proposed Taronga Zoo Sky Safari. (Source: Scott Carver, provided 12th February 2025)

3.4 Key Acoustic Assessment Considerations

The SEARs require that the Environmental Impact Statement (EIS) must include a noise and vibration assessment in accordance with the relevant EPA guidelines. The assessment must detail construction and operational noise and vibration impacts on nearby sensitive receivers and outline the proposed management and mitigation measures that would be implemented.

The key design considerations for the project are external noise emissions from operation of the following areas and equipment associated with the Sky Safari works:

- Breakout noise from building services and plant servicing the Sky Safari, including for cleaning and maintenance.
- Breakout noise from audio visual and / or public address systems in the Sky Safari stations.
- Patron noise relating to the use of the Sky Safari.

Noise emissions from each of these spaces / operations may need to be managed to limit environmental noise impacts on nearby residential receivers.

Construction activities may have a temporary noise impact on sensitive receivers inside and outside the zoo premises. This noise impact assessment considers these in detail.

3.5 Operating Hours

The Sky Safari will be open and in use every day of the year including Christmas Day.

It is intended that the Sky Safari will operate outside of regular Zoo hours to activate the site and create a new immersive experience to educate visitors on the work of the TSCA. The following hours are proposed as a maximum for the site:

- Sunrise & Early Morning Sessions

  Daylight savings (AEDT): 6:00am to 9:30am
  Non-daylight savings (AEST): 5:00am to 9:30am

- Zoo Operating Period

  9:30am to 5:00pm (September to April)
  9:30am to 4:30pm (May to August)

- Indicative Sunset & Twilight Sessions

  Daylight savings (AEDT): 5:00pm to 9:00pm
  Non-daylight savings (AEST): 5:00pm to 7:00pm

- Indicative Special Events: 5:00pm to 12:00am

The plant associated with the Sky Safari facilities would operate during these hours.

To meet safety standards, and comply with manufacturer specifications, commissioning and maintenance the following hours are proposed:

- Maintenance: 6:00pm to 6:00am

Zoo staff hours are typically from 6am to 5pm.

3.6 Site Details and Local Sensitive Receivers

The site is located within a suburban environment characterised by low to medium levels of activity throughout the day and decreasing noise levels in the evening and night.

Residential receivers dominate around the site. Existing neighbouring residential buildings that surround the site are over 170m distant from the proposal site, and are:

- Residential properties on Whiting Beach Road extending from the north-east, north and north-west.
- Residential properties on Bradley's Head Road to the north-east.

Figure 2 shows the location of the zoo and the surrounding area.

The existing residential receivers are located across the road from the Zoo premises boundary. There are no additional receiver developments planned or approved in the area. The existing residents represent the most affected receivers.

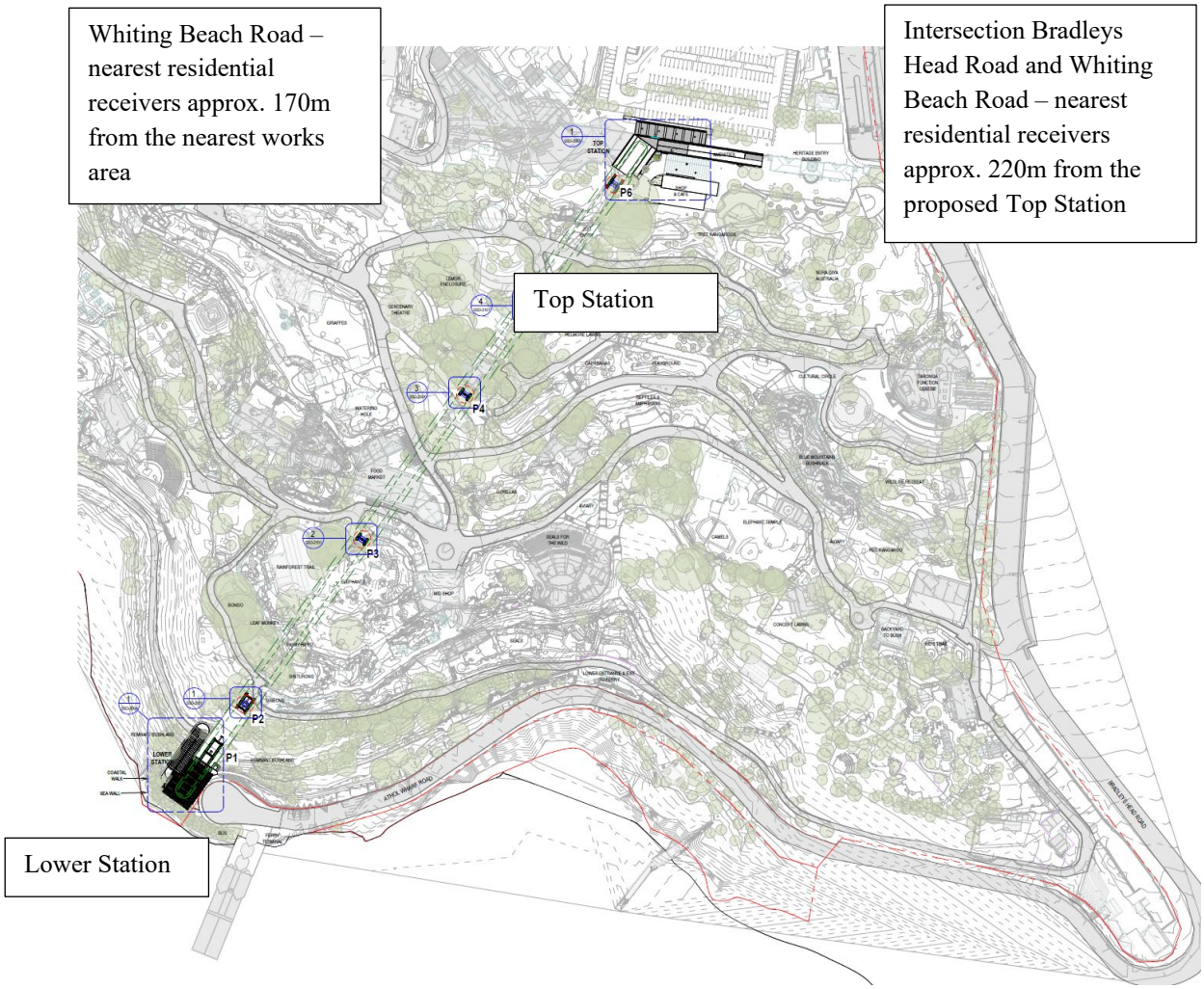


Figure 2: Proposed Taronga Zoo Sky Safari route. The nearest residential receivers to any part of the proposed Sky Safari are located at the intersection of Bradley's Head Road and Whiting Beach Road, opposite the north-east corner of the Zoo. Source: February 2025 plans by Scott Carver.

4 Existing Noise Environment

4.1 Noise survey approach

Environmental noise assessments for new developments in existing premises require an understanding of existing environmental noise in the absence of the development, to determine how audible and noticeable the development noise will be once the development is complete.

Noise surveys have been carried out by Acoustic Studio at the site and its surrounds in June and August 2023, and in May 2021. The noise surveys were carried out to determine the ambient and background noise levels affecting the site and at the nearest noise sensitive receivers, and to measure the existing noise levels generated by the zoo.

Long-term (unattended) noise monitoring was carried out, in combination with attended observations.

The measured noise levels were compared with data obtained previously in April and May 2017 to confirm that noise levels have not changed over the past 6 years. One reason for this data review over time was to confirm that the noise environment has not significantly changed due to potential reduced public activity related to COVID-19 in 2021, and also to confirm that background noise “creep”, or a steady increase, as not occurred over this time.

4.2 Observations

Typically, road traffic around the site is governed by people driving to the zoo during the day, and by local residential traffic in the evening (6pm to 10pm) and night (10pm to 7am). Frog noise became audible after the afternoon measurements finished in 2021, however this was not noticeable in June and August 2023. Aircraft noise is relatively insignificant, and is generally restricted to a few commercial seaplanes, helicopters and passenger jets flying at a distance. Some ferry noise from the harbour may at times be indistinctly audible at quiet times during the night. There are no industrial noise sources in the near vicinity.

4.3 Noise Monitoring Locations

Noise surveys have been carried out by Acoustic Studio at the site and its surrounds in June and August 2023 and May 2021, to determine the ambient and background noise levels affecting the site and at the nearest noise sensitive receivers.

The 2017, 2021 and 2023 measurement sites were two main Noise Catchment Areas defining residential zones around the site as shown in Figure 3.

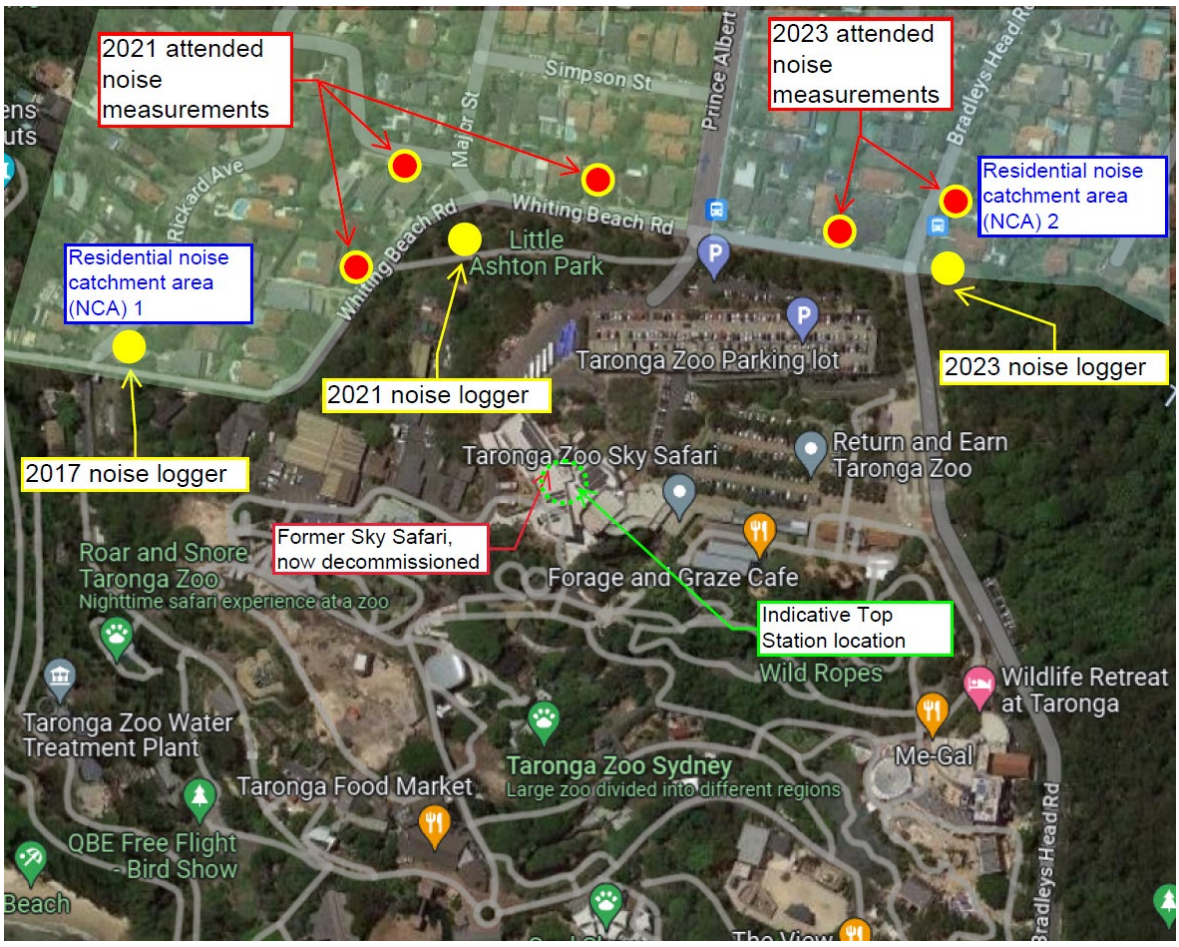


Figure 3: Location of 2017, 2021 and 2023 noise survey locations, and two Noise Catchment Areas (NCAs). Aerial map source: Google maps, accessed 3 August 2023.

4.3.1 Noise logger locations

The June 2023 noise logger location was at Clifton Park, on Bradley's Head Road. The 2023 noise monitoring location was selected to confirm whether the ambient noise environment on Bradley's Head Road was similar enough to the Whiting Beach Road 2021 survey location to be able to use the noise logger data from Whiting Beach Road for all residential areas around the zoo premises. The 2023 noise logger was installed on public land on Bradley's Head Road, secured to a fence that forms the boundary between Clifton Park and a residential receiver. This location was selected to represent the ambient and background noise levels at the nearest residences to Taronga Zoo on Bradley's Head Road, without undue influence from cars exiting and entering private driveways, and not affected by screening from residential boundary fences.

The 2021 noise monitoring location was selected to provide a secure noise logger location which best represents the nearest residential receivers on Whiting Beach Road, with minimal contribution of residential occupancy noise from cars exiting and entering driveways (etc).

The May 2021 data are considered valid, being less than 5 years old, however the decision was made by Acoustic Studio to carry out updated noise surveys in 2023. The aim was to supplement the 2021 data and to ensure that it was valid for all residential areas around the site.

As a note, the 2021 noise monitoring data was collected during the COVID-19 pandemic. While no lockdowns were in place at the time of the noise logging, Acoustic Studio reviewed publicly available news reports at the time and these indicated that traffic counts were still lower than pre-COVID levels. Therefore, the 2021 noise monitoring data has also been compared with the 2017 noise logger data which was obtained for a previous project (Taronga Zoo African Savannah and Congo Exhibit).

The previous long term unattended noise logging was conducted from 27th April to 5th May 2017. A residential construction site at the south-western cul-de-sac at Whiting Beach Rd was active in 2017 and was the reason for locating the noise logger location at Rickard Avenue.

The 2017, 2021 and 2023 noise logger locations are shown in Figure 3.

4.3.2 Attended noise monitoring locations

Attended noise measurements were carried out in 2021 and 2023 to measure variations in ambient and background noise levels in receiver areas, and to confirm that the noise logger data was representative of receiver boundaries, in accordance with the Noise Policy for Industry (NPfI).

The short-term attended measurements were also used to obtain octave band data of the existing background and ambient noise levels in environmental receiver locations, which are used to assess potential impacts from patron and music noise, making reference to the Liquor Administration Board (LAB) noise targets as a guide. The NPfI and LAB are discussed in Section 5 and 6.

Two attended measurement areas were selected as follows (refer to Figure 3):

- At street level, at the closest boundary of the Whiting Beach Road residences and also Rickard Road. This represents the existing noise environment at these residential property boundaries. Measurements were conducted in May 2021.
- At street level, at the closest boundary of Whiting Beach Road and Bradley's Head Road residences, between Prince Albert Road and Bradley's Head Road. This represents residential receivers which are most affected by road traffic accessing the zoo carparks. Measurements were conducted in August 2023.

Anthony Cano and Sav Shimada of Acoustic Studio Pty Ltd carried out the attended noise surveys.

The 2017, 2021 and 2023 measurement sites were in and around Whiting Beach Rd as shown in Figure 3.

4.3.3 Noise catchment areas

By comparing attended and unattended noise survey data, two Noise Catchment Areas (NCAs) were defined, as shown in Figure 3.

NCA 1, which is located to the west of Prince Albert Road, experiences lower daytime road traffic noise levels than at NCA 2. The entry to Taronga Zoo's staff and contractor on-site parking is located at Prince Albert Road, and the public entry to the carpark and bus laydown areas is located at Bradley's Head Road. Therefore NCA 2 is likely to experience both general local traffic and zoo-related traffic.

The NCAs, and the reasons for assigning two NCAs for the Taronga Sky Safari noise impact assessment are explained in more detail, in terms of the noise measurement data which are presented in Section 4.4.

4.4 Noise Monitoring Results

4.4.1 Long-term unattended noise monitoring results

Unattended noise monitoring was carried out between 16th and 20th June 2023, 15th and 28th May 2021 and also from 27th April to 5th May 2017.

Unfortunately Zoo staff observed that the 2023 noise logger was vandalised just prior to the scheduled noise logger collection. Rainy weather began when the logger was collected on the sixth day of logging, which would have affected any further noise logging over the subsequent days before the start of public school holidays. School holidays are not suitable for carrying out noise logging, due to atypical activity.

The 2023 noise logger data was collected and analysed and determined to contain five days' worth of valid noise data. This was compared with the 2021 data to determine whether the 2021 background noise levels were consistent enough to use for the entire site, including residential receivers along Bradley's Head Road. There were differences between the two sets of data, showing that day-time and evening noise levels along Bradley's Head Road are similar throughout the week, while the ambient and background noise levels at Whiting Beach Road drop on weekends. The night-time background noise levels at Bradley's Head Road are lower than at Whiting Beach Road, potentially because of less foliage noise in that location.

The differences in day / evening / night background noise levels are considered to be important for the Sky Safari noise impact assessment, because:

- Construction noise impacts will vary depending on the day of the week;
- Operational noise impacts would mostly be heard on Bradley's Head Road due to road traffic and potentially public address systems, and these potential effects may occur at night.

Therefore, for the Taronga Sky Safari noise impact assessment, two Noise Catchment Areas (NCAs) have been defined.

The 2023 and 2021 measurements were taken using a Ngara logger, Serial Number 878190. The 2017 measurements were taken using RTA02 logger #0038.

The 2021 noise logger location was on public land on Whiting Beach Road, opposite residential receivers. The reason the logger could not be installed directly at the receiver boundary was because there was no secure location which would not present a trip hazard to pedestrians, or which would not be affected by reflections from solid boundary fencing. Furthermore, the logger location on public land was not affected by residential occupancy noise including vehicles entering and exiting private driveways. Attended measurements were carried out near the noise logger site, but directly outside residential receiver boundaries. The attended measurements confirmed that the noise logger data was representative of the nearest residential receiver boundaries.

The 2017 noise logger location was at the end of the cul-de-sac at Rickard Avenue as the Whiting Beach Road location was affected by residential construction site noise. Observations during March, April and May 2017 indicated that the Rickard Avenue site was generally unaffected by residential construction noise, apart from infrequent audible construction events from the residence near the Whiting Beach Road.

Weather data was collected from the Bureau of Meteorology web site (www.bom.gov.au).

The measured noise levels were processed in accordance with the Noise Policy for Industry (NPfI, see Section 6.2.1) to determine the Rating Background Level (RBL) and ambient noise conditions for Day, Evening and Night time periods. The NPfI method for determining RBLs was also applied for various construction scenarios, for standard construction hours and out of hours works.

These levels are provided in **Table 1** (Whiting Beach Road, 2021), **Table 3** (Bradley's Head Road, 2023) and **Table 2** (Rickard Avenue, 2017).

Date	Descriptor	Measured sound level, dB(A)		
		Day (07:00-18:00)	Evening (18:00-22:00)	Night (22:00-07:00)
Friday 14/5/21	Ambient, L_{eq}	-	50	43
	ABL, L_{90}	-	41	35
Saturday 15/5/21	Ambient, L_{eq}	*[56] (weather affected)*	*[53] (weather affected)*	*[50] (weather affected)*
	ABL, L_{90}	*[41] (weather affected)*	*[45] (weather affected)*	*[43] (weather affected)*
Sunday 16/5/21	Ambient, L_{eq}	51	45	*[51] (weather affected)*
	ABL, L_{90}	39	39	*[39] (weather affected)*
Monday 17/5/21	Ambient, L_{eq}	*[54] (weather affected)*	40	44
	ABL, L_{90}	*[37] (weather affected)*	36	35
Tuesday 18/5/21	Ambient, L_{eq}	*[52] (weather affected)*	-	-
	ABL, L_{90}	*[37] (weather affected)*	-	-

Date	Descriptor	Measured sound level, dB(A)		
		Day (07:00-18:00)	Evening (18:00-22:00)	Night (22:00-07:00)
Friday 21/5/21	Ambient, L_{eq}	50	40	43
	ABL, L_{90}	37	36	35
Saturday 22/5/21	Ambient, L_{eq}	51	38	44
	ABL, L_{90}	37	35	35
Sunday 23/5/21	Ambient, L_{eq}	52	-	-
	ABL, L_{90}	40	-	-
Wednesday 26/5/21	Ambient, L_{eq}	-	53	49
	ABL, L_{90}	-	43	41
Thursday 27/5/21	Ambient, L_{eq}	52	47	48
	ABL, L_{90}	41	42	40
Weekday construction period	RBL	41 (std hours)	41 (OOH)	37 (OOH)
Saturday construction period	RBL	38, 8am – 1pm (std hours) 36, 1 – 6pm (OOH)	38 (OOH)	35 (OOH)
Overall	**Ambient, L_{eq}**	**51**	**48**	**46**
	RBL, L_{90}	**39**	**38**	**35**

Table 1: Results of long-term unattended ambient & background noise monitoring – May 2021 – Whiting Beach Road.

2017 data has been included in this acoustic assessment to supplement the 2021 data, because:

- The noise logger failed during the two-week 2021 measurement period;
- The COVID-19 pandemic in 2020 and 2021 has resulted in a decrease in typical road traffic and zoo visitor activity. A drop in day-time noise levels seen in the 2021 data is likely to be related to COVID-19 reduced zoo visitor activity; and
- To confirm that ambient noise levels have remained consistent over time.

The 2017 data is consistent with the 2021 and 2023 data, indicating that ambient and background noise levels have not increased over time.

The 2021 data is less than five years old and therefore still valid[1]. Both 2017 and 2021 sets of data have been used to determine the rating background and ambient noise levels to use in the operational and construction acoustic assessments at the Noise Catchment Area (NCA) located to the west of Prince Albert St.

[1] NSW TfNSW Infrastructure and Services Construction Noise and Vibration Strategy (April 2018) implies that noise survey data under five years old is considered to be valid, with this note on page 18: "If considered necessary (i.e. noise measurements are more than 5 years old), RBL measurements may be confirmed through the implementation of this [construction noise and vibration assessment] procedure."

Date	Descriptor	Measured sound level, dB(A)		
		Day (07:00-18:00)	Evening (18:00-22:00)	Night (22:00-07:00)
Thursday 27/4/17	Ambient, L_{eq}	56	48	50
	ABL, L_{90}	43	40	40
Friday 28/4/17	Ambient, L_{eq}	58	44	48
	ABL, L_{90}	41	37	38
Saturday 29/4/17	Ambient, L_{eq}	55	42	49
	ABL, L_{90}	40	38	37
Sunday 30/4/17	Ambient, L_{eq}	59	42	51
	ABL, L_{90}	40	37	37
Monday 1/5/17	Ambient, L_{eq}	54	48	48
	ABL, L_{90}	42	42	37
Tuesday 2/5/17	Ambient, L_{eq}	53	45	48
	ABL, L_{90}	41	40	38
Wednesday 3/5/17	Ambient, L_{eq}	54	44	51
	ABL, L_{90}	41	36	36
Thursday 4/5/17	Ambient, L_{eq}	55	43	49
	ABL, L_{90}	40	36	36
Overall	**Ambient, L_{eq}**	**56**	**45**	**49**
	RBL, L_{90}	**41**	**38**	**37**

Table 2: Results of long-term unattended ambient & background noise monitoring – April and May 2017 – Rickard Avenue.

Date	Descriptor	Measured sound level, dB(A)		
		Day (07:00-18:00)	Evening (18:00-22:00)	Night (22:00-07:00)
Friday 16/6/23	Ambient, L_{eq}	-	53	47
	ABL, L_{90}	-	42	33
Saturday 17/6/23	Ambient, L_{eq}	55	53	48
	ABL, L_{90}	42	43	34
Sunday 18/6/23	Ambient, L_{eq}	55	50	48
	ABL, L_{90}	41	42	34
Monday 19/6/23	Ambient, L_{eq}	*56*	53	48
	ABL, L_{90}	*42*	41	41
Tuesday 20/6/23	Ambient, L_{eq}	*55*	*51*	*54 [to 1am]*
	ABL, L_{90}	*43*	*39*	*35 [to 1am]*
Tuesday 15/8/23	Ambient, L_{eq}	-	55	(thunderstorm)
	ABL, L_{90}	-	30	
Wednesday 16/8/23	Ambient, L_{eq}	62	55	51
	ABL, L_{90}	40	35	31
Thursday 17/8/23	Ambient, L_{eq}	59	56	(invalid)
	ABL, L_{90}	43	35	-
Friday 18/8/23	Ambient, L_{eq}	62	(invalid)	(invalid)
	ABL, L_{90}	48	-	-
Saturday 19/8/23	Ambient, L_{eq}	58	54	52
	ABL, L_{90}	45	42	41

Date	Descriptor	Measured sound level, dB(A)		
		Day (07:00-18:00)	Evening (18:00-22:00)	Night (22:00-07:00)
Sunday 20/8/23	Ambient, L_{eq}	57	54	50
	ABL, L_{90}	42	30	*25*
Monday 21/8/23	Ambient, L_{eq}	59	56	50
	ABL, L_{90}	40	39	*28*
Weekday construction period	RBL	42 (std hours)	39 (OOH)	33 (OOH)
Saturday construction period	RBL	45, 8am – 1pm (std hours) 42, 1 – 6pm (OOH)	39 (OOH)	33 (OOH)
Overall	**Ambient, L_{eq}**	**58**	**54**	**50**
	RBL, L_{90}	**42**	**39**	**33 10pm – 7am** **41 5am to 7am** **37 10pm – 12am**

Table 3: Results of long-term unattended ambient & background noise monitoring – Bradley's Head Road. June 2023: adjacent to residential receiver. Logger was vandalised before the end of the 7-day monitoring period. August 2023: Zoo side of the road. Logger was set up to be less visible and more secure.

Date	Descriptor	Measured sound level, dB(A)		
		Day (07:00-18:00)	Evening (18:00-22:00)	Night (22:00-07:00)
Weekday construction period	RBL	41 (std hours)	41 (OOH)	37 (OOH)
Saturday construction period	RBL	38, 8am – 1pm (std hours) 36, 1 – 6pm (OOH)	38 (OOH)	35 (OOH)
Operational noise – NCA 1	**RBL, L_{90}**	**39**	**38**	**35**

Table 4: Background noise levels used for construction noise and operational noise assessment at NCA 1 (residential receivers along Whiting Beach Road to the west of Prince Albert Street). Based on 2021 survey data.

Date	Descriptor	Measured sound level, dB(A)		
		Day (07:00-18:00)	Evening (18:00-22:00)	Night (22:00-07:00)
Weekday construction period	RBL	42 (std hours)	39 (OOH)	33 (OOH)
Saturday construction period	RBL	45, 8am – 1pm (std hours) 42, 1 – 6pm (OOH)	39 (OOH)	33 (OOH)
Overall	**RBL**	**42**	**39**	**33 10pm – 7am** **41 5am to 7am** **37 10pm – 12am**
	LAeq	**58 dB$L_{Aeq(15\text{-}hour\ Day)}$** **56 dB$L_{Aeq(1\text{-}hour\ Day)}$**		**50dB$L_{Aeq(9\text{-}hour\ night)}$** **50dB$L_{Aeq(1\text{-}hour\ night)}$**

Table 5: Background and ambient noise levels used for construction noise and operational noise assessment applicable at NCA 2 (residential receivers on Bradley's Head Road, and at Whiting Beach Road between Bradley's Head Road and Prince Albert Street). Based on 2023 survey data from Bradley's Head Road / Whiting Beach Road intersection.

4.4.2 Short-term attended measurement results

Background and Ambient Noise Levels

Short-term noise monitoring was carried out in in May 2021, at locations shown in Figure 3, to obtain background and ambient noise levels. Measurements were taken between 10:30am and 11:30 on 28th May 2021, outside the boundaries of 13 Whiting Beach Road, 19 Whiting Beach Road, and 25 Rickard Avenue. These noise measurements represent Noise Catchment Area 1.

These measurements were taken to augment and confirm noise logger data.

A Brüel & Kjær Hand-held Analyser Type 2250, Serial Number – 3010373 was used to conduct attended noise monitoring in 2021. The last laboratory calibration date for the sound level meter was 20 November 2020. The calibration of the equipment was checked before and after the surveys with no variation in level observed.

A SVAN 971 sound level meter, Serial Number – 107445 was used to conduct attended noise monitoring in 2023. The last laboratory calibration date for this sound level meter was 9 June 2023. The calibration of the equipment was checked before and after the surveys with no variation in level observed.

Environmental noise measurement times included the most sensitive period that the proposed spaces would be occupied, including for external maintenance and cleaning (ie external cleaning between 6:00 am and 6:00 pm, and internal cleaning at night).

Noise levels at key locations within the zoo were measured by Acoustic Studio in March 2014 for a previous Taronga Zoo project, in March 2017 and again in May 2021.

Measured background noise levels were 45-48dBL_{A90}. Measured ambient noise levels were 52-56dBL_{Aeq}. These measurements confirmed that the noise logger data was valid and representative of the nearest affected receiver boundaries.

Short-term noise monitoring was also carried out on Tuesday 15th August 2023, during school term, to supplement noise logger data and to confirm that it was valid and representative of typical noise conditions in Noise Catchment Area 2.

The noise levels were also recorded in octave bands as these are used to assess audible emergence of noise from public address systems above the prevailing background noise levels. This forms part of the assessment for Bradley's Head Road residential receivers, because:

- The Sky Safari Top Station site compound access is near to these residents;
- The proposed Sky Safari will need to meet current standards for the provision of audible information systems, which may require more public address announcements than the original Sky Safari had; and
- The proposal is for the Sky Safari to operate outside standard Zoo opening hours, and during more noise sensitive evening hours.

The measured existing environmental noise levels are presented in **Table 6** below.

Location	Period	Description	Measured sound level, dB re 20 µPa								
			dB(A)	Octave band centre frequency, Hz							
				31.5	63	125	250	500	1k	2k	4k	8k
Nearest Residential Receiver Boundary NCA 1	7am to 6pm (Day) 28/5/20216pm to	Background Noise Level, L_{90}	39	52	46	40	36	36	35	31	21	21
		Ambient Noise Level, L_{eq}	44	57	51	44	41	41	41	36	26	26
Nearest Residential Receiver Boundary NCA 2	6pm to 6:10pm (Evening) 15/8/23	Background Noise Level, L_{90}	39	63	57	47	40	33	33	25	20	14
		Ambient Noise Level, L_{eq}	50	68	64	58	50	44	45	40	32	24

Table 6: Measured background and ambient noise levels from 28th May 2021 and 15th August 2023 attended noise surveys

5 Relevant Standard and Guidelines

5.1 Guidelines used for the Operational Acoustic Assessment

The following standards and guidelines are considered relevant to the project and have been referenced in developing the project noise criteria:

- Mosman Council Development Control Plan (DCP) 2012 – particularly the DCPs for Open Space and Infrastructure (2012), Business (2013) and Residential (amended 2013).
- Mosman Council Local Environment Plan (LEP) 2012.
- State Environmental Planning Policy (Biodiversity and Conservation) 2021.
- Protection of the Environmental Operations (POEO) Act 1997.
- Environmental Planning and Assessment (EP&A) Act 1979.
- State Environmental Planning Policy (Exempt and Complying Development Codes) 2008.
- NSW Noise Policy for Industry (NPfI) 2017.
- AS2107:2016, *Acoustics—Recommended design sound levels and reverberation times for building interiors.*

The following documents have been referenced to derive numeric noise criteria where not explicitly provided in the local and state planning documents listed above.

- NSW Liquor Administration Board (LAB) noise guidelines.
- World Health Organisation (WHO) "Guidelines for Community Noise" 1999.

Applicable guidelines for road traffic noise impacts are:

- NSW EPA *Road Noise Policy* (2011)
- Australian Standard AS 3671-1989 *Acoustics – Road traffic noise intrusion – Building Siting and Construction* (for guidance only; applies to siting of the receiver buildings).

It is understood that regular zoo patron and staff numbers are unlikely to change due to this project.

5.2 Guidelines used for the Construction Acoustic Assessment

This acoustic report does not examine in detail the potential impacts from construction noise and vibration on residential receivers, since methodology and timing of works have not been developed. A detailed construction noise and vibration impact assessment and management plan would need to be prepared by the contractor once the likely construction methods are developed.

The primary references are:

- The EPA *Interim Construction Noise Guideline* (2009)
- The EPA *Assessing Vibration – a Technical Guideline* (2006)

It is necessary to examine potential impacts from construction vibration on both residential receivers and the structures within the zoo premises. Early works will include excavation and potentially vibration-intensive construction activities such as piling.

Once the excavation and construction details for the early works are developed, the contractor would need to determine a construction methodology that will ensure no adverse effects on the any nearby sensitive structures inside the Zoo. Impacts on animals will be managed internally by Taronga Zoo and because it does not fall under POEO Act and EP&A Act assessment requirements, this aspect of construction noise and vibration assessment is not presented in this SSDA Acoustic Report.

Vibration effects on residential receivers are unlikely to be an issue given that they are over 70m from the construction site.

Historic buildings and structures have particular requirements for managing vibration effects on their cosmetic finishes and structure. The sensitive structures are to be assessed against Australian and international guidelines and standards, such as:

- Australian Standard AS 2187:2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives*
- British Standard BS 7385:2-1993 *Evaluation and measurement for vibration in buildings Part 2*
- German Standard DIN 4150: Part 3-1999 *Structural Vibration Part 3: Effects of Vibration on Structures.*

Vibration effects on buildings is a specialist acoustic field and will require careful collaboration between the acoustic specialist, the structural engineer, and the construction engineer.

6 Project Operational Noise Criteria

6.1 External Noise Emission Criteria - General

6.1.1 Local Development and Environment Plans

Mosman Council Development Control Plan (DCP) 2012 and Local Environment Plan (LEP) 2012 refer to environmental noise impacts in qualitative terms. The DCPs for Open Space, Business (2013), Residential (amended 2013). and Infrastructure (2012) have been referred to in preparing this acoustic report. In particular, the Infrastructure DCP 4.6 Objective 2: Acoustic privacy describes general noise considerations only.

State Environmental Planning Policy (Biodiversity and Conservation) 2021 is relevant to developments in Taronga Zoo. Noise criteria are not explicitly mentioned in the SEPP, but the potential for noise impacts are mentioned as requiring assessment.

6.1.2 Environmental Planning and Assessment Act (EP&A) 1979

The Environmental Planning and Assessment Act 1979 (EP&A Act) regulates the majority of planning approval and environmental impact assessment (EIA) requirements in NSW. Section 111 of the Act requires examination and consideration to the fullest extent possible of all matters affecting or likely to affect the environment by reason of its activities. Acoustic impacts are a common community concern to be addressed in an EIA.

6.1.3 Protection of the Environment Operation Act (POEO) 1997

The *Protection of the Environment Operations Act 1997* enables the Government to set out explicit policies and premise-based Environment Protection Licences (EPLs) which are regulated by the Environment Protection Authority NSW (EPA).

Taronga Zoo activities are conducted in accordance with Environment Protection Licence 1677, which contains no specific noise limits. Where an EPL contains no specific noise limits, accepted practice is to determine criteria in accordance with the POEO Act general provisions against the generation of "offensive noise", applying numerical criteria obtained from applicable environmental noise policies and guidelines.

Defining "offensive noise" for the purpose of an acoustic assessment is not a simple matter. The Protection of the Environment Operations (POEO) Act 1997 defines "Offensive Noise" as follows:

(a) that, by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances:

(i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or

(ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or

(b) that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances, prescribed by the regulations.

The "regulations" referred to in (b) above are the POEO (Noise Control) Regulations (2008). Very few of these apply to noise generated at the proposed Sky Safari. Whether noise from the Sky Safari operations is "offensive" therefore reduces, in most cases, to a question of whether it meets part (a) of the definition. There are no clear-cut criteria for this, but consideration can be given to:

- Whether the level of noise exceeds applicable goals and guidelines,
- Whether the nature, character or quality of the noise is "offensive" due to such characteristics as tonality, impulsiveness or verbal content,
- Whether the time at which it is made is problematic, such that it could interfere with sleep, or school examinations, etc.

The EPA Noise Guide for Local Government (DECCW, 2009) provides a checklist for offensive noise which can be applied to any noise-generating activities. In addition to the considerations listed above, the EPA checklist asks:

- Is the noise loud in an absolute sense? Is it loud relative to other noise in the area?
- Does the noise occur at times when people expect to enjoy peace and quiet?
- Is the noise atypical for the area?
- Does the noise occur often?
- Are a number of people affected by the noise?

The remaining consideration relates to "reasonable measures". It may be reasonable, for example, to manage a noise issue arising from Sky Safari stations which relocated, or which are operating for longer hours than previously. It may not be 'reasonable', on the other hand, to expect a significant reduction in noise from typical existing patron and Sky Safari equipment noise during normal zoo operating hours.

6.1.4 Defining environmental noise criteria

The noise definitions and conditions provided by the Mosman Council DCP, LEP and POEO are generally focused around a subjective assessment.

Acoustic Studio recommends determining suitable objective criteria for assessing offensive noise, for noise emissions from mechanical plant, sound systems and patrons.

Compliance with the criteria described in sections 6.2 will ensure that the general noise conditions described in this section (6.1) will be met.

6.2 External Noise Emission Criteria - Mechanical Plant

6.2.1 New South Wales Noise Policy for Industry (NPfI)

The NPfI provides the framework and process for deriving noise goals for consents and licences that enable the EPA to regulate industrial premises that are scheduled under the *Protection of the Environment Operations Act 1997*. The EPA NPfI provides additional guidance on assessment of changes to existing premises (infrastructure and / or operations).

The NPfI applies to fixed facilities, commercial premises and individual industrial sources such as heating, ventilating and air conditioning (HVAC) equipment. It is also typically applied for general maintenance noise such as cleaning activities, which may apply to external washing of Sky Safari cars. It provides guidance on the methodology for determining limiting noise criteria designed for external noise emissions typically associated with mechanical plant.

The NPfI does not apply to:

- Vehicles associated with a premise that are on a public road, including vehicles accessing the Zoo; or
- Amplified music/patron noise from premises.

The NSW NPfI defines environmental industrial noise goals in two ways. The goals apply at the most-affected point on or within the residential boundary and are location-dependent. They also depend on the occupancy: residential, commercial, educational, etc.

The NPfI considers the following when establishing the criteria:

- The *time of day* that the noise generating development will be in operation, defined by the following:
    - Day (7am to 6pm)
    - Evening (6pm to 10pm)
    - Night (10pm to 7am)
- The existing *Ambient* (L_{eq}) and *Background* noise levels (L_{90}) that surround the site.
- The *type of noise source* and its characteristics. The NPfI provides modifying factors for noise sources with certain characteristics that may potentially cause greater annoyance than other noise sources of the same level.

The residential ***intrusiveness*** criterion aims to control short duration noise impacts and is based on the existing background noise level, and is defined as:

$$L_{Aeq,15\ minute} \text{ from new noise source} \leq \text{Existing long-term } L_{A90,Day/Evening/Night} + 5.$$

The residential ***amenity*** criterion aims to maintain noise amenity for a particular land use. It defines recommended Amenity Noise Levels (ANL), for different neighbourhood types. For example, the suburban residential ANLs are:

- Day time (7am to 6pm): 55 $dBL_{Aeq\ (11hrs)}$
- Evening (6pm to 10pm): 45 $dBL_{Aeq\ (4hrs)}$
- Night time (10pm to 7am): 40 $dBL_{Aeq\ (9hrs)}$

The project-specific amenity noise level = recommended amenity noise level minus 5 dB(A).

To standardise the time periods for the intrusiveness and amenity noise levels, this policy assumes that the $L_{Aeq,15min}$ will be taken to be equal to the $L_{Aeq(period)}$ + 3 decibels (dB).

Modification factors apply to the amenity criterion when existing industrial noise exceeds the acceptable noise levels. No modification factors apply to the residential receivers surrounding Taronga Zoo.

The NSW NPfI applies "penalty" or "correction" factors to account for particular noise characteristics such as tonal, low frequency dominant, or intermittent noise. No penalty factors have been applied in this assessment of plant noise, based on the assumption that mechanical plant will be controlled at source to avoid intermittent, tonal, or low-frequency-dominant noise emissions.

Any non-operational period is excluded from an NPfI assessment. For the Taronga Zoo Sky Safari, it is assumed that some mechanical plant may be in operation 24 hours a day (server room air conditioning units), that general mechanical noise to power the cable cars would operate during the Sky Safari operational hours (Day, Evening and Night), and that there will be maintenance activities (such as external and internal cleaning activities, once operations are stopped at night).

6.2.2 Sleep disturbance

The potential for high noise level events at night and effects on sleep should be addressed in noise assessments.

The World Health Organisation (WHO) "Guidelines for Community Noise" 1999 suggest external noise levels of 55dBLAeq will result in negligible sleep disturbance effects. This ideal level does not account for intermittent noise events, or periods of higher noise.

Sleep disturbance needs to be assessed for this project because of the following proposed night-time operations, defined as being between 10pm and 7am:

- Sunrise & Early Morning Sessions

  Daylight savings (AEDT): 6:00am to 7am
  Non-daylight savings (AEST): 5:00am to 7am

- Sunset & Twilight Sessions

  Weekends (Fri-Sun) + Special Events: 10:00pm to 12:00am

- Maintenance including external washing of cars

  10:00pm to 6:00am

Vehicle arrival / departure will generate the same noise levels as any other vehicle currently using Whiting Beach Road and Bradley's Head Road accessing the staff and public carparks. Due to the proposed extended operation of the Sky Safari as noted above, more private vehicles will arrive and depart the Zoo during night time hours when compared with the previous Sky Safari which typically only operated during standard zoo opening hours.

The NPfI provides guidance on the assessment of sleep disturbance based on the predicted event $L_{Aeq(15min)}$ and event L_{Amax} noise levels at the receiver. The nearest affected receivers are located in NCA 2, nearest to the carpark entry / exit and also nearest to any of the proposed stations (the Top Station):

- Event $L_{Aeq(15min)}$ > 40dB(A) or Night time RBL (background noise level) + 5 dB (whichever is greater). For this project, the nearest NCA to any Sky Safari facility is in NCA2 (near the Top Station). The RBL-based Sleep Disturbance Screening Levels are:

  - Midnight to 5am (outside the proposed operational hours): NCA 2: 33+5 = 38dB$L_{Aeq(15min)}$. The greater value, **40dB$L_{Aeq(15min)}$**, is adopted as the project-specific Sleep Disturbance Screening level if there is any noise generated due to the proposed Sky Safari between midnight and 5am.

  - 10pm to midnight (proposed weekend and special event operational hours): NCA 2: 37+5 = **42dB$L_{Aeq(15min)}$**

  - 5am to 7am (early morning proposed start): NCA 2: 41+5 = **46dB$L_{Aeq(15min)}$**

- Event L_{Amax} > 52dB(A) or Night time RBL (background noise level) + 15 dB (whichever is greater). For this project, the Sleep Disturbance Screening levels based on the NCA 2 RBL are:

  - Midnight to 5am (outside the proposed operational hours): NCA 2: 33+15 = 48dBL_{Amax}. The greater value, **52dBL_{Amax}**, is adopted as the project-specific Sleep Disturbance Screening level if there is any noise generated due to the proposed Sky Safari between midnight and 5am.

  - 10pm to midnight (proposed weekend and special event operational hours): NCA 2: 37+15 = 52dBL_{Amax}

  - 5am to 7am (early morning proposed start): NCA 2: 41+15 = 56dBL_{Amax}

- At NCA1, for information: Event $L_{Aeq(15min)}$ > 40dB(A) or Night time RBL 35dB(A) (background noise level) + 5 dB (whichever is greater): **40dBL_{Aeq}**. Event L_{Amax} > 52dB(A) or Night time RBL 35dB(A) (background noise level) + 15 dB (whichever is greater): **52dBL_{Amax}**.

If any Sleep Disturbance Screening level is exceeded, then further assessment of sleep disturbance effects is warranted.

For the Stations, based on experience with existing audio-visual displays and construction activities at the zoo, Taronga Zoo has advised that a Sleep Disturbance assessment is not specifically required for the zoo animals, and that a detailed animal disturbance assessment would be conducted based on observations during operation.

6.2.3 Mechanical plant noise audible in zoo premises

There is no particular guidance for managing plant noise impacting on patrons, staff and animals in the zoo.

Acoustic Studio recommends adopting a 55dBLAeq criterion for plant noise emissions to walkways, outdoor public and staff areas, and animal enclosures.

6.2.4 Summary of environmental noise targets for mechanical plant

Based on the measured noise levels detailed in Section 4.4, and in accordance with the methodology outlined in the NSW NPfI, **Table 7** details the corresponding limits of allowable noise emission from mechanical plant and general maintenance activities associated with the development at the nearest receiver boundaries, defined as a Project Specific Noise Trigger Level (PSNTL).

Since this is a particularly low noise area, the existing day-time background noise levels are more than 5dB lower than the Acceptable Levels that define the Amenity Criterion. Therefore compliance with the more stringent Intrusiveness Criterion, which depends on the NCA, will also ensure compliance with the Amenity Criterion during Daytime hours. During Evening and Night time hours, the Amenity Level sets the PSNTL at both NCAs. The Night-time PSNTL is less than the Sleep Disturbance Level. Compliance with the PSNTL will result in negligible risk of Sleep Disturbance.

Period	Noise source / activities	NPfl Criteria, dBA			
		Amenity $L_{Aeq\ (period)}$	Intrusiveness $L_{Aeq\ (15\text{-}minute)}$	Project Specific Trigger Noise Level $L_{Aeq\ (15\text{-}minute)}$	Sleep disturbance $L_{Aeq\ (15\text{-}minute)}$, L_{Amax}
Day (7am-6pm)	Mechanical plant	50 (residences, zoo)	NCA 1: 44 NCA 2: 47	NCA 1: 44 NCA 2: 47	n/a
Evening (6pm-10pm)		40 (residences) 55 (zoo)	NCA 1: 43 NCA 2: 44	43	n/a
Night (10pm-7am)	Mechanical plant, Cleaning and maintenance	35 (residences) 55 (zoo)	NCA 1: 40 NCA 2: 38	38	NCA 1: 40, 52 NCA 2: 10pm to midnight: 42, 52 Midnight to 5am: 40, 52 5am to 7am: 46, 56

Table 7: NPfl project specific criteria for external noise emissions from cleaning and maintenance activities and mechanical plant.

6.3 Traffic noise targets

This report assesses changes in character, location and potential increase in traffic noise associated with the project.

It is understood that regular zoo patrons, staff numbers and deliveries are unlikely to increase due to this project. Traffic noise due to construction activities should be assessed.

Any additional traffic generated by this proposal needs to be assessed in accordance with the following guidelines:

- NSW EPA *Road Noise Policy* (2011).
- Australian Standard AS 3671-1989 *Acoustics – Road traffic noise intrusion – Building Siting and Construction* (for guidance only; applies to siting of the receiver buildings).

The Road Noise Policy is applicable to traffic-generating developments including major road infrastructure developments. The emphasis is on achieving a reasonable balance between what is achievable on different road types and the sensitivity of different receiver types to road traffic noise. This is not directly relevant to the Sky Safari proposal as it does not include any new or upgraded road infrastructure.

When considering land use redevelopment and the impact on residential land uses the RNP guideline states that *"In assessing feasible and reasonable mitigation measures, an*

increase of up to 2 dB"... (in relation to existing noise levels).. "represents a minor impact that is considered barely perceptible to the average person".

The RNP provides criteria for traffic noise from new roads or additional traffic generated on roads from land use development. The criteria apply externally, at the façade of affected receivers, and include a façade sound reflection component.

The RNP noise assessment criteria for traffic noise levels due to additional traffic generated on local roads from land use development are 55dB$L_{Aeq(11hr,\ 7am\ to\ 10pm)}$ and 50dB$L_{Aeq(9hr,10pm\ to\ 7am)}$.

Where the existing traffic noise levels currently exceed the dB $L_{Aeq\ (1hr)}$ RNP criteria, the increase in the traffic noise levels arising from the additional traffic generated from land use development is assessed in relation to the existing noise levels.

The Australian Standard has a different emphasis to the RNP, in that it aims to identify appropriate intrusive road traffic noise criteria in different building types. This is not applicable to the Sky Safari site as it is located in a quiet residential area with basic requirements for managing road traffic noise intrusion.

In the absence of directly applicable guidelines, policies or standards for assessing road traffic noise impacts from the Sky Safari, Acoustic Studio's approach is to examine the increase in traffic noise events and levels for most-affected sensitive receivers.

This acoustic report does not assess bus noise as the proposal will not change use of the existing bus operations serving the zoo.

6.4 External Noise Emission Criteria – Patrons and Sound Systems

6.4.1 Liquor Administration Board – Licenced Premises

The LAB has published guidance material on controlling noise from licenced premises. While it may not be directly applicable to the Sky Safari, it provides a method of determining quantitative noise targets for sound system and patron noise from the proposed outdoor areas around the Sky Safari stations, which are not explicitly covered by the NSW NPfI.

The LAB suggests the following typical environmental noise criteria for patron and venue sound system noise. These criteria apply at the boundary of the nearest affected residential receivers.

- 7am to 12am (midnight): L_{A10} from the premises are not to exceed the existing background noise level by more than 5dB, in any octave band from 31.5Hz to 8kHz inclusive.

- 12am (midnight) to 7am: L_{A10} from the premises are not to exceed the existing background noise level, in any octave band from 31.5Hz to 8kHz inclusive.

There may be times when the Sky Safari will be used from 5am to 7am, and from 6pm to midnight. Therefore the two assessment approaches are necessary for this proposal. Only the hours from midnight to 5am are excluded from the assessment, as the Sky Safari will not operate during these hours.

Aspects to note regarding the application of the above are:

- Noise from the premises are defined as a statistical measure (the top 10% noise level), but there is no definition as to how long the premise noise is to be measured for. Acoustic Studio has adopted the 15-minute measurement period defined in the the NPfI.

- The "background level" is not explicitly defined. Acoustic Studio determines the existing background noise level in accordance with the NPfI. The Day, Evening and Night time background noise levels are used to determine environmental noise criteria.

6.4.2 Sleep Disturbance Criteria

Some short-duration noises that occur at night may comply with the criteria described above, and yet be undesirable because of the sleep arousal effect, particularly between the hours of 10pm and 7am.

As noted in Section 6.2.2, the proposal is for extended operating hours for the new Sky Safari, and this will include night-time shoulder periods 5am – 7am, and 10pm to midnight.

The nearest residential receivers to the proposed Sky Safari station is in NCA2, near the Top Station.

6.4.3 Noise Emission Criteria for the Sky Safari (patrons and sound systems)

The adopted LAB criteria for the Sky Safari outdoor areas and walkway noise emissions are detailed in **Table 8**. As noted in section 6.4.1, the background noise level is determined in accordance with the NPfI, and noise criteria are determined for Day-time periods.

For assessment purposes, the lowest background noise levels measured in octave bands and the associated Project Criteria ($L_{10} \leq L_{90} + 5dB$) are detailed in **Table 8**.

Period	Description	Measured sound level, dB re 20 µPa									
		dB(A)	Octave band centre frequency, Hz								
			31.5	63	125	250	500	1k	2k	4k	8k
7am to 6pm (Day)	Day-time Background Noise Level, L_{90}	42	52	46	40	36	36	35	31	21	21
	Project Criteria, L_{10}	47	57	51	44	41	41	41	36	26	26
6pm to 10pm (Evening)	Evening Background Noise Level, L_{90}	39	63	57	47	40	33	33	25	20	14
	Project Criteria, L_{10}	44	68	62	52	45	38	38	30	25	19
10pm to midnight (Night shoulder)	10pm – 12am Night Background Noise Level, L_{90}	37	61	55	45	38	31	31	23	18	12
	Project Criteria, L_{10}	42	66	56	49	43	36	36	28	23	17
5am to 7am (Night shoulder)	5-7am Night Background Noise Level, L_{90}	41	57	51	44	41	41	41	36	26	26
	Project Criteria, L_{10}	46	62	56	49	46	46	46	41	31	31

Table 8: Patron and sound system noise recommended criteria at nearest residential receiver boundary in NCA2 (based on LAB, derived from attended and unattended measured background noise levels)

6.5 Internal Acoustic Criteria

The development will consider acoustic design compliance with the background noise levels and reverberation times listed in AS2107:2016. For areas which are not explicitly listed in AS2107, an acoustic consultant will be responsible for defining appropriate design background noise levels, reverberation times and internal acoustic separation in accordance with the principles of AS2107.

7 Operational Noise and Vibration Assessment and Recommendations

The proposal has been assessed based on information provided by Taronga Zoo Conservation Society.

7.1 Operational noise and vibration assessment methodology

The acoustic assessment has considered the following:

- The Sky Safari will generally be open and in use 7 days a week, encompassing Zoo operating hours Sky Safari operation which may extend to night time hours (per Section 3.5), as well as including cleaning and maintenance activities while the Sky Safari cable cars are stable overnight.
- Plant may operate 24-hours a day, 7 days a week for cleaning and maintenance, however the majority of plant associated with the Sky Safari operation would operate during the hours presented in Section 3.5. Depending on special events, early morning starts may run from before 7am, and some events may operate up until midnight. Therefore the most stringent assessment should be based on the lowest background noise period, being 5-7am..
- The public outdoor areas around Stations may include a sound system for providing information patrons. This may operate at any time during Sky Safari operating hours.
- Noise predictions at the nearest residential receiver boundaries consider the total noise contribution from all noise sources associated with the proposed Sky Safari.
- Distance attenuation, with conservative estimates for attenuation due to shielding from buildings, intervening topography and ground absorption.

7.2 Mechanical plant noise and vibration compliance

Plant associated with the operation of the proposed new Sky Safari should be controlled to ensure external noise emissions are not intrusive and do not impact on the amenity of nearby receivers, including receivers within the zoo such as staff offices, public walkways and open spaces, and animal enclosures.

At this stage, final plant selections and locations have not been made; therefore a detailed assessment has not been carried out.

The majority of plant will operate when the Sky Safari itself is operating. The plant would shut down between midnight and 5am. The exception is the maintenance facility, which may need to operate past midnight to wash the cable cars.

In the absence of preliminary plant noise data or locations, Acoustic Studio makes the following general comments:

- The nearest residential receiver is over 220m distant, with screening from topography or existing buildings. The expected attenuation between the noise source (at 1m from the source) and the nearest receiver is at least 48dB.
- To achieve the most stringent night-time noise target (39dB(A) at NCA 2), the source noise level would need to be no more than 87dB(A) at 1m from the source of the noise, or 77dB(A) at 3m from the source of the noise.
- The most restrictive criterion for the plant is 55dB(A) on open walkways, and publicly accessible outdoor spaces, staff areas and animal enclosures nearest to any mechanical inlet, outlet or outdoor unit. Achieving the 55dB(A) target within the zoo premises will easily ensure compliance with the relevant criteria at all other receivers at all times.
- The only noise source that would not normally operate during Sky Safari operating hours is the maintenance facility. This is located in the Storage building near the Top Station. In order to meet the night-time noise criterion of 40dB$L_{Aeq(15min)}$ and 52dBL_{Amax} at the nearest residential receivers at NCA1 (Whiting Beach Road) and NCA2 (Bradley's Head Road), the equipment at the maintenance facility would need to be no more than 85dB$L_{Aeq(15min)}$ and 97dBL_{Amax} at 1m from the noise source. This noise limit will easily be met.
- Attenuation and / or internally-lined ductwork may be required for exhaust and other fans in order to meet the internal noise criteria inside stations, and to meet the Zoo premises criteria in outdoor areas.
- Cable car washing including pressure hosing should ideally be carried out inside partial enclosures to protect nearby animal enclosures from noise.
- Noise emissions from the external plant may be controlled via a combination of:
    - locating the units as far from transient or occupied areas as possible;
    - with natural screening provided by existing zoo buildings, structure and topography; and
    - additional localised acoustic screening as required.

During the detailed design stage, the acoustic consultant should provide detailed design advice to the architect and mechanical engineer to ensure that noise emissions from mechanical plant are effectively controlled to meet the relevant criteria at the nearest receivers on the Zoo premises, which will then ensure compliance with criteria at the nearest residential receiver boundaries.

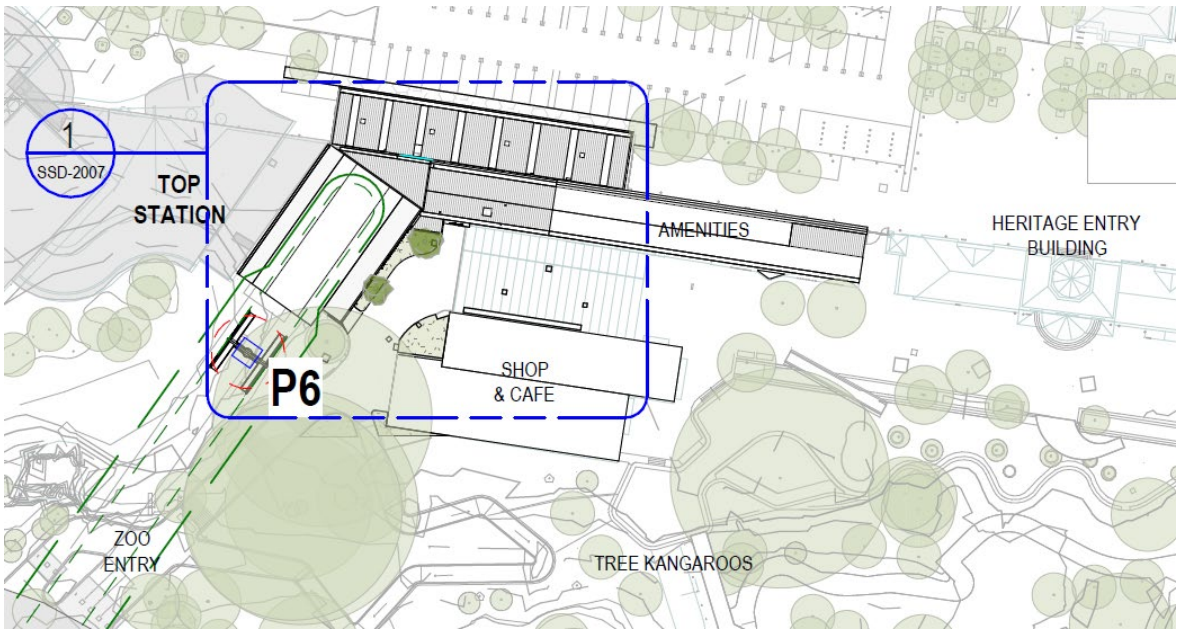


Figure 4: Proposed location of the Storage building which serves as a maintenance facility and wash area for the cable cars at Taronga Zoo. Source: February 2025 plans by Scott Carver.

Noise control considerations for the concept design include, but are not limited to, the following:

- The cable cars will be capable of travelling at doubled the speed of the now decommissioned Sky Safari.
- Scheduling of cable cars will be partly use-driven, with pulsing to typically limit queuing to ten minutes at each station, up to a maximum of 20 minutes' queuing during busy periods or where mobility needs require longer stops at stations.
- The $L_{Aeq(15min)}$ generated by the Sky Safari therefore needs to consider the cumulative noise levels from up to 40 cable cars stopping at any single station in a 15-minute interval, averaging 20-25 seconds between each cable car, with continuous mechanical plant noise including from the motor. The main source of noise from the cable car is the localised noise from moving off the cable to the girder on motorised rollers. This can cause a reverberant sound which may be audible a short distance from the roller.
- Any emergency generators may need to be located inside an enclosure with acoustic louvres, in order to prevent disturbing or startling animals, staff and patrons. It is generally accepted that emergency equipment can be tolerable at 5-10dB louder than typical operational equipment. However, the acoustic design will need to consider whether animals in nearby enclosures would be adversely affected by sudden noise generated by an emergency operator. In any case, meeting noise targets within the Zoo will ensure that applicable environmental noise criteria at residential receivers located outside the zoo.

- Any new pumps, including for a potential rainwater tank, may require a partial enclosure to provide screening for any nearby noise-sensitive animal enclosures and patron / staff outdoor areas.
- Split unit air conditioning with external condensers for operator offices may need to be located behind screens if they are located very near to noise-sensitive animal enclosures. However, typical office external condenser units are unlikely to need acoustic screening.
- Maintenance and cleaning would be carried out inside an enclosed Storage Building near the Top Station, using pressure hoses on concrete. This is likely to be the noisiest activity. Based on Acoustic Studio's database, pressure hosing can generate noise levels in the range of 95-100dB(A) at 1.5m from the ground level. Applying a conservative distance attenuation of 48dB to the nearest residential receiver, without any screening, the highest expected noise level of 47-52dB(A) would exceed the night-time target of 39dB(A) at NCA1. This demonstrates why a enclosure and closed door achieving a noise reduction of 13dB is necessary to meet environmental noise targets. A higher performance enclosure achieving 20dB noise reduction, with internal sound absorption installed under the roof, may be recommended to reduce noise impacts within Zoo premises (to minimise impacts on animal) and to manage noise exposure for cleaning staff.

7.3 Patron and Sound System Noise

7.3.1 Source Noise Levels

Table 9 shows typical sound levels expected from patrons using the Sky Safari.

A maximum of 350 people are expected to be at the Top Station at any one time, during peak periods (Day-time hours, during "mega-peak" events – public holidays and peak periods during school holidays). Up to 250 people are expected at the Lower Station. This is a combination of people queuing, getting on the cable car, and getting off the cable car.

Direct measurements of patron noise at Sky Safari stations is not possible as the original Sky Safari has been decommissioned. The voice data is taken from available acoustic literature and takes a conservative approach.

The patron source noise levels are considered to be conservative (ie higher than expected in practice). It is assumed that there will generally be at least one listener for each speaker, so 175 people are speaking and 175 people listening. This conservative approach has been adopted to account for the potential for worst-case scenario.

Voice generates directional sound, which is frequency dependent. As a conservative screening estimate, no directional attenuation has been accounted for in the environmental noise predictions. This is unrealistic but simplifies the calculations to assist in identifying any potential of environmental risk. If the simple screening calculation without directivity

shows no excess of environmental noise criteria, then it is safe to assume that the actual noise levels will be lower and will also comply.

Description	Sound pressure level, dB re 20µPa									
	Overall dB(A)	Octave band centre frequency, Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
L_{10} of 1 adult male speaking with moderate voice	59	38	42	52	58	60	52	46	43	37
L_{10} of 1 adult male speaking with raised voice	68	50	52	56	62	67	64	57	52	45
L_{10} of 175 patrons speaking all at once	+22	+22	+22	+22	+22	+22	+22	+22	+22	+22
Measured L_{10} of a group of approximately 30 children in outdoor zoo areas (2015)	76	55	58	55	50	53	66	74	53	41

Table 9: Sound levels (L_{10}) likely to be generated by patrons waiting at the Top Sky Safari station (peak)

7.3.2 Patron noise assessment

Patron noise from each Sky Safari station and associated outdoor area has been estimated for the following scenario.

- General patron noise from up to 175 people, speaking in raised voices (which is unlikely), during zoo opening hours. This scenario has been assessed as a worst case situation which may occur for the first few months after the new Sky Safari opens, as this area is expected to be an attraction when the facility opens.

The residential receivers are shielded from the Sky Safari station outdoor areas by natural topography and built structures. A conservative 5dB sound attenuation due to screening has been applied to account for this. **Table 10** below presents predicted worst-case patron noise at the nearest residential receiver. Full compliance is predicted.

The conservative prediction indicates full compliance with reference targets. It is expected that early morning special events would be held with smaller groups of up to half the peak number of people, and that voice levels would be moderate. This would easily achieve the 5-7am LAB noise limits at all residential receivers.

Location and condition	Description	Sound pressure level, dB re 20 µPa									
		dB(A)	Octave band centre frequency, Hz								
			31.5	63	125	250	500	1k	2k	4k	8k
Station outdoor area, 100 people, raised voices	External Sound Level at source, L_{10}	90	72	74	78	84	89	86	79	74	67
	Predicted Level at receiver, L_{10}	37	22	24	27	32	36	33	26	20	12
	Day Environmental Project Criteria, L_{10}	47	57	51	44	41	41	41	36	26	26
	Evening Environmental Project Criteria, L_{10}	44	68	62	52	45	38	38	30	25	19
	5-7am Environmental Project Criteria, L_{10}	46	62	56	49	46	46	46	41	31	31
	10pm – 12am Environmental Project Criteria, L_{10}	42	66	56	49	43	36	36	28	23	17
	Complies?	**Yes**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 10: Predicted patron noise levels (L_{10}) at the nearest residential receiver due to Sky Safari station outdoor area operations. Compares against the most stringent criteria, i.e. Day time and Evening at NCA1, Night time at NCA2.

7.3.3 Sound system noise

Noise generated within the Sky Safari Station outdoor areas may include sound system noise from Public Address systems. Audible information systems are expected to be required to comply with the Disability Discrimination Act.

Allowable levels for the sound system are provided in **Table 11** below as part of the assessment.

Table 11 indicates that the LAB reference targets would be met at all octave bands.

Location and condition	Description	Sound pressure level, dB re 20 µPa									
		dB(A)	Octave band centre frequency, Hz								
			31.5	63	125	250	500	1k	2k	4k	8k
Station outdoor area	Maximum Direct Sound Pressure Level at 1m, L_{10}	81	85	85	80	80	80	80	75	65	65
	Maximum Predicted Level at receiver, L_{10}	27	35	35	29	28	27	27	22	10	10
	Day Environmental Project Criteria, L_{10}	47	57	51	44	41	41	41	36	26	26
	Evening Environmental Project Criteria, L_{10}	44	68	62	52	45	38	38	30	25	19
	5-7am Environmental Project Criteria, L_{10}	46	62	56	49	46	46	46	41	31	31
	10pm – 12am Environmental Project Criteria, L_{10}	42	66	56	49	43	36	36	28	23	17
	Complies?	**Yes**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 11: Allowable sound levels (L_{10}) sound systems at the Sky Safari stations, to meet environmental noise criteria at residential receiver locations. Compares against the most stringent criteria, i.e. Day time and Evening at NCA1, Night time at NCA2.

It is noted that predictions are based on background noise criteria for the worst-case scenario (lowest measured existing background noise level) and the source noise levels are also assumed to be a worst-case scenario (i.e. noisiest likely), with contributions from simultaneous use / activities where applicable.

Therefore all scenarios are expected to comply with all criteria at the receiver boundaries at all times.

While the sound system levels provided above would meet environmental noise targets at residential receivers, further consideration of noise impacts on zoo staff, patrons and animals will be required during detailed design.

The sound system set up will most likely use directional speakers and volume inhibitors to minimise disturbance to zoo patrons, zoo staff, and to animals in nearby enclosures.

7.4 Traffic noise compliance

It is understood that regular zoo patron and staff road vehicle numbers are unlikely to change due to this project. The proposed Sky Safari will provide an enhanced offering for visitors travelling via public transport[2].

Buses will not be provided to specifically cater for the extended Sky Safari hours. This means that there are no additional buses using local roads due to the proposal.

The proposed Sky Safari will encourage visitors to use existing bus and other public transport services, due to improved accessibility and links between the ferry wharf and bus stop at the Lower Station.

However, with the extended operational hours proposed for the Sky Safari, the project may generate additional out-of-hours road traffic as patrons and staff arrive and depart outside normal Zoo opening hours.

Each vehicle event will be no louder than existing vehicles that use the road. Measured maximum event levels from existing traffic events are typically 60-65dB(A) at receiver façades. Therefore the maximum event noise levels will not increase due to the project and there will be no change in night time noise levels relating to potential sleep disturbance events.

The potential additive effect of more vehicles on the road outside current Zoo operating hours needs to be considered.

The NSW Road Noise Policy states that noise level increases of less than 2dB$L_{Aeq(period)}$ are generally not noticeable. If the event noise levels are the same (being the same type of typical private passenger vehicle), there would need to be more than 65% increase in the number of vehicle events over the assessment period to increase the overall traffic noise level by 2dB.

The traffic report indicates that existing car-pooling is likely to continue, and public transport use is likely to be enhanced due to the improved accessibility and access the proposed Sky Safari will provide for existing public transport (ferry and bus). Based on the traffic report, it is considered unlikely that extended operating hours will result in a 65% increase in hourly vehicle counts. This means that the potential additional out-of-hours vehicles are unlikely to result in a noticeable noise increase in accordance with the RNP.

Being a local road, it is recommended that patrons are reminded to arrive and depart the Zoo with consideration of the local residential community. This applies to patrons using public transport, walking, cycling, or using private vehicles.

[2] JMT Consulting *Taronga Zoo Sky Safari Transport Impact Assessment* Draft 31 May 2024

7.5 Cumulative operational noise impacts

In recognition of several recently completed and recently approved planned developments at Taronga Zoo's premises in Mosman, cumulative impacts need to be considered. The majority or Zoo developments, such as the Reptile and Amphibian Conservation Centre (SSD-17483577), the Taronga Wildlife Hospital (SSD-33211326), and Taronga Wildlife Hospital Nutrition Centre (SSD-17655146) are distant enough from the proposed Sky Safari and the nearest receivers to have no cumulative noise impact at residential receivers.

The Upper Australia Precinct (SSD-10456) is located near the proposed Sky Safari Upper Station. There is a potential for noise emissions from both the Upper Station and Upper Australia Precinct activities (particularly outdoor sound systems) to be additive.

The Upper Australia Precinct will only operate during standard Zoo opening hours (Daytime). The nearest residential receiver is located over 150m from the Upper Australia Precinct, the worst case noise emissions from the Sky Safari Upper Station Public Address system is predicted to be approximately 10dB below the applicable daytime noise target (refer to section 7.3.3).

Note that sound levels add logarithmically. If one sound source is 10dB below another at the same location, then the lower sound source does not contribute to the overall noise level (for example, 30dB + 40dB = 40dB). This means that, even if Upper Australia Precinct noise just meets the daytime noise reference target, the Sky Safari noise would not cause a measurable noise increase at the nearest residential receiver. The cumulative operational noise impact from the Sky Safari Upper Station and Upper Australia Precinct proposals is therefore predicted to comply with applicable environmental noise targets.

7.6 Summary of predicted operational noise compliance

Table 12 summarises the zoo activities associated with the current Sky Safari proposal, and demonstrates compliance with the applicable noise criteria for general operational noise.

Period		Mechanical Plant and Maintenance Project-Specific Noise Trigger Level, $L_{eq\ (15minute)}$, dBA	Sleep disturbance $L_{Aeq\ (15\text{-}minute)}$, L_{Amax}	Patrons and sound systems $L_{A10(15\text{-}minute)}$	Road traffic $L_{Aeq(1\text{-}hour)}$
Day (7am-6pm)	Criterion	NCA 1: 44 NCA 2: 47	n/a	NCA 1: 44 NCA 2: 47	Increase < 2dB
	Complies?	**Yes**	n/a	**Yes**	**Yes**
Evening (6pm-10pm)	Criterion	43	n/a	NCA 1: 43 NCA 2: 44	Increase < 2dB
	Complies?	n/a	n/a	**Yes**	**Yes**
Night (10pm-7am)	Criterion	38	NCA 1: 40, 52 NCA 2: 10pm to 12am: 42, 52 12am to 5am: 40, 52 5am to 7am: 46, 56	NCA 1: 40 NCA 2: 10pm to 12am: 42 12am to 5am: 38 5am to 7am: 46	Increase < 2dB
	Complies?	**Yes**	**Yes**	**Yes**	**Yes**

Table 12: Summary of compliance with project noise criteria at nearest residential receivers

8 Construction noise and vibration targets

This acoustic report presents a high level review of the potential impacts from construction noise and vibration on residential receivers, as work methods and plans are not yet developed. A full construction noise and vibration impact assessment and management plan may be prepared by the contractor once the structure and construction methods are developed further.

8.1 Airborne noise management levels

8.1.1 Airborne noise management levels for residential receivers

The EPA *Interim Construction Noise Guideline* (ICNG, 2009) defines standard construction hours during which the construction Noise Management Level (NML, $L_{Aeq,15min}$) is 10dB above the applicable period background noise level. A strong justification is required for conducting works outside standard construction hours, and the NML during these periods is significantly lower.

The ICNG clarifies that NMLs are not considered to be "criteria" or "limits". This is in recognition of the fact that construction noise is often difficult to effectively reduce due to the nature of large plant and equipment and noise-generating activities. The NML is to be considered a target to work towards, by applying feasible and reasonable mitigation.

The background noise level used for the construction phase noise assessment is taken from both the COVID-19 activity 2021 noise survey data, which is lower than pre-COVID-19 levels, and the pre-COVID-19 2017 noise survey data.

The ICNG also defines "Highly Affected" levels for daytime works, above which point there may be a strong community reaction against the noise. Evening and Night time works are not proposed.

Table 13 summarises the applicable residential construction noise criteria for different day-time periods during the week.

Period	Monday to Friday	Saturday	Sunday / Public Holiday	Highly Affected Level
Day: Standard construction hours	49 (7am – 6pm)	39 (8am – 1pm)	-	75
Day: Out of hours	-	41 (1pm-6pm)	44 (7am-6pm)	75

Table 13: Construction noise criteria (overall levels, $L_{Aeq,15min}$) at nearest residential receivers

8.1.2 Airborne noise management levels for non-residential receivers

Construction noise impacts on zoo staff and patrons need to be assessed.

For pedestrian walkways and exhibits, Acoustic Studio recommends applying a construction noise management level of 60-65dB$L_{Aeq(15minutes)}$.

This is 5-10dB higher than recommended levels in outdoor recreation areas in various environmental noise guidelines including the NSW EPA rail and road noise guidelines. It is also 8-11dB above measured background noise levels, and 2-8dB above ambient levels with groups of children, measured inside Taronga Zoo in March 2017. Due to the temporary nature of the construction and the transient use of the walkways, this is considered an appropriate target.

8.2 Ground borne noise management levels

The ICNG recommends ground-borne noise management levels at residences affected by nearby construction activities. Ground-borne or structure-borne noise is noise generated by vibration transmitted through the ground or structure and is re-radiated as audible airborne noise.

The ground-borne noise levels presented in **Table 14** below are for evening and night-time periods only, as the objectives are to protect the amenity and sleep of occupants during the more sensitive time periods.

Time of Day	Management level $L_{eq\ (15\ min)}$
Evening (6pm to 10pm)	40 dB(A) - Internal
Night (10pm to 7am)	35 dB(A) - Internal

Table 14: Residential construction noise criteria for ground-borne noise

There is no risk of structure-borne noise at the nearest residential receivers due to the distance attenuation through ground between works and receiver buildings. Therefore structure borne noise has not been predicted and assessed in detail in this report.

8.3 Vibration effects on structures

Once the structural details for the works are developed, a construction methodology will be determined that will ensure no adverse effects on any sensitive structures and sites.

Vibration limits to prevent vibration-induced damage in buildings shall be based on German Standard DIN 4150: Part 3-1999 *Structural Vibration Part 3: Effects of Vibration on Structures*, with reference also to British Standard 7385-2: 1993, *Evaluation and*

measurement for vibration in buildings. Guide to damage levels from groundborne vibration.

The duration of the works must be considered when determining the most relevant criteria. The vibration levels to protect a building from minor cosmetic damage in BS 7385-2 are component levels, and apply at the base of the receiver building.

Typically for NSW projects, the applicable vibration criteria for cosmetic damage to historic or heritage structures are taken from German Standard DIN 4150: Part 3-1999 *Structural Vibration Part 3: Effects of Vibration on Structures.* A short-term vibration velocity limit of 3mm/s (<10Hz) and 3-8mm/s (10-50Hz) is typically applied to historic or heritage buildings if they are considered to be structurally unsound.

Figure 5 below summarises vibration targets to protect buildings from cosmetic building damage. If vibration measurements are conducted in third octave bands (Hz), then the on-site limit curve shall apply. If vibration measuring equipment is only capable of measuring overall peak levels, then a peak particle velocity limit of 3mm/s (rms) shall apply on site for structurally unsound heritage items, and 5mm/s (rms) for structurally sound heritage items.

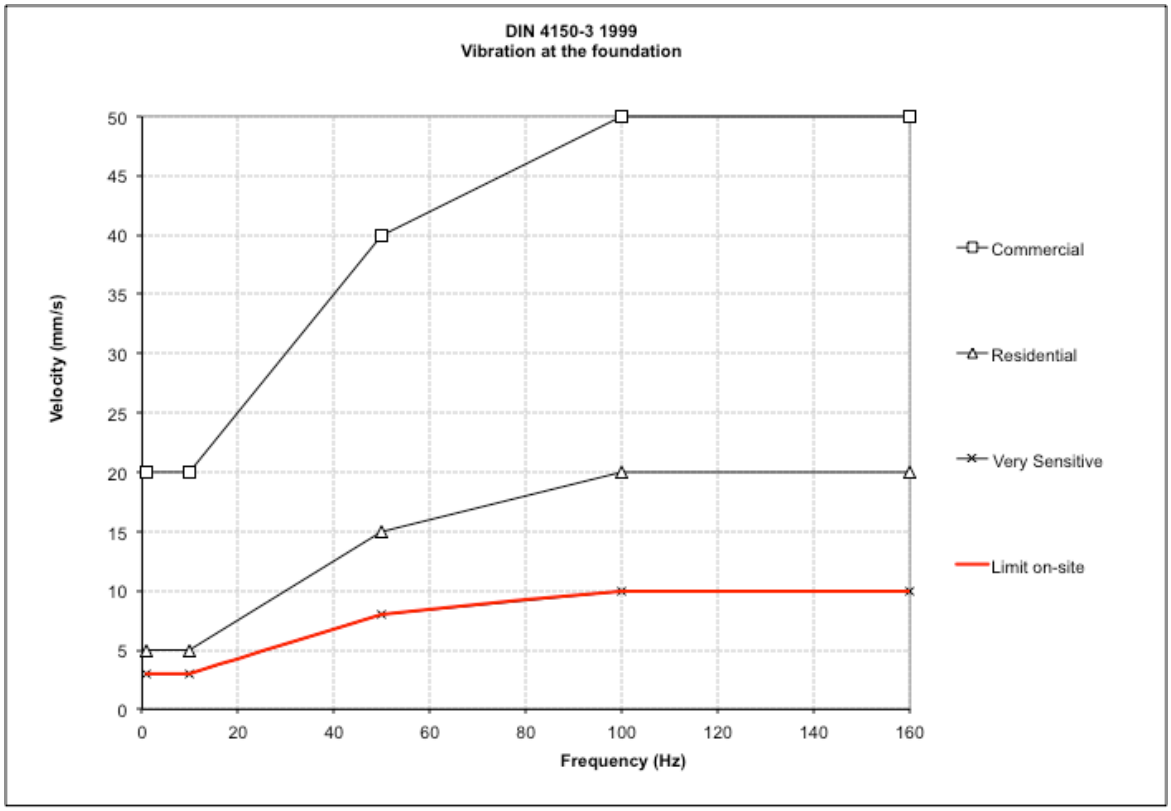


Figure 5: Vibration targets for protecting heritage and historic structures ("very sensitive"), and typical residential and commercial receivers.

Levels suggested by German Standard DIN 4150 are more conservative than the British Standard, and may be adopted as a vibration screening criterion as follows:

- 3 mm/s for structurally unsound structures or items

- 5 mm/s for residential dwellings and unreinforced buildings and structures;
- 20 mm/s for commercial buildings and reinforced concrete residential apartment buildings.

Acoustic Studio recommends adopting German Standard DIN4150 criteria for heritage or historic structures until a condition or structural survey is carried out and confirmed that the building is structurally sound. Once a condition survey has confirmed that buildings are structurally sound, heritage items should be assessed against the "residential / unreinforced structure" vibration criterion curve. This should be the limiting criterion on site, and meeting this criterion will ensure that commercial vibration criteria are also met.

8.4 Vibration effects on humans

The EPA guideline *"Assessing Vibration: a technical guideline, 2006"* provides suitable criteria that can be applied to the assessment of vibration and human comfort. The guideline makes reference to the British Standard BS 6472: 1992, which shares many similarities to the Australian Standards AS 2670.2: 1990.

The guideline provides vibration levels for which there is a low probability of comment or disturbance to building occupants. The criterion also considers the type of vibration being assessed, namely continuous, impulsive and intermittent vibration. Examples of these vibration types are provided in **Table 15** below.

Continuous	Impulsive	Intermittent
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria.

Table 15: Examples of vibration source types

There are no direct references for allowable vibration levels for Zoo exhibits and back of house areas. However, a useful reference is the criteria for human exposure to continuous and impulsive vibration are detailed in **Table 16** that follows. Vibration levels are assessed through the consideration of the summation of effects for vibration levels at frequencies from 1 to 80 Hz for all axes.

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous vibration					
Offices, schools, educational institutions	Day or night time	0.020	0.014	0.040	0.028
Workshops	Day or night time	0.04	0.029	0.080	0.058
Impulsive vibration					
Offices, schools, educational institutions	Day or night time	0.64	0.46	1.28	0.92
Workshops	Day or night time	0.64	0.46	1.28	0.92

Table 16: Preferred and maximum weighted rms values for continuous and impulsive vibration acceleration (m/s^2) 1-80 Hz

Note: Daytime is 7am-10pm and night time is 10pm to 7am.

Human exposure to intermittent vibration is assessed using the Vibration Dose Value (VDV). The VDV accumulates the vibration energy experienced over an extended period (daytime and night-time periods) from intermittent events. **Table 17** sets out the acceptable VDV values for intermittent vibration in similar uses of building to back of house and exhibit areas at Taronga Zoo.

Location	Daytime		Night-time	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Table 17: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

8.5 Construction-related road traffic

This report assesses changes in character, location and potential increase in traffic noise associated with the project during construction phase.

Any additional traffic generated by this proposal during construction phase needs to be assessed in accordance with the following guidelines:

- NSW EPA *Road Noise Policy* (2011).
- Australian Standard AS 3671-1989 *Acoustics – Road traffic noise intrusion – Building Siting and Construction* (for guidance only; applies to siting of the receiver buildings).

The Road Noise Policy is applicable to traffic-generating developments including major road infrastructure developments. The emphasis is on achieving a reasonable balance between what is achievable on different road types and the sensitivity of different receiver types to road traffic noise. This is not directly relevant to the Sky Safari proposal as it does not include any new or upgraded road infrastructure.

The Australian Standard has a different emphasis to the RNP, in that it aims to identify appropriate intrusive road traffic noise criteria in different building types. This is not relevant to the Sky Safari development.

Acoustic Studio's approach is to examine the increase in traffic noise events and levels for most-affected sensitive receivers.

If project-related traffic occurs during night-time hours (10pm to 7am), then the potential for sleep disturbance must be assessed.

The sleep disturbance criterion L_{AMax} not exceeding the $L_{A90,\,(15\ minute)}$ by more than 15 dB(A) is a screening criterion, not an absolute goal for the purpose of assessing impact from a project. It applies outside bedroom windows during the night-time period.

If the Sleep Disturbance screening criterion is exceeded, the detailed analysis should cover the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the NSW *Road Noise Policy* (2011).

Other factors that may be important in assessing the extent of impacts on sleep include:

- How often high noise events will occur
- Time of day (normally between 10pm and 7am)
- Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).

A further consideration for sleep awakening is whether the environmental noise has changed. The NSW *Road Noise Policy* (RNP, 2011) Section 5.3 "Response to a Change in Noise Level" states:

> *While people may express a certain tolerance for their existing noise environment, they may feel strongly about increases in noise. […] The difference in reported awakenings from sleep was equivalent to a difference of 7 dB in maximum noise levels.*

The RNP Section 5.4 "Sleep Disturbance" states that:

> *From the research on sleep disturbance to date it can be concluded that:*
>
> - *Maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep*
> - *One or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.*

The internal noise levels provided in the RNP are related to potential sleep awakenings.

Typically noise impact assessments consider the worst case scenario, when residential receivers have windows open sufficiently to provide natural ventilation. This would result in approximately 10 dB attenuation from outside to inside, through the open window. This situation is considered likely during warmer seasons.

When windows are closed, the likely sound attenuation through standard windows with poor seals (common in older houses) is approximately 20 dB.

Based on a minimum attenuation of 10 dB(A) with windows open, the first conclusion of the RNP suggests that short term external noises of 60 to 65 dB(A) are unlikely to cause awakening reactions. In addition, external levels of 75 to 80 dB(A) are unlikely to affect health and wellbeing significantly, provided that these events occur no more than twice in one night.

9 Construction noise assessment and recommendations

9.1 Construction sequence

The proposal is to be carried out in four main phases over a duration of approximately 24 months, as described in detail in the Construction Management Plan:

- Phase 1 – Pre-construction and site establishment
- Phase 2 – Removal of existing pylons (footings to be left in situ), Demolition of existing lower station and top station and storage area, Excavation in sandstone at existing lower station, Civil works including piling
- Phase 3 – Construction: Pylon structures, New Top and Lower Stations plus Maintenance and Office Buildings
- Phase 4 – Post construction activities (internal fit-out, landscaping, commissioning and handover).

The main phases of work have been described in terms of the following "noise scenarios". A scenario is a work phase, characterised by the type of plant and equipment used, concurrent activities, location of works, and timing of works. The duration of each scenario is not yet known.

The works phases shown below are indicative only. The Project Construction Management Plan (CMP) describes the works phases in more detail. Once the Contract is awarded, the Contractor will be responsible for preparing a Works Plan and Schedule which will have further detail about the works stages, timing, and plant. The updated Works Plan may include updates to the noise and vibration impact assessments for proposed methods and timing of each stage of work.

The works phases in this Noise Impact Assessment focuses on the main noise- and vibration-generating plant and activities, for the purpose of identifying any risk activities and assess any potential non-compliances with applicable noise and vibration targets.

Noise Scenario / Activity Description	List of plant	Notes about subjective impact
Phase A. Pre-Construction	Generators Trucks Hammers Hand tools	High vibration: N Tones or impulses: Y - reversing alarms
Phase B. Demolition, excavation, piling	Excavators Bulldozers Pulverisers Rock-breakers Concrete saws Piling Jackhammers Crane Tipping fill Removal of building waste	High vibration: Y Tones or impulses: Y
Phase C. Construction: Pylons, New Stations, Maintenance and Office Buildings	Truck and Crane Hand tools Removal of building waste	High vibration: Y - piling Tones or impulses: Y - reversing alarms
Phase D. Post Construction Activities (internal fit-out, landscaping, commissioning and handover)	Truck and Crane Diggers, excavators Hand tools	High vibration: Y – digger / excavator Tones or impulses: Y - reversing alarms

Table 18: Indicative work phases and subjective impact considerations

Figure 6: Existing Sky Safari which will be decommissioned and removed, and replaced with the proposed new Sky Safari. Provided by TZCS on 12h February 2025.

9.2 Hours of work

The hours of work affect community noise impacts. This is due to the fluctuations of ambient noise through the day, and the type of activities typically conducted by the community during Day, Evening and Night.

Standard construction hours defined in the *Interim Construction Noise Guidelines* (7am – 6pm, Monday to Friday, and 8am – 1pm, Saturday) are considered the least sensitive times of day.

The proposed works hours for this project are:

- Weekdays 7am to 5pm (Noting that NSW Standard construction hours are up to 6pm Monday to Friday)
- Saturdays 8am to 1pm (Standard NSW construction hours)

Construction vehicles may enter the zoo during the following hours:

- Weekdays 7am to 5pm
- Saturdays 8am to 1pm.

Hours of work and site access may be subject to change following receipt of the SSDA approval for these works.

The Principal's Representative may authorise variations outside the approved hours at such times and under such conditions as the Principal's Representative sees fit.

Out of hours work will be considered for special applications only when it becomes necessary. Relevant authority approvals will be obtained by the Contractor prior to any work being performed outside the approved development consent working hours.

Working outside these hours will only be considered by the Contractor where:

- It is an emergency;
- There is a situation that would create hazardous conditions;
- Plant breakdowns have delayed an activity that cannot be stopped; and
- The extended working hours will not impact on Taronga Zoo operations.

The Contractor will ensure that the Taronga Zoo representative and the relevant government authority are notified of this work with the details and the reasons for performing outside the designated hours. No work will proceed outside of hours without the prior approval of Taronga Zoo.

Significant deliveries will be carried out before Zoo opening hours. Smaller deliveries will be managed during Zoo operating hours (9am to 5pm), but will be restricted where possible.

It is noted that for the purposes of road traffic noise assessments, the hours before 7am are considered to be "night time" and are typically considered to be times when residential receivers are more sensitive to road traffic noise. For the purposes of construction noise assessments, the hours before 8am on Saturday are considered to be more noise-sensitive.

The Contractor's Construction Noise and Vibration Management Plan must state the hours of work, and any deviations to the schedule must be assessed and approved prior to commencing the altered works schedule.

10 Construction noise assessment considerations

10.1 Noise and Vibration Sources

Potential noise sources during the construction stage are identified in **Table 18**. These noise sources are based on the proposed works described in the Construction Management Plan. The total duration of the works to complete the Sky Safari is approximately 24 months.

Typical airborne noise levels associated with each noise source have been extracted from AS 2436-2010. For this assessment a conservative approach has been taken, which has applied the levels provided in the standard as $L_{eq,T}$ noise sound power levels.

The ICNG imposes a 5dB penalty for sources with a tonal noise content, or associated with high vibration levels. A 5dB penalty is also applied to vehicles with tonal reversing alarms. Non-tonal or broadband reversing alarms do not attract this 5dB penalty. The 5dB penalty is added to the predicted construction noise level at the receiver boundary. These activities have been identified in **Table 19**.

Table 19 also identifies potential sources of perceptible vibration. Vibration levels associated with plant typically depend on the material being worked on. For example jackhammers and excavator hammers used on age-hardened concrete or hard rock will generate higher levels of vibration than the same equipment used on soft limestone or brick.

Noise Source / Plant	Sound Power Level, $L_{eq,T}$ dB(A)	Sound Pressure Level, $L_{eq,T}$ dB(A), at 10m
Dump Truck (tipping material)	117	89 (+5dB penalty – tonal reversing alarm)
Truck, Forklift *(vibration source)*	107	79 (+5dB penalty – tonal reversing alarm)
Front end / Wheeled loader *(vibration source)*	111	83 (+5dB penalty – tonal reversing alarm)
Piler (bored)	111	83
Piler (impact sheet) *(vibration source)*	137	109 (+5dB penalty)
Piler (vibratory) *(vibration source)*	125	97 (+5dB penalty)
Rock breaker *(vibration source)*	118	90 (+5dB penalty)
Pulveriser mounted on excavator	104	76
Excavator *(vibration source)*	107	79
Vibratory roller *(vibration source)*	108	80 (+5dB penalty)
Bulldozer	108	80
Asphalt Paver *(vibration source)*	108	80
Asphalt Rotomill (scabbler)	111	83
Skidsteer loader (½ tonne) *(vibration source)*	104	76
Generator, 4 stroke portable petrol	103	75
Generator, diesel	113	85
Compactor *(vibration source)*	113	85
Wacker packer	100	72
Concrete Saw, handheld *(vibration source)*	117	89 (+5dB penalty)
Jack Hammer *(vibration source)*	121	93 (+5dB penalty)
Hammer / percussive drill *(vibration source)*	112	84 (+5dB penalty)
Electric drill *(vibration source)*	91	63
Electric hand tools	102	74
Welder	105	77
Mobile crane	106	78

Table 19: Typical mid-point sound power and pressure levels of plant typical to proposed construction. These sound level values do not include the 5dB penalty noted for some types of work. The 5dB penalty is added to the predicted sound level at the receiver.

10.2Methodology

The assessment considers the noise impact from each category of major works as follows:

- Noise predictions at receiver boundaries have been carried out for each piece of equipment that may be used during major works.
- Each piece of equipment is modelled as a point noise source.

- To provide a worst case $L_{eq\ (15min)}$ prediction, it is assumed that equipment is used continuously over the assessment period. However, for dump trucks, it is assumed that the noise from this particular piece of equipment is not used continuously and has been assessed to generate noise for 3 minutes out of a 15-minute assessment period.
- Predictions only consider the distance attenuation between source and receiver, which is conservative because the natural topography is likely to result in both shielding and ground absorption.
- It is assumed that works activities in various parts of the site may be carried out simultaneously.
- In accordance with the proposed work hours, noise predictions are to be compared with weekday Day-time, Saturday 6-7am, and Saturday 7am to 1pm noise management levels.
- Vibration levels are difficult to predict without detailed material and structural information which affects the vibration at source (related to the material being worked on), and the vibration transmission through the receiving structure. Therefore vibration risks have been assessed at a high level, based on measurements taken at other construction sites.
- It will be necessary to confirm vibration through monitoring early in the any works phase that involves high-vibration activities such as excavating, to re-assess whether levels are expected to exceed applicable criteria at heritage or historically significant structures.

11 Predicted Construction Noise Levels

Table 20 details the predicted construction noise levels from the Sky Safari redevelopment, at the nearest residential receivers. The nearest residential receivers are:

- Whiting Beach Road cul-de-sac, 170m to the west, nearest to the Lower Station. This is NCA 1, with a Day-time standard construction hour NML of 49dB(A).
- Bradley's Head Road / Whiting Beach Road intersection, 220m to the north-east, nearest to the Top Station. This is NCA 2, with a Day-time standard construction hour NML of 52dB(A).

The distance and modest shielding attenuation between the Lower and Top Station construction sites and the nearest residential receivers is approximately 50dB with respect to a location 1m from a construction noise source, and approximately 30dB compared with 10m from a construction noise source.

Noise and vibration risks are discussed in the accompanying text.

The tables provide noise level predictions for individual pieces of equipment and the combined contribution for activities that may occur simultaneously. Noise levels have been based on the typical mid point noise levels detailed in Section 10.1.

All works will be conducted over 60m distant from the nearest residential receivers.

Table 20 below shows conservatively predicted noise levels at residential and zoo receivers, without any noise mitigation measures applied. Since predicted noise levels exceed applicable targets, **Table 21** presents levels predicted when basic mitigation measures are applied, which are the use of hoarding, petrol generators, and bored piling.

As explained in Section 8.1.1, NMLs are not considered to be hard "limits". Exceeding the NMLs is not considered a "non-compliance", but rather leads to the requirement to consider reasonable and feasible mitigation. The five key mitigation measures described in **Table 21** suggest that the resulting noise levels may be up to 10dB above the NML at the nearest residential receiver. This is considered to be a marginal to moderate impact. The key mitigation measures are (if feasible and reasonable):

- Install hoarding and / or noise curtains;
- Use bored piling methods instead of vibratory or impact piling;
- Use petrol generators instead of diesel generators;
- Use small hand-held compactors (wacker packers) instead of large plate compactors;
- Use pulveriser attachments instead of hammer attachments on excavators.

Moderate impacts can be further managed by applying the mitigation measures described in the sections that follow.

Noise Scenario / Activity Description	List of plant (dBL_{Aeq} at 10m)	Highest Predicted Level at Residential Receivers – without noise mitigation	Comments relating to impact, comparing predicted levels with NMLs NCA 1 / 2: 49 / 52dB(A)
Phase A. Pre-Construction, Site Establishment	Petrol Generators (75) Diesel Generators (85) Trucks (79) Hammers (70) Hand tools (74) Tree removal and mulching (88)	45 55 49 40 44 48	Noisiest activities exceed NML. Similar to existing daytime ambient noise levels (55-56dB(A)), therefore impact from hand tools, hammers and petrol generators is considered negligible or minor. However, receivers within the Zoo will benefit from noise mitigation measures. Hoarding will reduce noise by approximately 10dB. Plan truck access routes and times to minimise impacts. Use petrol generator rather than diesel.
Phase B. Demolition, excavation, piling	Rock breaker (90) Pulveriser (76) Bulldozer (80) Excavator (79) Concrete saws (89) Bored Piling (83) Vibratory Piling (97) Impact Piling (109) Truck (tipping fill) (89) Jackhammers (90) Hammer / Percussive drill (84) Removal of building waste (84) Plate Compactor (85)	60 46 50 49 59 53 67 79 59 60 54 54 55	Most main activities exceed NML. Impact and vibratory piling methods, as well as rock breaking and demolition with jackhammers, are the highest impact plant. Impacts on receivers will require noise mitigation measures. Hoarding will reduce noise by approximately 10dB. Consider quieter methods for piling, cutting / breaking rock or masonry, compacting, tipping fill, and for collecting and removing waste.
Phase C. Construction: New Stations, Pylons, Maintenance and Office Buildings	Truck (79) Crane (78) Hand tools (74) Removal of building waste (84)	49 49 44 54	Most activities exceed NML. Similar to existing daytime ambient noise levels (55-56dB(A)), therefore impact at residences is considered negligible or minor. However, receivers within the Zoo will benefit from noise mitigation measures. Hoarding will reduce noise by approximately 10dB.
Phase D. Post Construction Activities	Truck (79) Truck (tipping fill) (89) Plate Compactor (85) Crane (78) Diggers, excavators (79) Hand tools (74) Asphalt paver (80)	49 59 55 48 49 44 50	Some activities exceed NML at residences. Receivers within the Zoo are likely to require noise mitigation. Hoarding and / or noise curtains will reduce noise by approximately 10dB. Consider quieter methods for compacting and tipping fill.

Table 20: Predicted worst-case construction noise levels at representative residential receivers, for indicative works phases and activities. These predicted levels assume no noise mitigation measures have been adopted, and conservatively assumes 5dB shielding from existing shielding from topography and buildings.

Noise Scenario / Activity Description	List of plant (dBL_{Aeq} at 10m)	Highest Predicted Level at Residential Receivers – with noise mitigation	Comments relating to impact, comparing predicted levels with NMLs NCA 1 / 2: 49 / 52dB(A)
Phase A. Pre-Construction	Petrol Generators (75) Trucks (79) Hammers (70) Hand tools (74) Tree removal and mulching (88)	35 39 30 34 38	Meets NML apart from mulching. Consider off-site mulching in a less noise-sensitive location, if patrons / staff / animals are sensitive to noise.
Phase B. Demolition, excavation, piling	Rock breaker (90) Pulveriser (76) Bulldozer (80) Excavator (79) Concrete saws (89) Bored Piling (83) Truck (tipping fill) (89) Jackhammers (90) Hammer / Percussive drill (84) Removal of building waste (84) Plate Compactor (85) Wacker Packer (72)	50 36 40 39 49 43 49 50 44 44 45 32	Most activities meet NML, or potentially a marginal 1dB above NML for the highest-noise demolition and excavation methods. Consider quieter methods for cutting / breaking rock or masonry (e.g. pulveriser), plate compaction (e.g. hand held wacker packer) tipping fill, and for collecting and removing waste. Silencers should be used where possible on noisy items such as jackhammers.
Phase C. Construction: New Stations, Pylons, Maintenance and Office Buildings	Truck (79) Crane (78) Hand tools (74) Removal of building waste (84)	39 39 34 44	Meets NML, and noise levels within the Zoo are likely to be acceptable for Zoo patrons, staff and most animals in outdoor enclosures.
Phase D. Post Construction Activities	Truck (79) Truck (tipping fill) (89) Plate Compactor (85) Wacker packer (72) Crane (78) Diggers, excavators (79) Hand tools (74) Asphalt paver (80)	39 49 45 32 38 39 34 40	Meets NML, and noise levels within the Zoo are likely to be acceptable for Zoo patrons, staff and most animals in outdoor enclosures. Consider quieter methods for compacting (e.g. wacker packer), and tipping fill (e.g. using impact protection mats to reduce noise).

Table 21: Predicted construction noise levels at representative receivers, for indicative works phases and activities with basic noise mitigation implemented. These predicted levels assume noise curtains or hoarding are used if existing shielding from topography and buildings is less than 5dB, petrol generator, pulveriser, hand-held compactor (wacker packer) and bored piling are used. Noise mitigation measures to control residual impacts are recommended.

General comments are as follows.

Local hoarding around the worksite is recommended for all external works. When works are moving around the site, including mobile cranes, jackhammers, and concrete saws, local "noise curtains" such as EchoBarrier or Flexshield will assist with reducing noise near the source.

If generators are required for the site set-up, petrol generators or biodiesel / solar hybrid generators should be used instead of conventional diesel.

Mulchers are known to generate high noise levels. This can be managed by carrying out the mulching at a less noise-sensitive site, for example in a different location within the Zoo so that the distance attenuation to the residences provides a noise benefit to both noise-sensitive animals and residential receivers.

Electric tools are to be selected instead of petrol or pneumatic tools where possible.

Rock breaking, with a hand-held jackhammer or hammer attachment on an excavator, both generate high noise levels and can be associated with vibration that needs to be managed. Alternative reduced vibration methods of demolishing concrete or rock include pulverisers, pineapple head attachment on excavators, and concrete saw cut methods to lift away concrete in pieces. Pulverisers and pineapple head attachments are also quieter methods than demolition hammers and concrete saws.

Piling has the potential to cause significant noise impacts. The method of piling also needs to consider vibration effects on the structures nearby. The piling method needs to be selected to minimise both noise and vibration impacts and therefore bored or screw type piling methods should be implemented if practicable.

Large plate compactors have the potential to generate vibration as well as noise that may impact on receivers within the Zoo. Low noise and vibration compaction methods should be used where possible, including use of hand-held wacker packers if suitable.

Truck access should be limited to designated time periods and site access gates should be as far as possible from sensitive enclosures and well-used walkways. Vehicle pathways around the site should be arranged to minimise the need for reversing. Where reversing is necessary, non-tonal reversing alarms should be implemented where safe and practical.

Further noise and vibration controls are discussed in detail in the following sections.

12 Noise Management and Mitigation Measures

12.1 General noise control elements

The noise and vibration objectives, management and mitigation measures in environmental assessment documentation are based on an initial design and construction methodology. It is expected that the works methodology and staging may be altered. Consequently it may be necessary to update the assessment and associated noise management plan at several stages throughout the project.

As a general rule for best practices, prevention and elimination of noise would be applied as universal work practice during construction, especially when construction works are to be undertaken outside recommended standard hours.

Where elimination and prevention are not feasible options, the reduction of the noise at the source and the control of transmission path between the construction site and the receiver are the preferred options for noise minimisation through engineering and or administration controls. Providing treatments at the affected residences or other sensitive land uses would only be implemented as a last resort.

Construction noise would be managed by implementing the strategies listed below:

- Plant and equipment
  - Use quieter work methods.
  - Use quieter equipment.
  - Use low noise and vibration piling methods such as bored or screw piling, pulveriser and pineapple head attachments for demolition and rock breaking, and small or hand-held compactors for compaction methods
  - Use mobile noise curtains for external works with noisy hand-held tools such as concrete saws and jackhammers
  - For noisy works, consider carrying out in continuous blocks not exceeding 3 hours each, with a minimum respite period of one hour between each block
  - Operate plant in a quiet and effective manner.
  - Plant used intermittently to be throttled down or shut down.
  - Use mains power supply where possible, rather than use generators.
  - Use one larger generator to power multiple plant items (ensuring safe cabling). Use petrol or small biodiesel generators instead of diesel generators.

- Switch off generators and plant engines when not in use.
- Maintain equipment regularly, and carry out inspections and maintenance if equipment used on site is noted to have unusual noise and / or vibration characteristics (such as squeaky tracked tyres, squeaking suspension, and high engine noise which may indicate poorly performing mufflers).
- Where appropriate, obtain acoustic test certificates for equipment

- On site noise management
  - Strategically locate equipment and plant. Locate generators away from sensitive receivers.
  - Avoid the use of reversing alarms through site layout to minimise reversing, or provide for alternative systems such as non-tonal reversing alarms.
  - Maximise shielding in the form of existing structures or temporary barriers.
  - Enclose the work site as far as possible from receivers, and use hoarding. Noise reductions of at least 10dB are expected due to effective hoarding.
  - Schedule the construction of barriers and structures so they can be used as early as possible.
  - Consider signage at walkways affected by construction noise.
  - Manage waste removal from the site to minimise noise impacts.
  - Reduce noise from metal chutes and bins by placing damping material in the bin.
  - Locate waste deposit bins as far as possible from sensitive receivers.
  - Where possible, carry out noisy fabrication work at another site (for example, within enclosed factory premises) and then transport to site.
  - Delivery vehicles to should be fitted with straps rather than chains for unloading, wherever possible.
  - Keep windows closed during all internal works.
- Consultation, notification and complaints handling
  - Provide information to affected neighbours and zoo patrons before and during construction as required.
  - Maintain good communication between the community and project staff.
  - Have a documented complaints process and keep register of any complaints.
  - Give complaints a fair hearing and provide for a quick response.
  - Implement all feasible and reasonable measures to address the source of complaint.
- Work scheduling
  - Schedule activities to minimise noise impacts.

- Ensure periods of respite are provided in the case of unavoidable maximum noise levels events.
- Avoid simultaneous operation of noisy plant within discernible range of a sensitive receiver. Ensure noisy plant schedules are clear in Works Plan.
- Keep truck drivers informed of designated routes, parking locations and delivery hours.
- Schedule deliveries to planned construction hours only.

- Mandatory site rules of conduct
  - Avoid the overuse of public address systems, radios or stereos outdoors.
  - No swearing or unnecessary shouting.
  - No unnecessary dropping of materials from height, throwing of metal items, and slamming of doors.
  - No extended periods of engine idling.

12.2Construction-related Road Traffic

Construction-related road traffic is a temporary noise source but one which requires assessment and management, particularly for heavy vehicles accessing the site.

Construction vehicles likely to be generated by the proposed construction activities include:

- Articulated trucks for the delivery of machinery (including mobile cranes and diggers);
- Trucks to collect demolition and excavated materials;
- Large and medium sized mobile cranes;
- Excavators on wheeled tracks or rubber tyres (rubber ducks);
- General vehicles such as concrete trucks, medium rigid trucks, tradespeople's utilities and courier vans.

The temporary additional traffic increase due to construction would not result in an increase of 2 dB, which is considered to be noticeable.

However, it is also important to recognise that heavy vehicles associated with construction can generate maximum noise levels which are higher than general car traffic, and can lead to greater disturbance than cars.

Taronga Zoo's vehicle policy includes a limit on heavy vehicle movements to be used for removing spoil of other materials to between 7:30am and 4:30pm Monday to Friday, and between 7:30am to 1:00pm on Saturday, or as required by Mosman Council.

Access routes will be limited to the main Whiting Beach and Bradley's Head Road for the Top Station main construction compound, and via Athol Wharf Road entry to the secondary site compound near the Lower Station. It is noted that both routes pass a residential area, and therefore driver behaviour should be managed to minimise impacts.

Engine braking should be avoided, speed limits strictly observed, and heavy braking and accelerating avoided. These noise avoidance driver behaviours may need to be enforced through observation and monitoring, and all contractors and subcontractors are to be made aware of the need for noise-considerate driver behaviour when travelling to and from the work site.

Truck arrivals to and departures from site should be scheduled to occur outside the busiest traffic periods, but where possible should also avoid noise-sensitive night time periods.

Over-sized vehicles and deliveries may be required out of standard work hour to meet road safety requirements (for example, under a Road Occupancy Licence). In such cases, residents may need to be informed in advance if there is a potential for Sleep Disturbance due to night-time construction vehicle passby events.

The user of "rubber duck" smooth-wheeled excavators should be maximised where practicable, for example to use on relatively stable ground surfaces, as the rubber tyre noise is significantly lower than tracked excavator wheels.

12.3 Communication and complaints

The following procedures are an example of the procedures that would be specifically adopted for complaints relating to noise.

Upon receipt of a complaint The Contractor would:

- Try to ascertain from the complaint which appliance is causing the problem i.e. inside or outside the site and in what position;
- Establish from the monitoring equipment if the allowable noise levels have been complied with;
- Establish if the appliance positioning has previously been highlighted as a problem area. If not and the noise levels are above the allowable limit, then the equipment and its position shall be noted;
- Move machinery if the allowable levels have been exceeded or take other acoustic remedial action.

If the activity is occurring outside normal working hours, the activity would be immediately stopped. Where stopping the activity would create a safety issue the activity may be permitted to continue only as long as is necessary to make the area safe. The activity would then cease.

Any activity which is directed to cease due to excessive noise would not recommence until the Project Manager is satisfied that the requirements of the relevant criteria can be met and has given permission to recommence the activity.

The Site Supervisor would ensure that a report of any incident is provided to the Project Manager.

The Project Manager would provide a report on the incident to the relevant stakeholders.

The Contractor would provide a 24 hour telephone contact number and this number would be prominently displayed on the site.

12.4 Timing of works

The assessment of proposed construction activities has indicated construction noise levels are likely to meet or be within 5dB of the standard daytime construction NML at the nearest residential receivers, provided that the following noise control measures together with best practices detailed in the previous sections are considered in order to minimise the noise impacts.

- Construction activities would typically occur during the prescribed standard hours (at the least sensitive times of the day).
- Where work must be carried out during noise sensitive periods, residents would be informed and management principles would be in place to ensure a minimal amount of impact. This may include:
    - Do not use noise sensitive equipment likely to exceed the relevant criteria i.e impact or vibratory piling rigs, and diesel generators, rock-breakers, concrete cutters and jackhammers without effective noise curtains.
    - Where possible limit construction works to those internal to buildings so as to contain the noise and minimise noise emissions externally.
    - Outside standard hours, only carry out activities at locations where compliance with the criteria (RBL+5) can be achieved.

12.5 Cumulative construction noise impacts

The Sky Safari construction phase may overlap with one other project at Taronga Zoo: the Wildlife Hospital (SSD-33211326). The Wildlife Hospital construction has commenced in the third quarter of 2024. There may be a six month overlap between the Wildlife Hospital and Sky Safari works.

The Wildlife Hospital is located over 100m from the Sky Safari works, and the noise levels from the Sky Safari are unlikely to increase the noise experienced by the nearest affected receivers located to the west of the Wildlife Hospital works.

To manage potential additional noise impacts, deliveries for concurrent projects should use the main entrance so that there is no increase in construction vehicle and delivery noise.

The Upper Australia Precinct and the Reptile and Amphibian Conservation Centre are both complete and are operational.

12.6 Equipment and plant selection

This assessment has been based on typical noise sources defined in AS 2436-2010. The contractor would aim to choose the quietest pieces of equipment where feasible and reasonable. If the final equipment selection varies significantly from items specified in **Table 18**, it is recommended that an additional assessment be carried out for noise sources other than those included in this report and revisions made to the noise management plan where necessary.

Based on the results of the assessment, key pieces of equipment have been noted to dominate the overall noise contribution at the receiver position including piling rigs, concrete saws, jackhammers and dump trucks.

Where possible alternative methods or selection of quieter equipment such as pulverisers would be considered. Lessening the time in use and ensuring equipment is not used simultaneously will further reduce the noise impact at residents.

Where possible, reduce the number of noise sources/activities running simultaneously at the same location.

Limit the number of site vehicles such as dump trucks at any one time.

A screen or enclosure would be used when carrying out external building works that are predicted to exceed the noise management level at environmental receivers. Typically screens and enclosures constructed with plywood would be sufficient. Reference shall also be made to specific screening and enclosures detailed in Appendix F of AS 2436:2010.

12.7 Vibration Management Measures

It is the contractor's responsibility to identify potential vibration generating sources in the proposed work methods.

The contractor shall refer to the demolition and landscaping plans to determine where rock cutting, excavation, piling, or other vibration-generating activities are to occur. The contractor shall refer to the Structural Engineer's report and plans to identify structurally sensitive or historic or sensitive structures requiring protection from vibration.

The Contractor would carry out a review of vibration generated by construction activities. The levels of vibration generated will be site specific and will depend upon the type of

activity, the particular equipment used, and the proximity of the construction activity to the nearest occupied spaces within the affected properties. The Contractor would carry out a preliminary vibration survey, which will determine whether a means of vibration mitigation will be necessary on the site.

12.7.1 Works requiring a vibration assessment

A preliminary vibration assessment is to be carried out for each key vibration generating activity, ie:

- Piling
- Rock breaking
- Pulverising
- Concrete saw cutting
- Jackhammering
- Percussive / Hammer drilling
- Concrete and brick drilling
- Any other activities proposed by the contractor which is likely to generate perceptible vibration.

These activities should also be monitored for the risk of cosmetic damage.

When considering the measured vibration impact associated with construction works, the following would be taken into account.

- The layout of the site, including the location of static sources of vibration.
- Techniques used in construction to minimise generated vibration levels.
- Hours of work with regard to the nature of operations in the affected receivers and the duration of the works.

12.7.2 Dilapidation survey

Vibration-intensive activities such as heavy demolition, excavation, tunnelling and piling often warrant condition surveys and monitoring. Condition surveys are particularly important for heritage or historically important items and features, as well as structures which have been identified as potentially susceptible to damage.

The key heritage items in the vicinity of the project (within 50m of each station) are:

- Top Station: Main Entrance Building, Original path 1916-1974, Former pathway 1935. The Top Station / Storage building will require removal of some of the external heritage-listed wall, as shown in **Figure 7**.
- Lower Station: Original Elephant Walk and Associated Structure 1916-1979, Miniature Railway and Station 1935-1979, Marry-Go-Round 1935-1981, Original Pathway, 1916-1979, Former Wallaby / Nursery Enclosure 1920-1988.

Along the Sky Safari route, heritage and potentially vulnerable structures near pylons include, but are not limited to:

- Rock faces and overhangs which are part of the natural landscape – some of these may have already been pinned, however others may require a structural assessment to determine whether propping or pinning is needed;
- Any built elements including stairs and retaining walls near proposed pylon locations which may be susceptible to damage from construction vibration are to be visually inspected. A dilapidation or condition survey within 50m of any station, building, maintenance facility or pylon location will identify any other features which may be susceptible to construction-related vibration due to existing damage, cracking or other evidence of being structurally unsound or vulnerable.
- Any built elements that are near to excavation and piling locations require an assessment to determine whether they are to be retained, and if so, whether particular care is needed to protect them. For example, there is a modern retaining wall near pylon 6 which, if retained, is likely to withstand typical construction vibration but would need to avoid having holes drilled into its buried concrete strut supports.

TCSA have provided Acoustic Studio with heritage maps which identify potential items of historic or heritage significance in or near the site. They include built features and trees. These items are to be protected from vibration and other construction-related effects.

Figure 7: Aerial plans showing items of historic or heritage significant within and surrounding the site (Top Station at top, Lower Station bottom). Provided by TCSA 22 May 2024.

The Contractor's Works Plan should identify and describe heritage items and other potentially vulnerable structures which will themselves be subject to demolition and potentially reconstruction works, including a retaining and external wall within the site.

Any works affecting the heritage or other potentially vulnerable items, requires close consultation with a heritage specialist as well as a structural engineering and / or civil engineering specialist for planning and carrying out the works.

The Contractor would be required to conduct a dilapidation survey up to 50m from the work site prior to high vibration works.

12.7.3 Vibration monitoring inside the Zoo

Preliminary vibration monitoring is to be carried out for each key vibration generating activity, i.e.:

- Excavator with hammer attachment
- Percussive piling
- Rockbreaking
- Jackhammering
- Concrete saw cutting

- Percussive / Hammer drilling
- Concrete and brick drilling
- Any other activities proposed by the contractor which is likely to generate perceptible vibration.

The purpose of the vibration monitoring is to assess the risk of potential structural damage to historic, heritage or other vulnerable structures within the premises.

Monitoring is also required in situations where there are changes in equipment and activities or work procedures that might affect existing vibration control measures. The monitoring procedure would be carried out with appropriate equipment so as to provide results that are readily comparable to the preliminary survey and relevant criteria provided in Section 8.3 and 8.4.

If vibration monitoring is required at any item or structure with heritage or historic significance, the method of affixing the vibration sensor will need to be reviewed and approved by a heritage consultant to ensure that there is no damage to the item or structure.

12.8 Noise monitoring and reporting

Due to the low predicted construction noise impact risk on residential receivers, provided that the recommended noise control measures can be applied, noise monitoring at residential receiver locations is unlikely to be required.

Noise monitoring is recommended if noise-intensive piling such as impact sheet piling cannot be avoided, or other activities that result in residential noise level predictions exceeding the NML by more than 10dB. For example, noise monitoring may be considered during heavy demolition, excavation and piling works.

Additional positions (for example, in the Zoo premises) may also be selected for noise monitoring.

It is recommended that if noise monitoring is carried out, then it should be for a minimum of 1 week during the period where the greatest impacts are expected, or for the duration of the noisy works (whichever is less). Monitoring results can be reviewed at the end of the week, however could be reviewed on more regular intervals depending on the type of work and level of noise expected. The requirement for further monitoring would be reviewed after this time or sooner if deemed necessary by the Acoustic Consultant and Project Manager.

12.9 Construction noise and vibration compliance

This report establishes applicable noise management levels or targets for the proposed works. Potential vibration effects have been identified.

Works that will require careful noise and vibration management include pneumatic breakers during rock-breaking, percussive piling, concrete pumps, and dumping spoil into trucks. This list is not exhaustive.

The contractor may be requested by Taronga Zoo to prepare a detailed Construction Noise and Vibration Noise Management Plan for the works once the demolition and construction method is more progressed. This Plan would focus on managing impacts within the Zoo premises, and will need to outline the proposed stages of work, plant and equipment to be used, and times of day during each week that construction is expected to occur. The Plan will need to demonstrate that all feasible and reasonable measures will be applied to meet the relevant Noise Management Levels.

All feasible and reasonable measures to meet the applicable Noise Management Levels will need to be identified and applied.

Acoustic Studio strongly recommends that works are conducted during standard construction hours where possible. However, where the works are expected to be inaudible at the most affected residential receivers, some out of hours works may be necessary. Such flexibility would ensure that public safety within zoo premises is not compromised by construction activity, while still maintaining acoustic amenity for local residents. An example is building fit-out works carried out entirely within the new buildings, provided that windows and doors are kept closed.

Particular consideration of construction-related road traffic noise impacts is required. Construction vehicles are to observe the Zoo requirements described in the Construction Management Plan.

Dilapidation surveys are recommended for nearby historic and heritage structures.

13 Summary and Conclusions

A noise assessment has been carried out for the proposed Taronga Zoo Sky Safari development at Taronga Zoo, Mosman.

External noise emissions associated with the operation of the Sky Safari have been assessed. The assessment has adopted methodology from relevant guidelines to assess particular noise sources and expected worst-case impacts as follows:

- External mechanical plant and maintenance noise emissions – NSW Noise Policy for Industry (NPfI) overall A-weighted noise criteria;
- Patron and sound system noise (e.g. from Public Address systems) – LAB octave band criteria (as a reference, although not strictly applicable, to assess potential for disturbance due to this noise).

Short-term and week-long ambient noise monitoring has been carried out to establish the existing background noise levels of the neighbourhood.

The noise impacts have been predicted at the most sensitive boundary positions, taking into account distance attenuation, building and ground reflections, directivity and, where applicable, shielding by the zoo buildings / structures.

A general operational environmental noise assessment has been carried out for mechanical plant and cleaning and maintenance activities. These noise sources are likely to be effectively controlled through:

- Appropriate design and location of the mechanical systems during the detailed design stage: responsibility of the architect, builder and mechanical and acoustic consultants;
- Design of directional public address speaker systems and provision of screening, if required to minimise noise spill (primarily to prevent disturbance to animals in nearby enclosures); and
- Management controls for the timing of cleaning and maintenance activities, such as pressure hosing cable cars inside the enclosure with doors closed.

A high level construction environmental noise assessment has been carried out, based on assumptions about the type of equipment that would be used on site. These noise sources are likely to be effectively controlled through:

- Hoarding around the work site, and local enclosures of noisy plant or activities;
- Selection of quieter plant, including a commitment to use quieter petrol or biodiesel / solar generators rather than diesel generators if generators are required;
- Use of electric rather than pneumatic or petrol hand tools where possible;
- Selection of quieter methods where possible and appropriate, particularly for piling, excavation and jackhammering;

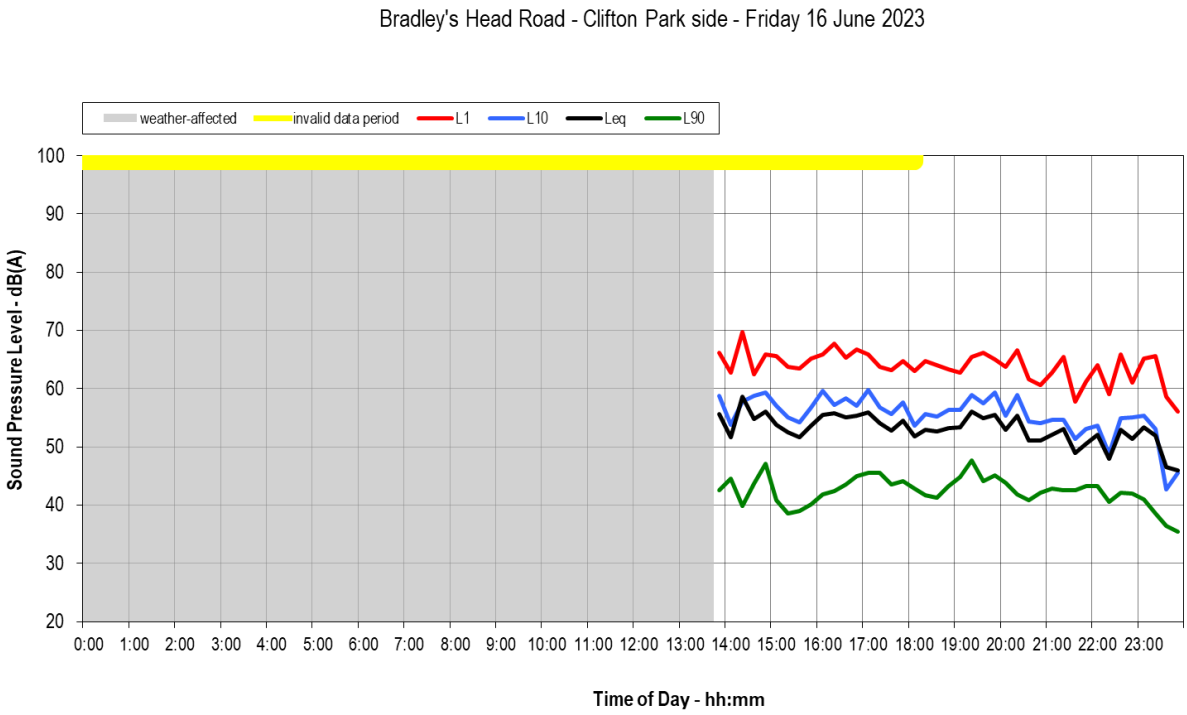
- Selection of low vibration work methods where possible and appropriate;
- Vibration monitoring and management controls for historic, heritage and other potentially vulnerable structures.

Provided the recommendations detailed in this report are correctly implemented, it is anticipated that the Sky Safari construction and operations will have no adverse noise impact at the nearest residential receivers.

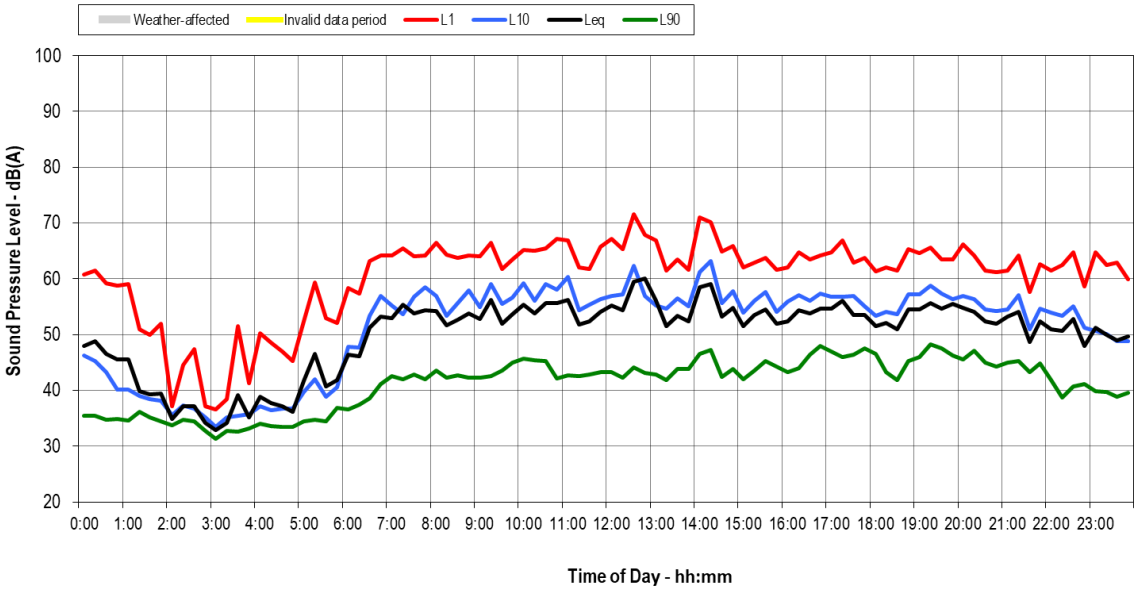
APPENDIX

Noise logger graphs

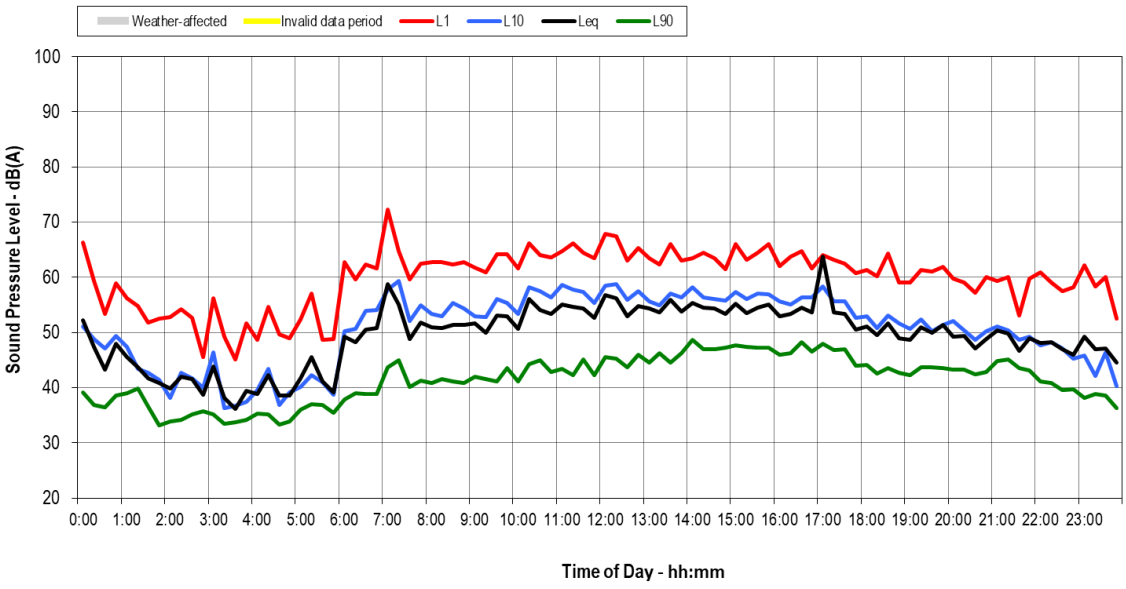
2023 data from Bradley's Head Road (Clifton Park side) – full seven days could not be recorded after noise logger was vandalized. Only data prior to equipment damage is presented.



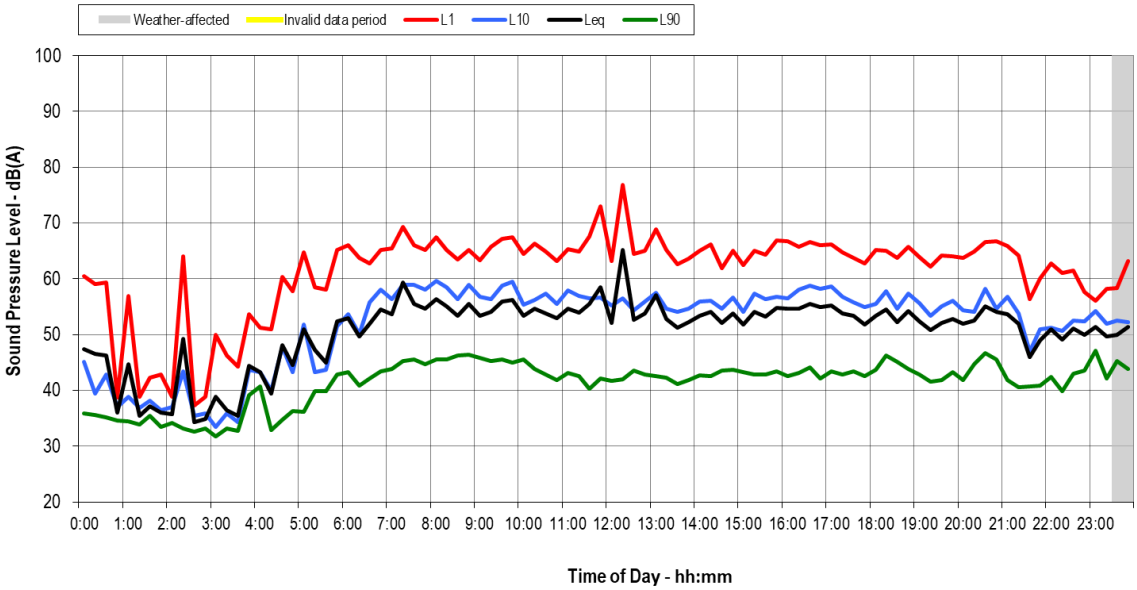
Bradley's Head Road - Clifton Park side - Saturday 17 June 2023



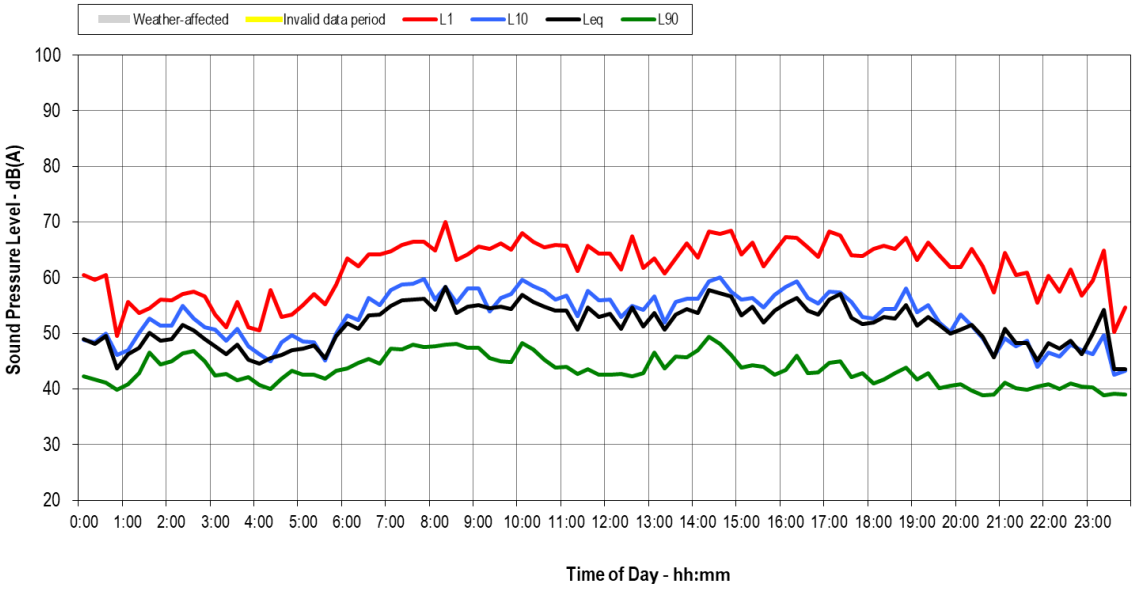
Bradley's Head Road - Clifton Park side - Sunday 18 June 2023

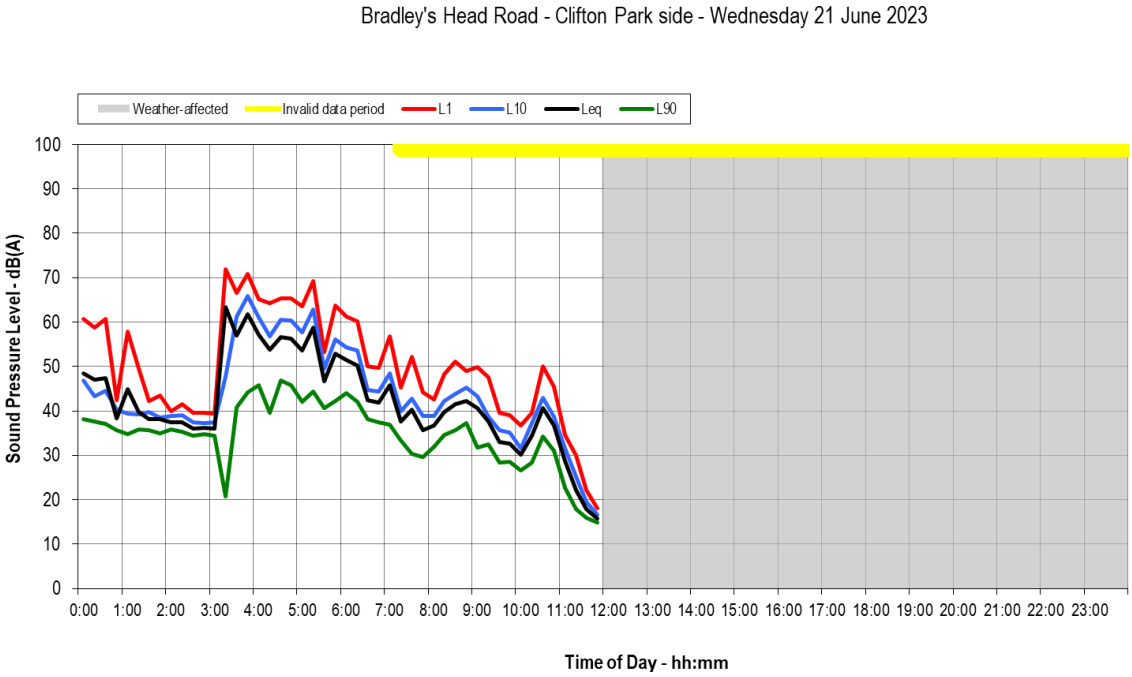


Bradley's Head Road - Clifton Park side - Monday 19 June 2023

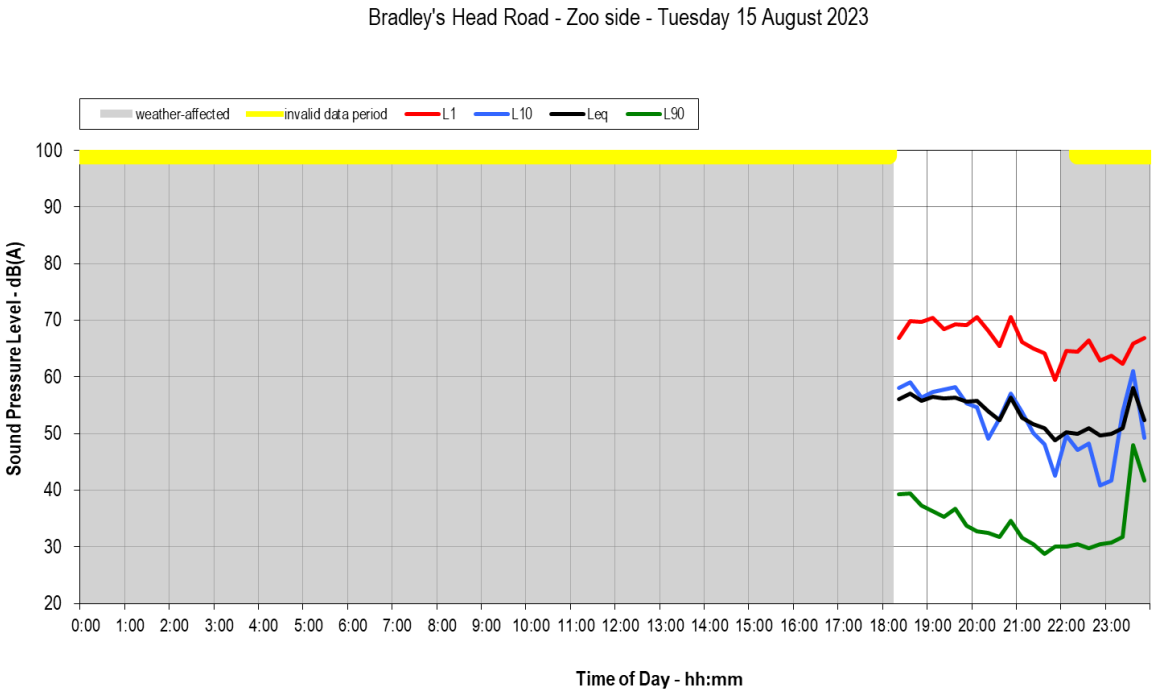


Bradley's Head Road - Clifton Park side - Tuesday 20 June 2023

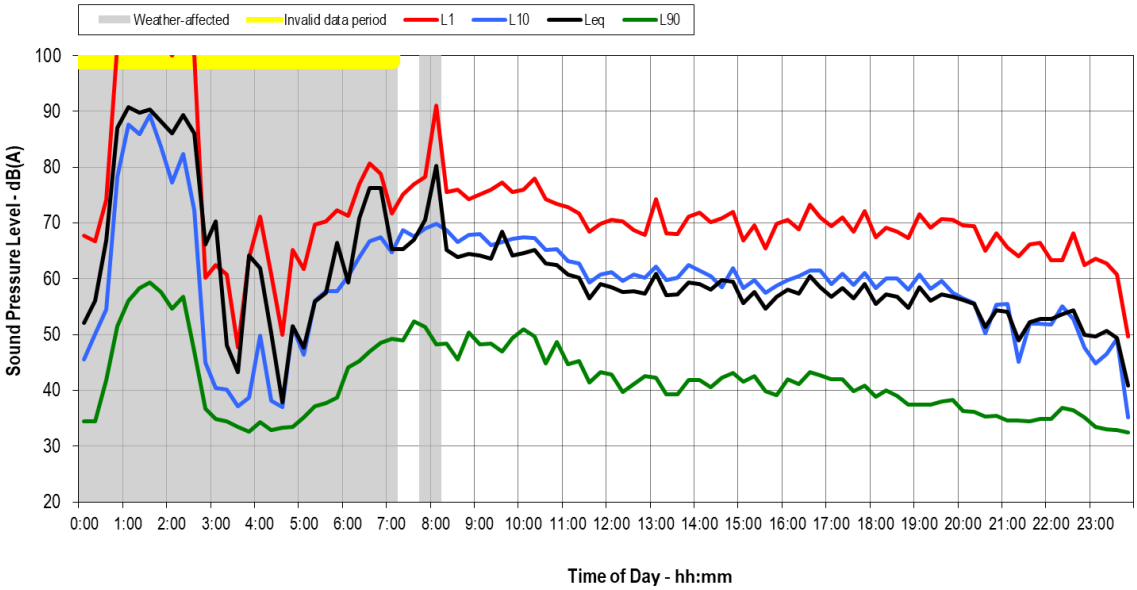




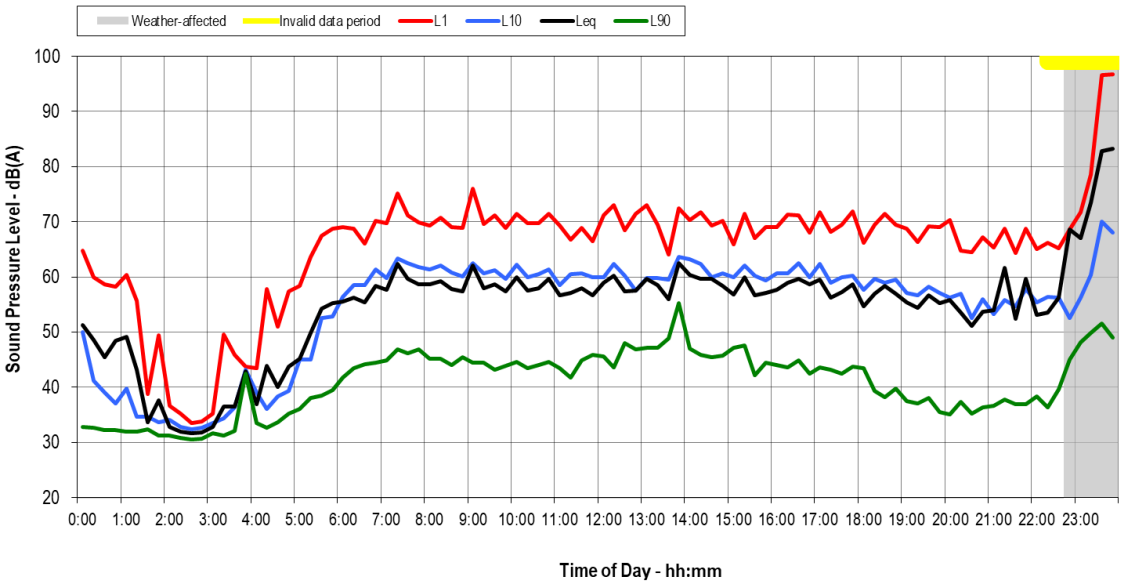
2023 data from Bradley's Head Road – zoo side (secure location). Some unexplained high noise levels measured at night on 16th to 17th August 2023 ad 17th to 18th August 2023. This data has been excluded from the analysis.



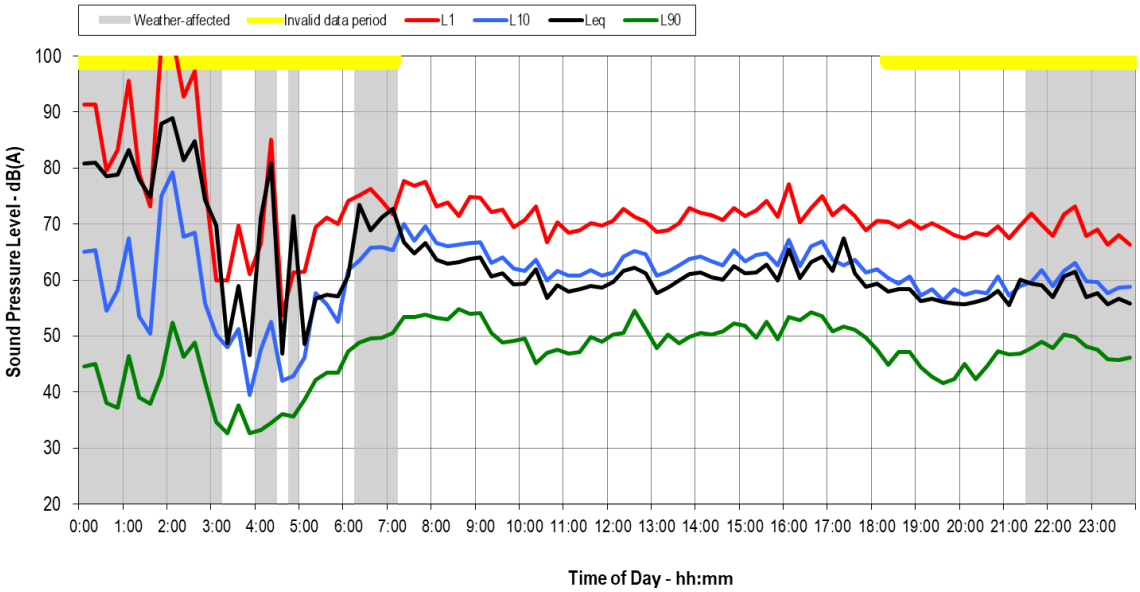
Bradley's Head Road - Zoo side - Wednesday 16 August 2023



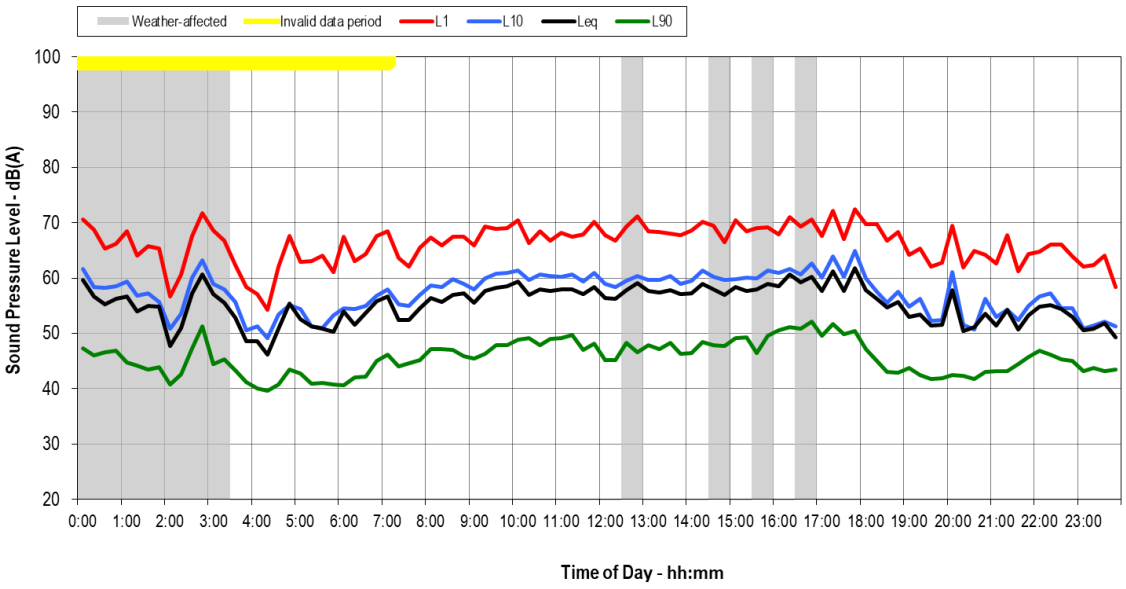
Bradley's Head Road - Zoo side - Thursday 17 August 2023



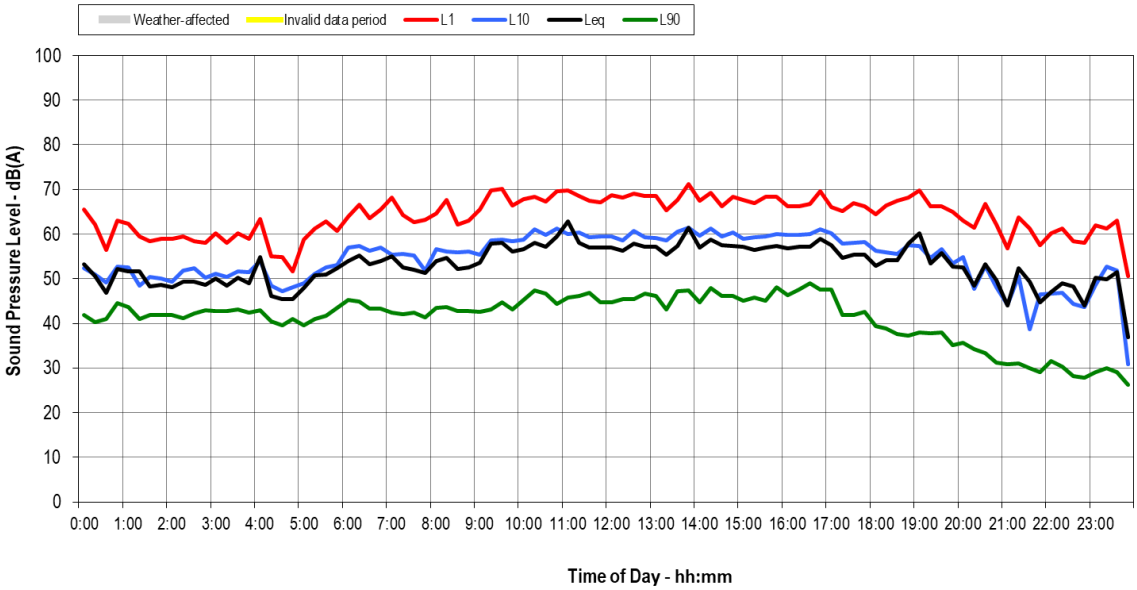
Bradley's Head Road - Zoo side - Friday 18 August 2023



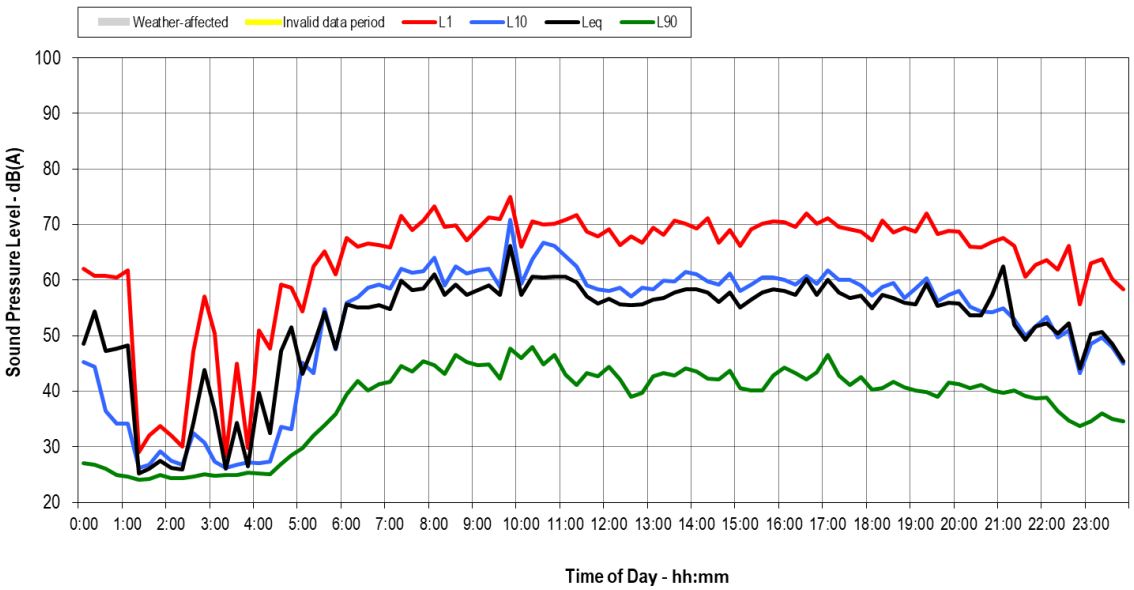
Bradley's Head Road - Zoo side - Saturday 19 August 2023



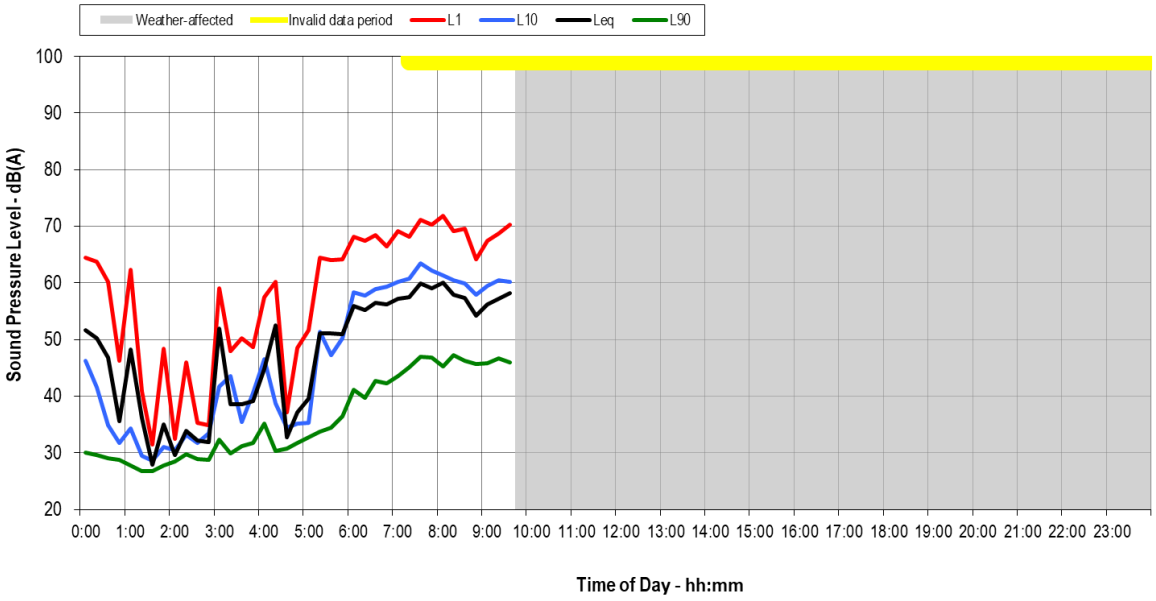
Bradley's Head Road - Zoo side - Sunday 20 August 2023



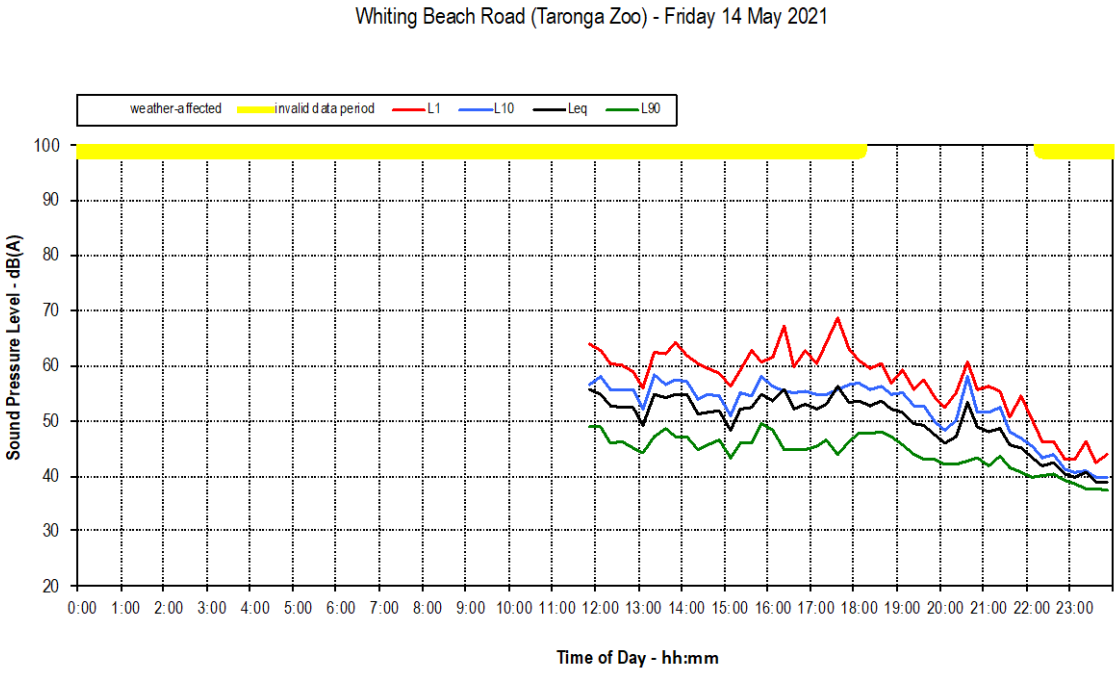
Bradley's Head Road - Zoo side - Monday 21 August 2023

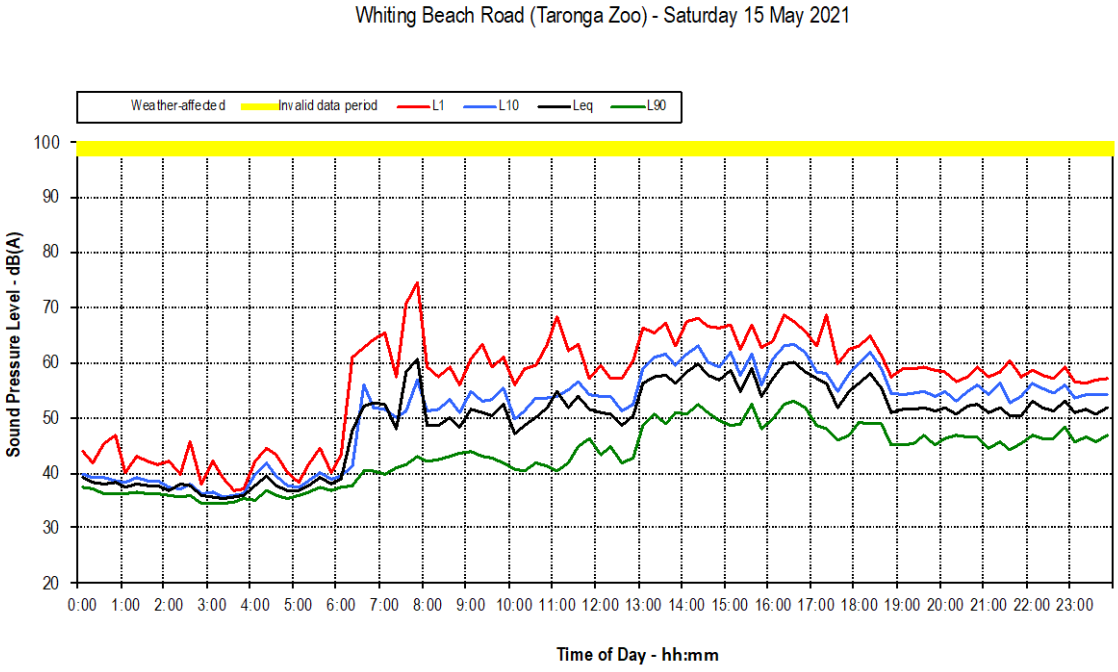


Bradley's Head Road - Zoo side - Tuesday 22 August 2023

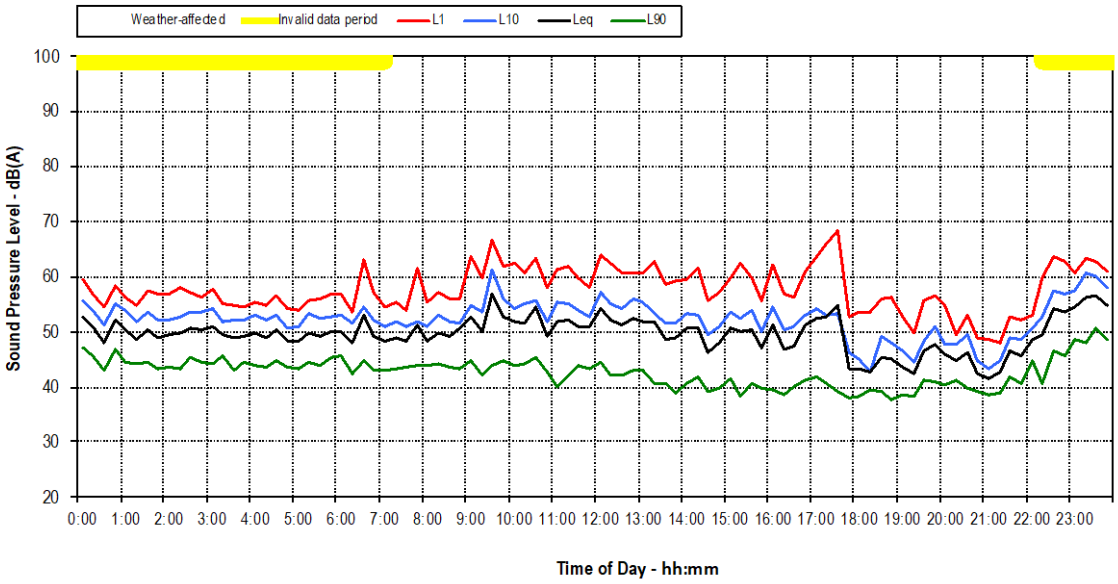


2021 data – Potentially affected by COVID-19 reduced activity. Also weather-affected and missing data due to intermittent logger failure.

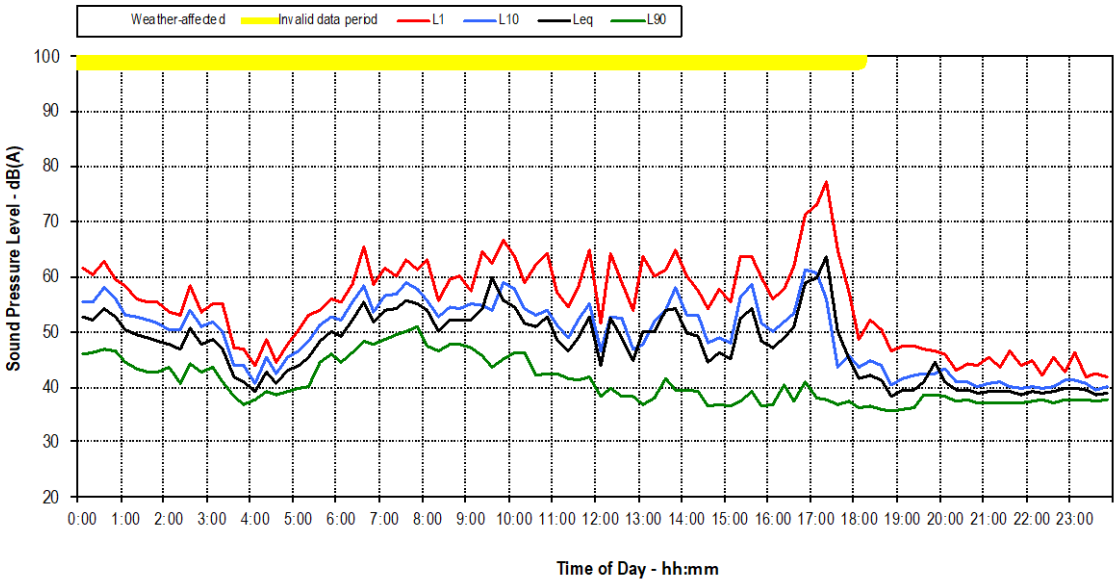




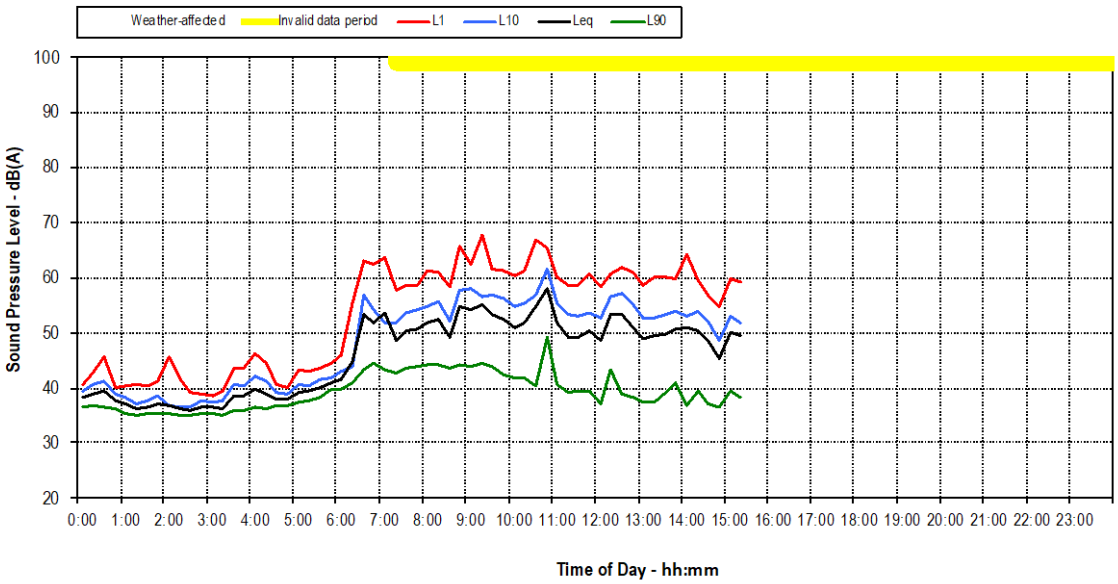
Whiting Beach Road (Taronga Zoo) - Sunday 16 May 2021



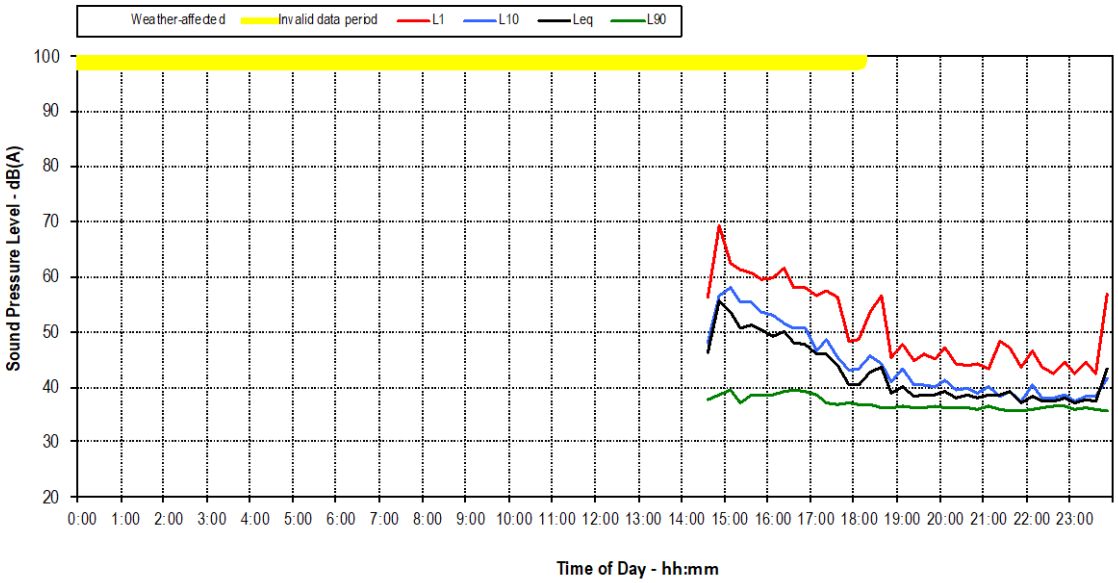
Whiting Beach Road (Taronga Zoo) - Monday 17 May 2021



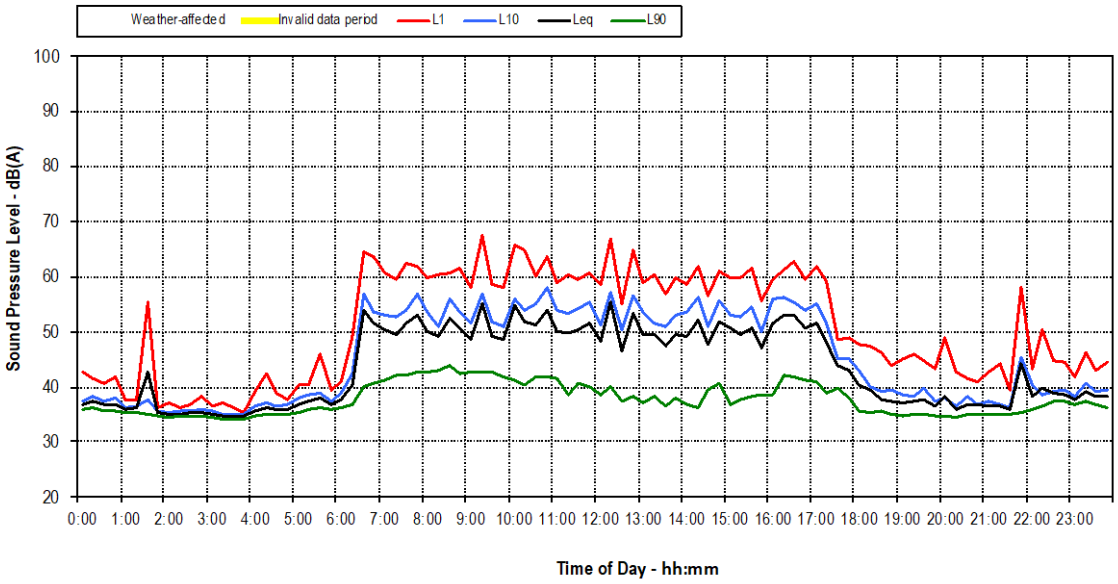
Whiting Beach Road (Taronga Zoo) - Tuesday 18 May 2021



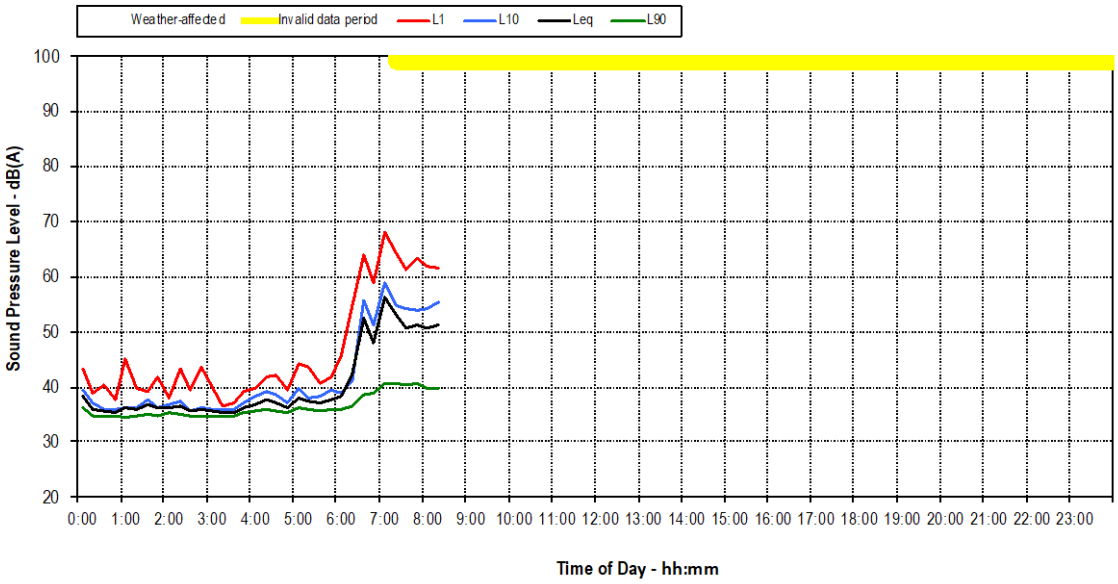
Whiting Beach Road (Taronga Zoo) - Friday 21 May 2021



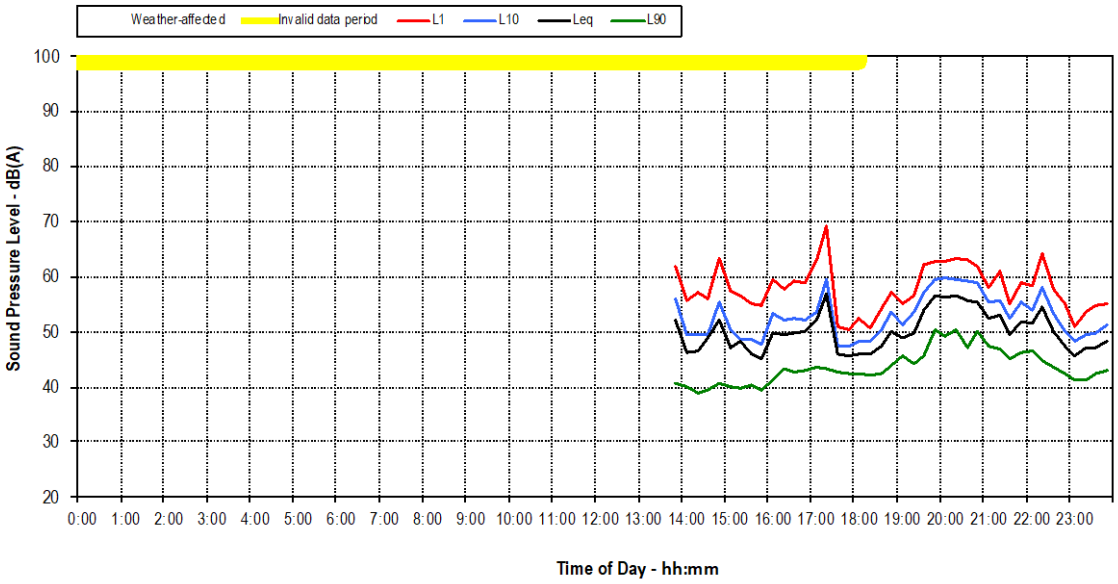
Whiting Beach Road (Taronga Zoo) - Saturday 22 May 2021



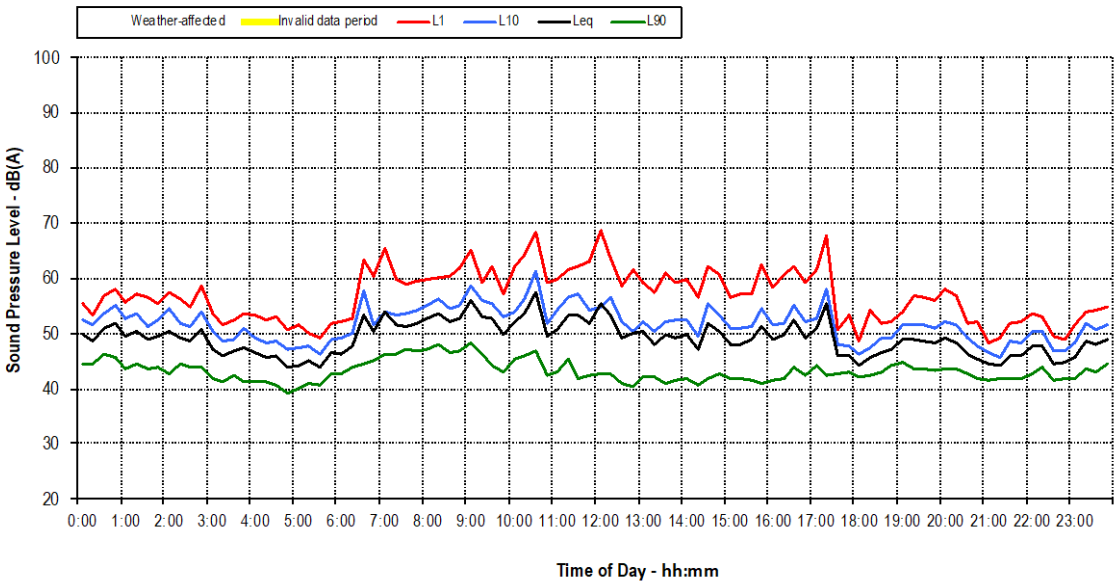
Whiting Beach Road (Taronga Zoo) - Sunday 23 May 2021



Whiting Beach Road (Taronga Zoo) - Wednesday 26 May 2021

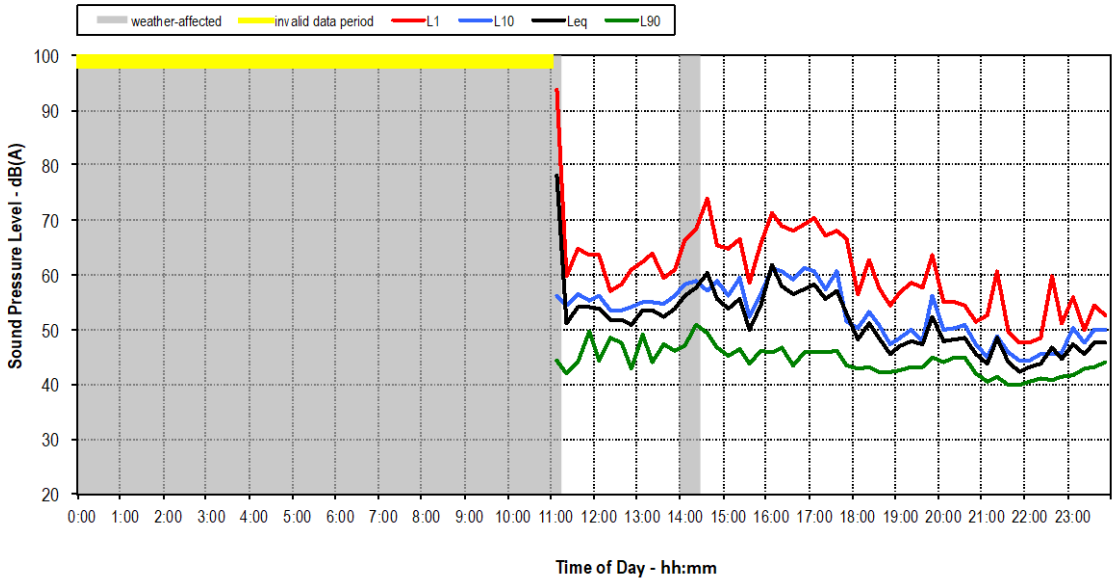


Whiting Beach Road (Taronga Zoo) - Thursday 27 May 2021

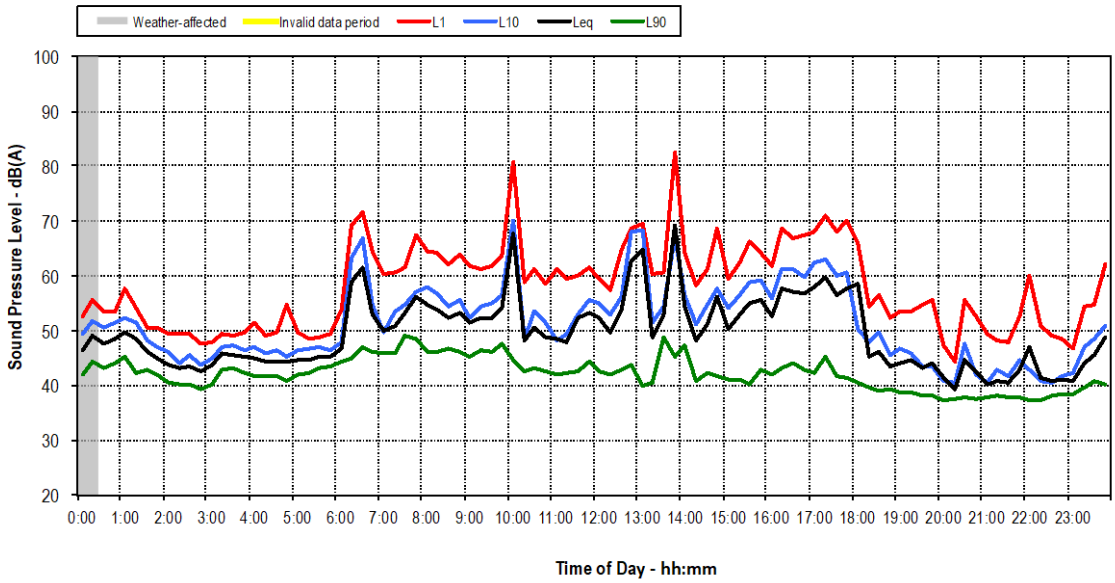


2017 data – Not affected by COVID-19 reduced activity (pre-COVID-19), and still valid as less than five years old.

Taronga Zoo - Rickard Rd - Thursday 27 April 2017



Taronga Zoo - Rickard Rd - Friday 28 April 2017



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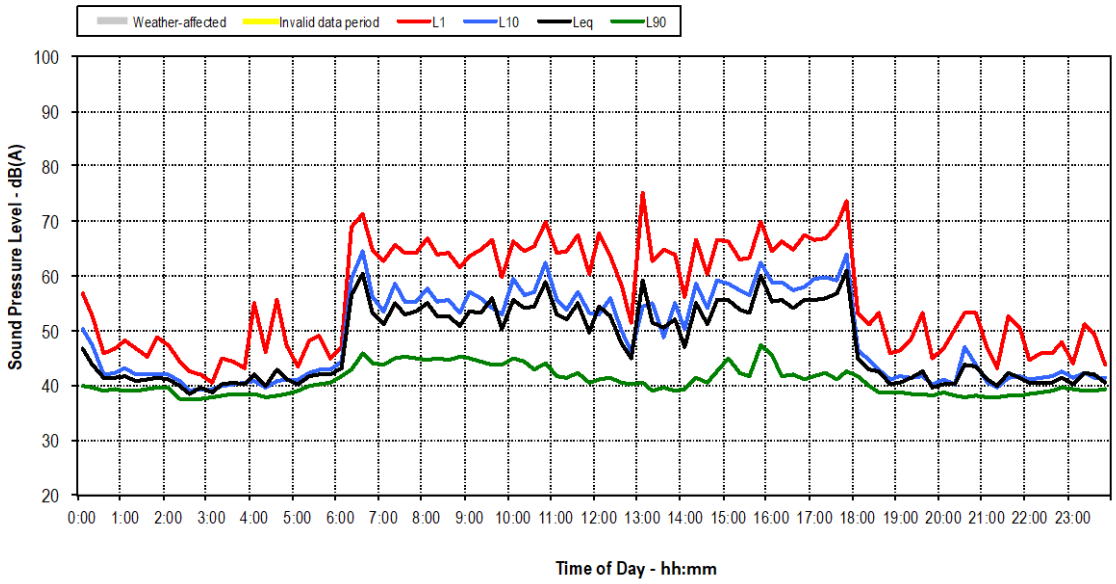

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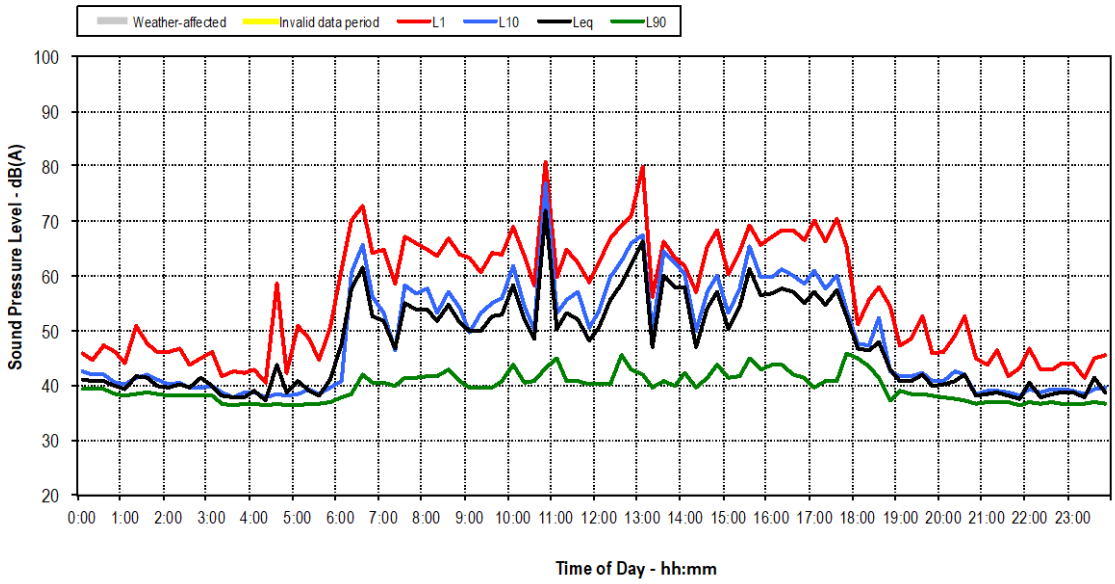
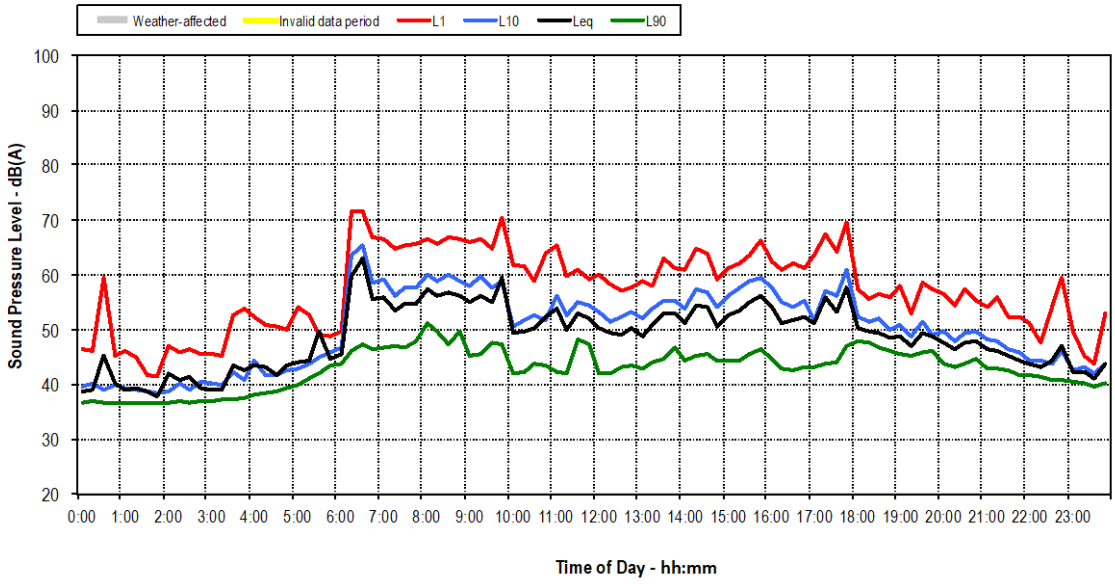


Taronga Zoo - Rickard Rd - Monday 01 May 2017



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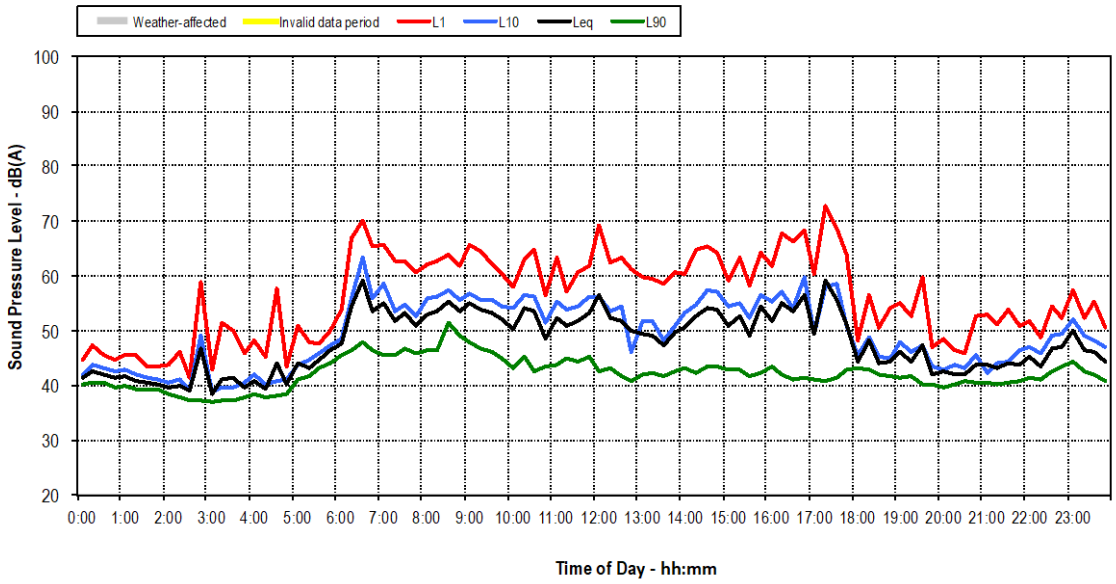

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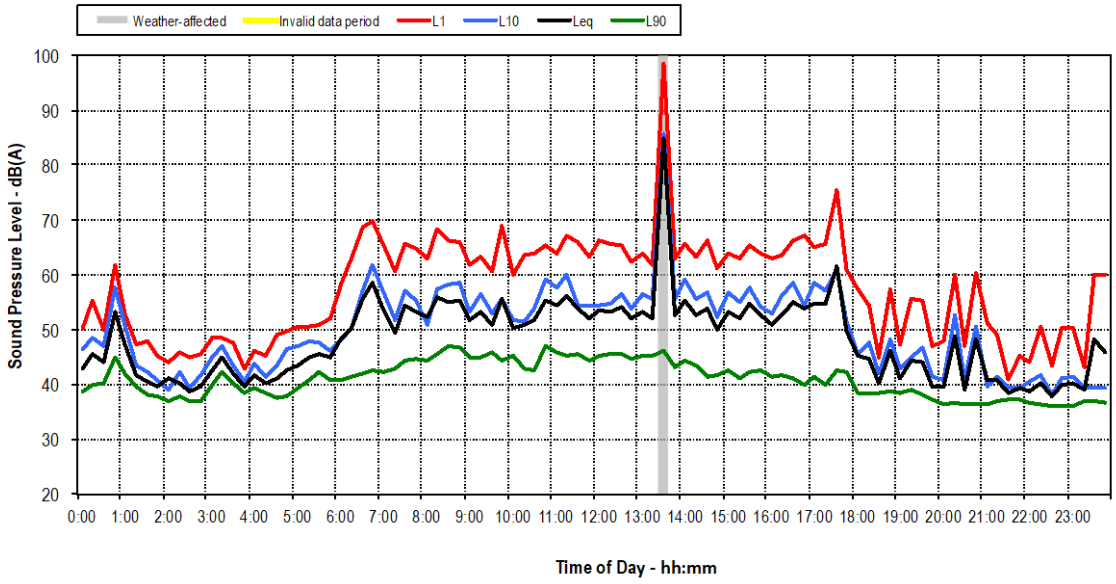
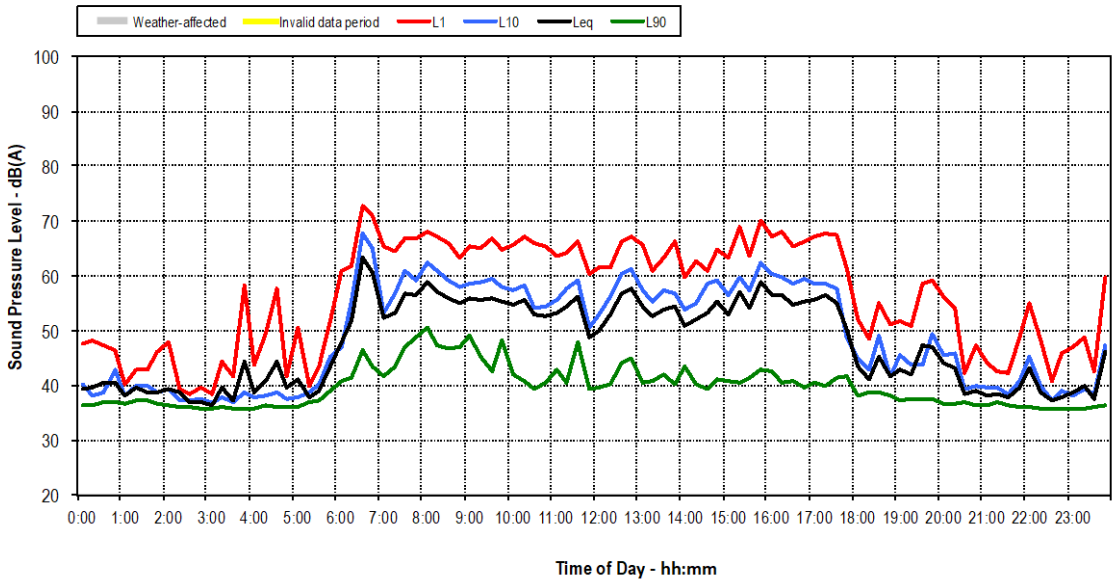


Taronga Zoo - Rickard Rd - Thursday 04 May 2017



Taronga Zoo - Rickard Rd - Friday 05 May 2017