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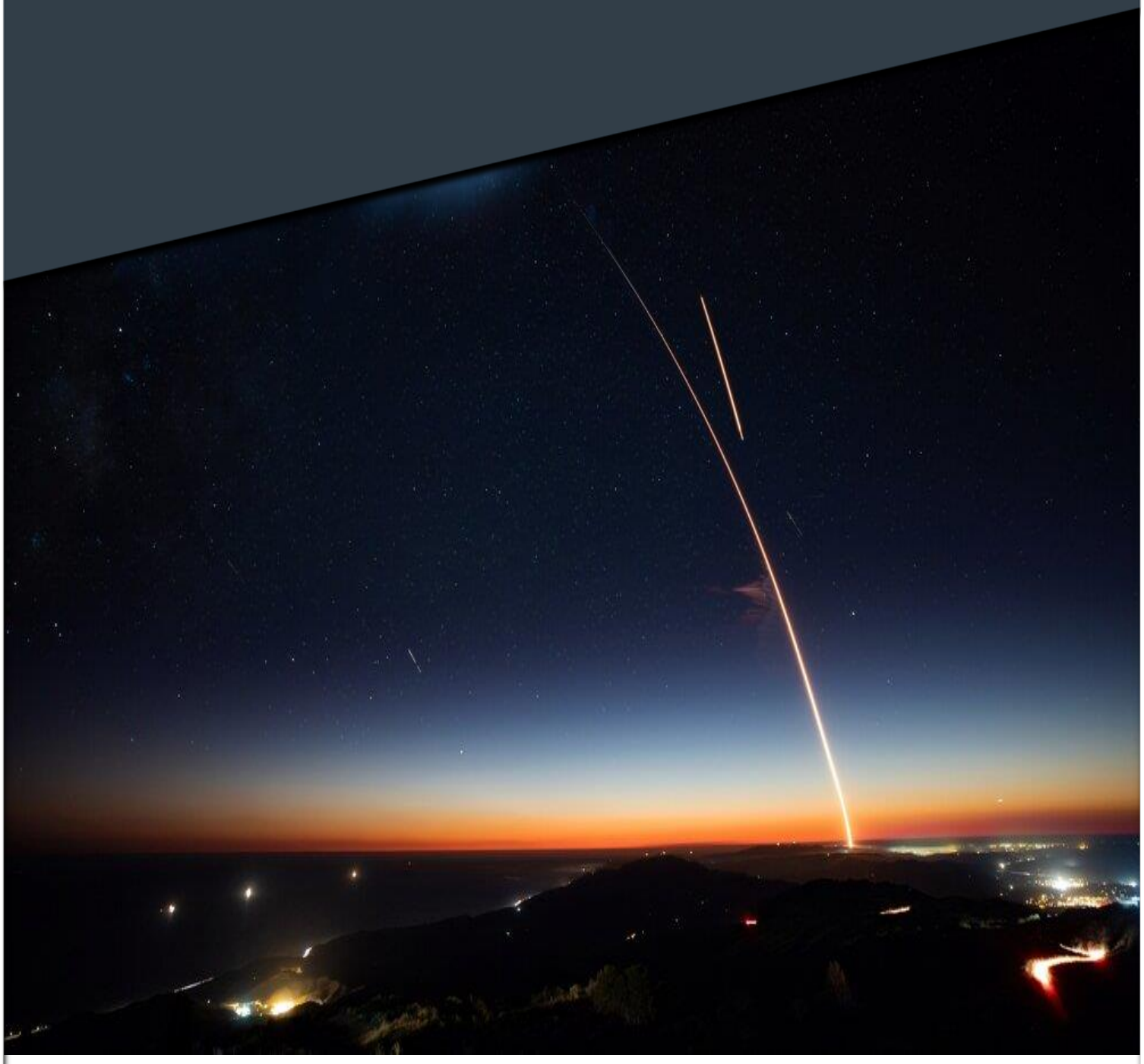
Whalers Way Orbital Launch Complex
Southern Launch
21-Dec-2020
Doc No. 60627263-AC-RP-0001

Whalers Way Orbital Launch Complex - Environmental Assessment Report

Noise and Vibration



Revision 3 – 21-Dec-2020
Prepared for – Southern Launch – ABN: 33 621 420 504

Whalers Way Orbital Launch Complex - Environmental Assessment Report

Noise and Vibration

Client: Southern Launch

ABN: 33 621 420 504

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Reviewed by David Peoples

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
0	20-Apr-2020	Draft for comment	Lee Evans Principal Engineer - Acoustics	
1	24-Jul-2020	Final Draft	David Peoples Technical Director - Acoustics	
2	10-Sep-2020	Final for review	David Peoples Technical Director - Acoustics	
3	08-Dec-2020	Final	David Peoples Technical Director - Acoustics	

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Appendix B
Baseline monitoring B

Executive Summary

Southern Launch propose to construct the Whalers Way Orbital Launch Complex (the Project). The Project is located on the southern tip of the Eyre Peninsula in Sleaford and features two launch facilities and supporting infrastructure. An environmental noise and vibration assessment has been undertaken to support project planning and required statutory approvals.

Overview

The assessment included a desktop study to identify the relevant legislature and sensitive receptors near the proposed project footprint, the undertaking of baseline noise measurements, and the development of a construction and operational noise impact assessment.

Legislature

Human amenity impacts from industry are regulated in South Australia by the *Environment Protection Act 1993*, specifically the *Environmental Protection (Noise) Policy 2007* (Noise EPP). These documents do not include specific regulatory requirements for managing noise and vibration impacts from space operations. This information has been sought from international regulatory authorities and scientific publications.

Baseline conditions

The sensitive receptors identified within the Project study area include nearby wildlife (assessed separately) and residences approximately 2.5 kilometres from the closest Project launch site.

The baseline noise environment was measured at five different locations over several days in conjunction with the preliminary ecological fieldwork. The background levels in the study area were considered typical of rural and remote areas with low residential density and little exposure to transportation or industrial noise.

Construction and operational impact assessment

Construction and operation scenarios were based on data provided by Southern Launch and information from projects of a similar nature. These scenarios were used to calculate the potential impacts associated with key project activities. Construction noise was assumed to be concentrated around the Project Areas with notable impacts likely to be limited to regions within 500 to 1000 metres of the works. No residences were noted within this distance from the proposed works.

The proposed launch facility would include buildings and supporting infrastructure that provide office space, workshops and storage areas. The operational noise produced by activities within these spaces is unlikely to impact the neighbouring areas if noisy workshop equipment and plant is adequately mitigated.

Noise from launches and stationary rocket testing are predicted to temporarily alter the quiet setting of the natural environment with noise briefly above the measured ambient level at distances further than five kilometres from the launch.

This sudden noise increase is likely to cause a disturbance to residents at nearby properties, particularly if launches were to occur at night. Noise produced by the rocket is expected to be loudest during the initial thrust at ground level (15 – 30 seconds) and gradually reduce as the engines decrease power while the vehicle ascends away from noise sensitive areas (1 – 2 minutes).

Indicative noise levels during a launch were predicted to be lower than the Day Night Level (DNL) of 65dB(A) that is used by the United States, Federal Aviation Administration (FAA) to assess the significance of noise exposure from aircraft operations at nearby residential properties.

Mitigation measures

Engineered source mitigation includes a noise suppressing water deluge system and blast walls to channel the rocket exhaust away from the pad and sensitive receptors.

Southern Launch would also develop a stakeholder engagement plan to inform residents prior to launch activities and a monitoring plan that would include the measurement of noise during launches to verify the effectiveness of onsite mitigation measures.

1.0 Introduction

1.1 Project Overview

AECOM Australia Pty Ltd (AECOM) were engaged by Southern Launch.Space Pty Ltd (Southern Launch) to undertake an environmental noise and vibration assessment for the Whalers Way Orbital Launch Complex (WWOLC) (the Project). Southern Launch seek to establish infrastructure that will support the launch of domestic and international launch vehicles providing the safest and most cost-effective orbital launch site in the world servicing the growing demand for Polar and Sun Synchronous Orbit satellite insertion.

Southern Launch currently have a number of customers who will be ready to launch from the proposed facility from early 2021. The current development proposal for the Launch Complex is anticipated to be undertaken in five phases across up to four locations on the subject site between 2020 and 2024.

The indicative staging is as follows:

- Stage 1 - A permanent launch pad and permanent launch support infrastructure
- Stage 2 - A second permanent launch pad and permanent launch support infrastructure
- Stage 3 - A permanent range operations centre and permanent visitors centre
- Stage 4 - A permanent engine test stand and test support infrastructure
- Stage 5 - Non-conventional launch facilities (not part of the current application).

The Project comprises of the following key components, which hereinafter will be referred to as the Project Area:

- Launch Site A
- Launch Site B, including the construction of a new road alignment to the east and south
- Infrastructure Site D, including the construction of a new road alignment to the south
- Range Control Site E
- Whalers Way Road upgrade
- Access track upgrades to the north and west of Infrastructure Site D.

The Project was declared a Major Development by the Minister of Planning on 22 August 2019. As such, a range of environmental assessments are required to support the Major Development Application that Southern Launch is preparing.

1.2 Location

The Project Area is located at the southern tip of the Eyre Peninsula in Sleaford, commonly known as Whalers Way (see Figure 1). It is approximately 25 km southwest of Port Lincoln in South Australia (SA), in the District Council of Lower Eyre Peninsula and comprises a portion of the allotment identified in Table 1. The land is owned by Theakstone Property Pty Ltd. Southern Launch have entered into a Commercial Access License (‘the License’) with Theakstone Property Pty Ltd for specified purposes associated with the Southern Launch Project.

The Project Area has access from Right Whale Road at the north eastern corner of the land. Access to the project Area from Port Lincoln follows Proper Bay Road, Fishery Bay Road to Right Whale Road before entering the site and continuing via private access track commonly known as Whalers Way Road.

Table 1 Certificate of Title of Project Location

Allotment	Plan	Hundred	Volume	Folio
101	71437	Sleaford	5993	374

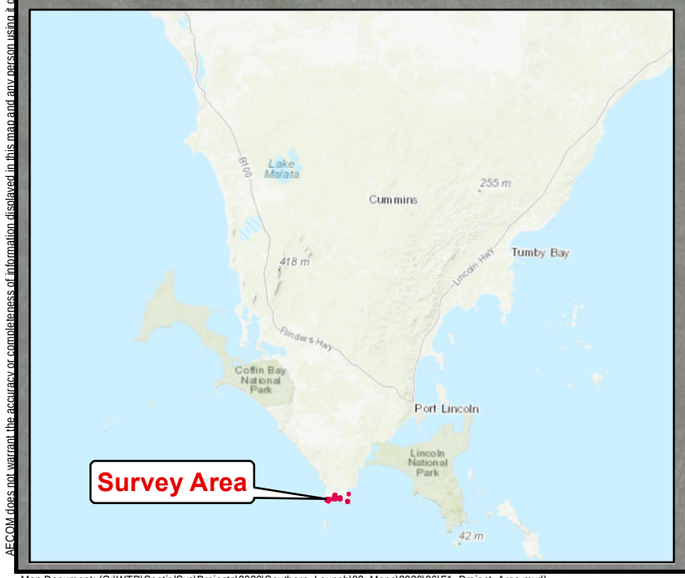
Infrastructure Site D

Launch Site B

Launch Site A

Range Control Site E

Whalers Way Rd



PROJECT ID 60627263
CREATED BY brierej
LAST MODIFIED brierej 01 DEC 2020

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Coordinate System: GDA 1994 MGA Zone 53
0 140 280 560
metres
1:20,000 (when printed at A3)

LEGEND

- Project Area
- Construction Zones

Project Area

Southern Launch Whalers Way

Flora and Fauna Assessment

Whaklers Way, SA

Figure
1

Map Document: (G:\WTR\SpatialSys\Projects\2020\Southern_Launch\02_Maps\2020\06\F1_Project_Area.mxd)

1.3 Objectives

The State Planning Commission (SPC) has prepared Assessment Guidelines (dated 23 July 2020) for the preparation of an Environmental Impact Statement (EIS) for the WWOLC.

These guidelines outline items that are relevant to the assessment of noise and vibration impacts from the Project Area, including:

- Identification of sensitive receptors
- Description of the existing environment and site conditions
- Assessment of the worst case predicted noise from the construction, non-launch operational activities, and any on site rocket engine testing and launches
- Confirmation of consistency and compliance with relevant regulatory requirements
- Description of what reasonable and practicable mitigation measures will adopted to minimise impacts at nearby sensitive receptors

The contents of this report been developed in consultation with the South Australian Environment Protection Authority (EPA) and the Department for Environment and Water (DEW). Both departments have provided preliminary feedback on this assessment that has subsequently been considered when updating this report.

This assessment will inform the EIS which will be submitted to the South Australian Government.

1.4 Assessment context

Noise and vibration have the potential to adversely affect wildlife, humans, heritage structures, sensitive habitat and infrastructure located near construction activities. Noise pollution is sound at a level which is annoying, disruptive or physically harmful to people and wildlife.

In humans, noise impacts can include annoyance, sleep disturbance, productivity loss and negative health effects. In wildlife, impacts may include changes in behaviour and physical harm, which have the potential to adversely impact sensitive wildlife populations.

Note that the noise and vibration impacts to wildlife have not been discussed in this report. Impacts relevant to wildlife have been described within the report - *Whalers Way Orbital Launch Complex Terrestrial Biodiversity Technical Report*.

2.0 Project Components

2.1 Construction Phase

The components of the development of the Project are detailed as follows:

- Change of use of land to introduce an additional use of an aerospace facility in the form of a launch site
- Construction of buildings and infrastructure, including but not limited to:
  - Assembly Buildings (temporary and permanent)
  - Range Control Facilities
  - Diesel and / or Hydrogen Fuel Cell Powered Generators
  - Helicopter Pad(s)
  - Water Tanks
  - Water Capture and Treatment Systems
  - Launch Pads
  - Lightning Rods
  - Anemometer Towers
  - Engine test stands
  - Propellant (Liquid, Hybrid and Solid) Storage
  - Secure Block Houses
  - Blast Walls
  - Bunding (for Blast Wave Deflection)
  - Installation of Fibre Optic and Satellite Communication Systems within the Whalers Way Road Upgrade clearance footprint
  - Installation of High Voltage Power Lines within the Whalers Way Road Upgrade clearance footprint
- Construction of internal access roads
- Land division in the form of a lease extending beyond five (5) years
- Visitor viewing area and interpretative facilities
- Temporary infrastructure associated with development and construction, including but not limited to:
  - Temporary concrete batching plant
  - Temporary site and construction offices and facilities
  - Temporary laydown areas
  - Temporary access tracks.

2.1.1 Launch Site A and Launch Site B

The launch facility at Site A is intended to cater for larger conventional launch vehicles of greater than 30 tonnes up to over 100 tonnes. Launch Site A is intended to form Stage 2 of the Project and is anticipated to be constructed in 2023 or later.

The launch facility at Site B is intended to cater for larger conventional launch vehicles from micro sized (less than 10 tonnes) up to approximately 50 tonnes.

Site B is intended to form Stage 1 of the Project and is anticipated to be constructed as soon as the Project receives relevant regulatory approvals.

Launch Site A and Launch Site B will comprise the following elements:

Assembly building

The assembly building will cater for the assembly of the launch vehicles after transport of their components to the site. The building will be approximately 48 metres by 24 metres with a minimum seven metres internal clear height. The building will have internal crane facilities and will allow the design vehicle to enter the building for internal unloading.

The building will have integrated facilities to allow occupation between 20 and 40 staff at peak periods with facilities including toilet and changing facilities, kitchen facilities and offices. The building will be designed to maintain positive pressure for vehicle hygiene purposes.

Roadway between Launch Pad and Assembly Building

The roadway will be concrete construction with rails to allow for the transport of launch vehicles between the assembly building and the launch pad.

Launch Bunker

The launch bunker will be a reinforced building which will provide protection to staff in case of explosion or other contingency during the launch process. The building will cater for up to seven staff during launches and will include integrated kitchen and toilet facilities. The building will be designed to be sealed and will feature air filtration systems.

Stormwater

Site stormwater systems will be based around retaining all stormwater captured on the site footprint. Water will be stored in a lined basin at the downstream end of the site.

Upstream flows will either be captured and retained or intercepted and diverted around the site. Captured stormwater will be utilised in the water deluge system which ameliorates acoustic impacts during the launch. The deluge system will result in significant demand for retained stormwater, through water being converted to steam during the launch process.

Potable Water

Initially, potable water will be supplied by truck and stored on-site in tanks. As the site is developed, the potable water will be sourced from the stormwater detention basin, treated and then pumped into the tanks. To cater for up to 50 staff on site during peak periods, potable water will be stored in three 25,000 litre water tanks.

Power

Initially, the site will have a generator to supply all power needs. As the Whalers Way site is developed, it is anticipated that the site will either have access to mains or main on-site power generation with a system including solar and battery storage.

Wastewater

The proposed use is not anticipated to generate large quantities of wastewater, which will predominantly derive from toilet and kitchen facilities. Site operations, other than the deluge water for the launches, the management of which is addressed separately, will have a low water demand and therefore low generation of wastewater. The site will have a package wastewater treatment system with the capacity to cater for the requirements of 50 people.

Fire

Initially, water for firefighting needs will be trucked in and stored in the water tanks on site. Once developed, firefighting needs could be taken from the stormwater detention basin.

Irrigation

Areas surrounding the assembly building, launch pad and roadway will be landscaped with grasses and low shrubs and are to be irrigated. Irrigation water will be sourced from the wastewater treatment system and the detention basin. Irrigation is subject to detailed design. An irrigation management plan and water quality monitoring program will be developed to manage this. All irrigation will occur within the Project Area footprints. Irrigated areas are surrounded by gravel areas with a minimum buffer zone of 23 metres at one point with most irrigation having a gravel/asphalt buffer zone of greater than 30 metres.

Detention Basin

The detention basin at the downstream end of the site is designed to be multifunctional. The basin will capture all stormwater and all launch deluge water. The basin will also store additional irrigation water and surplus firefighting water. The basin will be capable of being automatically refilled from the main dam at Infrastructure Site D, once developed, on a demand basis. Pumping for refilling to be automatic and conducted at night. The basin will be lined with polymer dam lining and will be fenced.

Water Deluge System

Water deluge is required to mitigate two impacts resulting of a launch. Primarily, the water deluge system reduces noise impact by generating water droplets. The water droplets interact with the generated sound waves and convert them to heat energy through the water being turned to steam. The secondary impact is the heat generated by the launch vehicle. The water deluge reduces the heat impact on surrounding concrete and infrastructure.

The design of the water deluge system is to cater for 1000 L/s at 20 metre head with the water storage being in a 150,000 litre tank elevated on a 20 metre tower. Water is to be pumped into the tower over an eight hour period with delivery by gravity operation.

Launch Pad

Launch pad will be required to cater for significant bending moments as launch vehicles are lifted into position. Launch vehicles may be up to 30 metres tall with a mass of 100 tonnes at Launch Site A and 50 tonnes at launch Site B. It is envisaged that the launch pad concrete will be tied into the flame trench concrete to assist in mitigating the bending moments imposed by lifting a launch vehicle into position.

It is envisaged that the launch pad will be approximately one metre thick (potentially more) and could potentially require piles to counter the bending moment imposed by lifting a launch vehicle into place. Anchor bolts are to be designed and installed to allow for the launch pedestals to be secured in position. Those anchor bolts are to be of an appropriate size and are to be connected into the pad reinforcement to cater for the bending moment imposed by lifting a launch vehicle into place. The launch pad will have removable sections over the flame trench.

Removable Launch Pad Sections

There are to be three concrete platforms which can be craned into and out of position over the flame trench as per the drawing. Each platform is to be appropriately reinforced and supported by 250 millimetre thick reinforced concrete. Each platform is to be wide enough to fit over the trench and four metres long. Each platform is to be securable in position to ensure the launch vehicle thrust does not lift it out of position.

Flame Trench

The flame trench is to be five metres wide and 35 metres long. The trench will have a sump at the low point. Any liquid which remains in the flame trench after a launch needs to be collectable and able to be returned to the detention basin and not enter the environment. All deluge water over the launch pad should naturally flow into the flame trench to ensure capture.

Fuel and Oxidiser Bunds

The fuel and oxidiser bunds are concrete bunded areas where the tanks storing the fuels will be located.

Flare Stack & Cold Box

The flare stack will allow for the disposal of surplus fuels by burning off. Surplus oxidisers will be disposed of though disposal into the cold box.

Blast Walls

Blast walls are to be constructed at the fuel bund, oxidiser bund and launch bunker. Blast walls are a combination of poured in situ reinforced concrete retaining walls fronted with earth bunds.

Pads – Heli, Lidar & Radar

The launch site will feature a helipad which will be of asphalt construction and will include lighting, windsocks and painting are to be to the appropriate standard. The helipad provides for emergency access to the site and is not intended to cater for routing use.

The lidar and radar pads are to be concrete with access to electricity and comms. These facilities will allow for tracking of the vehicles post launch.

Radio and Other Towers

A radio tower located adjacent to the launch bunker is to be 30 metres high. Two camera towers are to be no less than 15 metres high. Lightening Towers will be constructed around the site to protect launch infrastructure and vehicles from electrical storms.

Lighting

Lighting of the launch facilities will be provided for both security and operational purposes. Area lighting will also be provided from buildings and potentially towers.

Commercial Vehicle Access and Parking

Roads for commercial vehicles are to be designed to cater for 19 metre semi-trailer vehicles. There will be very low vehicle movements in respect of heavy vehicle movements.

Vehicle movement generators for the launch site include:

- Launch Vehicle Fuel delivery (3 per week)
- Oxidiser delivery (3 per week)
- Generator Fuel delivery (1 per week)
- Septic Tank Pump Out (1 per week)
- Launch Vehicle transport to site (1 per week) and
- Crane movements (3 per week).

Two vehicle parking spaces for delivery vehicles, one adjacent to the fuel bund and one adjacent to the oxidiser bund, will be of concrete construction.

Fences and Gates

Perimeter fence is to be 2000 millimetre tall wire mesh topped with three strands of barbed wire. Two double gates are required for access control at the perimeter fence. Perimeter fencing will need to fully enclose the detention basin.

1200 millimetre tall tubular steel edge protection fencing is required around the flame trench. Some of the edge protection fencing is required to be removable to allow the installation of a launch platform.

Site Security

In addition to the physical security IP closed-circuit television (CCTV) is to cover the site entrances and throughout the site. All buildings and structures are to be alarmed.

Waste

All waste is to be contained on-site in appropriate receptacles and trucked off-site by a licensed contractor in accordance with regulatory requirements. Waste types are typical for an office structure and will include kitchen and office waste.

Waste fuels will be burnt off using the flare stack. Waste oxidisers will be disposed of in the cold box. Fuels/Oxidisers/Chemicals which cannot be disposed of in the flare stack or cold box will be trucked off-site by a by a licensed contractor in accordance with regulatory requirements.

Parking

The staff parking area is to be of asphalt construction to meet the relevant standards in respect of parking dimensions and number of disabled carparks.

Rocket Motor Test Site

Site A will allow for the testing of rocket motors in a controlled environment. The facility will include the installation of a 20 metre by 20 metre concrete pad. Steel frames to support the motors will be designed and fabricated on a case by case basis by clients and installed on the pad for short periods of time.

2.1.2 Infrastructure Site D

Infrastructure Site D will initially consist of a quarry and workspace to produce engineered pavement materials. That site will be developed over time to include:

- Dam – 30 megalitre capacity
- Pump Station
- Electrical Generation or Storage Site
- Workshop
- Rocket Storage Building and

Infrastructure Site D is located at the low point of the catchment area for the proposed dam. Surrounding facilities (workshop, pump station etc) need to be designed to ensure all overland flow water from the catchment reaches the dam.

Dam

The location of the proposed dam has been identified to have suitable material for civil construction around the site. Materials recovered will be used on the subject site for bulk fill and road pavements.

The dam will have a capacity of 30 megalitres and installation of the dam will include polymer lining. The dam will be enclosed by an 1800 millimetre chain mesh fence with three strands of barbed wire. The dam will be bounded by a gravel roadway to allow for vehicle access for maintenance.

Pump Station

The water stored in the dam will be pumped directly to water storage on sites Launch Sites A and B and Range Control Site E.

Workshop

The proposed workshop will be the base for site wide maintenance staff. The workshop will be a shed of approximately 20 metres by 15 metres with an internal clear height of seven metres. The workshop is a steel portal warehouse type structure on a reinforced concrete slab.

The workshop will contain a single office, toilet, shower, kitchen and meal facilities for staff. The open areas of the shed will feature space to undertake maintenance and repair works which are non-launch vehicle related. The workshop will cater to an estimated staff level of five at the ultimate development of the site.

Rocket Storage Building

The rocket storage building will be used to store small (typically less than three metre length) rockets. The building will be hardened to meet appropriate standards for this type of facility. The building will have firefighting facilities to meet appropriate standards for this type of facility.

The site will be enclosed by an 1800 millimetre high chain mesh fence topped with three strands of barbed wire and a lockable double gate. The structure will have two (connected) blast walls located adjacent to it.

2.1.3 Range Control Site E

Range Control Site E is the range control building which will oversee operations on the site. It will also have a visitor information centre and the main operations area for security and emergency services. The building will be positioned close to the entry to the site from Right Whale Road.

The building is to be approximately 25 metres by 12 metres and will be architecturally designed to enhance the launch experience for visitors. The building will feature bitumen carparking with spaces for staff and visitors, including disabled spaces in accordance with relevant standards. The car parking area will also feature dedicated car parking for emergency services.

The facility will provide integrated office accommodation, toilet facilities and kitchen facilities for up to 40 staff and 20 VIPs/visitors. The VIPs/visitors would be watching the launch.

Roof stormwater will be captured and directed to three 25,000 litre tanks to be utilised as potable water and for firefighting requirements. Swales will direct overland stormwater flows around the site. Suitable water quality treatment and detention will be provided for stormwater from carparking and other hard surface areas.

Wastewater will be treated by a package wastewater treatment system and irrigated onto a dedicated area. Waste will typically be office and kitchen waste which will be stored in appropriate receptacles and removed from site by a licensed contractor.

2.2 Operations Phase

The Project will cater for launches by a variety of customers. The number of launches is anticipated to grow over time, with approximately six launches anticipated in the first year of operations, increasing to a maximum of 36 launches in year five of operations.

The facility has been uniquely designed to enable the launch sites to be used by multiple customers, who will transport their equipment and launch vehicle stages to the site before undertaking final assembly in preparation for the launch. Once the launch is complete, the customer will remove their equipment and vacate the launch site ready for occupation by the next customer.

Typically, a launch cycle will run in the order of 3-5 weeks from occupation to vacation of a launch site, however the exact timeframe will vary based on the nature of the launch vehicle and the specific requirements of an individual launch mission.

Following vacation of a launch site, routine inspections, maintenance and repair will be undertaken.

When a launch site is not occupied, the intensity of activity will typically be very low, particularly in times where no maintenance or repair work is occurring. Accordingly, the intensity of use of the site will vary throughout the course of the year, with times where there is no material activity on-site and only routine security present. At other times, when multiple launch sites are occupied, the level of activity will be more significant with larger numbers of staff on site.

A typical launch timeline is described in the Section 2.2.1. This best describes the ebb and flow of the proposed use of the Project Area.

The vehicles which will be launched from Whalers Way could be solid, hybrid or liquid fuelled. They will range in height from less than five metres to approximately 30 metres.

2.2.1 Typical Launch Timeline

The nature and activity associated with each launch will be unique, based on the specific requirements of the mission. However, the process for launches will have a high degree of commonality in activities as the launch site is occupied and preparations for the launch proceed. Furthermore, launches are a highly structured operation requiring input and oversight of numerous Australian State and Federal agencies.

A typical launch will see an increase in the intensity of site operations approximately 21-28 days prior to the launch. The following timeline indicates a typical sequence of activities leading up to and following a launch.

- 4 weeks prior to launch date:

  - QA processes are completed at site and the launch site is verified as being suitable for occupation by the customer
  - Specific notification with and coordination with local stakeholders and regulatory authorities is undertaken.
- 3-4 weeks prior to launch date:
  - Launch vehicle components will arrive in Australia to an off-site reception facility
  - Customs and import processes will be undertaken, followed by an initial acceptance inspection
  - It is anticipated that off-site installation of components will occur as required to minimise the amount of assembly (and assembly time) required at the Project Area. It should be noted that proposed concept of multi-use launch infrastructure is a relatively unique concept. Customers want to find the most cost-effective way to launch into space. This includes embracing newer technologies that would minimise the amount of time they spend at a launch site, hence it is anticipated that the initial installation processes for both launch vehicles and payloads will occur offsite. This could occur in Port Lincoln, Adelaide or elsewhere in Australia. The customer will undertake acceptance inspections of the launch site ready for formal occupation.
- 2-3 weeks prior to launch:
  - The customer will occupy the launch site. Once this occurs, the customer will begin to bring equipment to the site. The number of personnel on-site (both customer and Southern Launch personnel) will begin to increase approximately three weeks prior to launch and will continue to increase progressively as the launch approaches.
- 1-2 weeks prior to launch:
  - By this time the customer has occupied the launch site. Depending on the nature of the launch, the launch vehicle will be transported to site between 7-14 days prior to the launch
  - The launch vehicle will be brought to site in the form of partially assembled stages for mating on-site
  - As the stages of the launch vehicle are brought to site by truck, they will be transported into the assembly building
  - During this period, the Southern Launch Range Operations Manager will continue coordination and liaison with local authorities in advance of the launch
  - The Launch Table is moved into position at the launch pad in preparation for the installation of supporting infrastructure
  - At this point there will be a further increase in equipment being brought to site, with radio and IT equipment for the management and monitoring of the launch being delivered
  - In the assembly building, the vehicle assembly continues, with stages being mated and other external and internal components added to the launch vehicle
  - Externally, systems including fuel, oxidiser, communications and IT are connected to the launch table
  - There will be a continued increase in the number of staff at the site during this period.
- 7 days prior to launch:
  - Fuels and oxidisers trucked to site and decanted into the on-site storage at the launch pad
  - Vehicle assembly continues and the connection of systems to the launch table also continues.
- 2-7 days prior to launch:

  - At this time, the major assembly of the launch vehicle will be close to complete. This enables one or more 'Dress rehearsals' of launch to be undertaken. These processes will test roll-out, erection and countdown procedures, however, do not involve engine firing although they can involve fuelling the launch vehicle. Typically, after a dress rehearsal is complete, the launch vehicle will be rolled back to the assembly building for storage
  - Coordination continues with local authorities and external regulatory authorities
  - There will be a continued increase in staff numbers, with peak staff numbers typically reached at some point during this period.

- One day prior to launch:
  - The day prior to launch will be focussed on checking and testing of systems in preparation of the launch. This will include a run through of checks similar to launch day and verification all systems associated with the launch are working
  - On the day prior to launch the flight readiness review will be undertaken and a go/no-go decision will be made. If a no-go decision is made, a rescheduled launch date may be determined
  - Relevant liaison with State / Commonwealth agencies to confirm regulatory arrangements in place.

- Day of launch:
  - On the launch day there will be the final roll-out of vehicle to launch pad for launch. The vehicle will be attached to launch table and erected. Umbilicals will be attached to the vehicle and launch system checks begin
  - One hour before launch - Following completion of roll-out procedures, the final preparation of the vehicle for launch will proceed. This will include evacuation of staff from the launch pad to safe areas of the site. Once the evacuation is completed, fuelling of the launch vehicle commences which involves decanting the fuel and oxidiser into the internal tanks for the vehicle. Once fuelling commences, critical countdown commences and final critical system checks undertaken
  - 30 seconds before lift-off the deluge water system activates
  - Vehicle engine(s) ignite for lift off. Umbilicals and collections to launch table disconnect and the vehicle commences vertical ascent. The vehicle clears the tower and continues on launch trajectory

- Post-launch site activities:
  - Following the launch of the vehicle, launch pad systems will be made safe. This will include initial checks, following which fuel, oxidiser and cryogenic lines will checked and purged
  - Once the launch pad is made safe a comprehensive set of checks for foreign object damage at the launch pad and surrounding areas will be undertaken
  - Mission control and range control continue to monitor the launch vehicle until after payload separation, which will typically occur 1-2 hours after launch
  - Once the launch vehicle payload has separated, systems shutdown procedures begin, and disassembly of the launch pad and other equipment can proceed. This will include the launch table being disconnected and packed away
  - The customer disassembles and vacates assembly building and launch pad
  - Once the customer has vacated, acceptance checks are undertaken by Southern Launch
  - As required, maintenance and repair work undertaken on-site between customers and
  - The launch sequence then starts again for subsequent customers.

2.2.2 Suborbital Rockets

Whalers Way will also be used to launch rockets that do not go into orbit around the Earth. These rockets are known as sounding rockets or suborbital rockets. They are used to access altitudes between 50 and 120 kilometres, which are too high for balloons to reach, and too low for satellites. Typical purposes for sounding rocket missions include:

- Atmospheric research
- Test and qualify space systems and
- STEM education.

The payloads these rockets are often quite small, weighing in the range of two to 20 kilograms. Their composition would potentially include electronics, metallic structures, optical materials like glass or ceramics, and batteries. These small payloads can be launched to altitudes above 120 kilometres, from which they can descend through the atmosphere.

Because they have small payloads and address specific research questions, many sounding rockets are designed to be low-cost and rapidly deployable. They will generally be smaller than orbital rockets. They may consist of more than one rocket stage. Thrust is mostly provided by solid propulsion but can also be supplied through other propulsion technologies including hybrid and liquid.

Certain developers of orbital launch vehicles use suborbital flights to test stages. If these flights test the first stage of an orbital vehicle, the launch will more closely resemble an orbital launch. If these launches test upper stages, they will generally resemble scientific-type sounding rocket flights, but have engineering payloads instead of experiments. These kinds of launches are not likely to happen more than once or twice during the development of an orbital launch vehicle and as such, will be relatively rare occurrences, happening no more than once per year.

When launched at overland rocket ranges, sounding rocket payloads are normally recovered and reused, with the rocket body being single use and lost during standard operation. Since launches at Whalers Way will be over the water, it will be impractical in many cases to recover the payloads and they would be left to sink in the ocean.

Frequency of launch – Given the potential complexity of retrieving payloads from the open ocean, sounding rocket launches will be infrequent on the Whalers Way site and will generally be undertaken at Southern Launches Koonibba site. It is envisaged that there would typically be one or two sounding rocket launches undertaken at Whalers Way per year with a maximum of potentially six per annum. This number is additional to the estimated 36 conventional launches per annum at the Whalers Way site.

The T-Minus Engineering Dart is an early example of the sounding rockets that Southern Launch intends to operate. That vehicle consists of lightweight and powerful booster motor and a smaller dart-shaped payload compartment that separates from the booster and continues substantially further downrange. The dart component is between 900 and 1500 millimetres with a diameter or less than 50 millimetres. The dart will have a total mass, including payload, of between three and five kilograms. This component of the rocket will reach speeds of between Mach 5 and 6.

The Booster is approximately two to three metres in length, up to approximately 400 millimetres diameter with a loaded mass of between 15 and 30 kilograms. The booster section of the sounding rocket will return to earth between three to eight kilometres downrange. The dart section will return to earth between 40 to 150 kilometres downrange.

3.0 Legislative Framework

An overview of the Commonwealth and State legislation that is relevant to environmental aspects of this assessment is presented in Table 2.

Table 2 Legislation description and relevance to the Project

Legislation	Description and Project Relevance
Commonwealth	
Space (Launches and Returns) Act 2018	The Space (Launches and Returns) Act 2018 and Space (Launches and Returns) (General) Rules 2019 provide a framework and criteria that is relevant to the approval of space activities in Australia. This includes the information required to support the application relevant to environmental impacts and approvals. The general rules state that applicants consider the impact of their intended activity on the environment and provide information on how any adverse effects on the environment are to be monitored and mitigated. However, specific acoustic values to be considered and protected during the planning of a Project are not detailed. Note: Airports Act 1996 and the Australian Noise Exposure Forecast (ANEF) requirements are not applicable to space operations and have not been referenced in this assessment.
South Australia	
South Australian Development Act 1993	The *Development Act 1993* (Development Act) provides for planning and regulates development in the State, to regulate the use and management of land and buildings and the design and construction of buildings. Subject to this Act, no development may be undertaken unless the development is an approved development. A development is an approved development if, and only if, a relevant authority has assessed the development against, and granted consent in respect of the provisions of an appropriate Development Plan.
South Australian Environment Protection Act 1993	The South Australian Environment Protection Authority (EPA) provides noise criteria for noise sources in order to satisfy the General Environmental Duty, as defined under the South Australian *Environment Protection Act 1993*. The noise criteria are set by the *Environment Protection (Noise) Policy 2007* (Noise EPP).
Environment Protection (Noise) Policy 2007 (Noise EPP)	The Noise EPP provides noise goals for operational and construction noise sources in order to satisfy the general environmental duty as defined by Section 25 of the South Australian *Environmental Protection Act 1993*. Noise goals are determined based on the land uses for the noise sources and receptor, as promoted by the relevant development plan. Noise from aircraft operations is excluded from this policy.

4.0 Methodology and assumptions

This section describes the methodology for undertaking this assessment. An approach has been applied to take account of the existing environment, potential impacts of the Project and how to avoid, minimise or manage the risk of impact.

The key stages of the assessment have been listed below:

- **Baseline conditions:** Overview of the project study area, sensitive receptor locations and baseline noise levels.
- **Assessment criteria:** A summary of the noise and vibration criteria used to assess the acoustic impact on the identified sensitive receptors.
- **Impact assessment:** Desktop assessment to establish construction and operational impacts.
- **Mitigation measures:** Description of additional mitigation measures where impacts are predicted to exceed the criteria.

4.1 Baseline conditions

The aim of the existing conditions assessment is to identify where sensitive receptors are located relative to the proposed Project Area and to characterise the existing acoustic environment.

It is important to establish the existing noise environment throughout the Project study area to:

- To verify the known contributions from existing noise and vibration sources prior to the impact assessment
- Develop appropriate criteria and limits that would guide the impact assessment.

4.1.1 Study area

The majority of the land located adjacent to the Project is sparsely-populated rural land. This type of land use is typically quieter than suburban areas and is usually more sensitive to the introduction of a new commercial noise source.

A study area up to five kilometres from the Project, including the nearest residential locations, was considered appropriate to assess the noise and vibration impacts in this environment.

4.1.2 Classification of sensitive receptors

The identification and classification of sensitive receptors was undertaken via site investigations and a desktop study using available aerial imagery and geospatial data.

Sensitive wildlife receptors were identified in the *Whalers Way Orbital Launch Complex Terrestrial Biodiversity Technical Report* (AECOM, 2020).

4.1.3 Measurement of existing noise environment

Baseline noise monitoring was used to quantify the existing noise environment at sensitive receptors near the proposed Project Area. Noise monitoring consisted of unattended measurements at five measurement locations.

Existing noise levels were monitored and reported with reference to the following descriptors:

- **L_{A90} noise level**: The dB(A) noise level that is exceeded for 90 per cent of a specified period. Commonly referred to as the *background* noise level.
- **L_{Aeq} noise level**: The L_{Aeq} reflects all noise occurring during the measurement period. It approximately equates to the average level for many typical environmental noise scenarios. L_{Aeq} is typically used to quantify industrial noise, and to assess environmental noise impacts.

The existing noise levels were measured with reference to *AS 1055:2018 - Acoustics - Description and measurement of environmental noise.*

Unattended noise monitoring was undertaken at each location for up to two weeks. Equipment was set up in a free field location with the microphone at least 3.5m from all reflecting surfaces and away from

extraneous noise sources. All noise monitoring equipment had current laboratory calibration status at the time of the measurements. Monitoring results and locations are summarised in the tables and maps shown in Section 5.2.

4.2 Assessment criteria and context

Potential impacts to humans during the construction and operation phases of the Project may be caused by a disturbance of the acoustic environment.

4.2.1 Construction noise

The Noise EPP provides specific criteria for construction noise under *Part 6 – Special noise control provisions – Division 1 – Construction noise*.

Under the Policy, construction activity with an adverse impact on amenity must not occur on a Sunday or public holiday, and on any other day except between 7.00am and 7.00pm. The criteria are applicable at noise-affected premises for determining whether construction activities result in noise with an adverse impact on amenity. These criteria are presented in Table 3.

Table 3 Summary of construction noise criteria

Time	Noise Criteria
Monday to Saturday, 7:00 am to 7:00pm	No specific construction noise limit. Minimise construction noise where possible.
All other times, and public holidays	$L_{Aeq,\ 15min}$ should not exceed 45 dB(A). L_{Amax} should not exceed 60 dB(A).

It is assumed that construction works would occur between Mondays and Saturdays within the 7:00am to 7:00pm time period. Within these hours, there is no specific construction noise limit, although construction noise should be minimised where possible.

4.2.2 Operational noise (Office and workshop activities)

The noise from a noise source complies with the Noise Policy requirements if:

- it does not exceed the relevant indicative noise level as measured at a noise affected premises, or
- it is not higher than 5 dB(A) above the background noise level as measured at the noise affected premises.

Residential areas in the vicinity of the project would be located on land use categorised as Rural Living. Accordingly, the Indicative noise factor for Rural Living would apply to this assessment.

The *background plus 5 dB* criteria at the nearest noise affected premises have been approximated using the average background levels shown in Section 5.2.1.2. The levels relevant to this assessment are presented in Table 4. Note that only one of the following tests needs to be met to satisfy the requirements of the Noise Policy.

Table 4 Noise criteria summary

Description	Noise goals [$L_{eq(15\text{-}min)}$, dB(A)]	
	Day	Night
Indicative noise factor for Rural Living	47	40
Background plus 5 dB	29	36

In accordance with the noise policy "*the predicted source noise level (continuous) for the development should not exceed the relevant indicative noise level less 5 dB(A)"*.

As such, the criteria for the project would be:

- $L_{eq(15\text{-}min)}$ 42 dB(A) - Daytime hours (7:00am and 10:00pm on the same day)
- $L_{eq(15\text{-}min)}$ 35 dB(A) - Night-time hours (10:00pm on one day and 7:00am on the following day)

The operational impact assessment for noise sources assessed in accordance with this policy is presented in Section 4.3.2.1.

4.2.3 Operational noise (Rocket launch or testing)

The United States Federal Aviation Administration (FAA) uses the Day-Night Level (DNL) to describe the daily noise energy exposure based on annual aviation activities. FAA defines a "significant impact" due to aviation noise as a sensitive location exposed to noise greater than a DNL of 65 dB(A) (FAA, 2018). The DNL is a 24-hour average of noise level with a 10-dB penalty for noise at night. This night-time adjustment is made to account for increased human sensitivity to noise at night.

The FAA notes that the application of this criterion should be considered carefully when determining the noise impact in areas of low existing noise levels. The criterion is presented in Table 5.

Table 5 Preliminary operational noise criterion - human amenity

Activity	Operational noise criteria
Rocket launch and testing	DNL 65 dB(A)

Noise levels from rocket launches have been compared to the DNL however other noise parameters have also been presented to help describe noise exposure impacts from single events in Section 6.0.

These include[1]:

- Maximum A-weighted Sound Level (L_{Amax}): *the maximum sound pressure level over the duration of a single event.*
- Sound Exposure Level (SEL): *A logarithmic measure of the total acoustic energy transmitted to the listener during the event. However, SEL does not directly represent the sound level heard at any given time. Mathematically, it represents the sound level of a constant sound that would generate the same acoustical energy in one second as the actual time-varying noise event.*

Results from the assessment of launch operations are presented in Section 6.3.

4.2.4 Ground vibration

DIN 4150-3 outlines ‘safe limits’ as Peak Particle Velocity (PPV) levels up to which no damage due to vibration effects have been observed for particular classes of buildings. Damage is defined as anything from minor non-structural effects such as superficial cracking in cement render to the separation of partitions or intermediate walls from load bearing walls. Safe limits applicable to vibration levels of a short duration are summarised in Table 6.

[1] Blue Ridge Research and Consulting. (2017). *RUMBLE Launch Vehicle Acoustic Simulation Model Version 2.0 User Guide. Asheville*.

Table 6 Structural damage 'safe limits' for construction-induced short-term vibration on structures (DIN 4150-3)

Group	Type of structure	Peak particle velocity (PPV) in millimetres per second (mm/s)		
		At foundation at a frequency of:		
		Less than 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50
2	Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. heritage-listed)	3	3 to 8	8 to 10

4.2.5 Air overpressure

Structural damage to nearby buildings and human disturbance can be caused by high levels of air overpressure. High levels of air overpressure can often be perceived by humans as vibration as it can cause windows to rattle and other building elements to shake.

A literature review was undertaken to determine the most-appropriate criteria to apply to air overpressure produced by rocket launches. It was found that a maintaining a level below 133 dB (linear) peak would minimise the chance of damage to buildings and other structures.

This is consistent with the level applied to blasting activities within the Australian Standard AS 2187.2-2006 *Explosives – Storage and use Part 2: Use of explosives.*

4.3 Impact assessment

This study assesses the noise and vibration impacts of activities in the construction and operational phases of the Project. The general approach to the impact assessment for both construction and operational activities includes the following steps:

- Identify sensitive receptors likely to be impacted within the study area
- Determine the source, location, duration and timing for each activity that may cause an impact
- Calculate the level of noise or vibration produced by each activity at the identified sensitive receptors
- Compare predicted levels to the assessment criteria relevant to each activity
- Recommend conceptual mitigation for managing noise and vibration impacts that are predicted to exceed the assessment criteria.

The methodology and assumptions used for the impact assessment have been documented in the following sections.

4.3.1 Construction impact assessment

Details of the facilities being proposed for Southern Launch are summarised in Section 2.0. The Project activities that may produce noise or vibration that could cause negative impacts to the nearby

sensitive receptors are listed in Table 7. Most noise and vibration would be produced within the designated sites shown in Figure 1 with exception of vehicles accessing the sites, and any necessary roadworks for the construction of access roads.

Table 7 Description of Project activities associated with construction and operation

Project Activity	Description of activities
Site preparation	Vegetation clearing
	Topsoil stripping
	Excavation for the construction of a quarry then to be transformed into a 30 ML dam
	Construction of temporary site compounds including concrete batching plant
	Installation of hardstands, offices etc
	Stockpiling
Utility construction	Excavation
	Trenching
	Installation of utilities and associated infrastructure
Drainage	Culvert installation
Structures	Construction and installation of infrastructure and buildings associated with launch pad facilities including: • assembly buildings (temporary and permanent) • range control facilities • diesel and / or hydrogen fuel cell powered generators • helicopter pad(s) • solar arrays • water tanks • water capture and treatment systems, • launch pads • lightning rods • anemometer towers • engine test stands • propellant (liquid, hybrid and solid) storage • secure block houses • blast walls • bunding (for blast wave deflection) • installation of fibre optic and satellite communication systems • installation of high voltage power lines • excavation and construction of flame trench and the installation of a water deluge system.
Civil and Road Works	Construction of access roads
	Cutting construction
	Drainage controls

4.3.1.1 Proposed working hours and schedule

Construction works would only be conducted during the daytime, and it is assumed that these would comply with the recommended construction hours defined by the Noise EPP, described in Section 4.2.

Table 8 Indicative works phases

Phase	Location	Working hours	Indicative timing
1	Site B	7am to 5pm (Monday to Saturday)	Four months
2	Sites A and D		11 months
3	Sites C, E and E		18 months

4.3.1.2 Construction activities and equipment

Indicative construction stages have been developed based on the description of the project components in Section 2.0 and the project activities listed in Table 7. Worst-case scenarios have been developed based on all fixed and mobile plant equipment operating simultaneously over the relevant assessment period for the activities presented in Table 9.

Table 9 Assumed facility construction activities

Activity reference	Activity	Description
C1	Site preparation	Site set-up within the construction footprint is required to provide a safe and efficient area for construction activities.
C2	Utility construction	Existing ground levels would be excavated/built up and levelled to allow for the installation of utilities and associated infrastructure.
C3	Foundations	Steel reinforced concrete foundations and footings would be installed which the permanent buildings, equipment and supports would sit on and be fixed to.
C4	Structural works	Construction and installation of infrastructure and buildings.
C5	Testing and commissioning	Mechanical and electrical equipment are also mechanically and electrically tested to make sure they have been installed correctly and are ready for commissioning. Commissioning involves fine tuning of equipment and instrumentation by running the facilities through various operating ranges. Once the facility passes all checks per the commissioning plan, it is ready to be handed over to Operations.
C6	Roads, landscaping and reinstatement	The final facility will have some permanent roads, kerbs, pavement, landscaping and permanent fencing.

4.3.1.3 Construction equipment sound power levels

Indicative sound power levels for the construction equipment that may be used for the above staging are presented in Table 10. The sound power levels were obtained from international construction noise standards and AECOM databases.

Table 10 Assumed construction plant and equipment for assessment

Equipment	Equipment sound power level [L_{eq}, dB(A)]	Operation time (% of a 15- minute period)	Assumed facility construction scenarios					
			C1	C2	C3	C4	C5	C6
Air compressor	91	50%				1	1	
Angle grinder	107	100%			2			
Asphalt Paver	104	70%						1
Circular bitumen saw	115	100%			2			
Compactor	122	100%		2				
Concrete batching plant	115	100%	1	1	1	1		
Concrete truck	107	100%			2			1
Crane	98	100%			1		1	
Dozer 20T	109	100%						
Drill	88	50%				3		
Excavator 30T	103	100%	1	2				
Franna crane 20T	99	100%				1		
Generators	102	100%	2			4	1	
Grader	115	100%						1
Mulcher	114	100%	1					
Roller	102	100%	1	1				1
Semi-trailer	108	100%			1	2		
Skid steer	97	100%	1		2	2		
Tipper 12T	108	100%	1					
Truck, 10T	108	50%						1
Truck, dump	109	100%	1	2				1
Ute 4x4	101	25%	2	2	2	2	2	2
Water truck 10,000L	115	100%		1				
Welding machine	101	50%				1		
Activity Sound Power Level [L_{eq}, dB(A)]			**120**	**125**	**120**	**117**	**115**	**119**

4.3.1.4 Construction equipment vibration source levels

Table 11 presents the vibration levels of various construction equipment that could be used during the construction stage of the project, as provided in:

- BS5228-2, *Code of practice for noise and vibration control on construction and open sites. Vibration*
- FTA document, the Department for Environment Food and Rural Affairs (DEFRA) document *Update of Noise Database for Prediction of Noise on Construction and Open Sites 2005*
- South Australian DPTI guidelines

These vibration levels have been used to identify potential impacts at sensitive receptor locations.

Table 11 Typical vibration levels from construction activates (various sources)

Activity	Typical Levels of Ground Vibration (PPV, mm/s)
Vibratory Roller[1]	1.5 mm/s at 25 m
Hydraulic Rock Breakers (levels typical of a large rock breaker in hard sandstone)	4.5 mm/s at 5 m 1.3 mm/s at 10 m 0.4 mm/s at 20 m 0.1 mm/s at 50 m
Excavator Excavator – 12-18T hammer Excavator – 18-34T hammer	0.2 mm/s at 40 m 1.09 mm/s at 40 m 6.11 mm/s at 40 m
Grader	2.5 mm/s at 5 m
Truck traffic (over maintained road surfaces)	0.2 mm/s at 10 m
Truck traffic (over irregular surfaces)	2 mm/s at 10 m
Impact pile driving	≤ 15 mm/s at distances of 15 m ≤ 9 mm/s at distances greater than 25 m Typically below 3mm/s at 50m
Continuous Flight Auger (CFA) piling	Negligible vibration at distances greater than 20 m from the piling
Jackhammer	1 mm/s at 10 m
Asphalt profiler	0.15 mm/s at 5 m

Notes:

1. Higher levels could occur at closer distances depending on local conditions and the roller operation. Vibration levels may vary between continuous pass-by and start/stop (changing direction).

4.3.1.5 Calculation of impacts

Noise propagation from the proposed construction activities has been calculated assuming simple geometric spreading of sound from each noise source. This method has been used to highlight if there are sensitive receptors located within a distance from the works that could be impacted.

Ground-borne vibration levels as a result of equipment operating within the vicinity of sensitive buildings were predicted using empirical formulae that accounts for the distance between vibration source and receptor.

4.3.2 Operational impact assessment

Operational noise levels have been assessed for following activities:

- Launch complex supporting infrastructure, including buildings, dams and workshops.
- A rocket launch or testing.

The methodology for predicting operational noise impacts is further discussed in the following sections.

4.3.2.1 Supporting infrastructure assumptions

Noise from the operation of the launch facility would include industrial noise from the Project Area including generator noise, vehicle movements and other typical operational noise.

Supporting infrastructure has been modelled as operating separately for the assessment. Noise emissions from key plant and activities were based on international standards and the AECOM noise source database.

Typical values for winching cranes and generators were obtained from British Standard *BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise*.

Noise propagation calculations were performed assuming simple geometric spreading of sound from each noise source. Assumptions have been made where necessary in terms of estimations of the noise level, location, and expected operation of noise sources.

The following assumptions have been made to assess the typical operational noise levels of launch complex:

- Day to day operation of the facility would require generators supporting office buildings, dams, workshops and launch facilities.
- Workshop activities would be similar to those at a mechanical workshop.
- Noise from the launch vehicle erector has been assumed to be similar to that of a large mobile crane.

The following table provides a breakdown of the proposed noise sources, estimated sound power levels, and the duration of each activity within a seven-day period.

Table 12 Expected operation scenarios and duration

Activity	Duration of activity within a 7-day period	Estimated sound power level
General office activity and vehicle movements	5 days	L_{eq} 97 dB(A)
Auto mechanic noise	Up to 2 days	L_{eq} 114 dB(A) inside workshop
Launch vehicle erector (similar to a mobile crane winch)	10 minutes	L_{eq} 98 dB(A)

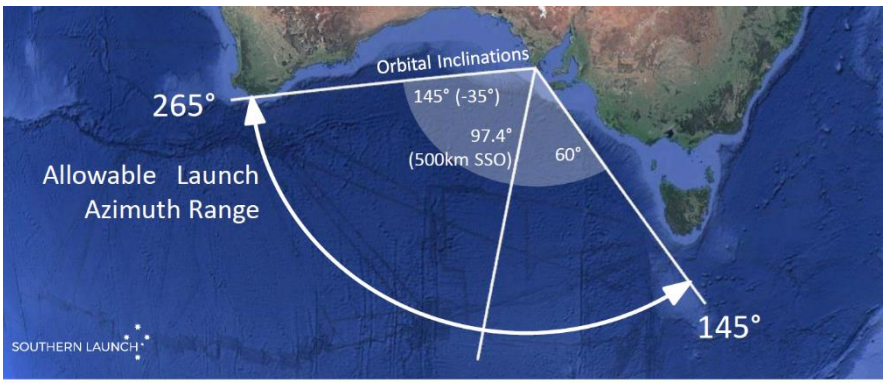
4.3.2.2 Rocket launch and rocket testing assumptions

The main noise sources associated with a rocket launch or test can be attributed to the engine and exhaust. Environmental noise levels produced by these sources during rocket launch and testing events were predicted using the RUMBLE computer modelling package developed in the United States by Blue Ridge Research and Consulting.

This modelling package is used evaluate the far-field environmental noise impact associated with inflight and static operations of subsonic commercial launch vehicles. The software is approved by the United States Federal Aviation Administration and considered suitable to use during the development stage of the Project. It has been recently used for environmental assessments including the SpaceX DragonFly Vehicle at the McGregor test site in Texas.

The modelling assumptions input into the RUMBLE model are summarised in Table 13.

Table 13 Noise modelling assumptions

<table>
<tr><th>Item</th><th>Assumption</th></tr>
<tr><td>Launch sites</td><td>-34.937273, 135.629525 (Site A)
-34.933906, 135.643307 (Site B)</td></tr>
<tr><td>Azimuth</td><td>The maximum range of azimuths that the site is likely to support is from 145 deg to 265 deg:
 

A single scenario of a launch with a trajectory in a southerly direction has been assumed. This is considered a reasonable approach as vertical launches have been assumed to produce a similar noise impact at ground level regardless of the azimuth.</td></tr>
<tr><td>Nominal Trajectory</td><td>
<table>
<tr><th>Stage</th><th>Trajectory and speed</th></tr>
<tr><td>Lift off</td><td>• Notional speed: 0 km/h
• Notional altitude: 0 m
• Notional downrange distance: 0 m</td></tr>
<tr><td>10 seconds after lift-off</td><td>• Notional speed: 106 km/h
• Notional altitude: 192 m
• Notional downrange distance: 0 m</td></tr>
<tr><td>30 seconds after lift-off</td><td>• Notional speed: 389 km/h
• Notional altitude: 1520 m
• Notional downrange distance: 20 m</td></tr>
<tr><td>1 minute after lift-off</td><td>• Notional speed: 1042 km/h
• Notional altitude: 7,200 m
• Notional downrange distance: 780 m</td></tr>
<tr><td>2 minutes after lift-off</td><td>• Notional speed: 3,880 km/h
• Notional altitude: 38,000 m
• Notional downrange distance: 17,600m</td></tr>
<tr><td>2.5 minutes after lift-off</td><td>• The first stage of the launch vehicle separates</td></tr>
</table>
Notes:
Notional Speed: Notional velocity of launch vehicle
Notional altitude: Notional altitude of launch vehicle above initial launch height
Notional downrange distance: Notional offset distance from initial launch location within range of azimuths</td></tr>
<tr><td>Potential Rockets</td><td>• Medium size solid
• Small size liquid
• Small solid sounding rocket</td></tr>
</table>

Item	Assumption
Maximum sound power of rocket	Notional sound power level of 140 dB(A) based on Southern Launch specifications.
Launch vehicle	Maximum thrust at lift off of launch vehicle of ~1,200KN is assumed. The Falcon v1.1 launch vehicle was selected from the RUMBLE database due to the similar levels of thrust to the maximum assumed. This is considered a conservative assumption as Southern Launch would typically launch much smaller rockets.
Number of launches	Maximum of one launch per week with up to 36 per year. A launch could be undertaken during day or night-time hours. Accordingly, assumed launch numbers have been assumed to be spread evenly between day (7am to 10pm) and night (10pm to 7am).
Launch testing (Site A)	Typically, prior to each launch of a liquid propellant rocket there would be single a “stack test” involving the first stage engine firing for approximately 10 to 15 seconds. This would take place with the rocket clamped down on the pad and the water sound suppression system operating. Solid rockets would not have any pre-launch firing tests. It has been assumed that rocket testing would be undertaken up to 10 times per year between 7am and 10pm only.

Predicted noise levels due to rocket launch and testing operations have been described using the following acoustic descriptors:

- Day-Night Average Sound Level (DNL)
- Sound Exposure Level (SEL)
- Maximum A-weighted Sound Level (L_{Amax})

These descriptors are relevant to the assessment criteria presented in Section 4.2. Grid noise maps showing the predicted noise levels were mapped at 5-dB intervals (see Section 6.2).

4.3.2.3 Sonic booms

Air overpressure would be produced by sonic booms when the rocket reaches a velocity faster than the speed of sound (supersonic). Extreme impacts from large sonic booms can result in an adverse behavioural or physiological response.

A literature review of similar launch facilities has been conducted to identify the risk of impact from sonic boom based on the location and proposed direction of launch.

4.4 Initial mitigation and management measures

The project design, construction methodology and operation strategies were progressed at the commencement of this impact assessment. Accordingly, mitigation measures that were already incorporated in the project planning have been considered within the assessment.

These initial mitigation and control measures have been summarised in Table 14.

Table 14 Planned mitigation and management measures

Design aspect	Mitigation and management measures
Construction noise management	If a construction activity results in noise with an adverse impact on amenity, all reasonable and practicable measures must be taken to minimise noise resulting from the activity in order to minimise the impact.

Design aspect	Mitigation and management measures
	This includes (but is not limited to) the following measures to the extent that is practicable: • Scheduling particularly noisy activities to commence after 9.00am where reasonable and practicable to do so. • Locating noisy equipment (such as masonry saws) or processes so that their impact on neighbouring premises is minimised (whether by maximising the distance to the premises, using structures or elevations to create barriers or otherwise). • Shutting or throttling equipment down whenever it is not in actual use. • Ensuring that noise reduction devices such as mufflers are fitted and operating effectively. • Ensuring that equipment displaying wear-induced noise characteristics is repaired or maintained prior to use. • Operating equipment and handling materials so as to minimise impact noise. • Using off-site or other alternative processes that eliminate or lessen resulting noise.
Water deluge system	Water deluge systems reduce noise impact by producing water droplets that interact with the generated sound waves. The sound energy is converted into heat energy through the water being turned to steam. This reduces emission of engine and booster noise from the launch pad. Water-based acoustic suppression systems are in common usage on launch pads, where they offer typical noise reductions of 3-5dB
Blast wave bunding	Blast walls are to be constructed to channel the rocket exhaust away from the pad.

Mitigation measures in addition to those outlined in Table 14 would be developed where emissions are predicted to be non-compliant with the criteria in Section 4.2, or where it is considered necessary to preserve the existing acoustic environment (Section 25 of the Environment Protection Act 1993).

4.5 Report clarifications

Note the following points of clarification with respect to the assessment presented in this report:

- The construction equipment and methodology was still in development at the time of reporting. Assumptions have been made using typical activities and equipment for each documented work stage.
- Helicopter movements to and from the site are for emergency purposes only and have not been assessed as part of typical operations.
- The impacts due to sonic booms have not been calculated using computer modelling.
- Occupational health and safety of staff working at Southern Launch (including those using the viewing areas) has not been considered and would be managed separately.
- Wildlife impacts have not been presented. This assessment is presented in the *Whalers Way Orbital Launch Complex Terrestrial Biodiversity Technical Report*.
- The underwater impact of jettisoned material from space vehicle launches has not been considered.
- The underwater acoustic modelling has not been undertaken for this assessment (see Section 6.3.2).

5.0 Baseline conditions

5.1 Sensitive receptors

There are no dwellings immediately adjacent to the proposed Project Area. There are a number of (approximately three) residential dwellings located to the north-east of the study area at Fishery Beach (See Figure 2). The nearest residential noise sensitive receptors to the launch and infrastructure sites are shown in Table 15.

Table 15 Sensitive receptors near launch activities

Location	Residential
Site A	~4.5km
Site B	~3.5km

5.2 Measurement results

Unattended background noise monitoring was undertaken at five locations between Tuesday 17th March and Friday 19th March 2020. Monitoring equipment was installed during the preliminary flora and fauna study.

Each monitoring location was described in terms of the vegetation present in the area as outlined in Table 16. Notes included in this table provide an indication of the typical noise environment of each monitoring location.

Table 16 Measurement locations and site descriptions

Site ID	Site description	Environment notes
1	Eucalyptus angulosa, low mixed Mallee	Low Mallee, average height approximately 1.5m tall. Some leaf rustle noise. No sea noise noted.
2	Eucalyptus angulosa, low mixed Mallee	Noise logger placed in semi open area where breaks in dense bush. No sea noise noted.
3	Eucalyptus diversifolia, mixed low Mallee	Noise logger placed in semi open area where breaks in dense bush, quite large areas of low heath breaks within patches. No sea noise noted.
4	Degraded leucopogon parvifolius, Open shrubland	Noise logger located approximately 300 metres away from windmill. No sea noise notes.
5	Beyeria lechenaultia, very low shrubland	Gentle sea noise audible at western end. Very low levels of shrub noise, with very low shrubland average height of 0.5m.

A summary of the monitoring locations, including equipment details and the duration of the monitoring is shown in Table 17.

Table 17 Measurement locations, duration and equipment details for unattended background noise monitoring

Site ID	GPS coordinates		Noise monitoring			Laboratory calibration expiry[1]
	Latitude	Longitude	Serial number	Start	End	
1	34°56'22.98"S	135°40'53.40"E	765699	17/03/2020 1015h	19/03/2020 1502h	11/10/2020
2	34°55'54.59"S	135°39'23.72"E	187447	17/03/2020 1030h	19/03/2020 1455h	28/05/2021
3	34°55'55.78"S	135°38'48.77"E	409167	17/03/2020 1040h	19/03/2020 1450h	13/08/2021
4	34°55'31.61"S	135°38'52.48"E	409174	17/03/2020 1050h	19/03/2020 1440h	13/08/2021
5	34°56'18.21"S	135°37'35.58"E	465445	17/03/2020 1000h	19/03/2020 1430h	12/10/2020

1. Note: Sound level meter calibration is valid for two years from the calibration date.

Calibration checks were conducted before and after monitoring to ensure that there were no variations in calibration throughout the monitoring period. Baseline unattended noise monitoring locations are shown in Figure 2. Further details of the monitoring methodology, results and derivation of criteria are provided in Section 4.1.

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Legend

- Monitoring Locations
- Residential Locations
- Construction Zones
- Project Layout

UNATTENDED NOISE MONITORING LOCATIONS AND RESIDENTIAL RECEPTORS

Client: Southern Launch

Whalers Way Orbital Launch Complex - Environmental Assessment Report: Noise Assessment

Figure

2

A4 size

5.2.1.1 Weather conditions

The meteorological data captured from Port Lincoln weather station and obtained through the Bureau of Meteorology was used to identify periods where measured noise levels should be adjusted or removed due to extraneous weather.

Adverse weather conditions were considered where wind speeds were noted to be greater than 5 m/s and/or rainfall was measured to be greater than 0.3 millimetres in an hour. The data from each site was investigated and data was omitted where adverse weather conditions, or extraneous noise events, affected the measurements.

5.2.1.2 Average background noise levels (L_{A90})

A summary of the measured background noise levels is provided in Table 18.

Table 18 Background noise monitoring results (average measured L_{A90} noise level)

Site	Description	Measured L_{A90} Noise Level, dB(A)	
		Day	Night
1	Low mixed Mallee	24	32
2	Low mixed Mallee	23	30
3	Low mixed Mallee	23	26
4	Open shrubland	27	35
5	Very low shrubland	24	30

5.2.1.3 Ambient noise levels (L_{Aeq})

The average measured ambient noise level for the day-time, evening and night-time periods at each unattended monitoring location is shown in Table 19.

Table 19 Ambient noise monitoring results (average measured L_{Aeq} noise levels)

Site	Description	Measured L_{Aeq} Noise Level, dB(A)	
		Day	Night
1	Low mixed Mallee	42	37
2	Low mixed Mallee	38	33
3	Low mixed Mallee	39	30
4	Open shrubland	46	41
5	Very low shrubland	51	48

5.2.1.4 Observations

Key observations from the existing conditions noise monitoring include:

- Overall, background noise levels in the study area were low. This is typical of rural and remote areas with low residential density and little to no exposure to transportation or industrial noise.
- The night-time background noise levels are greater than the day-time background noise levels at all locations. Reasons for this have not been established, however, it is possible for this to be caused by insects or birds.

It is expected that the residences identified in Section 4.1 would likely experience similar background noise levels to those measured at the five monitoring locations. The local acoustic environment being predominantly influenced by weather-induced noise, such as wind interaction with nearby vegetation and wildlife.

6.0 Impact assessment

Noise generated by construction and operational stage of the project has the potential to temporarily change the existing acoustic environment. This section presents predicted noise levels associated with the noisiest project activities and the assessment of the potential noise impacts to human amenity.

6.1 Construction noise

6.1.1 Construction noise levels at distance

Noise levels at various distances from the indicative construction scenarios are shown in Table 20.

Table 20 Noise impact set back distances

Activity reference	Construction works	Sound pressure level, L_{Aeq}, dB(A), at distances from source						
		25m	50m	100m	200m	500m	1000m	2000m
C1	Site preparation	78	72	66	60	54	48	42
C2	Utility construction	83	77	71	65	59	53	47
C3	Foundations	78	72	66	60	54	48	42
C4	Structural works	75	69	63	57	51	45	39
C5	Testing and commissioning	73	67	61	55	49	43	37
C6	Roads, landscaping and reinstatement	77	71	65	59	53	47	41

6.1.1 Construction safe working levels at distance from vibration

Table 21 presents the safe working distances which relate to cosmetic/structural damage and adverse human response for vibration-intensive construction equipment, in relation to the vibration criteria outlined in Section 4.2

Table 21 Construction safe working levels

Plant	Rating / description	Cosmetic damage safe working distances (m)			Human response safe working distances[1] (m)
		Heritage	Residential	Industrial	
Drop hammer	3t Enclosed (30kJ per blow assumed)	40	23	6	100
Drop hammer	25 kJ per blow	40	23	6	100
Drop hammer	5 kJ per blow	17	10	3	35
Excavation	-	2 [1]	1 [1]	<1	Avoid contact with structure
Hydraulic jacking rig	-	3	1.5	<1	Avoid contact with structure
Jackhammer	Handheld	1 [1]	1 [1]	<1	Avoid contact with structure
Large hydraulic hammer	(1,600 kg – 18-34t excavator)	34	22	7	73

Plant	Rating / description	Cosmetic damage safe working distances (m)			Human response safe working distances[1] (m)
		Heritage	Residential	Industrial	
Medium hydraulic hammer	(900 kg – 12-18t excavator)	12	7	2	23
Pile boring	≤ 800 mm	3	2	<1	N/A
Small hydraulic hammer	(300 kg – 5-12t excavator)	4	2	<1	7
Vibratory rig	50 kJ per cycle	50	30	8	100
Vibratory rig	10 kJ per cycle	23	15	3.5	100
Vibratory roller	< 50 kN (typically 1-2t)	8	5	2	15-20
	< 100 kN (typically 2-4t)	10	6	2	20
	< 200 kN (typically 4-6t)	20	12	3	40
	< 300 kN (typically 7-13t)	25	15	4	100
	> 300 kN (typically 13-18t)	30	20	6	100

1 Based on Table 1 in BS6472-1:2008

6.1.2 Discussion

Construction noise levels are calculated to be less than 51 dB(A) at the nearest residence for the worst-case construction scenario (during utility construction at Site E, activity reference C2). These levels are compliant with the assessment criteria as there are no specific noise criteria for construction works occurring between Monday and Saturday, 7.00am to 7.00pm, excluding public holidays.

Although construction noise is likely to be audible at times it is unlikely that construction noise would present a significant impact to the existing acoustic amenity at the closest residential locations if good practice construction methods are adopted. Vibration impacts are also expected to be limited to within 100 metres of the work area and would be unlikely to disturb humans at any stage of construction.

Accordingly, it is recommended that the good practice construction noise management measures listed in Table 14 are incorporated into the applicable environmental management plan.

6.2 Operation of supporting infrastructure

6.2.1 Operational noise levels from office, workshop and crane activity

Assumed operational noise levels and setback distances from generators and supporting launch infrastructure have been presented in Table 22.

Table 22 Setback distances and estimated noise levels from typical site facilities and supporting infrastructure

Facility/process	Sound pressure level, dB(A), at distances (in metres) from source						
	25	50	100	200	500	1000	2000
Building generators	62	56	49	40	29	20	<20
Workshop activity	59	53	48	38	25	<20	<20

Facility/process	Sound pressure level, dB(A), at distances (in metres) from source						
	25	50	100	200	500	1000	2000
Lifting crane	61	54	47	37	26	<20	<20

In addition to these fixed operational noise events, up to 16 truck movements per week have been assumed as listed in Section 2.0.

The maximum (L_{Amax}) noise produced by a single truck movement would be approximately 85 dB(A) at 10 metres from a passby. These above truck movements are expected throughout the day and are not expected to cause significant noise impact.

6.2.2 Discussion

Noise generated from buildings generators and other supporting launch infrastructure and activities have been predicted to be less than 20 dB(A) at distances greater than one kilometre from the launch facilities. These noise levels would likely be inaudible at the nearest residential locations at Fishery Bay, which are more than 2.3 kilometres away from any launch facility. It is unlikely that typical operational activities, excluding a rocket launch or testing, would cause disturbance to the habitants of nearby residences.

6.3 Operation of launch vehicles

Noise from launches and testing would temporarily alter the quiet setting of the natural environment for one to two minutes during launches and for up to 15 seconds during testing. These events have the potential to disturb nearby residents.

Parameters relevant to the disturbance of humans have been considered when calculating the impacts from the operational noise associated with launch vehicles. Table 23 provides and overview of the parameters and assumptions for each scenario. A full list of assumptions has been included within Section 4.2.3.

Table 23 Modelling scenarios

Parameter, dB(A)	Scenario	Noise Map results
L_{max}	The maximum instantaneous sound pressure level for a single subsonic launch assuming the loudest rocket from each proposed launch site.	Figure 4 (Site A) Figure 5 (Site B)
SEL	The Sound Exposure Level for a single subsonic launch assuming the loudest rocket from each proposed launch site.	Figure 6 (Site A) Figure 7 (Site B)
DNL	The combined future equivalent sound level for a 24 hour period assuming up to 36 launches per year and 10 tests. The following has been modelled for this assessment: • Site A launches: 9 day (7am to 10pm) and 9 night (10pm to 7am) • Site B launches: 9 day (7am to 10pm) and 9 night (10pm to 7am) Site rocket testing: 10 day (7am to 10pm) for a duration of 15 seconds for each test	Figure 8 (Site A & B)

Note that the above levels have not been produced for the purpose of determining compliance as there are no regulations that specify required levels for the operation of space facilities in Australia. The predicted levels have been compared to those presented in Section 4.2.3 as a reference point for the discussion of impacts with reference to the proponents general environmental duty[2].

[2] Environment Protection Act 1993

6.3.1 Predicted noise levels

This section presents the predicted noise levels associated with the launch and testing of rockets followed by a discussion in Section 6.3.2 outlining how these levels may impact the amenity of nearby residents. Table 24 provides an overview of the predicted level at each residence.

The noise levels presented are considered a conservative approximation based on the information available at the time of the assessment. Proposed operation is likely to feature much smaller rockets (i.e. quieter) than those modelled for all launches. Furthermore, the noise reduction from the initial mitigation measures (water deluge and blast walls) captured within the design (See Section 4.4) have not been included within the results presented (limitation of modelling software).

Table 24 Sensitive receptors near launch activities

Location	Launch from Site A		Launch from Site B		Day-Night Average Sound Level (DNL)
	L_{Amax}	SEL	L_{Amax}	SEL	
Residence A	95	112	99	116	63
Residence B					
Residence C					

An indicative histogram for noise received by these residencies over the time of a launch has been shown in Figure 3. The initial thrust produced by the launch vehicle is expected to produce high levels of noise starting a few milliseconds after ignition. The greatest noise produced is expected to occur when the rocket is at maximum thrust close to the ground. The predicted levels are expected to radiate omnidirectionally away from this location as shown in the following noise contours.

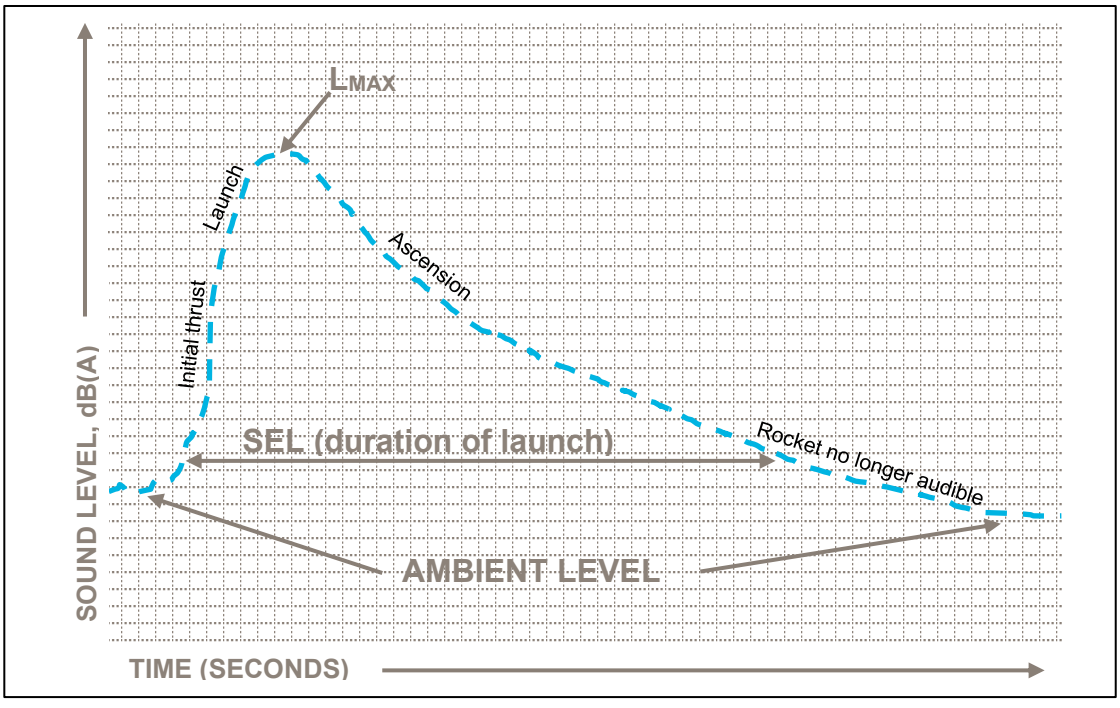

Figure 3 Noise level from a nominal launch over time

The DNL is not shown above as it is calculated using a person's cumulative exposure to sound over a 24-hour period, expressed as the noise level for the average day of the year on the basis of annual operations[3].

[3] https://www.faa.gov/regulations_policies/policy_guidance/noise/basics/

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L_{Amax} Noise Levels

- 85 dBA
- 90 dBA
- 95 dBA
- 100 dBA
- 105 dBA
- 110 dBA
- 115 dBA
- 120 dBA
- 125 dBA
- 130 dBA
- 135 dBA

Features

- Construction Zones
- Residential Locations

CALCULATED L_{AMAX} NOISE LEVELS FOR A ROCKET LAUNCH AT LAUNCH SITE A

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Figure 4

A4 size

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L_{Amax} Noise Levels

- 85 dBA
- 90 dBA
- 95 dBA
- 100 dBA
- 105 dBA
- 110 dBA
- 115 dBA
- 120 dBA
- 125 dBA
- 130 dBA
- 135 dBA

Features

- Construction Zones
- Residential Locations

CALCULATED L_{AMAX} NOISE LEVELS FOR A ROCKET LAUNCH AT LAUNCH SITE B

Client: Southern Launch

Whalers Way Orbital Launch Complex - Environmental Assessment Report: Noise Assessment

Figure 5

A4 size

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0 750 1,500
Meters

Scale 1:40,000 (when printed at A4)

Sound Exposure Level

- 105 dBA
- 110 dBA
- 115 dBA
- 120 dBA
- 125 dBA
- 130 dBA

Features

- Residential Locations
- Construction Zones

CALCULATED SINGLE LAUNCH SOUND EXPOSURE LEVEL AT SITE A

Client: Southern Launch

Whalers Way Orbital Launch Complex - Environmental Assessment Report: Noise Assessment

Figure 6

A4 size

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0 750 1,500
Meters

Scale 1:40,000 (when printed at A4)

Sound Exposure Level

- 105 dBA
- 110 dBA
- 115 dBA
- 120 dBA
- 125 dBA
- 130 dBA

Features

- Residential Locations
- Construction Zones

CALCULATED SINGLE LAUNCH SOUND EXPOSURE LEVEL AT SITE B

Client: Southern Launch

Whalers Way Orbital Launch Complex - Environmental Assessment Report: Noise Assessment

Figure 7

A4 size

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0 750 1,500
Meters

Scale 1:40,000 (when printed at A4)

Day Night Noise Levels (DNL)

- 55 dBA
- 60 dBA
- 65 dBA
- 70 dBA
- 75 dBA

Features

- Residential Locations
- Construction Zones

COMBINED DNL NOISE LEVELS FOR A ROCKET LAUNCH AT LAUNCH SITE A, SITE B AND TESTING AT SITE A

Client: Southern Launch

Whalers Way Orbital Launch Complex - Environmental Assessment Report: Noise Assessment

Figure 8

A4 size

6.3.2 Discussion

The cumulative noise exposure (DNL) from the proposed ultimate operating scenario (36 yearly launches) is predicted to below the proposed assessment criteria of DNL 65 dB(A) used to assess the noise impact from launch sites. Achieving a DNL 65 dB(A) indicates that the overall level and frequency of the planned Southern Launch activities are less likely to cause a significant community response to noise as per FAA recommendations.

This does not mean that a launch would not cause annoyance or disturbance. At this stage of the project it is assumed that a rocket could be launched at any time over a 24-hour period. Consequently, the maximum instantaneous noise produced by an individual rocket launch or static test is likely to cause disturbance at the neighbouring properties, particularly if these activities are undertaken at night.

Maximum external noise levels (L_{Amax}) of up to 95 dB(A) and 99 dB(A) were calculated outside the residential property nearest to Launch Site A and Launch Site B respectively. Noise similar to this level is likely to be of short duration (seconds) when a launch vehicle is close to the ground. This level would decline after launch due to the gradual decrease in energy output from the rocket and increased altitude. A lower audible sound associated with the rocket engine may persist after the launch (approximately 1 – 2 minutes) under quiet conditions.

The external levels transferring to the inside a typical residential building during a launch would likely be high enough to disturb sleep. Noise during a day launch or test may also be at an annoying outdoor level for a brief period (less than one minute) before ambient levels returned to normal. For context, a comparable level of sound could be experienced by standing close to a train passby or below an aircraft flyover at low altitude.

Additional mitigation at the source to reduce these levels may not be feasible as the design has already incorporated a water deluge system (example shown in Figure 9) to reduce both near and far field noise impacts and blast walls/bunds to reflect acoustic energy away from the launch vehicle and sensitive areas. These are noted as two of the most effective noise suppressants when a rocket is in a launch position (Lubert, 2017).

Figure 9 Kennedy Space Centres Launch Pad 39A water sound suppression system (NASA - https://www.nasa.gov/missions/shuttle/f_watertest.html)

Administrative measures proposed by Southern Launch would also include a plan to notify residents of upcoming launch activities and to restrict human presence within required set back distances prior to a launch. This may not necessarily reduce the noise level exposure but would prepare residents for a loud acoustic event and inform them about the activities being undertaken on site.

A noise monitoring and reporting program would also be developed to verify noise impacts of launch activity on nearby residents. Details of the ongoing monitoring program are provided in Section 7.2.

It is recommended that further considerations are made during detailed design regarding the scheduling of launches at night as impacts would be greatest during this time.

6.3.3 Sonic booms

The potential impact from sonic booms has been determined by comparing the impact of other launch facilities with a similar planned azimuth, trajectory and rocket size. The audible component of a sonic boom may sound similar to a single distant thunder clap. Exposure to this sound in a quiet environment could cause an unexpected disturbance to sensitive receptors.

Supersonic speeds are assumed to occur approximately three kilometres from the coast during vehicle ascent over the ocean. Sonic booms produced during vehicle ascent are typically directed in front of the vehicle and the entire boom footprint is usually some distance downrange of the launch site (SpaceX, 2020).

Furthermore, the rockets proposed for the Southern Launch facility are also relatively small which would limit the size of sonic boom being created. This means that the vehicle is unlikely be big enough or located close enough to land to produce a focused boom that could reach the surface.

Furthermore, impact assessments for suborbital rocket launch facilities in the United States (FAA, 2009) have concluded that sonic booms are less likely to contribute to other noise impacts associated with the launch if they occur over the ocean at a high altitude. Rocket landing events can often result in single or multiple sonic booms as vehicles return to subsonic speeds however this type of activity is not proposed by Southern Launch.

Hence, the overpressure produced by the sonic boom is not expected to exceed the assessment criteria of 133 dB(L) on land.

6.3.4 Ground vibration

The extent of ground and structural vibration produced by the acoustic environment near the launch vehicle is expected to be limited to the buildings supporting the launch. This consideration is related to the design of the facility and is outside the scope of this assessment.

No evidence of damage or significant disturbance caused by ground vibration during typical launch and testing operations was found when undertaking the literature review in preparation for this assessment.

7.0 Mitigation measures

7.1 Construction

Noise impacts from construction activities have not been identified as a significant risk at this stage of the project. Nevertheless, all reasonable and practicable measures must be taken to minimise noise resulting from the construction in order to reduce the chance of an adverse impact on the amenity of nearby residencies.

7.2 Operation

Impacts during typical daily operations were predicted to achieve the noise policy levels. Consequently, a significant impact on the environment is unlikely and additional mitigation has not been recommended.

Noise during the testing and launching of rockets have incorporated planned mitigation measures including:

- Using blasting walls or bunds near launch and testing sites
- Operation of a water deluge system

Details of the above system will be refined during the detailed design phase of the project.

In addition to the above it is recommended that the following mitigation measures are considered:

- Scheduling of launch testing during the day only and minimising night launches where feasible to do so.
- Development of a stakeholder engagement plan with procedures for notifying residents in advance of all planned launch events.
- Development of a noise monitoring and reporting program to verify noise impacts of launch activities on nearby residents. This should include the following:
    - Measurement of all launches within the first 12 months of operation at up to three locations with at least one location being the closest residential receptor
    - Measurement of new launch vehicles (not measured in the first 12 months) at up to three locations with at least one location being the closest residential receptor
    - Details of the effectiveness of onsite noise mitigation measures and the verification of the predicted noise levels
    - Reported response from nearby residents.

The above measures should be included within the Operational Environmental Management Plan (OEMP) developed for the Project.

8.0 Conclusion

This report presents a preliminary assessment of the potential noise impacts of the proposed Whalers Way Orbital Launch Complex.

Existing conditions

Noise monitoring of the existing environment throughout the Project study area was used to develop an understanding of the existing background levels.

Background noise levels were considered typical of rural and remote areas with low residential density and little to no exposure to transportation or industrial noise.

Construction noise impact assessment

The construction works would likely occur between 7am and 5pm, Monday to Friday, excluding public holidays. This would be within the allowable construction hours for the South Australian Noise EPP, where no criteria are applied.

The risk of significant construction noise impacts is considered low based on the scenarios assessed in this report.

Operational noise impact assessment

A desktop study has considered the potential operational noise impacts due to the operation of the proposed Project, as well as noise associated with the launch and testing of a sub-orbital rocket.

The risk of significant noise impacts due to the typical operation of the launch facilities, including office buildings, workshops and other supporting infrastructure is considered to be low based on the scenarios presented in this report.

Noise levels were predicted to be below the DNL of 65 dB(A) for residents closest to the launch sites. However, the maximum instantaneous noise produced by an individual rocket launch or static test is likely to cause disturbance at the neighbouring properties, particularly if these activities are undertaken at night.

Mitigation measures

Initial mitigation was incorporated into the construction and operation impact assessments.

The proposed source controls were considered the best practice mitigation measures available to the project for launch and testing activities (water deluge noise suppression system and blast walls).

Stakeholder engagement and administration actions have been recommended to ensure nearby residents are informed about launch activities. Noise monitoring was also recommended to confirm predicted noise levels and the effectiveness of onsite noise mitigation.

9.0 References

Legislation, Australian Policies and Guidelines

Commonwealth *Space (Launches and Returns) Act 2018*

South Australian *Development Act 1993*

South Australian *Environment Protection Act 1993*

South Australia *Environmental Protection (Noise) Policy 2007 (Noise EPP)*

Australian Standards

Australian Standard 2436-2010 *Guide to noise and vibration control on construction, demolition and maintenance sites*

Australian Standard AS 2187.2-2006 *Explosives – Storage and use Part 2: Use of explosives*

Overseas and International Standards

FAA, 14 CFR Part 150 - Airport Noise Compatibility Planning

British Standard 5228-1:2009 *Code of practice for noise and vibration control on construction and open sites –Part 1: Noise*

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Appendix A

Glossary

Appendix A Glossary

Term	Definition	
'A' Weighted	Frequency filter designed to adjust the absolute sound pressure levels to correspond to the subjective response of the human ear. The A-weighting filter emphasises frequencies in the speech range (between 1 kHz and 4 kHz) which the human ear is most sensitive to. When an overall sound level is A-weighted it is expressed in units of dB(A).	
Ambient noise	Ambient noise is the all-encompassing noise at a point comprising sound from all noise sources near and far. The equivalent continuous sound pressure level. L_{Aeq}, is typically the descriptor used to describe ambient noise.	
Background level (L_{90} *or* L_{A90})	The underlying noise level present in the ambient noise when extraneous noise (such as a lawnmower and dogs barking) is removed. The L_{90} sound pressure level is used to quantify the background level. For a day, evening or night period means the arithmetic average of the L_{A90} levels for each hour of that period for which the commercial, industrial or trade premises under investigation normally operates. The background level shall include all noise sources except noise from commercial, industrial or trade premises which appears to be intrusive at the point where the background level is measured.	
Decibel [dB]	The measurement unit of sound.	
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A three decibel increase in the sound pressure level corresponds to a doubling in sound energy. An increase or decrease of three decibels is typically considered to be the smallest change in sound level that a listener can detect. A change of five decibels, however, is clearly noticeable. A 10 dB increase in the sound pressure level corresponds to a perceived doubling in volume. This increase is typically perceived to sound twice as loud. The table below shows the sound pressure level that would be typically experienced when exposed to different sources:	
	0 dB(A)	Threshold of human hearing
	30 dB(A)	A quiet country park
	40 dB(A)	Whisper in a library
	50 dB(A)	Open office space
	70 dB(A)	Inside a car on a freeway
	80 dB(A)	Outboard motor
	90 dB(A)	Heavy truck pass-by
	100 dB(A)	Jack hammer / subway train
	110 dB(A)	Rock concert
	115 dB(A)	Limit of sound permitted in industry
	120 dB(A)	747 take off at 250 metres
Frequency [f]	Frequency is measured in Hertz (Hz).	

Term	Definition
	The frequency corresponds to the pitch of the sound: a high frequency to a high-pitched sound and a low frequency to a low-pitched sound.
Insertion loss	The reduction in sound pressure level at a receptor by inserting a barrier between the source and considered receptor.
Impulsiveness	A noise is more annoying when it has an impulsive component (such as banging noise). Where a noise source is impulsive, an adjustment is made to allow for the additional annoyance caused by the impulses.
L_{eq}	Equivalent (energy averaged) noise level measured over a time period. This noise descriptor is commonly used in environmental noise policies and assessments. The time period the measurement is averaged over may be included in the subscript, i.e. $L_{Aeq,\ 30min}$.
L_{90}	The noise level exceeded 90% of the measurement period. This descriptor is used to represent the background noise level.
L_{max}	The maximum sound pressure level measured over the measurement period. The A-weighted form is denoted 'L_{Amax}'.
Noise-sensitive area	The SEPP N-1 noise limits and NIRV recommended noise levels are set at noise-sensitive areas. These are mainly residential dwellings, but can include, for example, motels and tourist establishments. They do not include schools. Noise is assessed at the property boundary or within 10 m of a dwelling, whichever is the lesser.
Octave band	The International Standards Organisation has agreed upon preferred frequency bands for sound measurement and the octave band is the widest band for frequency analysis. The upper frequency limit is approximately twice the lower frequency limit and each band is identified by its band centre frequency. Typical Octave Band frequencies for environmental noise assessments are: 31.5Hz, 63Hz, 125Hz, 250Hz, 500Hz, 1kHz, 2kHz, 4kHz, 8kHz.
One-third octave band	Where more detailed information about a noise is required, standardised one-third octave band analysis may be used. There are three one-third octave bands for each octave band. (e.g. 25Hz, 31.5Hz, 40Hz one-third octave bands cover the same frequency range as the 31.5Hz octave band).
Sensitive receptor	Areas where the occupants, buildings or land use are potentially susceptible to the adverse effects of exposure to noise and vibration.
Sound power level	The total sound emitted by a source.
Sound pressure level	The amount of sound at a specified receiving point.
Tonality	Noise is subjectively more annoying when it has a tonal component (a perceptible hum or whine). Tonality can be determined by subjective assessment or from one-third octave band analysis of the noise. Where a noise is tonal, an adjustment is made to allow for the additional annoyance caused by the tone.

Appendix B

Baseline monitoring

Appendix B Baseline monitoring

The average measured noise levels by time period are presented at the bottom of each monitoring summary. The methodology for calculating the average, minimum and maximum noise levels for each monitoring location was as follows:

- The $L_{A90\ (day/evening/night)}$ (arithmetic average) and $L_{Aeq\ (day/evening/night)}$ (logarithmic average) was calculated for each single day of the monitoring period.
- The overall minimum, maximum and average noise level was calculated for each time period (day/evening/night) of the monitoring period. These values are presented in the following summary tables. Time periods containing extraneous noise events or inclement were omitted from this calculation.

Details of the monitoring instrumentation and location are presented in Section 5.2 of the report.

Noise Monitoring Data Sheet

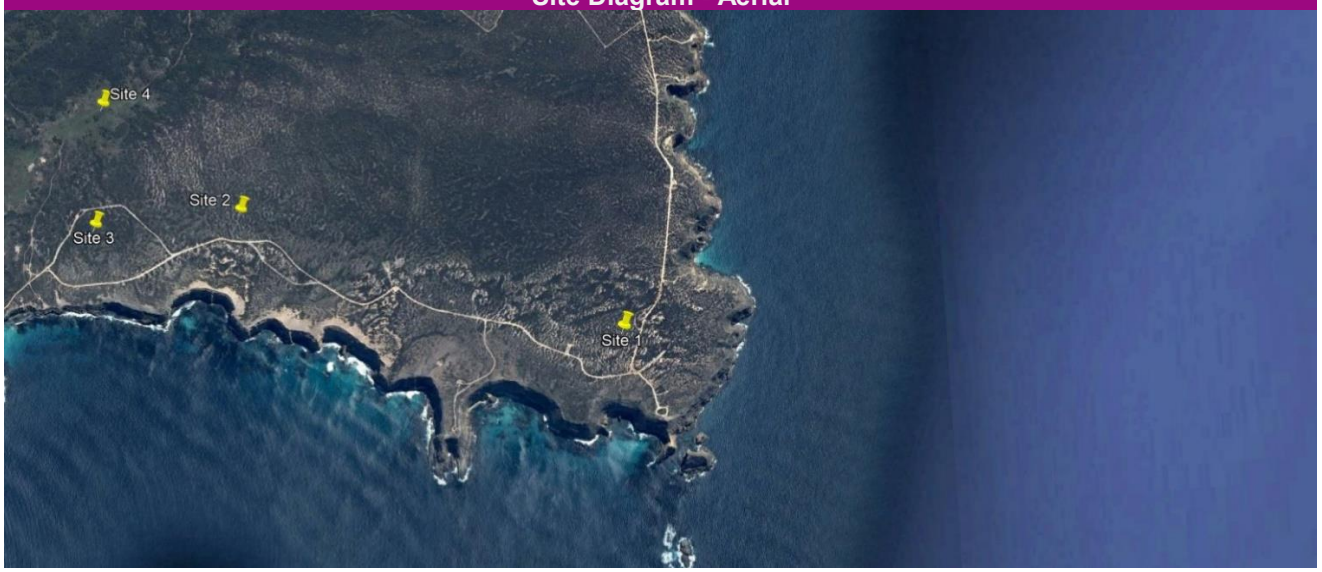
Southern Launch

SITE ID
1

From	17/03/2020 10:30	Mic. Height (m)	1.2 - 1.5 m	Address	Site 1
To	19/03/2020 14:45	Meas. Type	Environmental	Suburb	Whalers Way
Pre Calibration	94.0	Inst. Type	Rion NL-21	District	South Australia
Post Calibration	94.0	Inst. Serial #	187447	Longitude	135°40'53.40"E
Sample Int.	15 min	Operator	AECOM	Latitude	34°56'22.98"S

LA90(Day) (7am-10pm)	24.1 dB(A)	LA90(Night) (10pm-7am)	31.9 dB(A)

Site Diagram - Aerial



Site Photographs

AECOM

Noise Monitoring Data Sheet

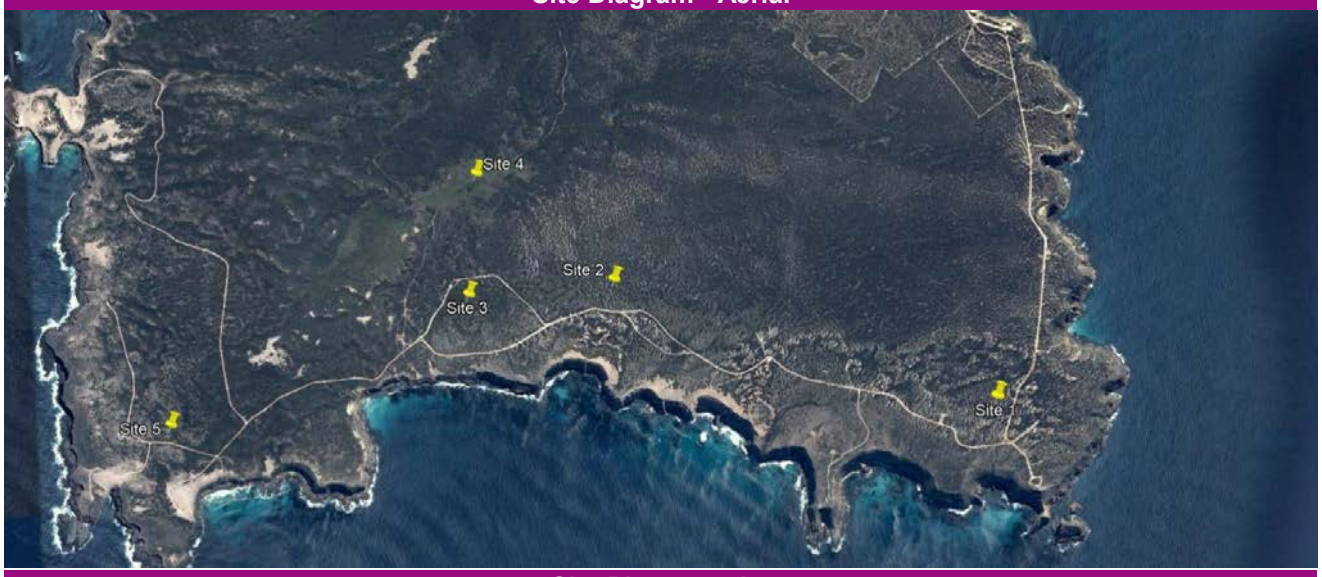
Southern Launch

SITE ID
2

From	17/03/2020 10:45	Mic. Height (m)	1.2 - 1.5 m	Address	Site 2
To	19/03/2020 14:30	Meas. Type	Environmental	Suburb	Whalers Way
Pre Calibration	94.0	Inst. Type	Rion NL-21	District	South Australia
Post Calibration	94.0	Inst. Serial #	409167	Longitude	135°39'23.72"E
Sample Int.	15 min	Operator	AECOM	Latitude	34°55'54.59"S

LA90(Day) (7am-10pm)	23.4 dB(A)	LA90(Night) (10pm-7am)	29.6 dB(A)

Site Diagram - Aerial



Site Photographs

AECOM

Noise Monitoring Data Sheet

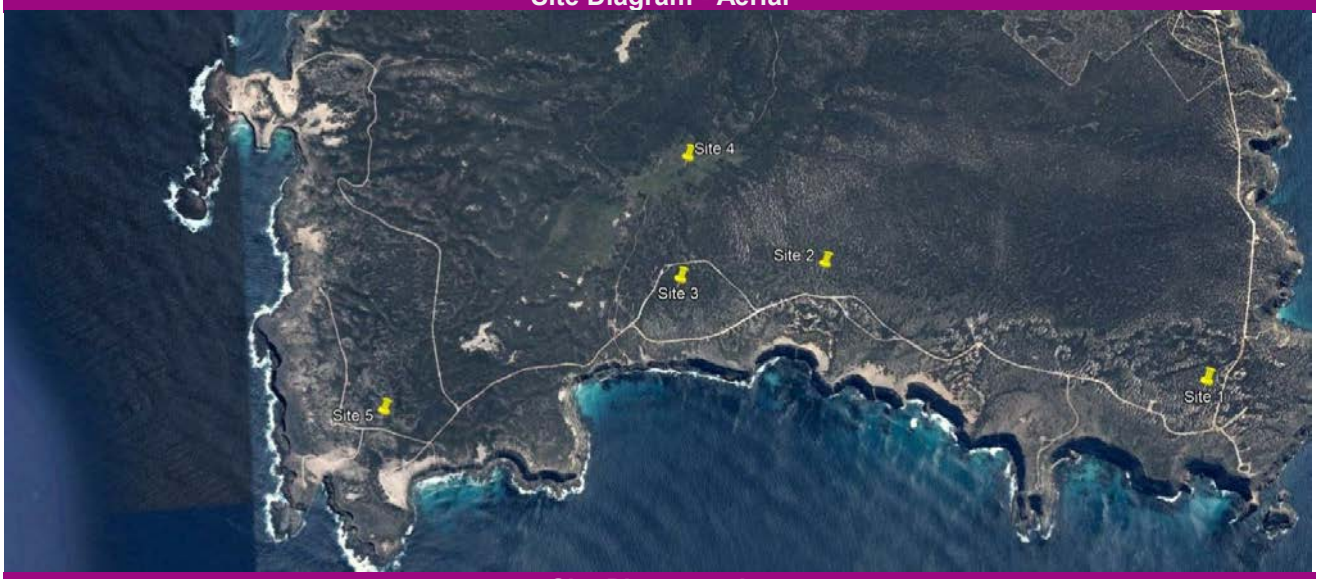
Southern Launch

SITE ID
3

From	17/03/2020 10:45	Mic. Height (m)	1.2 - 1.5 m	Address	Site 3
To	19/03/2020 14:15	Meas. Type	Environmental	Suburb	Whalers Way
Pre Calibration	94.0	Inst. Type	Rion NL-21	District	South Australia
Post Calibration	94.0	Inst. Serial #	409174	Longitude	135°38'48.77"E
Sample Int.	15 min	Operator	AECOM	Latitude	34°55'55.78"S

LA90(Day) (7am-10pm)	22.8 dB(A)	LA90(Night) (10pm-7am)	26.1 dB(A)

Site Diagram - Aerial



Site Photographs

Noise Monitoring Data Sheet

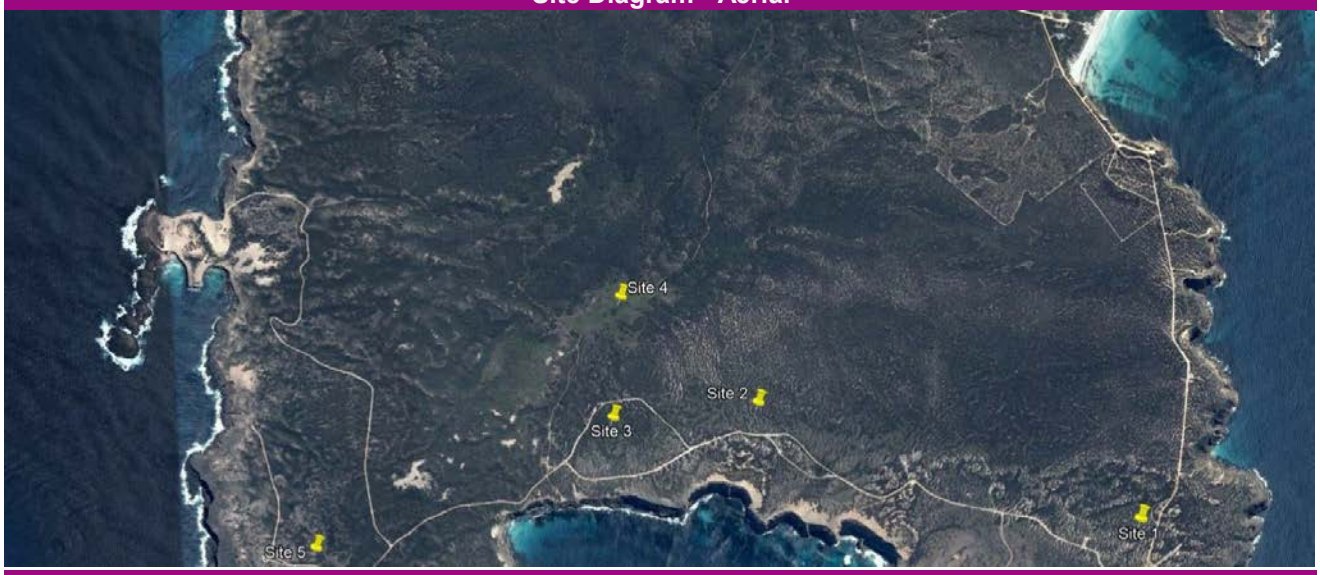
Southern Launch

SITE ID
4

From	15/03/2020 10:00	Mic. Height (m)	1.2 - 1.5 m	Address	Site 4
To	17/03/2020 13:00	Meas. Type	Environmental	Suburb	Whalers Way
Pre Calibration	94.0	Inst. Type	Rion NL-21	District	South Australia
Post Calibration	94.0	Inst. Serial #	465445	Longitude	135°38'52.48"E
Sample Int.	15 min	Operator	AECOM	Latitude	34°55'31.61"S

LA90(Day) (7am-10pm)	27.3 dB(A)	LA90(Night) (10pm-7am)	34.7 dB(A)

Site Diagram - Aerial



Site Photographs

Noise Monitoring Data Sheet

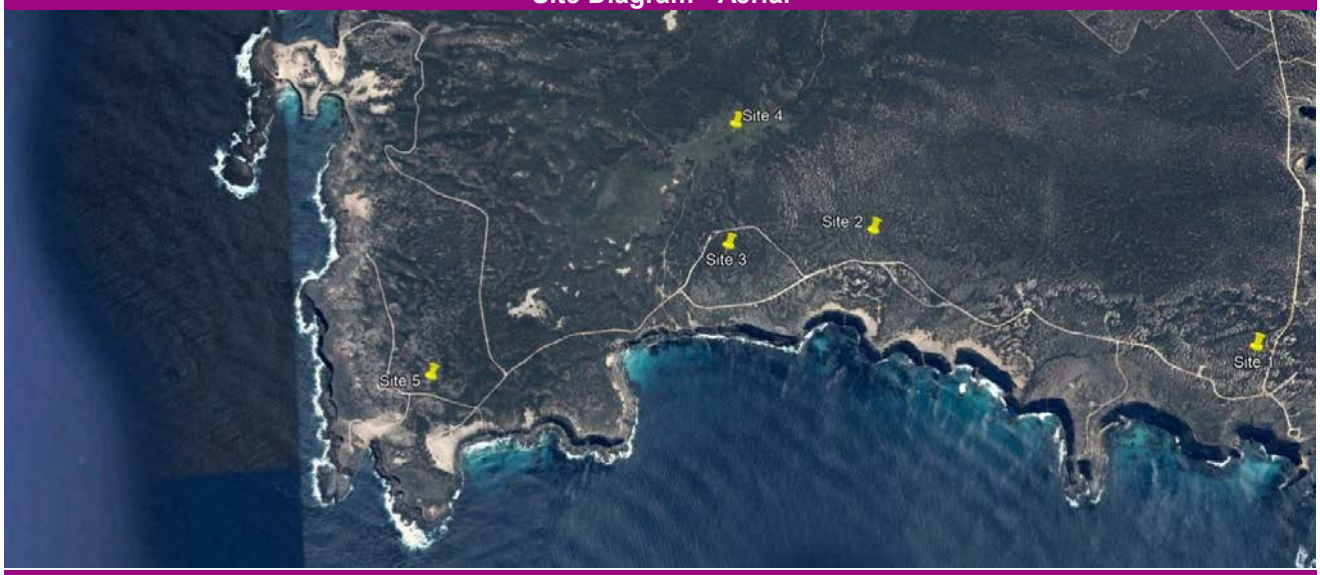
Southern Launch

SITE ID
5

From	13/03/2020 8:00	Mic. Height (m)	1.2 - 1.5 m	Address	Site 5
To	15/03/2020 12:45	Meas. Type	Environmental	Suburb	Whalers Way
Pre Calibration	94.0	Inst. Type	Rion NL-21	District	South Australia
Post Calibration	94.0	Inst. Serial #	765699	Longitude	135°37'35.58"E
Sample Int.	15 min	Operator	AECOM	Latitude	34°56'18.21"S

LA90(Day) (7am-10pm)	24.3 dB(A)	LA90(Night) (10pm-7am)	30.0 dB(A)

Site Diagram - Aerial



Site Photographs

AECOM