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Amphibian Scaffolding

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Limitations			
This report has been prepared for the titled project and client, in accordance with our agreed scope of work, reference: PA-01076/SC2, dated 31 May 2023.			
This report should not be used or relied upon for any other project or purpose without the written authorisation of Pulsar Acoustics Ltd. Pulsar Acoustics Ltd accepts no responsibility or liability for the consequences of this document if it is used for a purpose other than for the project to which it was intended. The findings and opinions included herein are based on measurements and information gathered prior to the date the report was issued. If additional information becomes available which may affect our comments, conclusions or recommendations, then Pulsar Acoustic Ltd should be informed. We then reserve the right to review the information, assess any new potential concerns, and modify our advice accordingly.			



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1.0 - Introduction

Amphibian Scaffolding are proposing to replace the existing open storage yard area with a new building known as Warehouse 2. This building will enable all the scaffolding equipment items currently being stored outside to be placed within the building.

Pulsar Acoustics have previously undertaken a BS4142 assessment and planning permission has been granted with the following planning condition:

“3 - The development shall not be occupied until a Noise Management Plan, including hours of operation, hours of deliveries/collections, full details of loading/unloading arrangements and all noise mitigation measures, including the design and layout of the warehousing as well as any acoustic barriers, has been submitted to and approved in writing by the Local Planning Authority.

The Noise Management Plan shall be in accordance with the recommendations in the previously submitted Pulsar Acoustics Assessment Report (ref PA-01076-01-Rev02) and shall be implemented in full on occupation of each building/phase and complied with thereafter unless otherwise agreed in writing by the Local Planning Authority.”

Since planning was granted we have revisited site to undertake additional acoustic measurements to assist with the design and layout process for Warehouse 2, and to provide noise management plan guidance.

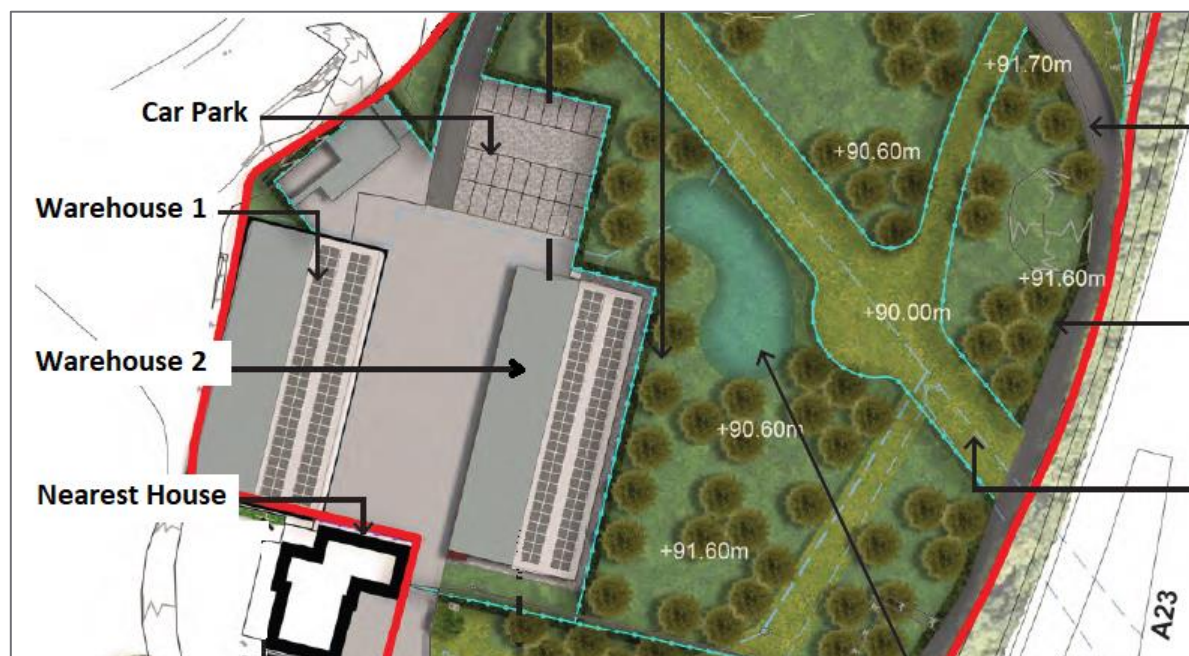
This report should be read in conjunction with Pulsar Acoustics Assessment Report, ref: PA-01076-01-Rev02.



2.0 - Site Description and Proposal

There is currently a large outdoor yard area used as storage for many items of equipment. The new warehouse building is proposed to store all this equipment.

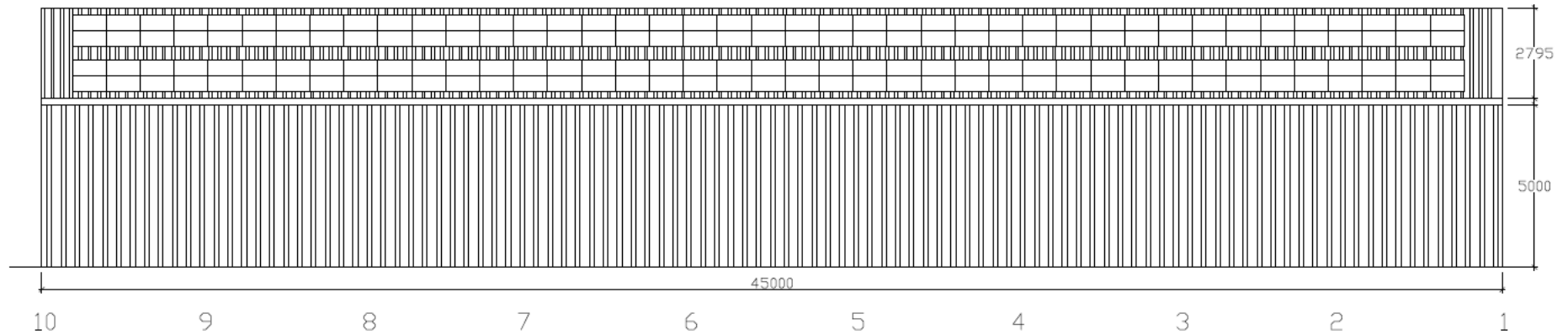
Warehouse 2 is to sit opposite the existing Warehouse 1 building. Warehouse 2 is to be approximately 45m long, 20m wide and around 8m high at the peak of the pitched roof. Its position can be seen annotated on the site plan below.



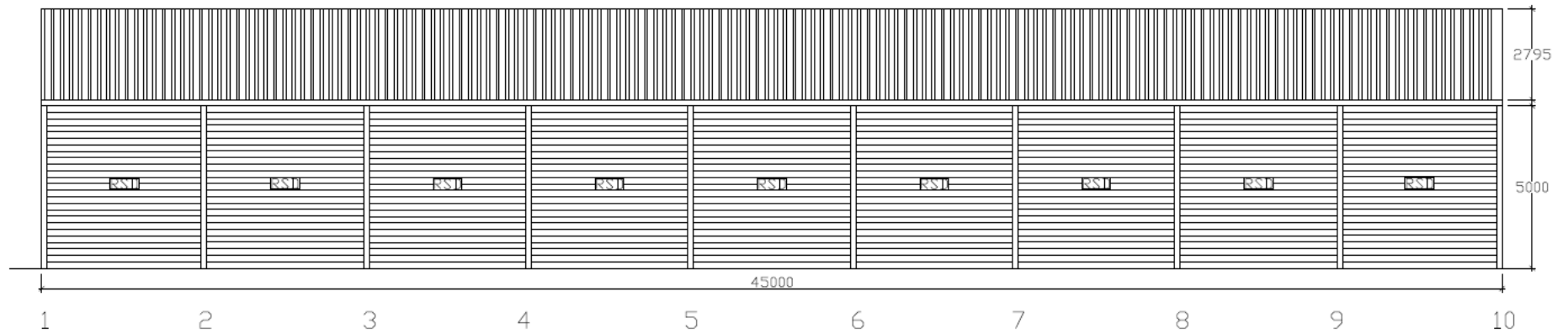


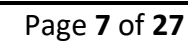
The proposed elevation and roof plan drawings are copy and pasted below.

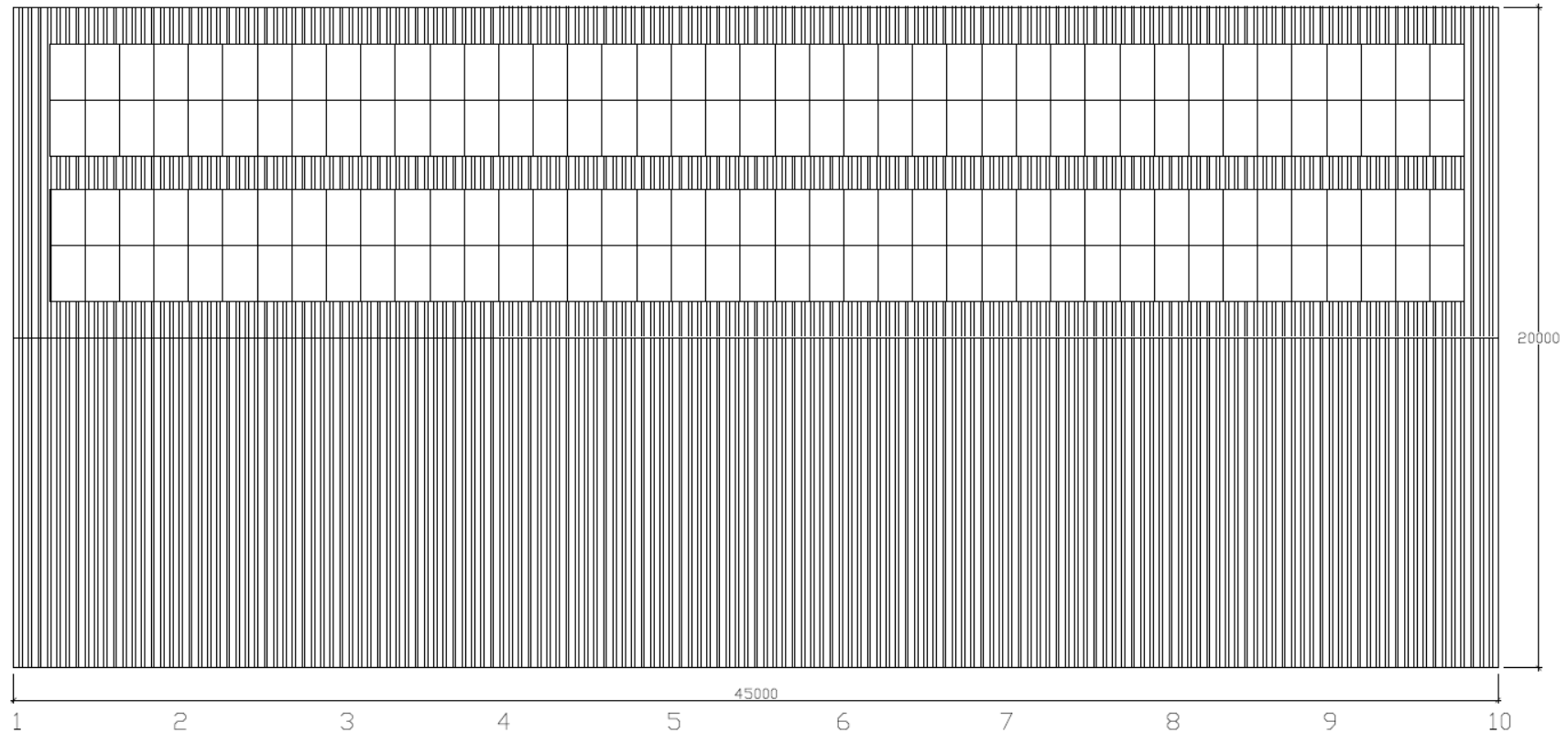
East Elevation



West Elevation





Roof Plan

Existing Warehouse 1 has seven loading bays. We understand Warehouse 2 is to be thought of as fundamentally a mirror image of Warehouse 1 but with nine loading bays.

The layout in Warehouse 1 is set up such that the workers can load/unload the trucks as efficiently as possible. There is a pole rack at the rear with various lesser used miscellaneous items on the shelves above, to the side of the trucks between the bays are piles of planks and boxes of fittings.



To assist with understanding the proposals and descriptions we have annotated a selection of photos below.









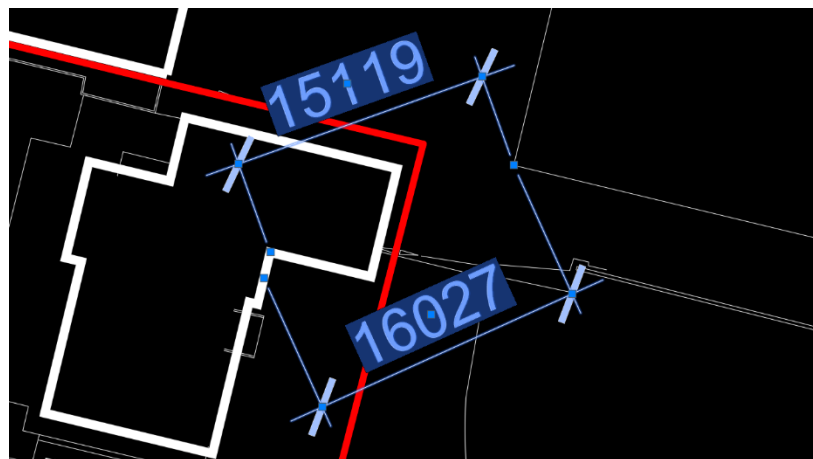
3.0 - Acoustic Criteria

The overriding acoustic criteria was determined by undertaking a BS4142 assessment, as described in the Pulsar Acoustics Assessment Report PA-01076-01-Rev02.

This report determined that the existing lowest background noise level outside the residential property around 05:30am was 58dBA L90,15min, due to traffic flow on the busy A23 which was the dominant noise source in the absence of scaffolding activities.

Due to the 'impulsive' noise characteristics of scaffolding activities a 9dBA penalty was included.

Therefore the noise level design target for activities associated with Warehouse 2 is 49dBA Leq,15min to be measured outside of the nearest noise sensitive residential window. We note the nearest residential bedroom window is around 15m to 16m away from the corner of the Warehouse 2 building as confirmed by the CAD drawing below.



Our assessment and calculations are therefore based on achieving a resultant noise level of 49dBA Leq_{15min} at this window.

A site photo of the window is shown below.





4.0 - Additional Site Surveys

4.1 - Sound Insulation Test

To assist with the design proposals for Warehouse 2 sound insulation tests were undertaken for Warehouse 1 on 15 June 2023.

It should be noted that the large roller shutter doors are the dominant acoustic weakness of most industrial units. We understand Warehouse 2 is proposed to have similar large roller shutter doors to those tested at Warehouse 1.

The table below presents the inside to outside octave band frequency (Hz) sound reduction (dB) through Bay 1 and 4 doors, determined at a measurement distance of 15m with all the doors closed.

Description	Inside to Outside Sound Reduction (dB) at Octave Band Frequency (Hz) to 15m							
	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz
Sound Insulation - Warehouse 1 - Bay 1	18	25	29	28	25	29	36	29
Sound Insulation - Warehouse 1 - Bay 4	19	24	27	27	25	29	32	36
Average	18	24	28	28	25	29	34	32

4.2 - Activity Noise Survey

Within Warehouse 1 the loudest activities in a working day happen early morning. When the workers arrive they park to the north of site, they enter the warehouse on foot and start loading and unloading the trucks which are already situated within. During this time their activities include the clanging and banging sounds from loading and unloading planks, poles, various fittings and accessories, and then the rumble of the truck engines as they drive away.

The trucks return around 3pm onwards. They simply park up and go home. Currently they do not load/unload the trucks in the afternoon unless they need to specifically cater for contracts with significant equipment requirements or those which could be much greater distances away.



A sound level meter was set up in Warehouse 1 to measure the activity noise levels associated with the trucks in Bays 1 and 2.

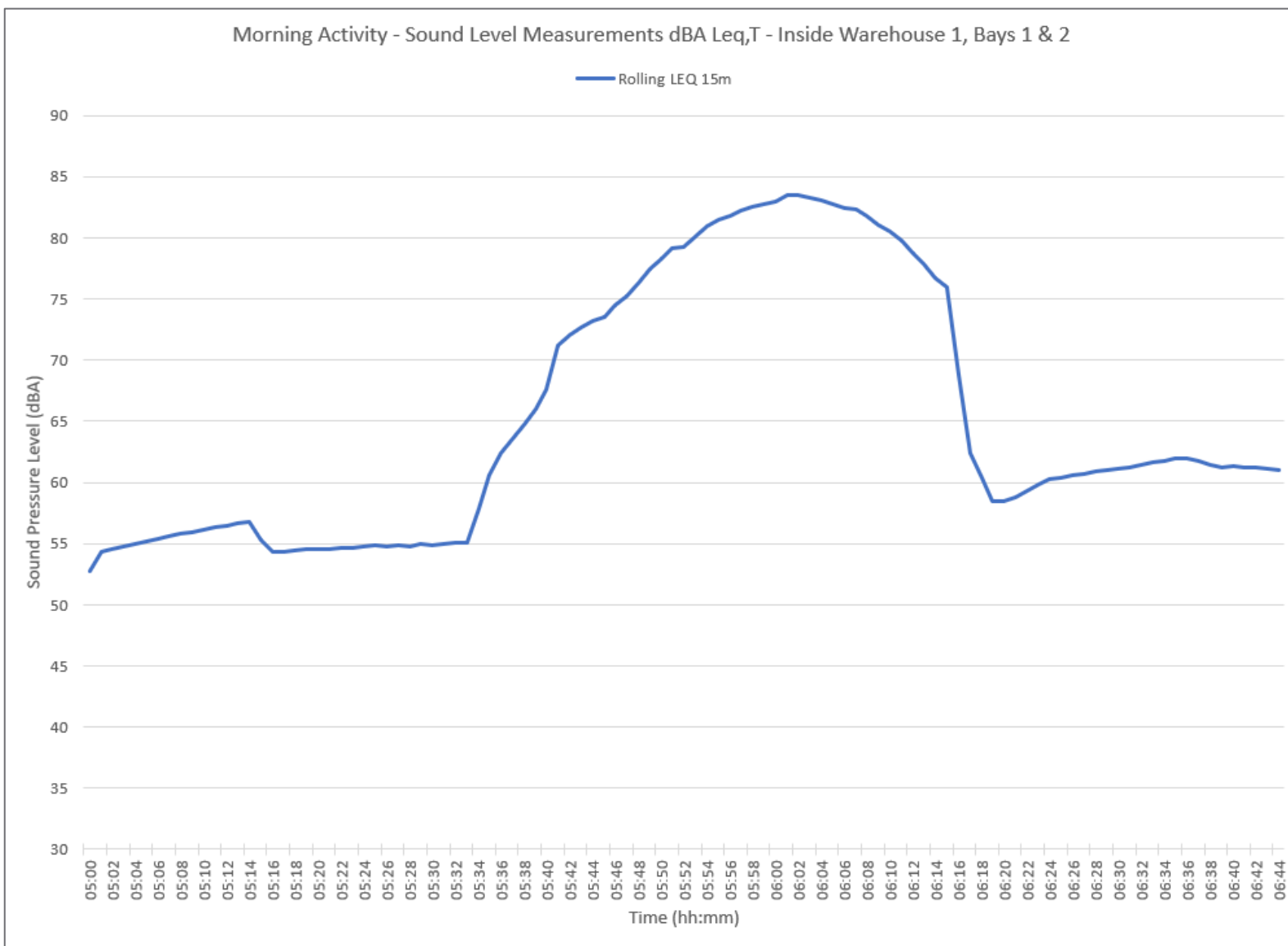
During this time we captured the noise from two teams of workers energetically loading and unloading two trucks simultaneously whilst the engines were running. Subjectively we note this appears to be the worst-case cumulative combination of activity noise anywhere on site.

Although we were focussing on the activities operating within Bays 1 and 2, it should also be noted that the warehouse is fully open inside, and as such our noise measurements include the additional reverberant noise radiating from activities and trucks located in the other bays. During the measurement period shown below there were a total of 5 trucks inside Warehouse 1 which were loaded and drove away.

The equipment was set to measure data in 1-minute intervals so that the continuous dBA Leq_{15min} noise levels could be calculated from 05:00 hours to 06:45 hours.

You can see that around 6:00am the noise levels peaked when all the trucks were fully loaded and were driven away.

This data is presented on the graph below.





During this period the highest dBA Leq_{15min} value measured was 83dBA inside Warehouse 1. The associated octave band spectral frequency data is presented in the table below.

Description	Sound Pressure Level (dB) at Octave Band Frequency (Hz)								dBA
	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz	
Highest Leq_{15min}	71	73	74	74	77	79	76	69	83

5.0 - Warehouse 2 Assessment

We have spoken with G.E. White & Sons who are the proposed building supplier/installer (<https://www.gewhiteandsons.com/>). We understand the construction of Warehouse 2 building is to comprise the following:

- Roof = 80mm thick insulated composite panel. Typically 0.7mm metal outer layer and 0.5mm inner layer with PIR foam insulation in between. Example manufacturers include Kingspan, Euroclad, Tata and Rhino.
- Walls = as per roof above but 60mm thick.
- Loading bay doors = Large roller shutters similar to existing Warehouse 1.

Until Warehouse 2 is constructed and the site operations evolve around its use, it is difficult to accurately predict all the benefits it will provide, or accurately determine its acoustic performance. Until then this report will assume the same layout and activity noise from Warehouse 1 is repeated in Warehouse 2.

It is necessary to consider the impact of noise on the nearest residential window breaking out through the roller doors and through the wall/roof building fabric.

The table below considers the potential noise breakout from Warehouse 2 through the roller doors to the residential window based on the measurements made at Warehouse 1.



Description	Sound Levels (dB) at Octave Band Frequency (Hz)								dBA
	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz	
Highest Leq, _{15min} in Bays 1 & 2	71	73	74	74	77	79	76	69	83
Average sound insulation to 15m distance	18	24	28	28	25	29	34	32	
Predicted highest Leq, _{15min} at residential window	53	49	46	46	52	50	42	37	55

As can be seen in the table above, we predict a resultant noise level of around 55dBA Leq,_{15min} incident at the residential window assuming activities in Warehouse 2 are comparable to those in Warehouse 1.

This level is 6dBA higher than the target level of 49dBA as described in Section 3.0, and as such additional mitigation measures would be required.

We would suggest the most appropriate acoustic mitigation measure would be to install a barrier between both warehouses at the height of 5m tall between the eaves of the buildings. The barrier should be built solid and continuous from ground level using material with minimum mass per unit area of around 20kg/m².

Our preliminary calculations indicate that a 5m tall barrier should be capable of reducing sound by more than the 6dBA required above. The table below presents our calculations.

Description	Sound Levels (dB) at Octave Band Frequency (Hz)								dBA
	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz	
Highest Leq, _{15min} in the absence of barrier	53	49	46	46	52	50	42	37	55
5m barrier sound reduction	-5	-5	-6	-6	-8	-9	-11	-14	
Predicted Leq, _{15min} at residential window	48	44	40	40	44	41	31	23	47



It is also necessary to consider noise breakout directly through the side wall and roof. The exact manufacturer of the insulated wall and roof panels has not been selected, and as such we have not been provided with any acoustic data to review.

However, the construction of insulated wall and roof panels for industrial buildings appears to be fairly similar across many brands/makes/models. For the purposes of this assessment we have considered the following Kingspan product acoustic data.

Acoustic Test Results Appendix A - Wall/Facade Panel Construction

Octave Band Sound Reduction Index (R) and Weighted Sound Reduction Index (R_w)

Wall	Panel and Lining	Octave Band Sound Reduction Index R								R_w	C_w	Surface Weight Kg/m ²
		63	125	250	500	1k	2k	4k	8k			
1W	AWP/60 + no lining	15	16	19	23	26	22	39	–	25	-3	18
2W	AWP/60 + F	12	19	32	42	50	52	60	–	43	-10	30
3W	AWP/60 + W15	14	17	31	40	48	46	56	–	41	-10	28
4W	AWP/60 + W15 + F	17	24	37	45	52	54	64	–	47	-9	40
5W	AWP/60 + P + W12	16	22	37	45	51	50	63	–	46	-10	41
6W	AWP/60 + P + W12	18	23	35	44	49	50	61	–	45	-8	41
7W	AWP/60 + I + P + W	18	24	37	48	53	55	63	–	48	-10	4
8W	KS1000 RW/40 + I + L	13	14	29	38	40	45	55	–	38	-9	20
9W	KS1000 RW/40 + I + L	12	16	30	40	44	51	64	–	40	-9	20
10W	AWP/70 + no lining	20	15	17	23	18	25	40	46	24	-4	12.5



Acoustic Test Results Appendix B - Roof Panel Construction

Octave Band Sound Reduction Index (R) and Weighted Sound Reduction Index (R_w)

Roof	Panel and Lining	Octave Band Sound Reduction Index R								R_w	C_w	Surface Weight Kg/m ²
		63	125	250	500	1k	2k	4k	8k			
1R	KS1000 LP/45 + I + 2 x SB	27	32	47	61	69	69	75	–	58	-11	–
2R	KS1000 RW/40 + I + L	8	17	32	43	48	54	60	–	43	–	2
3R	KS1000 RW/40 + I + L	11	19	36	48	54	61	73	–	46	–	19
4R	KS1000 RW/40 + I + Py	17	27	39	44	49	57	67	–	48	–	31
5R	KS1000 RW/30 + no lining	–	17	20	23	23	23	41	–	25	-3	–
6R	KS1000 RW/30 + I + L	–	18	35	50	55	59	60	–	44	-11	–
7R	KS1000 RW/50 + I + L	–	19	34	48	52	56	63	–	44	-10	–
8R	KS1000 RW/80 + I + L	–	20	36	48	50	66	70	–	46	-11	–
9R	KS1000 RW/80 + no lining	–	18	21	23	20	38	42	–	26	-4	–
10R	KS1000 RW/80 + no lining	20	18	20	24	20	29	39	47	25	-3	–
11R	KS1000 RW/80 + I + PL	18	19	22	29	31	40	58	49	32	-4	–
12R	KS1000 ZIP/90 + no lining	19	18	19	20	17	35	38	44	23	-4	–
13R	KS1000 LP/80 + no lining	19	19	19	22	19	35	39	46	24	-4	–
14R	KS1000 RT + no lining	20	19	21	22	22	32	38	44	25	-2	–
15R	KS1000 TS + no lining	20	16	15	23	29	39	45	53	27	-4	27



With consideration for the Kingspan products we have reviewed the literature and note the '1W - AWP/60 + no lining' (60mm) is most likely to be similar to the proposed wall, and '10R - KS1000 RW/80 + no lining' (80mm) is most likely to be similar to the roof construction.

The table below presents the octave band sound reduction index for each.

Description	Octave Band Frequency (Hz) Sound Reduction Index (dB)								Rw
	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz	
Wall - 1W - AWP/60 + no lining	15	16	19	23	26	22	39	39*	25
Roof - 10R - KS1000 RW/80 + no lining	20	18	20	24	20	29	39	47	25

* Note this is a pessimistic estimate as the test data does not provide this frequency.

To check the wall construction has the potential to control noise breakout we have undertaken the calculation below.

Description	Sound Levels (dB) at Octave Band Frequency (Hz)								dBA
	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz	
Highest Leq,15min	71	73	74	74	77	79	76	69	83
Wall - AWP/60mm Kingspan	-15	-16	-19	-23	-26	-22	-39	-39	
15m distance loss plane wave surface method	-15	-15	-15	-15	-15	-15	-15	-15	
Predicted Leq,15min at residential window	41	42	40	36	36	42	22	15	44

To check the roof construction has the potential to control noise breakout we have undertaken the calculation below.

Description	Sound Levels (dB) at Octave Band Frequency (Hz)								dBA
	63Hz	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz	8000Hz	
Highest Leq,15min	71	73	74	74	77	79	76	69	83
Roof - KS1000 LP/80mm Kingspan	-20	-18	-20	-24	-20	-29	-39	-47	
15m distance loss plane wave surface method	-15	-15	-15	-15	-15	-15	-15	-15	
Predicted Leq,15min at residential window	36	40	39	35	42	35	22	7	44



When considering noise breaking out through the roof or wall, the calculations above suggest the resultant noise level at the nearest noise sensitive window would be around 44dBA Leq,15min and as such be capable of achieving the 49dBA target.

It must be noted that the calculations provided in this section are based on the individual wall/roof components, and do not account for the potential acoustic weaknesses formed at junctions where materials/components are connected which can only be determined via testing.

6.0 - Noise Management Plan

Until Warehouse 2 is constructed and the site operations evolve around its use, it is difficult to accurately predict the benefits it will provide or determine its acoustic performance.

Only when it is fully operational will it be possible to determine if there is the need to modify any working practices, layout or part of the construction. Therefore it must be noted that this report can only provide noise management plan guidance, based on the existing activities we have witnessed, proposed usage and the predicted acoustic performance of Warehouse 2.

We present the following noise management plan guidance to be implemented, which we feel provides the best chance of achieving the desired noise target, in the absence of the required information which can only be obtained once Warehouse 2 is operational. In the event that the noise target is not quite met, it should be achievable with minimal retrofit modification to the building, the layout or working procedures.

Layout

Warehouse 2 is currently assumed to be a mirror image of Warehouse 1. Therefore the racking at the rear will contain poles at lower level with lesser used items on the shelves above. The planks and fittings will be positioned between the loading bays.

The storage racking and equipment must be positioned and installed so that it does not come in to contact with the building to avoid the chance of structureborne noises caused by a physical impact.



In any areas of the building where there is a high risk of accidental physical impacts, one must consider installing rubber bump stops to absorb some of the accidental impact.

The equipment should be positioned so that forklift trucks can operate inside the warehouse with the doors shut.

In general one should aim to locate the noisiest activities at the far ends of the warehouses away from the houses. Especially consider the noisiest 'workshop' tools and equipment, i.e. electric saws for cutting boards or poles.

Determine if it might be possible to utilise the bays nearest the houses for storing lesser used items, such that the layout enables the bay doors closest to the houses to rarely be opened.

Operational Procedures

In terms of mitigating noise there are numerous opportunities to consider which will have an acoustic benefit, but might require business operations to be modified in term of time and procedure. Until Warehouse 2 is fully operational the balance between acoustic and business performance cannot be accurately determined or adapted.

At all times site management must consider best practice with a view to reducing activity noise. It will be necessary to consider how site could evolve and how best to maintain operational performance.

Staff must arrive and enter through the pedestrian door at the north end of Warehouse 2.

Large roller doors must be closed at all times other than the brief moment required to let a vehicle in or out.

Truck engines must only be started when they are ready to leave. No excessive revving or unnecessary horn use.

When a truck returns to site in the afternoon it must park in the first available bay which is furthest away from the houses.
When the trucks leave site in the morning they should vacate together as close in time as possible.



To mitigate the risk of some trucks not being ready to leave together due to a delay in loading/unloading, consider the afternoon period should be used to load the trucks so that they are ready to leave together in the morning. Therefore the only reason to open the doors is for them to drive away together. After this time the vast majority of site activities can happen inside Warehouse 2 with the doors shut.

Until the trucks return in the afternoon the only reason to briefly open the doors would be for other vehicle movement, such as deliveries or transferring equipment between warehouses.

Site operating hours to be:

- 06:00 hours to 17:00 hours Monday to Friday.
- 06:00 hours to 13:00 hours Saturday.
- Closed Sunday and Bank Holiday.

It must be noted that occasionally the yard is used outside of these hours to cater for when vehicles become stuck in traffic, and/or for exceptional circumstances. The timing of exceptional circumstances cannot be predicted. Exceptional circumstances generally relate to rectifying dangerous structures out of hours for company clients and the emergency services (fire & police). Dangerous structures tend to arise during extreme weather conditions and/or emergency incidents.

Site management should regularly review working practices on site and consider the potential noise implications of purchasing any new equipment, and/or changing any working procedures. As a result it might be necessary to improve the acoustic sound insulation of the building or modify the working procedures.

Training should be provided to staff so they are aware of the required procedures.

**Warehouse Construction**

This document has been based on our understanding of the proposed construction and site activities. However, until Warehouse 2 is fully operational only then would it be possible to accurately determine its acoustic performance.

If in the future it determined that the acoustic performance needs enhancing, one or more of the following retrofit solutions will need to be considered:

- Acoustic weakness at junctions where panels/components are joined. Typically if there is an acoustic weakness it is because the junction is not quite airtight. Solutions often include sealing the gaps with acoustic mastic and/or overlapping with additional material.
- Sound insulation of wall/roof panel not sufficient. Depending on the improvement required it is usually a case of firstly infilling the recess between columns/beams/joists with acoustic insulation, next one would need to consider if over cladding the inside with additional board material if required. Various acoustic fixtures and fittings are available that can be easily retro fitted.
- Sound insulation of large roller doors is not sufficient. Unfortunately very few companies have sound insulation data for their doors and the acoustic performance of a roller shutter door can be greatly reduced in many ways simply due to installation workmanship. Threshold seals with the ground might not sit flat either due to misalignment or the concrete is not level. The guide rails need to be perfectly parallel to the doors. Gaps around the frame perimeter are not suitably sealed to the building structure. The mass/thickness of the door is not sufficient and as such it is possible to purchase a thermally insulated 'acoustic' roller shutter door.
- Internal partitioning to create different 'rooms' within the warehouse. For example between bays or localised around a particularly noisy activity.



7.0 - Conclusion

Pulsar Acoustics has reviewed the existing operational activities, we have undertaken additional measurements to understand the typical worst-case noise levels inside Warehouse 1, and have used this information to consider the acoustic implications of Warehouse 2.

Our assessment has determined that with the addition of a barrier installed between Warehouse 1 and 2, and by imposing various working procedures on site, there is potential for the desired noise target to be achievable.

It must be noted that until Warehouse 2 is constructed and fully functional, and site operations can evolve around its use, it is difficult to accurately predict the benefits it will provide, or determine its real-life acoustic performance.

However, based on our current understanding of the existing and proposed activities and warehouse constructions, we have proposed noise management plan guidance which we feel provides the best chance of achieving and maintaining the desired noise target.



APPENDIX A - Acoustic Terminology

The following is an explanation for some of the acoustic parameters used in this report to describe the measurements and mitigation.

- **dB** The decibel is used as a measurement of sound pressure level. It is the logarithmic ratio of the noise being assessed to a standard reference level. This approach is advantageous for handling sound levels, where the ratio of the highest to lowest sound which humans could encounter, can be as high as 1,000,000 : 1. The ratio is considered with respect to the quietest and loudest sound we can hear. This is the threshold of hearing at the frequency of 1000Hz, which is taken as 20μPa (2×10^{-5} Pa) of pressure for the average person. (A decibel is simply a ratio and is used in many other industries too, but most commonly in acoustic or electrical signal analysis.)
- **dBA** The human ear is more susceptible to mid-frequency noise than to higher and lower frequencies. To take account of this when measuring noise, the 'A' weighting scale is used so that the measured noise corresponds to the overall level of perception by the average human. It is also possible to calculate the 'A' weighted noise level by applying certain corrections to an un-weighted frequency spectrum (Hz). The measured or calculated 'A' weighted noise level is known as the dBA level.
- **Leq,T** The equivalent continuous sound level in decibels, equivalent to the total sound energy measured over a stated period of time and is also known as the time-averaged sound level.
- **dBA Leq,T** The A-weighted equivalent continuous sound level in decibels measured over a stated period of time 'T', and is sometimes written dB LAeq,T.
- **L90** This parameter is the noise level exceeded for 90% of the period T (i.e. the quietest 10% of the measurement) and is often used to describe the background noise level.
- **dBA Lmax** The maximum dBA noise level recorded during the measurement interval period.

When discussing sound levels as decibels we use a logarithmic scale, therefore the dBA values do not follow a linear relationship. When discussing similar noises, a change of 10dBA represents a doubling or halving of subjective loudness. A change of 3dBA is just perceptible by a human, but is a doubling/halving of sound energy. (i.e. 50dBA + 50dBA = 53dBA).

If you require a more detailed explanation for any of the acoustic principles or parameters discussed in this report please do not hesitate to ask.