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# ASSESSMENT OF ENVIRONMENTAL NOISE IMPACT FROM USE OF PROPOSED ZIP WIRES IN LIVERPOOL CITY CENTRE

**On behalf of:**

**Zip World Ltd**

Report No: P19-551-R01-V1
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# ASSESSMENT OF ENVIRONMENTAL NOISE IMPACT FROM USE OF PROPOSED ZIP WIRES IN LIVERPOOL CITY CENTRE

Report prepared by:
Hepworth Acoustics Ltd
21 Little Peter Street
Manchester
M15 4PS

On behalf of:
Zip World Ltd

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| Report prepared by:<br>Paul Bassett BSc MSc FIOA – Technical Director |

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|---|
| Report checked by:<br>Donald Quinn BSc FIOA – Managing Director |

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# 1.0 INTRODUCTION

1.1 Hepworth Acoustics Ltd was commissioned by Zip World Ltd to carry out a study into the likely noise impact associated with the use of a proposed Zip Wire facility in Liverpool City Centre.

1.2 The proposed facility comprises two long parallel zip wires starting from the St John's Beacon tower and landing on the roof of the Central Library building to the north.

1.3 We understand that the proposed operating hours would be up to 09:00 – 20:00 hours in the summer months. There would not be any use of the zip wire at night.

1.4 The riders would descend in pairs down the two wires and we understand that the anticipated numbers would be between 20 and 30 pairs of rider descents per hour during busy periods. The riders would descend in a sitting position suspended from the wires by a small 'trolley' of the type that is used at the Zip World 'Titan' site in Gwynedd, North Wales.

1.5 The proposed zip-wires would be located in a predominantly commercial area of Liverpool city centre well away from any residential areas. In a telephone conversation with the relevant Environmental Health Officer (EHO), Dr. Ian Rushforth, it was agreed that the nearest 'noise-sensitive' building with a residential type use is the Marriott Hotel. The EHO suggested that the nearest actual dwellings not screened by other buildings are likely to be apartments at Old Haymarket. In terms of the latter, these appear to be apartments above ground floor commercial premises on the corner of Old Haymarket and Victoria Street.

1.6 The noise assessment has therefore focused on potential impact of noise from use of the zipwires at the Marriott Hotel and the apartments further away at Old Haymarket.

1.7 This study has therefore involved the following:-

- Inspecting the proposed zip wire route and carrying out noise measurement surveys to establish the prevailing noise climate of the area.

- Visiting an operational Zip World site in Gwynedd and carrying out noise measurements of use of the zip wires, to obtain 'source noise' level data for subsequent use in noise calculations for the Liverpool development.
- Developing a computerised noise model for the Liverpool zip wires using specialist acoustic software.
- Using the noise model to calculate likely noise emissions from the proposed zip wire facility.
- Commenting on the likely magnitude of any noise impact.

1.8 The author of this report has the following qualifications:- BSc(Hons) in Environmental Science; the Institute of Acoustics' 'Diploma in Acoustics and Noise Control'; MSc in Environmental Acoustics. He has 30 years of experience in the assessment and control of environmental noise and is a Fellow of the Institute of Acoustics.

1.9 The various noise units and indices referred to in this report are described in Appendix I. All noise levels mentioned in the text have been rounded to the nearest decibel, as fractions of decibels are imperceptible.

## 2.0 AMBIENTNOISE SURVEY

2.1 A noise measurement survey has been carried out at two locations in the area of the proposed development, the purpose of which is to obtain data on the prevailing noise climate of the area. The locations were discussed with the Environmental Health Officer beforehand and were as follows:

A) – on Marriott Hotel building : on an accessible balcony

B) – on the Library building : high up on the roof near to the proposed landing stage

2.2 The proposal was to install auto-logging sound level meters (with all-weather kits) to enable noise levels to be measured over several days including a weekend.

2.3 From an initial external inspection it was found that there were limited opportunities for installing a sound level meter at the Marriott Hotel. The main roof is curved, the windows have restricted opening, and most of the balconies are dummy balconies with no access. However, with the co-operation of the hotel, it was possible to install a sound level meter on a third-floor balcony in the north-east elevation of the building.

2.4 At Location 2, on the roof of the library, the only suitable position (away from public areas and building services plant) to secure the sound level meter was on a roof above the roof terrace.

2.5 The noise monitoring locations are indicated in Figure 1.

2.6 The prevailing noise climate at the two locations was measured continuously in consecutive 15-minute periods between the afternoon of Thursday 7 November and Monday 11 November 2019.

2.7 Details of the instrumentation used for the surveys, together with comments on weather conditions, are listed in Appendix II. The noise meters and calibrators that were used have independent calibration certification and the calibration level of the meters was checked at the start and end of the surveys with no significant variation in level occurring.

## Results

2.8 The results of the baseline noise survey are shown in chart form in Appendix II.

2.9 The survey included some prolonged periods of rain on the Thursday and Saturday. However, stable dry and sunny weather occurred on the Friday and Sunday of the survey. Thus, whilst all of the noise survey results are shown in Appendix II, separate charts of the results are also provided for the proposed operating periods (i.e. up to 09:00-20:00 hours) for the Friday and Sunday.

2.10 On the Sunday of the survey period, some roads in the city centre were closed in the morning because of Remembrance Sunday. The road closures included St John's Lane and St George's Place between Old Haymarket and Lime Street (and also closure of Queen's Square bus station). The noise data measured during the road closures are included in the charts in Appendix II but are excluded from Table 1 below and subsequent analysis.

2.11 The noise survey results between 09:00-20:00 hours (but excluding Sunday morning road closures) are summarised in Table 1.

**Table 1: Summary of Noise Survey Results**

**(a) Marriot Hotel**

| Day/Time | Measured Noise Levels (dB) | | |
|---|---|---|---|
| | $L_{Amax(15\ mins)}$ | $L_{Aeq(15\ mins)}$ | $L_{A90(15\ mins)}$ |
| Friday 8 November (09:00-20:00 hours) | generally 75 - 87 | generally 66 - 70 | generally 60 - 62 |
| Sunday 10 November (09:00-20:00 hours) | generally 76 - 90 | generally 66 - 68 | generally 60 - 61 |

**(b) Library**

| Day/Time | Measured Noise Levels (dB) | | |
|---|---|---|---|
| | $L_{Amax(15\ mins)}$ | $L_{Aeq(15\ mins)}$ | $L_{A90(15\ mins)}$ |
| Friday 8 November (09:00-20:00 hours) | generally 67 - 80 | generally 56 - 57 | generally 54 - 55 |
| Sunday 10 November (09:00-20:00 hours) | generally 64 - 77 | generally 55 - 56 | generally 52 - 53 |

2.12 At the Marriott Hotel the noise climate was due to road traffic noise and there was very little difference between the data measured on Friday and Sunday. The measured ambient noise levels

were steady being generally over 66 dB $L_{Aeq(15\ min.)}$ , with background noise levels steady at over 60 dB $L_{A90(15\ min.)}$. Short-term peaks of noise were generally between 75 – 90 dB $L_{Amax}$.

2.13 On the roof of the Central Library the measured noise levels were lower being further away from busy roads in the area. Again, there was little difference between the data measured on Friday and Sunday. The measured ambient noise levels were steady being generally over 55 dB $L_{Aeq(15\ min.)}$ , with background noise levels generally between 52 – 55 dB $L_{A90(15\ min.)}$. Short-term peaks of noise were generally between 64 – 80 dB $L_{Amax}$.

## 3.0 OBSERVATIONS AND NOISE MEASUREMENTS AT ZIP WORLD 'TITAN'

3.1 Hepworth Acoustics have made a visit to the 'Titan' zip wire facility at Llechwedd Quarry, in North Wales to observe and understand the operations and to obtain 'source' noise measurements for use in calculations for the proposed development. Although, the zipwire operation is not identical to that proposed at Liverpool (as discussed later in this report) we understand that it is the most similar one operated by Zip World.

**Observations**

3.2 At the 'Titan' site the riders are suspended in 'feet down' sit harnesses. The harnesses are suspended from the wires by 'trolleys'. These trolleys are fairly small and light and are fixed to the harness of each person, and thus are carried by the person between the different zip wire routes. (The same type of trolley is proposed for the Liverpool zip wires).

3.3 There are 3 different zip wire routes at Titan, each of which are comprised of 4 parallel wires. It was noted that mostly all 4 wires on each route were used for each group descent, although sometimes there were only 3 people, and occasionally 2.

3.4 It was noted that the zip wire system is operated by gravity alone. There is no mechanical and electrical plant or equipment involved.

3.5 At the launch platform members of staff supervise the attachment of the trolley of each person to the wire. When all safety checks have been made, a supervisor counts '3-2-1-go' and the group descent starts.

3.6 As the speed of the descent increases, the friction of the trolley on each wire generates a noise. As the descending riders approach an observer near the wires, the noise level from the trolleys/wires gradually increases and reaches a maximum when the riders on the zip wires pass by.

3.7 Some people made one or more 'whoops' as they descended, whilst some people did not make any sound. In our judgement the predominant noise of the descent was from that generated by the trolleys on the wires rather than from the people.

3.8 At the landing stage there is a speed arrestment mechanism ('stop trolley') which stops the descent of each person and there is an impact sound as the end of each trolley hits the arrester.

**Noise Measurements**

3.9 Although we have previous noise survey data obtained at Zip World Titan the results are some years old and therefore some updated noise measurements were taken on Sunday 3 November 2019.

3.10 The noise measurements were carried out using a Rion NL-27 'Type 1' sound level meter mounted on a tripod. Calibration checks were carried out both before and after the measurement periods with no significant variance in levels.

3.11 The noise measurements were taken in 'free-field' conditions and at a microphone height of approximately 1.4m above the ground. The noise levels were measured in terms of $L_{Amax}$ and SEL values. One-third octave band frequency analysis was also carried out. The results of the A-weighted noise measurements are shown in Appendix III and are summarised below.

3.12 From the recent noise measurements, the measured SEL value for a single (heavy) rider measured at 5m below the wire was 83 dB(A). At 50m distance to the side of the zipwire route an SEL value of 71 dB(A) was measured for a pair of riders descending. At the landing stage, short-term peaks of noise from the impact of the rider's trolley with the brake stop device were up to an SEL value of 82 dB(A) for one rider at a distance of 10 metres.

3.13 This data has been used as a basis for undertaking noise calculations/modelling for the Liverpool development as described in Section 4.

# 4.0 COMPUTER MODELLING OF NOISE FROM PROPOSED ZIP WIRES

## Approach

4.1 Computerised noise calculations have been undertaken for use of the proposed Liverpool zip wires using the specialist noise modelling software CadnaA, produced by Datakustik. The software has been used to develop a 3D model of the area of the city centre nearest to the zip wire route based upon digital Ordnance Survey topographical data that we have obtained. Heights of the launch point and landing platform have been based on drawings and information provided to us by the design team.

4.2 The calculation procedure takes into account the source levels of noise from riders descending the zip wires, and also noise from the stop trolley at the landing stage. We understand that each line at Liverpool will actually have two stop trolleys, one placed behind the other with a separation distance of over 40m in between. We have assumed that the main impact noise will be at the first stop trolley, with a reduced noise emission from the second stop trolley due to the lower speed at that point.

4.3 The noise model is used to calculate noise propagation factors in accordance with 'ISO9613: Acoustics – Attenuation of sound during propagation outdoors', such as distance attenuation, ground absorption, acoustic screening, reflections and atmospheric absorption.

4.4 The calculations assume 100% hard ground, a temperature of 10$^{o}$C and relative humidity of 70%.

4.5 The calculations of zip wire noise were modelled in CadnaA on the basis of a 'moving point source' of 2-person descents on the zip wire route. Noise levels have been calculated for a busy one-hour period assuming maximum use which, we are informed by Zip World, will be up to 30 pairs of people descending per hour.

4.6 The likely noise levels from use of the zip wires have been calculated in terms of a 1-hour $L_{Aeq}$ value. However, it should be noted that the 1-hour $L_{Aeq}$ value for 30 pairs of descents per hour is exactly the same as the 30-minute $L_{Aeq}$ value for 15 pairs of descents per half hour, etc.

4.7 The calculations are based upon the noise source data obtained from the Zip World 'Titan' site with the data input in octave bands. However, some adjustments have had to be made to take account of differences between the Titan and Liverpool operations.

4.8 Firstly, although the same ISC Type 'RPO76.2 ZipSpeed' rider trolleys will be used at Liverpool that are used at Titan, the wire will be of a different type. At Titan the trolleys run on fairly smooth 16mm diameter cables whereas at Liverpool, 12mm diameter '6 x 19' wire ropes are to be used. The latter type is formed of 6 major strands, with each strand containing 19 individual wires, and the 6 major strands are wrapped around a central wire core. Thus, it is considered that the more rope-like appearance of the proposed zipwires at Liverpool may provide more friction than at Titan and thus this could generate more noise. Zip World do not currently operate a zip wire of this construction type at the speeds proposed at Liverpool and therefore it is not possible to actually measure this system in use at the relevant speeds.

4.9 Secondly, the speeds proposed at Liverpool are generally faster than those that occur at Titan. We understand that the speed of the descent depends on the weight of the rider. At Liverpool it is expected that 120kg riders would reach a maximum speed of 52-55 mph and a terminal speed at the landing platform of 50-54 mph, whilst a lighter 50kg rider would reach a maximum speed of 37-40 mph and a terminal speed at the landing platform of 31-35 mph. At Titan, we understand that the descent speeds are up to a maximum of 50 mph and with typical arrival speeds of 35-40 mph at the landing stage.

4.10 Therefore, to take account of these differences, and in the absence of any relevant empirical data, we have added 5 dB(A) to the data obtained at Zip World Titan in our calculations for the Liverpool. This has been applied not only to the descent noise but also at the (first) stop trolley at the landing stage.

4.11 The zip wire noise levels have been calculated in $L_{Aeq(1\ hour)}$ at the Marriott Hotel for different elevations and at different heights, and also at the apartments in Old Haymarket.

4.12 Also, the $L_{Aeq(1\ hour)}$ noise level contours have been plotted over the general area at a height of 1.5 metres above local ground heights and are shown in Figure 2.

## Results

4.13 The calculated noise levels from the proposed development during a busy one-hour period are shown in Table 2.

**Table 2: Predicted Noise Levels**

| Location | Predicted Noise Level from Use of Zip Wires dB $L_{Aeq(1\ hour)}$ |
|---|---|
| '1' Marriott Hotel - SE elevation - 1st floor level | 61 |
| '2' Marriott Hotel - SE elevation - 5th floor level | 62 |
| '3' Marriott Hotel – NE elevation – 1st floor level | 64 |
| '4' Marriott Hotel – NE elevation – 5th floor level | 64 |
| '5' Old Haymarket apartments – 1st floor | 57 |
| '6' Old Haymarket apartments – 5th floor | 57 |

4.14 Table 2 shows that the predicted noise levels are 61 – 64 dB $L_{Aeq(1\ hour)}$ outside the Marriott Hotel.

4.15 A lower noise level of 57 dB $L_{Aeq(1\ hour)}$ is calculated outside apartments at Old Haymarket because they are further away.

4.16 Comments on the implications of the predicted noise levels are provided in Section 6.

## 5.0 NATIONAL GUIDANCE ON NOISE IMPACT

5.1 There are no specific guidelines for assessing the noise impact on residential amenity resulting from use of zip wires, nor any other similar recreational/leisure activity. General national planning guidelines and noise standards are described below.

5.2 Overarching planning guidance for England is set out in the National Planning Policy Framework (NPPF) 2019. The NPPF provides some general guidance to local authorities on taking noise in to account in planning policies and decisions. This includes guidance (in paragraph 180) that those planning policies/decisions should aim to 'mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life'.

5.3 The *Noise Policy Statement for England* (NPSE) 2010, which is referred to the in NPPF, includes three aims:

i. Avoid significant adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

ii. Mitigate and minimise adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

iii. Where possible, contribute to the improvement of health and quality of life through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

5.4 However, as stated above, there is no specific guidance on numerical acoustic assessment/design criteria for proposed new leisure developments, such as that proposed at Liverpool, provided in the NPPF and accompanying on-line guidance on noise, nor in the NPSE document.

5.5 There is general advice on acoustic design goals for certain types of development in British Standard 8233:2014 'Guidance on sound insulation and noise reduction for buildings'. For proposed new

dwellings the standard recommends suitable acoustic design criteria for inside habitable rooms. However, in Liverpool city centre, unless they have been adequately designed and sound insulated, existing dwellings are unlikely to meet those criteria due predominantly to the level of traffic noise. The standard offers no guidance on noose from developments such as zip wires.

5.6 One commonly used British Standard for assessing industrial type noise is BS4142:2014 'Methods for rating and assessing industrial and commercial sound'. The standard is based upon a comparison of the industrial noise with the background noise in the area, and where appropriate penalties are applied which take account of certain characteristics of the noise. However, this standard only relates to noise of an industrial nature e.g. noise from industrial and manufacturing processes, or other fixed installations which comprise mechanical and electrical plant, or noise of an industrial nature at commercial premises. Noise from recreational activities and people is specifically excluded from the scope and assessment procedure of BS4142. Therefore, the proposed zip wire development falls outside the scope of BS4142. Nevertheless, we consider that it is appropriate to consider the predicted $L_{Aeq}$ noise levels from the Liverpool development at the nearest residential location (and other locations) in the context of the prevailing noise climate at that location.

# 6.0 COMMENTS ON NOISE IMPACT

## Marriott Hotel

6.1 In Table 3 the predicted $L_{Aeq(1\ hour)}$ noise levels at the Marriott Hotel from operation of the proposed zip wire development are compared with the existing $L_{Aeq}$ and $L_{A90}$ noise levels that were measured outside the hotel during the recent survey.

**Table 3: Predicted Development Noise Levels v Existing Noise Levels**

| Location | Predicted Noise Level from Development dB $L_{Aeq(1\ hour)}$ | Existing Measured Noise Levels |
|---|---|---|
| Outside Marriott Hotel | 61 - 64 | 66 - 70 dB $L_{Aeq}$ , 60 - 62 dB $L_{A90}$ |

6.1 The hotel is in a city centre location and the elevations nearest to the proposed zip wire route are adjacent to a busy bus station and next to the busy St John's Lane, with associated levels of noise.

6.2 Thus Table 3 shows that the range of the predicted zip wire noise is only marginally above the measured $L_{A90}$ background noise and is below the existing ambient $L_{Aeq}$ noise levels measured in the area.

6.3 Therefore, it is considered that operation of the proposed zip wire development will not result in any significant adverse noise impact on the hotel rooms at the Marriott Hotel.

## Apartments at Old Haymarket

6.4 Table 2 shows that the predicted noise level from operation of the zip wires is 57 dB $L_{Aeq(1\ hour)}$ outside apartments at Old Haymarket. This is a relatively modest level of noise in this urban setting.

6.5 The apartments, depending on their exact location, are exposed to traffic noise from one or more busy roads including Victoria Street, the Birkenhead Tunnel portal and Churchill Way. In the context of this traffic noise it is considered that the relatively modest level of noise from the zip wires at Old Haymarket is likely to be below the prevailing noise climate of the area. Therefore, it is concluded

that operation of the proposed zip wire development will not result in any significant adverse noise impact on apartments at Old Haymarket.

**Other Locations**

6.6 We understand that the Central Library is fully supportive of the proposed zip wire development and is happy to accommodate the landing stage on the roof, with associated activity and noise. However, the EHO suggested that the circular Picton Reading Room may be more noise-sensitive than other parts of the library. This is located to the south-east of the landing stage area and has a domed roof. The building does not appear to have any windows in the curved walls but there is a decorative glass dome in the centre of the circular roof.

6.7 The calculated noise level from use of the zip-wire is 64 dB $L_{Aeq(1\ hour)}$ outside the central glass dome in the roof of the reading room. This is a relatively modest level of external noise. Assuming that the glass dome is 6mm thick the resulting break-in noise would be expected to be around 30-35 dB $L_{Aeq}$ inside the reading room. Such noise values are within acceptable levels for libraries that are recommended in British Standard 8233:2014.

6.8 The proposed zipwire would overfly the St John's Gardens. From the noise contour plot in Figure 2 the noise levels from the zipwire are calculated to be 61-65 dB $L_{Aeq(1\ hour)}$. In areas of the memorial gardens away from the busy St John's Lane and the A59 roundabout this is likely to be above the current ambient noise level. It is therefore recommended that during any special official remembrance events that take place in or near the gardens use of the zip wires is temporarily stopped.

**Scope for Noise Mitigation**

6.9 Zip wire installations do not readily lend themselves to noise mitigation primarily because of their height and because there is no mechanical/electrical plant involved. However, the north-end of St John's Gardens (and the Library roof) will experience the periodic sound of the rider trolleys impacting with the stop trolleys that slow the riders down on approach to the landing stage. We consider that there may be some scope for reducing this impact noise by investigating the possibility of using more resilient (i.e. softer) contact materials.

6.10 At the Zip World Titan site we noted that both the end buffer on the riders trolley, and the facing of the stop trolley, were made of hard materials, which results in an impact noise. Clearly safety concerns are paramount, and resistance to wear and tear is important, but if it were feasible to incorporate softer contact materials such as rubber or neoprene the impact noise would be reduced. However, this would need liaison with manufacturers of the relevant hardware and such product development, with associated testing and trials, is likely to take time and therefore this should be viewed as a long-term aim.

## 7.0 SUMMARY AND CONCLUSIONS

7.1 Hepworth Acoustics Ltd has carried out a study into the likely noise impact associated with operation of a proposed Zip Wire facility in Liverpool city centre.

7.2 The proposed facility would be located in the city centre in a predominantly commercial area away from any major residential areas. The noise assessment has therefore focused on potential impact of noise at the nearest noise-sensitive property which is the Marriott Hotel.

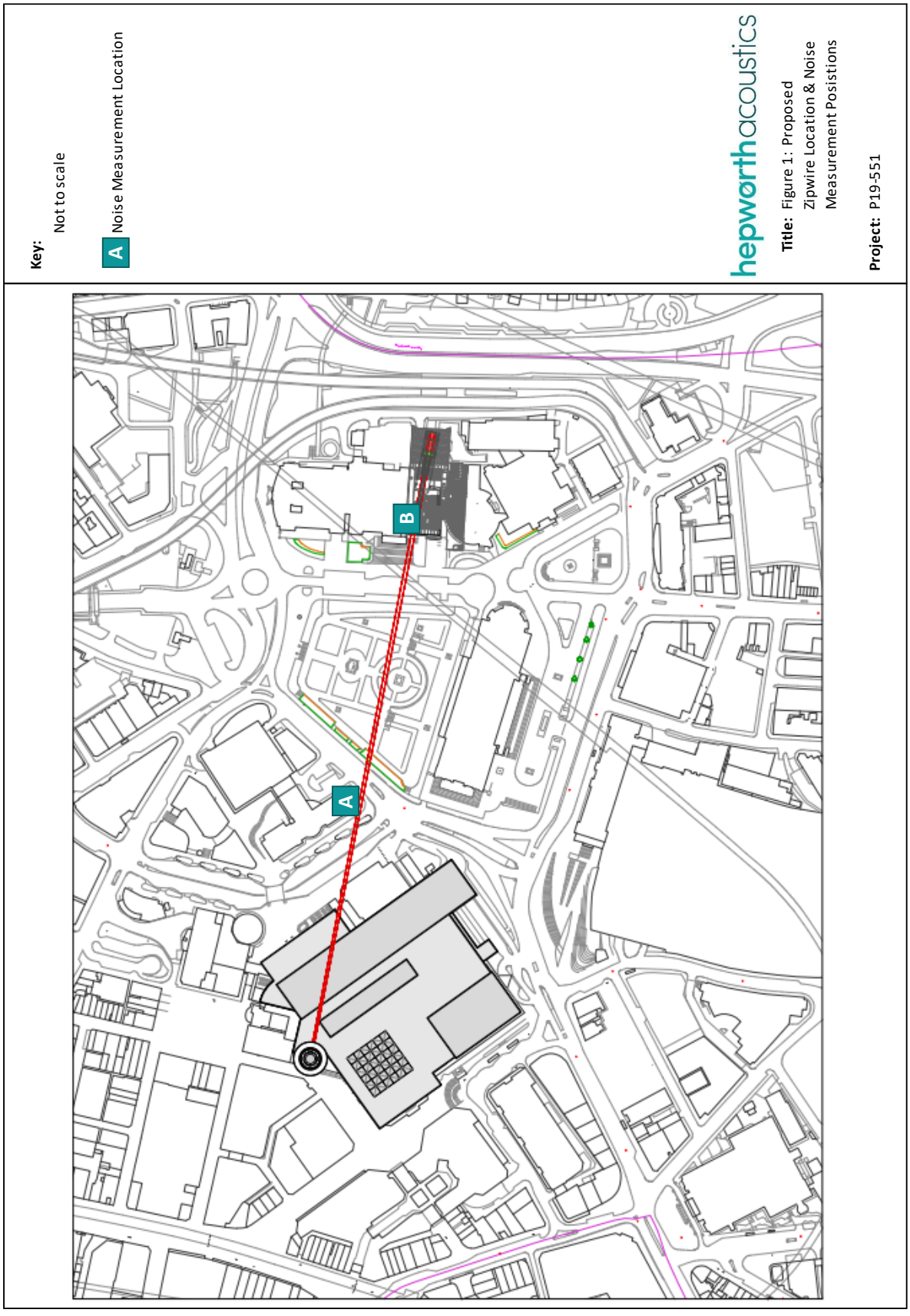
7.3 A baseline noise survey has been carried out to establish the prevailing noise climate of the area. The ambient noise climate was found to be fairly high outside the Marriott Hotel due to the level of road traffic noise.

7.4 Likely noise levels from the proposed development have been calculated using a standard calculation method. The calculations are based on 'source' noise levels that have been measured at an operational Zip World centre in North Wales, but including a safety margin to account for the different type of wires proposed at Liverpool.

7.5 The predicted zip wire noise outside the Marriott Hotel is only marginally above the measured $L_{A90}$ background noise and is below the existing ambient $L_{Aeq}$ noise levels. It is considered, therefore, that operation of the proposed zip wire development will not result in any significant adverse noise impact on the hotel rooms at the Marriott Hotel.

7.6 Lower noise levels from the zip wires have been calculated at residential locations in Old Haymarket which are considered to be below the prevailing noise climate of the area. Therefore, it is concluded that operation of the proposed zip wire development will not result in any significant adverse noise impact on apartments at Old Haymarket.

7.7 However, it has been recommended that during any special remembrance events that take place in St John's Gardens use of the zip wires is temporarily stopped. Also, we have recommended that the feasibility of reducing the contact noise between the rider's trolley and the stop trolleys near the landing stage is investigated.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A Noise Measurement Location
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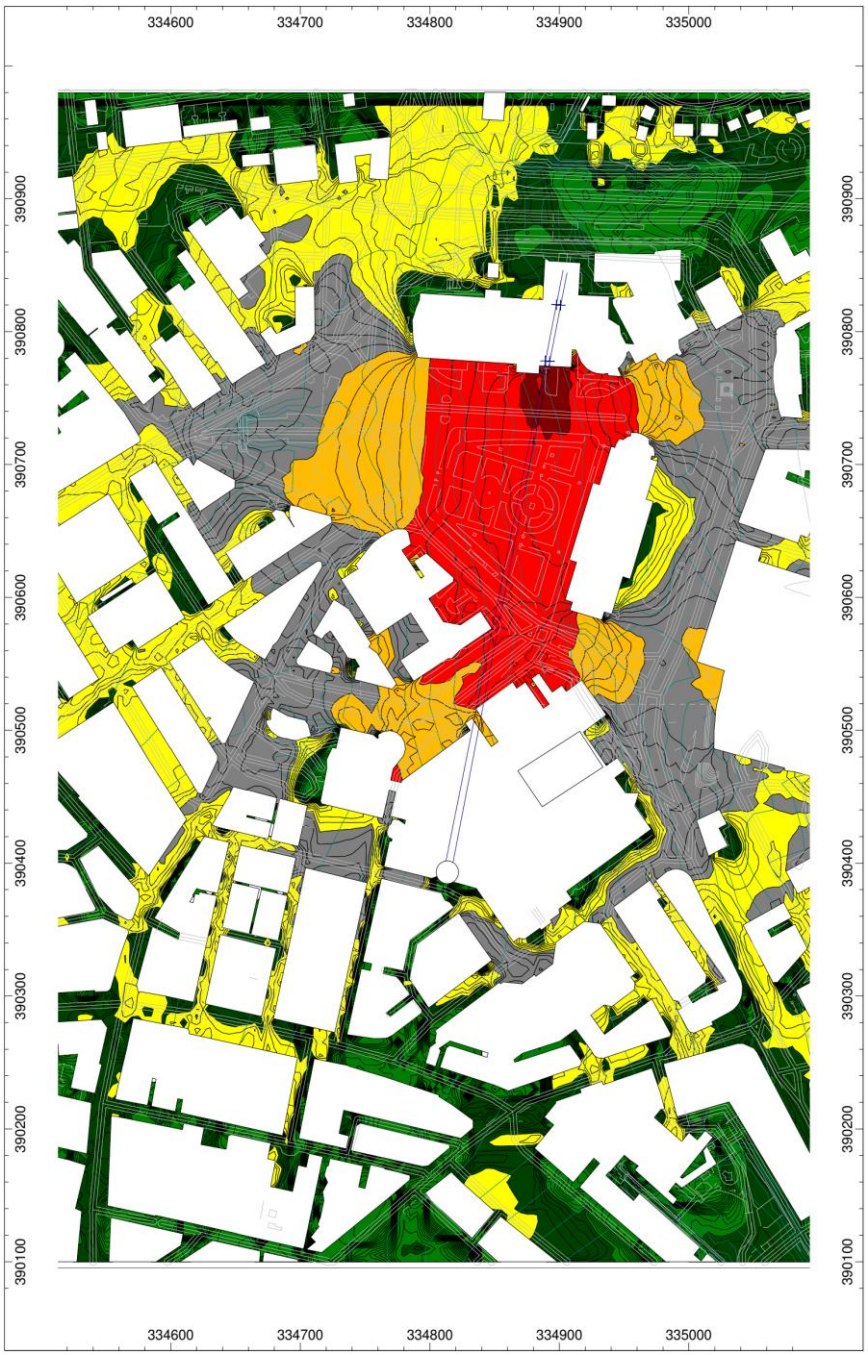
Title: Figure 1: Proposed Zipwire Location & Noise Measurement Posistions
Project: P19-551
A
B




**Key:**

Not to scale

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> 0.0 dB
> 35.0 dB
> 40.0 dB
> 45.0 dB
> 50.0 dB
> 55.0 dB
> 60.0 dB
> 65.0 dB
> 70.0 dB
> 75.0 dB
> 80.0 dB
> 85.0 dB

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**Title:** Figure 2: Calculated Noise Contours in $L_{Aeq,1hr}$ at 1.5m

**Project:** P19-551

## Appendix I: Noise Units & Indices

### Sound and the decibel

A sound wave is a small fluctuation of atmospheric pressure. The human ear responds to these variations in pressure, producing the sensation of hearing. The ear can detect a very wide range of pressure variations. In order to cope with this wide range of pressure variations, a logarithmic scale is used to convert the values into manageable numbers. Although it might seem unusual to use a logarithmic scale to measure a physical phenomenon, it has been found that human hearing also responds to sound in an approximately logarithmic fashion. The dB (decibel) is the logarithmic unit used to describe sound (or noise) levels. The usual range of sound pressure levels is from 0 dB (threshold of hearing) to 120dB (threshold of pain).

Due to the logarithmic nature of decibels, when two noises of the same level are combined together, the total noise level is (under normal circumstances) 3 dB(A) higher than each of the individual noise levels e.g. 60 dB(A) plus 60 dB(A) = 63 dB(A). In terms of perceived 'loudness', a 3 dB(A) variation in noise level is a relatively small (but nevertheless just noticeable) change. An increase in noise level of 10 dB(A) generally corresponds to a doubling of perceived loudness. Likewise, a reduction in noise level of 10 dB(A) generally corresponds to a halving of perceived loudness.

### Frequency and Hertz (Hz)

As well as the loudness of a sound, the frequency content of a sound is also very important. Frequency is a measure of the rate of fluctuation of a sound wave. The unit used is cycles per second, or hertz (Hz). Sometimes large frequency values are written as kiloHertz (kHz), where 1 kHz = 1000 Hz.

Young people with normal hearing can hear frequencies in the range 20 Hz to 20 kHz. However, the upper frequency limit gradually reduces as a person gets older.

The ear is not equally sensitive to sound at all frequencies. It is less sensitive to sound at low and very high frequencies, compared with the frequencies in between. Therefore, when measuring a sound made up of different frequencies, it is often useful to 'weight' each frequency appropriately, so that

the measurement correlates better with what a person would actually hear. This is usually achieved by using an electronic filter called the 'A' weighting, which is built into sound level meters. Noise levels measured using the 'A' weighting are denoted dB(A) or dBA.

## Glossary of Terms

When a noise level is constant and does not fluctuate, it can be described adequately by measuring the dB(A) level. However, when the noise level varies with time, the measured dB(A) level will vary as well. In this case it is therefore not possible to represent the noise climate with a simple dB(A) value. In order to describe noise where the level is continuously varying, a number of other indices can be used. The indices used in this report are described below.

$L_{Aeq}$ This is the A–weighted 'equivalent continuous noise level' which is an average of the total sound energy measured over a specified time period. In other words, $L_{Aeq}$ is the level of a continuous noise which has the same total (A–weighted) energy as the real fluctuating noise, measured over the same time period. It is increasingly being used as the preferred parameter for all forms of environmental noise.

SEL This is the A–weighted 'sound exposure level' measured for a specific noise event such as a passing train, or in our case noise from a descent of a zip wire route. It is a measure of the total sound level of the event normalised to a 1-second period.

$L_{Amax}$ This is the maximum A–weighted noise level that was recorded during the period of the noise measurement.

$L_{A10}$ This is the A–weighted noise level that was exceeded for 10% of the time period of the measurement. It is most commonly used as a measure of road traffic noise.

$L_{A90}$ This is the A–weighted noise level that was exceed for 90% of the time period of the measurement. It is a measure of the background noise.

## Appendix II: Ambient Noise Survey Results

Dates: 7 – 11 November 2019

Equipment: Rion NL52 'Type 1' sound analyser (serial no. 00610193), all-weather kit,
Rion NL-52 'Type 1' sound analyser (serial no. 0921176), all-weather kit,
B&K Type 4231 calibrator (serial no. 2482588)

Weather during noise surveys (from Meteo forecasts and observations):

Thursday 7 November : Persistent rain in daytime, drier overnight. Light NE breeze in daytime in increasing to 12mph overnight, 6°C in daytime reducing to 4 °C at night.

Friday 8 November : Dry and mainly sunny with brisk NW breeze, 5 - 8°C. Overcast, calm and cold 0-2 C overnight.

Saturday 9 November : Mainly wet, cold 2-4 °C, SE veering NE light winds. Overcast and cold 2-4 °C overnight, with light NE/N breeze.

Sunday 10 November : Dry and mainly sunny, 3-7°C, calm to light N breeze. Overcast in evening with light S breeze. Rain in night with increasing SW wind.

Monday 11 November : Showery , strong W wind 15-20mph. 7-8 °C .

All results in following charts in dB(A)

Chart 1 – Marriott Hotel : all days/times

Chart 2 - Marriott Hotel : Friday 09:00-20:00

Chart 3 - Marriott Hotel : Sunday 09:00-20:00

Chart 4 – Library roof : all days/times

Chart 5 - Library roof: Friday 09:00-20:00

Chart 6 - Library roof: Sunday 09:00-20:00

**Chart 1 – Marriott Hotel - all results/all times**

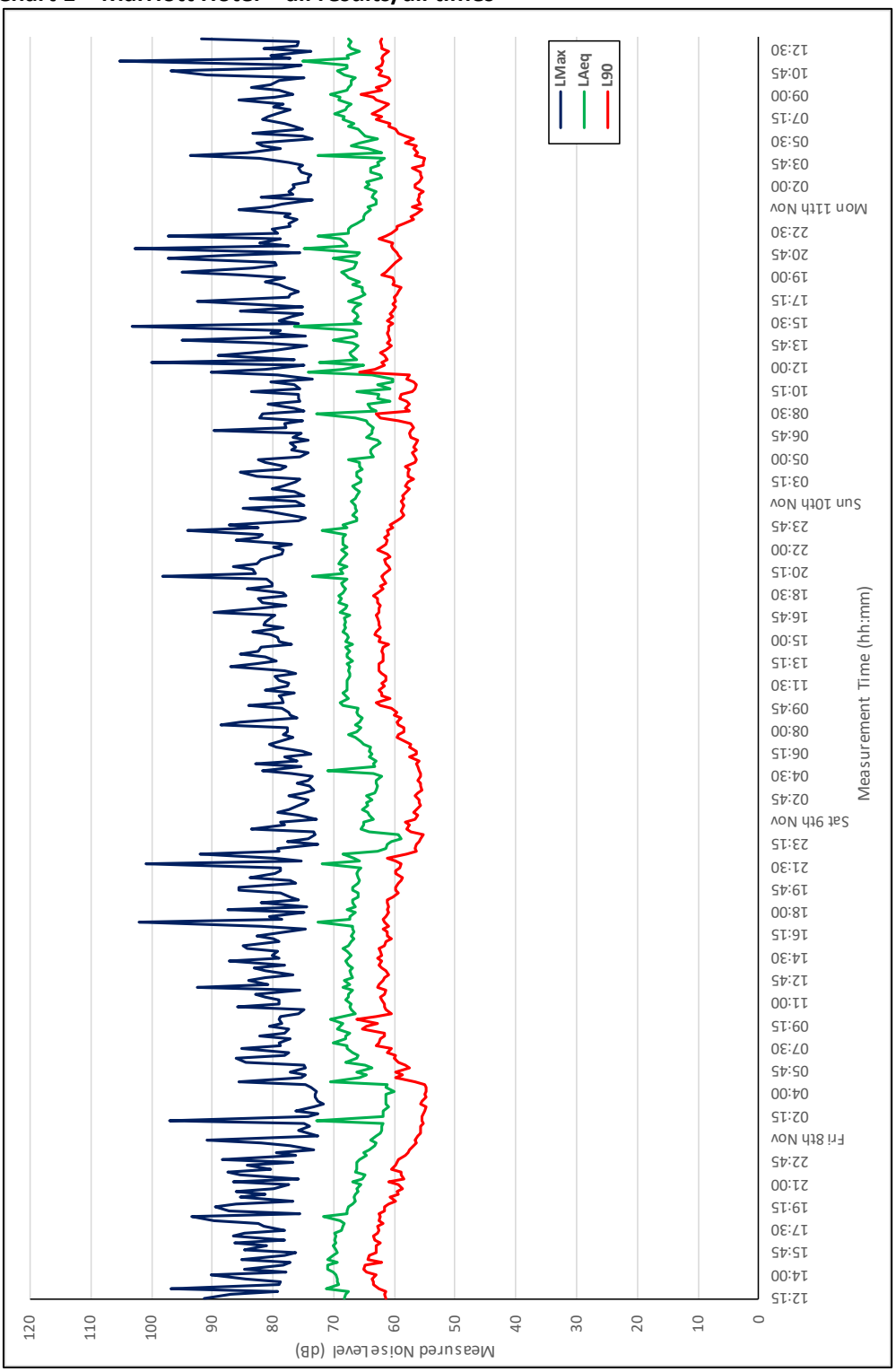


**Chart 2 – Marriott Hotel - Friday 8 November 09:00-20:00**

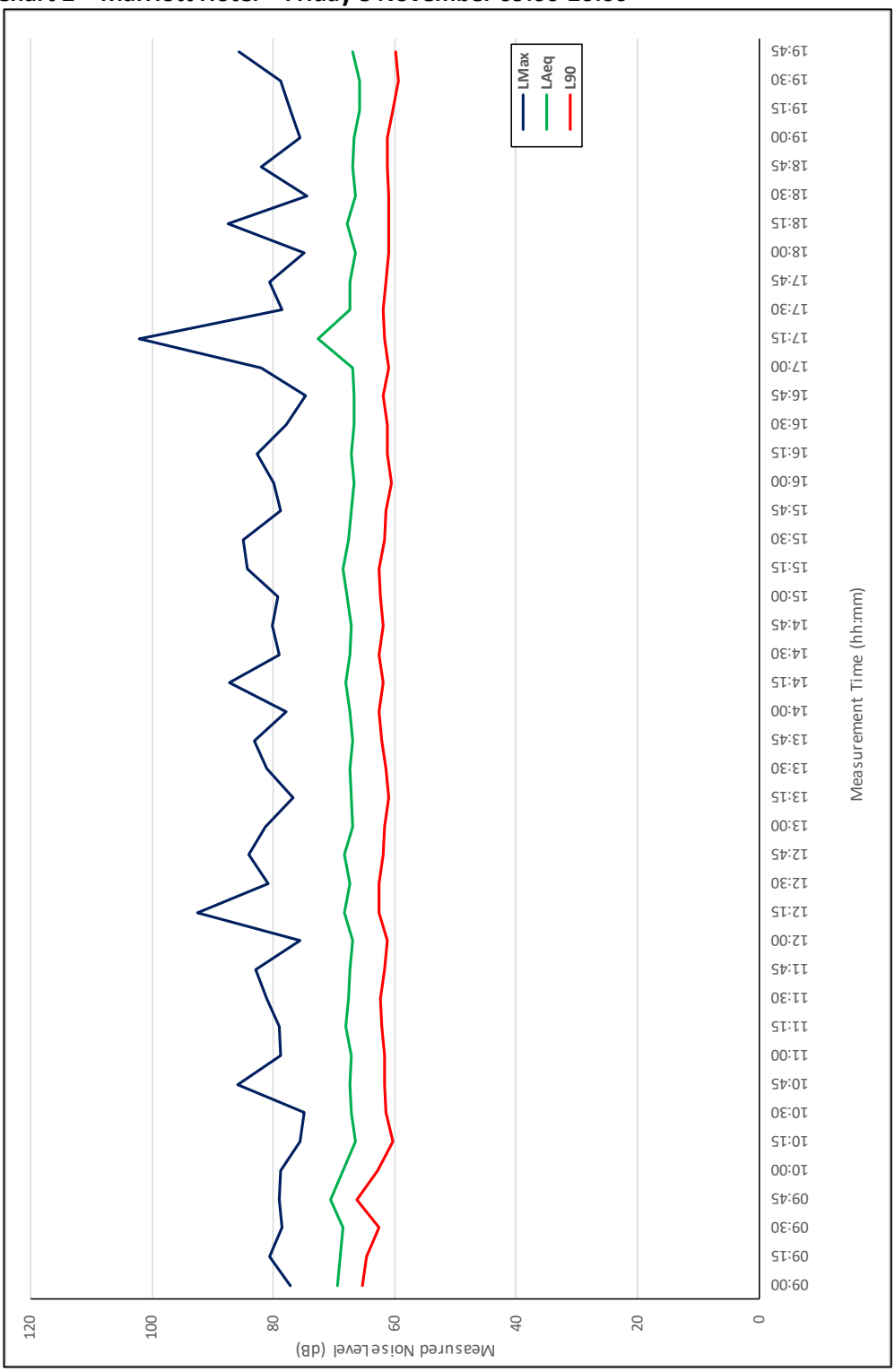


**Chart 3 – Marriott Hotel - Sunday 10 November 09:00-20:00**

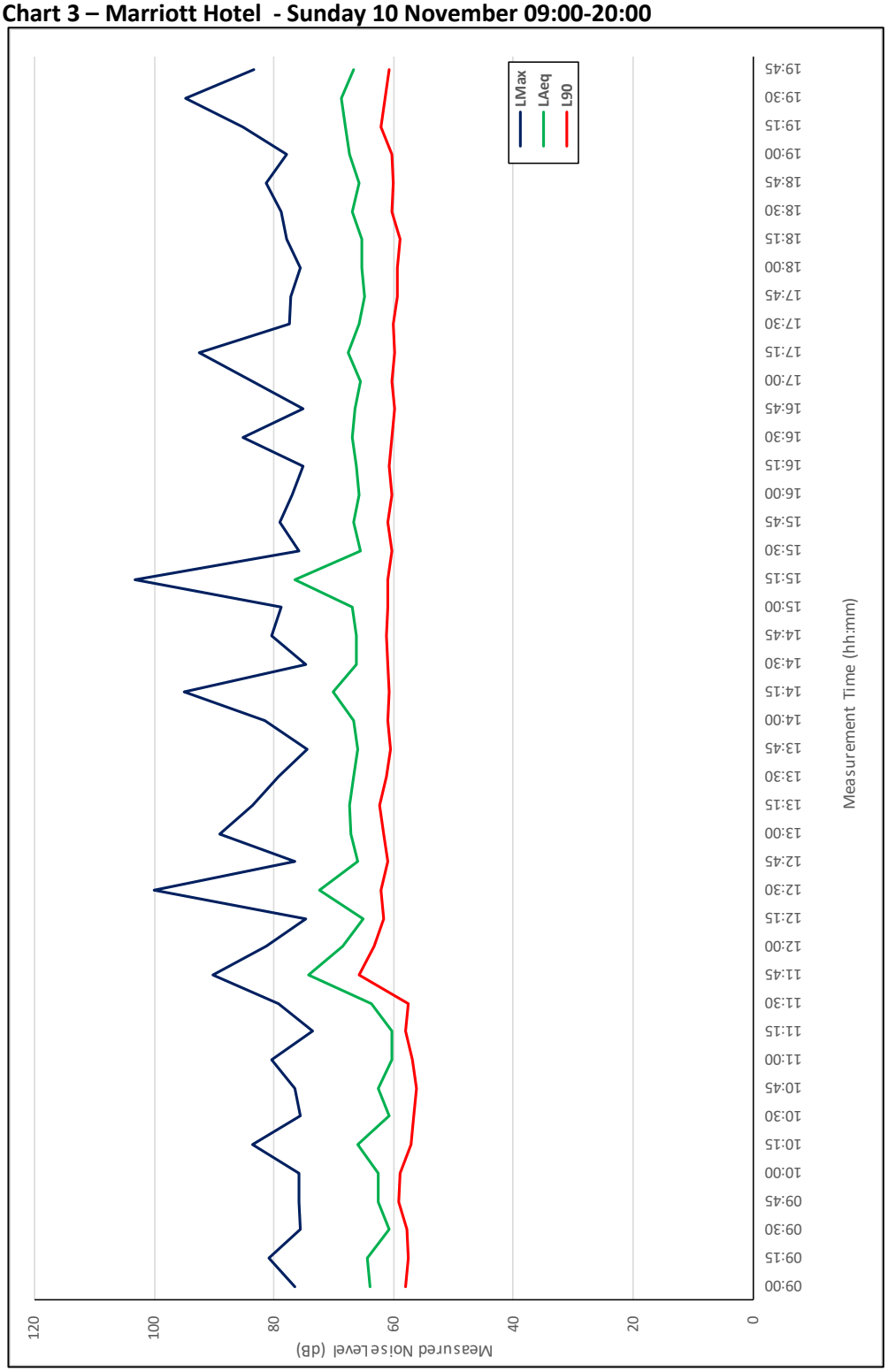


**Chart 4 – Library Roof - all results/all times**

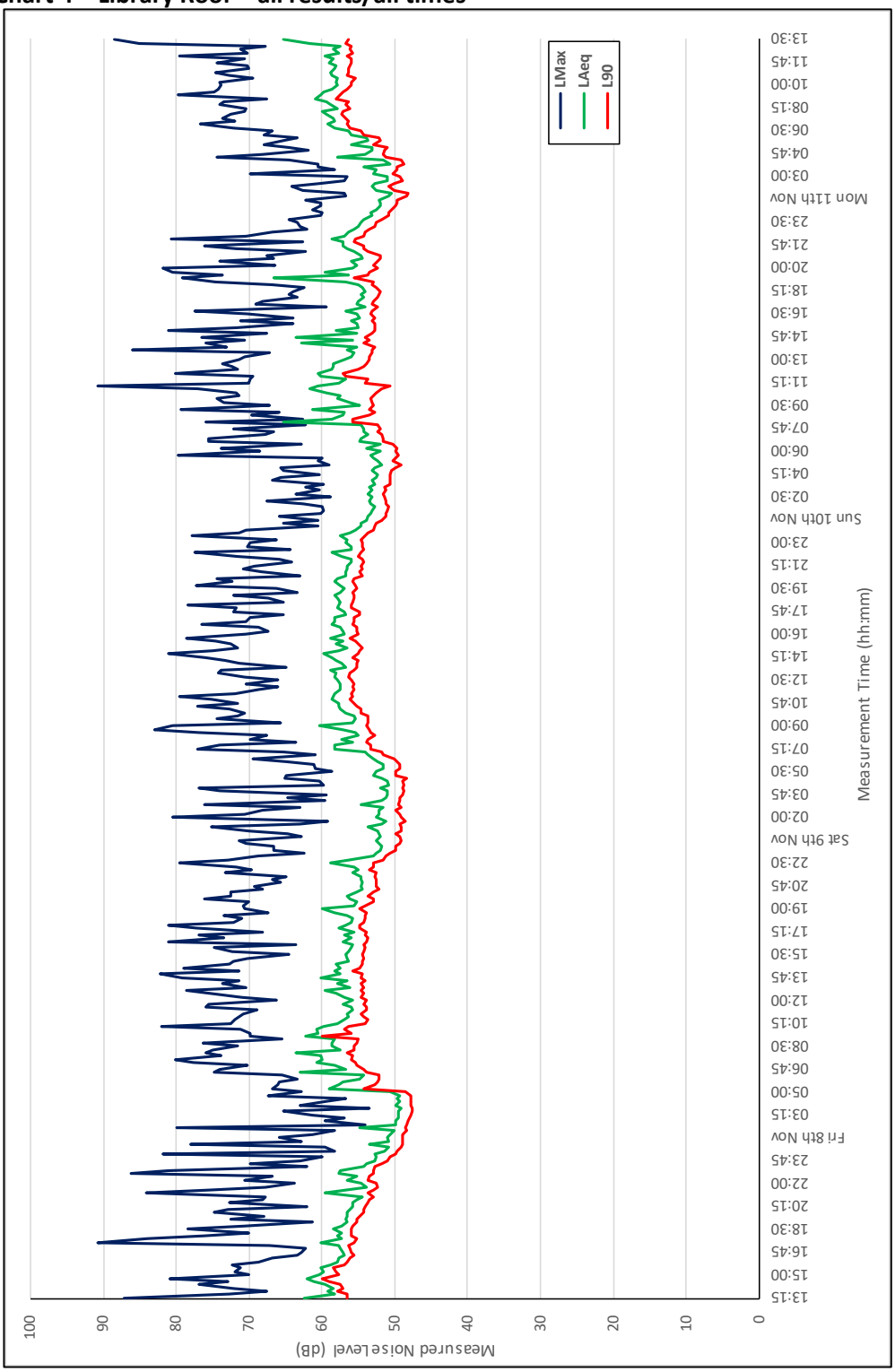


**Chart 5 – Library Roof - Friday 8 November 09:00-20:00**

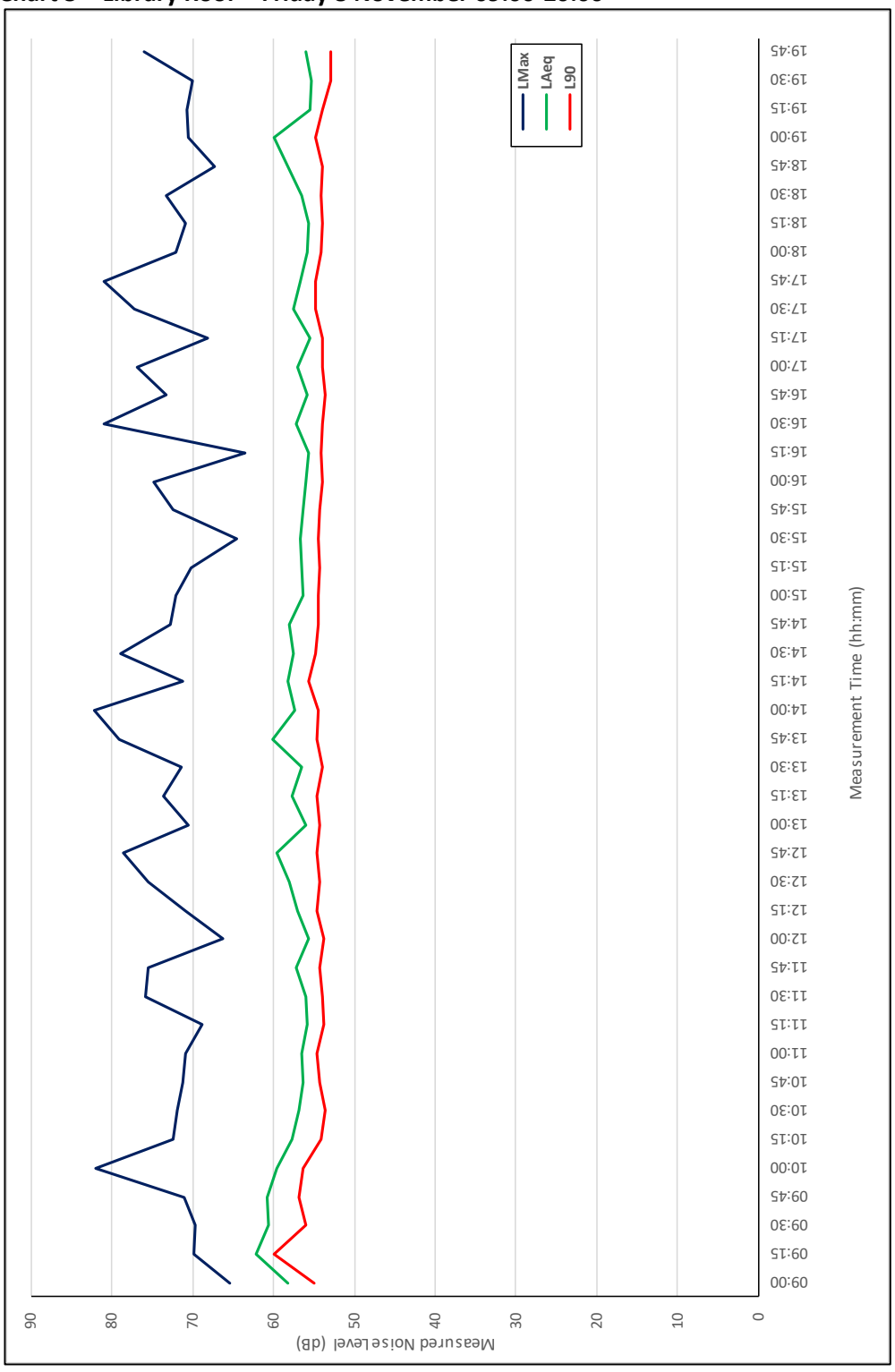
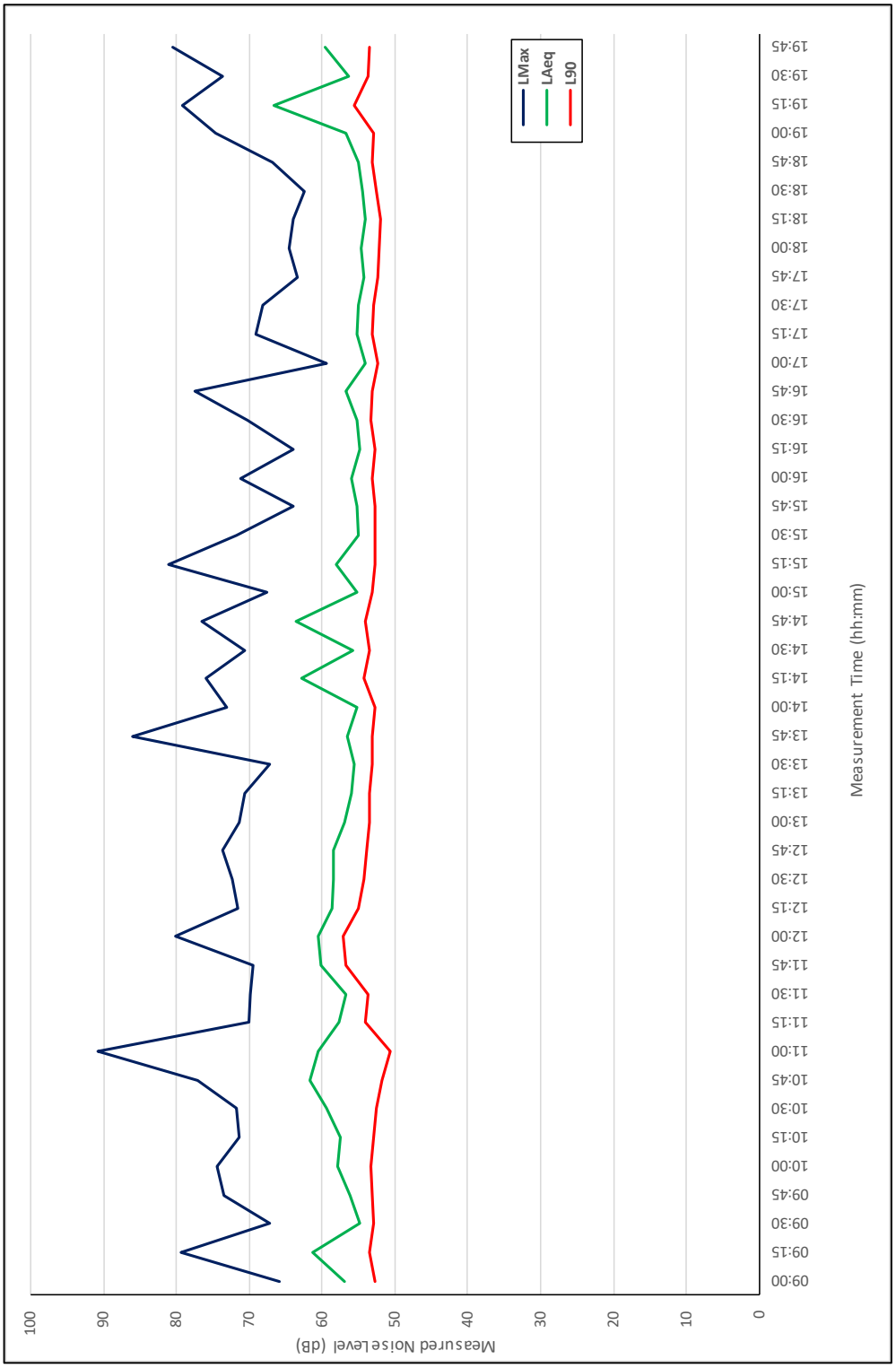


**Chart 6 – Library Roof - Sunday 10 November 09:00-20:00**



## Appendix III: Noise Measurements at Zip World Titan

Date: Sunday 3 November 2019

Equipment: Rion NA-27 'Type 1' sound analyser (serial no. 10632001) with tripod and Castle GA607 Calibrator.

Weather: Mainly dry, overcast at first after earlier rain, 6/8 cloud after 12:00, cold, calm.

All results in dB(A)

**Location : c50m South of Bravo**

| Descent | Measured Noise Levels (dB) | | No. of People in Descent |
|---|---|---|---|
| | $L_{Amax}$ | SEL | |
| 1 | 68.4 | 76.8 | 4 |
| 2 | 63.2 | 70.6 | 2 |
| 3 | 62.8 | 70.8 | 2 |
| 4 | 66.2 | 72.2 | 3 |

**Location : Directly Underneath Bravo** (wires c5m above)

| Descent | Measured Noise Levels (dB) | | No. of People in Descent |
|---|---|---|---|
| | $L_{Amax}$ | SEL | |
| 1 | 79.3 | 82.0 | 2 |
| 2 | 78.5 | 78.8 | 1 |
| 3 | 81.7 | 83.4 | 1 |
| 4 | 78.7 | 83.9 | 2 |

**Location : Near Landing Platform of Bravo** (at arrestment location, 10m from nearest wire in use)

| Descent | Measured Noise Levels (dB) | | No. of People in Descent |
|---|---|---|---|
| | $L_{Amax}$ | SEL | |
| 1 | 83.0 | 83.8 | 3 |
| 2 | 81.3 | 83.4 | 3 |
| 3 | 82.1 | 82.3 | 3 |
| 4 | 81.3 | 78.5 | 1 |
| 5 | 82.5 | 82.3 | 1 |