HOODLANDS, BRISTOL

Vibration Assessment

Reference: 10905.RP02.VIB.1
Prepared: 15 July 2021
Revision Number: 0

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Vibration Assessment

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Revision	Comment	Date	Prepared By	Approved By
0	First issue of report	18 June 2021	Joe Allen	Torben Andersen
1	Updated based on comments received from Turley	15 July 2021	Joe Allen	Torben Andersen

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The recommendations within this report relate to acoustics performance only and will need to be integrated within the overall design by the lead designer to incorporate all other design disciplines such as fire, structural integrity, setting-out, etc. Similarly, any sketches appended to this report illustrate acoustic principles only and again will need to be developed in to full working drawings by the lead designer to incorporate all other design disciplines.

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1.0 INTRODUCTION

The land at the Hoodlands, Hambrook Lane, is being developed into 50 residential dwellings. The development is part of the wider East of Harry Stoke New Neighbourhood Policy Allocation. The site is located on ground to the South of the railway line serving Bristol Parkway railway station.

RBA Acoustics has been commissioned to undertake a vibration survey in order to ascertain whether the proposed dwellings are likely to be affected by train induced vibration, either in the form of tactile vibration or re-radiated noise.

This report presents the results of the Due Diligence stage vibration survey undertaken at the site and associated BS 6472 assessment and conclusions.

2.0 ASSESSMENT CRITERIA

It is necessary to consider two sets of criteria when assessing train-induced vibration and its potential impact on dwellings. Not only will the disturbance be perceived as tactile vibration, but the vibration may also result in structure-borne re-radiated noise.

When assessing vibration and re-radiated noise levels generated by either surface or underground train movements, reference should be made to the following guidelines.

2.1 Vibration

BS 6472-1:2008 "Guide to Evaluation of Human Exposure to Vibration in Buildings Part 1: Vibration sources other than blasting" provides guidance on predicting human response to vibration in buildings over the frequency range 0.5Hz to 80Hz.

BS 6472 is based on the evaluation of vibration measurements with regards to adverse comment from occupants, rather than criteria relating to health and safety or structural damage.

In terms of assessing what impact the perceptibility of structure-borne vibration has on a person the standard promotes the use of the vibration dose value (VDV). The VDV determines an overall dose value accounting for intermittent, impulsive or continuous vibration experienced by a person and rates the level in terms of subjective response. Table 1 details the relationship between vibration dose and human annoyance:

Table 1 – VDV Values

Place and Time	Low probability of adverse comment ($m/s^{-1.75}$)	Adverse comment possible ($m/s^{-1.75}$)	Adverse comment probable ($m/s^{-1.75}$)
Residential Buildings 16h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential Buildings 8h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

The above values can be used for both vertical and horizontal vibration, provided that they are calculated according to the appropriate frequency weightings.

2.2 Re-Radiated Noise

There are no specific UK or international standards that define when ground borne noise becomes significant. As a result there are no formal criteria against which assessment of ground borne noise inside residential buildings can readily be made.

It is commonly accepted that vibration levels resulting in re-radiated noise levels of up to 35dBA $L_{max(s)}$ should not result in nuisance or complaints, whilst levels above 40dBA $L_{max(s)}$ will make complaints likely. $L_{max(s)}$ re-radiated noise levels between 35dBA and 40dBA are considered perceptible but not a cause of complaint.

In addition, recent rail transit systems (Jubilee Line Extension, Crossrail and Channel Tunnel Rail Link) have adopted a re-radiated noise criterion of 40dBA $L_{max(s)}$ for residential buildings potentially affected by train induced vibration in order to ensure a low degree of impact.

We would therefore advise a 40dBA $L_{max(s)}$ criterion be adopted for the residential areas in order to ensure minimal likelihood of complaint from re-radiated noise.

N.B. The proposed development will also be affected by airborne noise intrusion (as the rail lines are overground) where a criterion of 45dBA $L_{max(f)}$ has been adopted.

3.0 TRAIN MOVEMENTS

3.1 Passenger Train Movements

During our time on site two different types of passenger trains were noted.

Great Western Railway (GWR) with an approximate frequency of five trains an hour in either direction were noted during the measurement period.

Cross Country trains were also noted with an approximate frequency of three trains an hour in either direction during the measurement period.

All train pass-bys were relatively slow with estimated speeds of 20-30mph.

Overall, an average of 8 train pass-bys per hour were noted during the measurement period. Review of the Realtime Trains website indicates that at peak time up to approximately 11-12 train pass-bys per hour occur in the daytime (07:00 – 23:00 hours), while approximately 17 train pass-bys occur in total during the night-time (23:00 – 07:00 hours.

3.2 Freight Trains

During our time on site one freight train was observed. This freight train was noted to be fully loaded and therefore considered representative of the worst-case freight train movements.

Review of the Realtime Train website indicates that approximately 15 freight trains pass by during a typical daytime and approximately 9 freight trains pass by during a typical night-time period. It must however be noted that the nature of the rail freight industry results in services being subject to alteration at short notice in some cases at the request of the end customers.

4.0 VIBRATION MEASUREMENTS

4.1 Instrumentation

Full details of the equipment used are provided in Appendix B.

The accelerometers were calibrated both prior to and on completion of the survey with no calibration drifts observed.

4.2 Methodology

Vibration measurements were undertaken for a number of passenger train movements and one freight train movement at two measurement positions on 22 and 27 April 2021. The positions are described in detail below:

Position 1: Measurements were undertaken on a metal base plate placed on the existing ground. This location was in the northern corner of the site approximately 90m from the railway line.

Position 2: Measurements were undertaken on a metal base plate placed on the existing ground. This location was approximately halfway along the north-eastern boundary of the site approximately 120m from the railway line.

The approximate locations of the vibration measurement positions are shown on the Site Plan in Figure 1 in Appendix D.

Vertical and horizontal axis measurements were undertaken at all positions.

5.0 RESULTS

The ground-borne vibration levels for a number of passenger train pass-bys have been analysed into third-octave bands and the data summarised on the attached graphs. Graphs 1 – 2 present the maximum (rms) vertical vibration levels measured at each position for the individual train passbys. Graphs 3 – 6 present the maximum (rms) horizontal vibration levels measured at each position for the individual train passbys.

6.0 PREDICTION ASSUMPTIONS

Vibration levels presented in Graphs 1-6 are as measured within the ground. In order to estimate the resultant vibration levels and re-radiated noise levels within the building we have made the following assumptions:

6.1 Prediction Procedures

Our calculations have been based on the following:

(i) Empirical prediction procedures as detailed within the following references:

- "A Prediction Procedure for Rail Transportation Ground-borne Noise and Vibration" – Nelson and Saurenman : Transportation Research Record 1143.
- "Handbook of Urban Rail Noise and Vibration Control" – Nelson, Saurenman, Wilson : US Department of Commerce – National Technical Information Services – February 1982.

(ii) Previous research undertaken by RBA Acoustics on building response to ground-borne vibration within a variety of different building frame types.

6.2 Drawings

Our assessment has been based on the layout detailed in Drawing No. HDF-JTP-SW-GL-DR-A-SL-5000 Revision 1.

7.0 PREDICTED LEVELS OF VIBRATION & RE-RADIATED NOISE

7.1 Tactile Vibration – Vibration Dose Values (VDVs)

Table 2 details the predicted Vibration Dose Values (VDVs) for both the daytime and night-time periods. Only the vertical axis has been considered as the floor structures will vibrate predominantly in this axis.

Table 2 – Predicted $Vdv_{b,Day}$ And $Vdv_{b,Night}$

Measurement Position	Period	Vertical VDV (m/s$^{-1.75}$)	BS 6472	
			Low Probability of Adverse Comment (m/s$^{-1.75}$)	Adverse comment possible (m/s$^{-1.75}$)
1	Day	0.006	0.2 – 0.4	0.4 - 0.8
	Night	0.005	0.1 – 0.2	0.2 - 0.4
2	Day	0.006	0.2 – 0.4	0.4 - 0.8
	Night	0.005	0.1 – 0.2	0.2 - 0.4

Our calculations indicate that the Vibration Dose Values associated with train movements during both the day and night-time periods are significantly below those expected to result in a "low probability of adverse comment". These could therefore be considered negligible.

7.2 Re-Radiated Noise Levels

Table 4 presents the range of predicted re-radiated $L_{max(s)}$ noise levels from train pass-bys.

Table 3 – Predicted Re-Radiated Noise Levels

Measurement Position	Noise Levels (dBA)	Proposed Criterion (dBA)
1	15-22	40
2	3-13	40

Levels predicted for the nearest houses to the railway line are significantly below the 40dB criterion for all trains. Noise levels will reduce as the distance from the railway line increases, therefore all houses within the development will be significantly below the criterion.

7.3 Discussion

There are no exceedances in levels of re-radiated noise, tactile vibrations or perception levels for any area of the development. This is for all types of trains, i.e. passenger and freight. Therefore, no mitigation is required.

8.0 CONCLUSIONS

Detailed vibration measurements have been undertaken at the Hoodlands site.

The vibration measurements have been analysed on an empirical basis and shown to be significantly within recommended criteria for vibration.

We therefore consider that planning approval should be acceptable in terms of vibration impact.

Appendix A - Acoustic Terminology

dB	Decibel - Used as a measurement of sound pressure level. It is the logarithmic ratio of the noise being assessed to a standard reference level.
dB(A)	The human ear is more susceptible to mid-frequency noise than the high and low frequencies. To take account of this when measuring noise, the 'A' weighting scale is used so that the measured noise corresponds roughly to the overall level of noise that is discerned by the average human. It is also possible to calculate the 'A' weighted noise level by applying certain corrections to an un-weighted spectrum. The measured or calculated 'A' weighted noise level is known as the dB(A) level. Because of being a logarithmic scale noise levels in dB(A) do not have a linear relationship to each other. For similar noises, a change in noise level of 10dB(A) represents a doubling or halving of subjective loudness. A change of 3dB(A) is just perceptible.
L_{eq}	L_{eq} is defined as a notional steady sound level which, over a stated period of time, would contain the same amount of acoustical energy as the actual, fluctuating sound measured over that period (1 hour).
L_{Aeq}	The level of notional steady sound which, over a stated period of time, would have the same A-weighted acoustic energy as the A-weighted fluctuating noise measured over that period.
L_{An} (e.g L_{A10}, L_{A90})	If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The L_n indices are used for this purpose, and the term refers to the level exceeded for n% of the time, hence L_{10} is the level exceeded for 10% of the time and as such can be regarded as the 'average maximum level'. Similarly, L_{90} is the average minimum level and is often used to describe the background noise.
$L_{max,T}$	The instantaneous maximum sound pressure level which occurred during the measurement period, T. It is commonly used to measure the effect of very short duration bursts of noise, such as for example sudden bangs, shouts, car horns, emergency sirens etc. which audibly stand out from the general level of, say, traffic noise, but because of their very short duration, maybe only a very small fraction of a second, may not have any effect on the L_{eq} value.

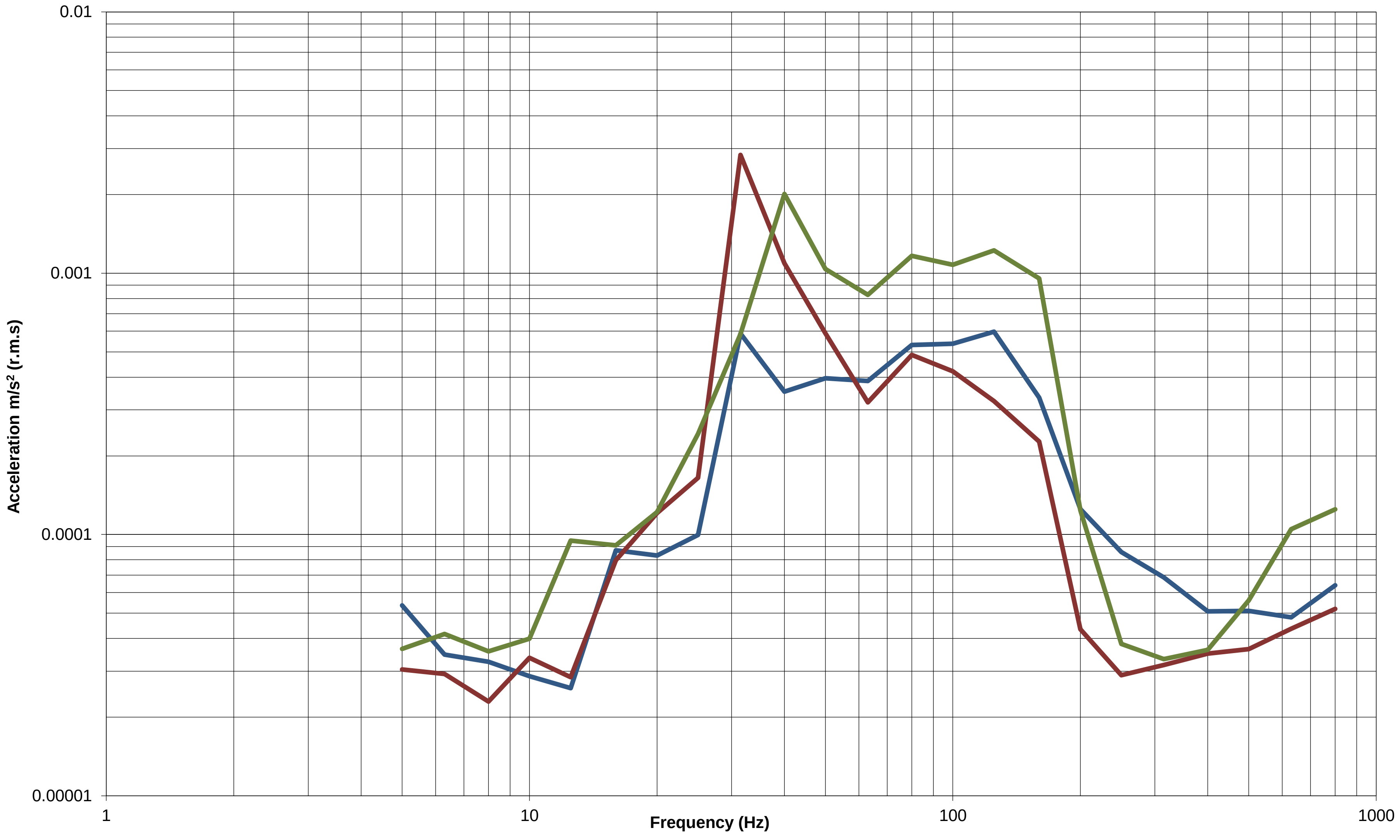
Appendix B - Instrumentation

The following equipment was used for the measurements

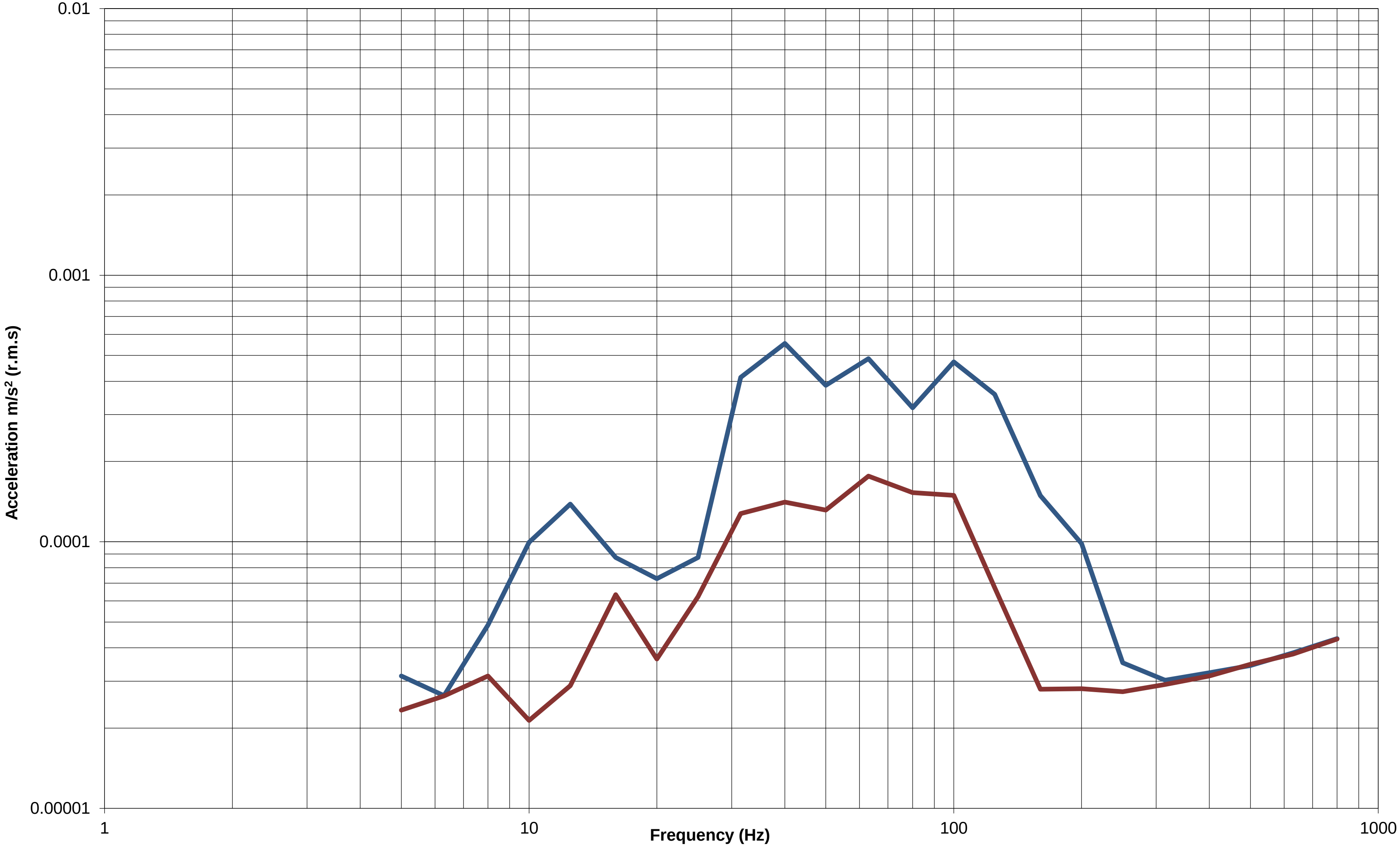
Manufacturer	Model Type	Serial No.	Calibration	
			Certificate No.	Valid Until
Svantek Accelerometer	SV84	K2309	14012998	2 March 2022
SINUS Acoustic Multi-channel Universal Real-time Analysis Instrument (SAMURAI)	-	-	-	-

Appendix C – Graphs and Site Plans

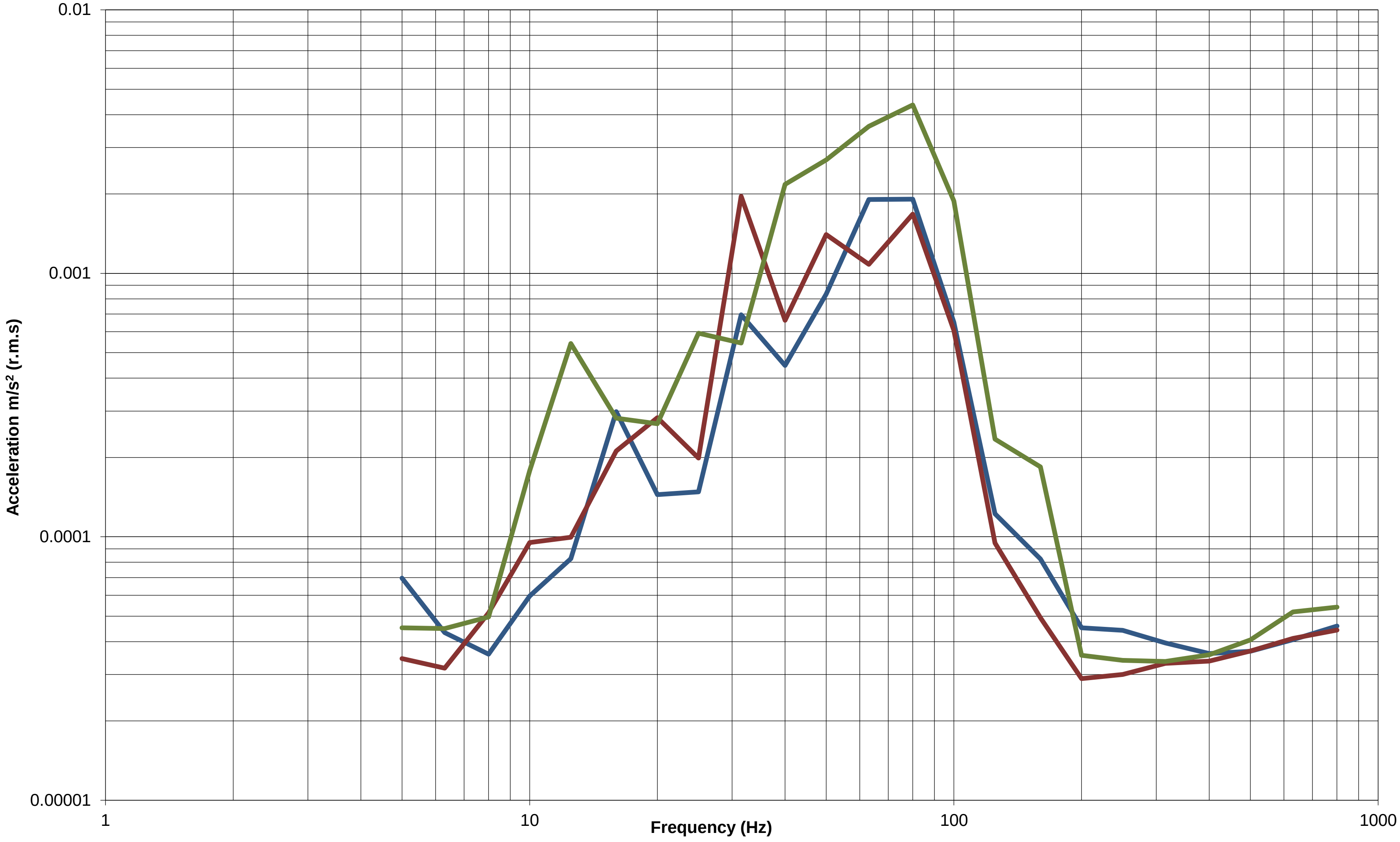
Address: Hoodlands, Bristol
Position: 1
Vertical Axis



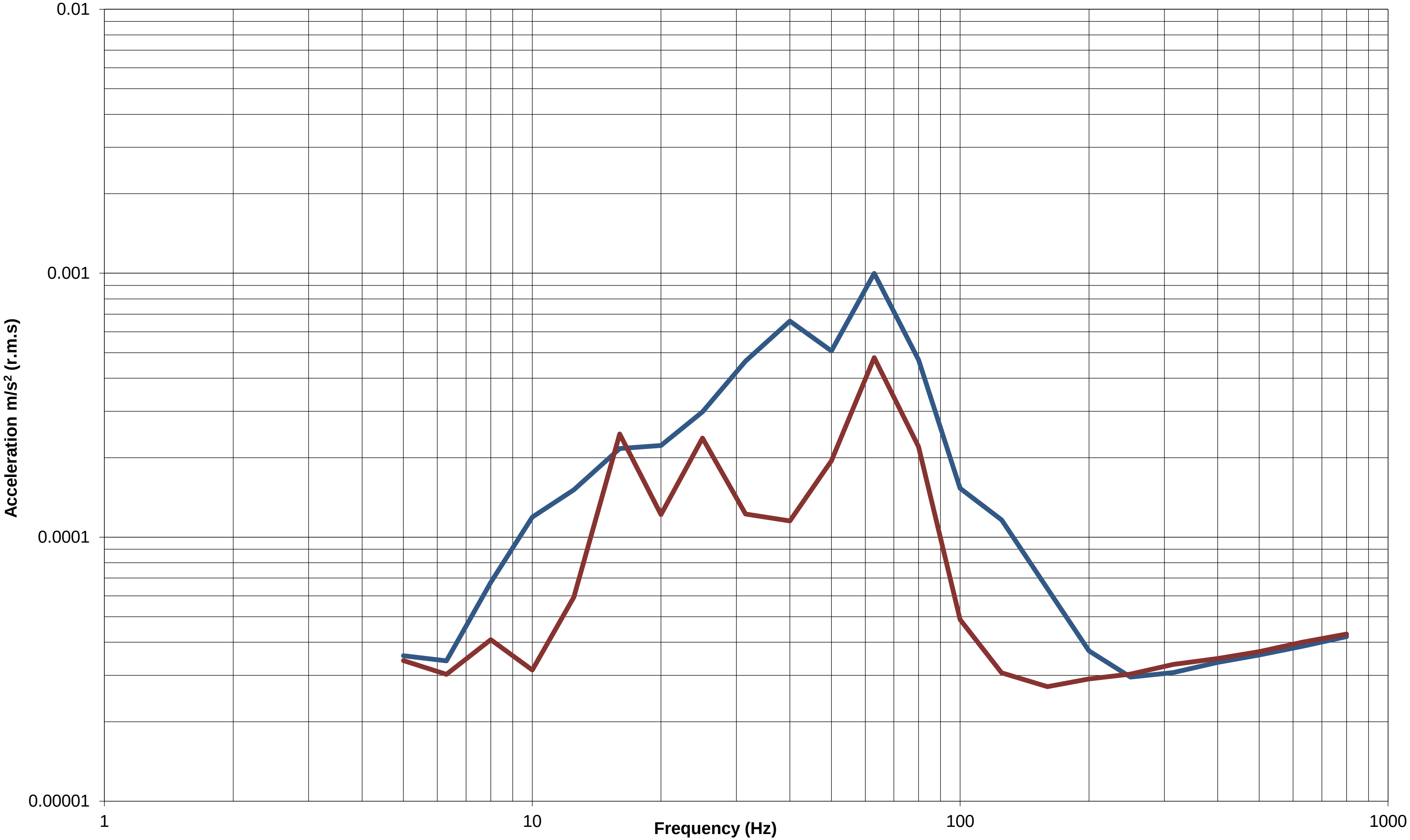
Address: Hoodlands, Bristol
Position: 2
Vertical Axis



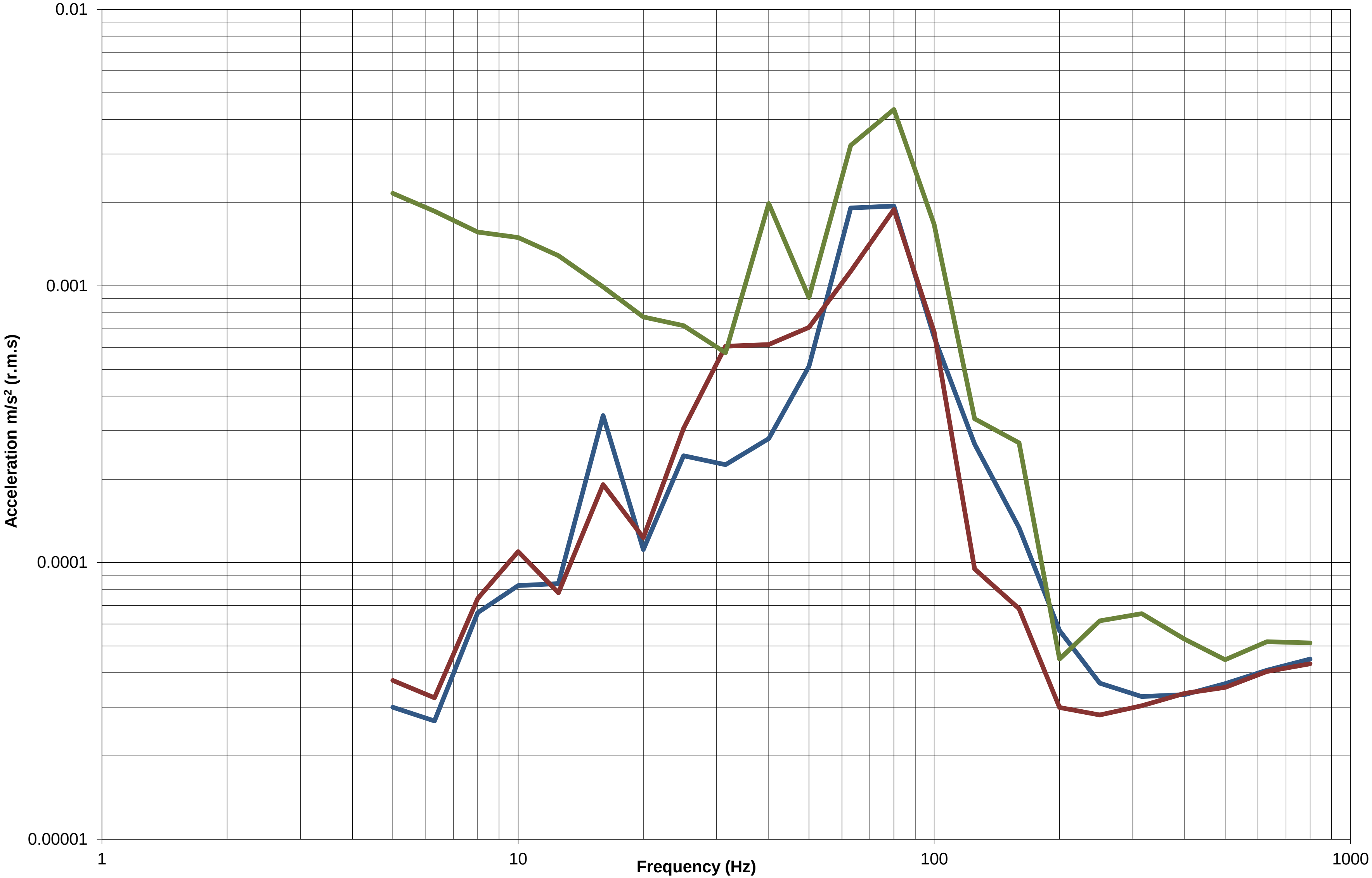
Address: Hoodlands, Bristol
Position: 1
Horizontal Parallel Axis



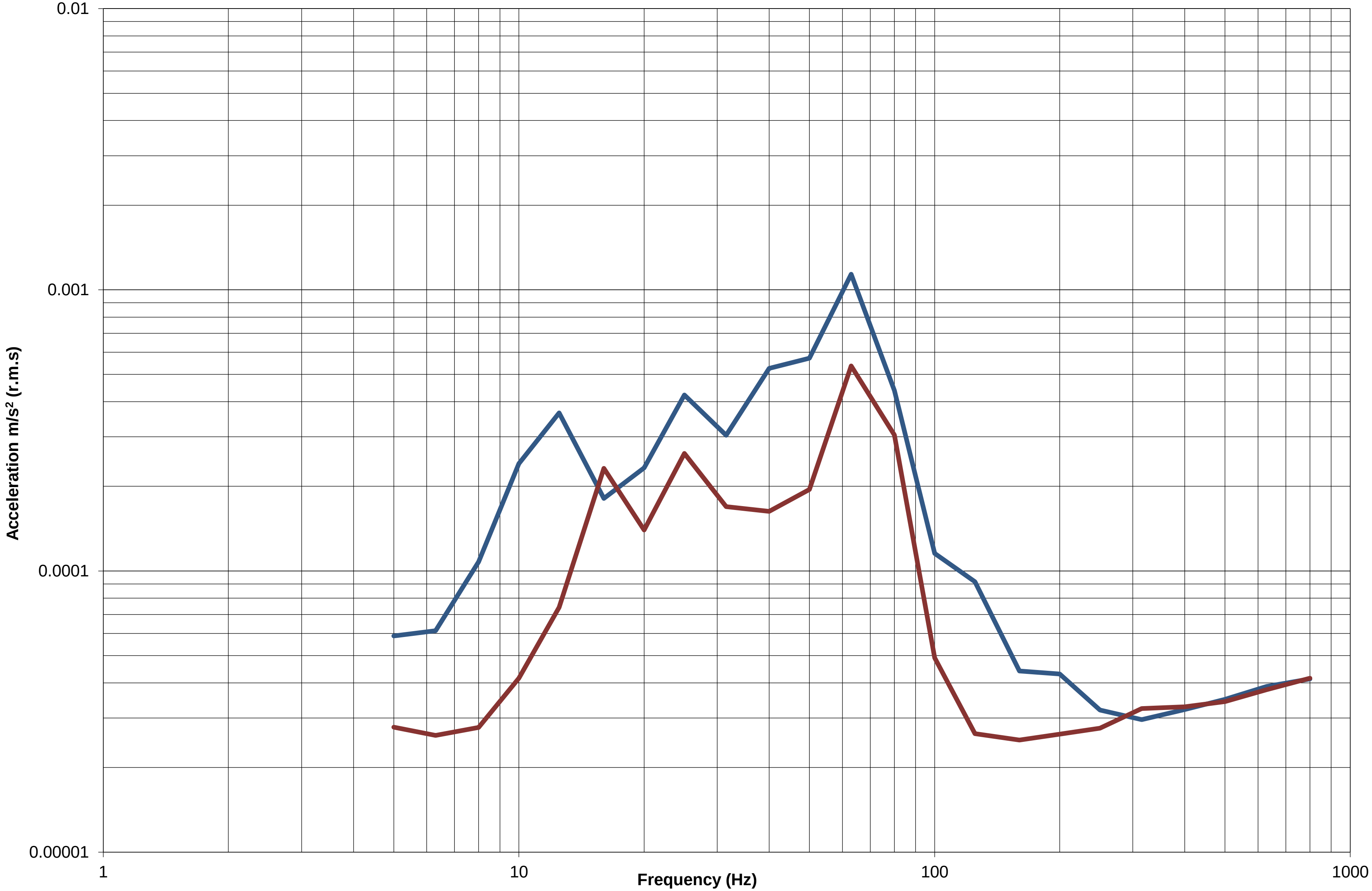
Address: Hoodlands, Bristol
Position: 2
Horizontal Parallel Axis

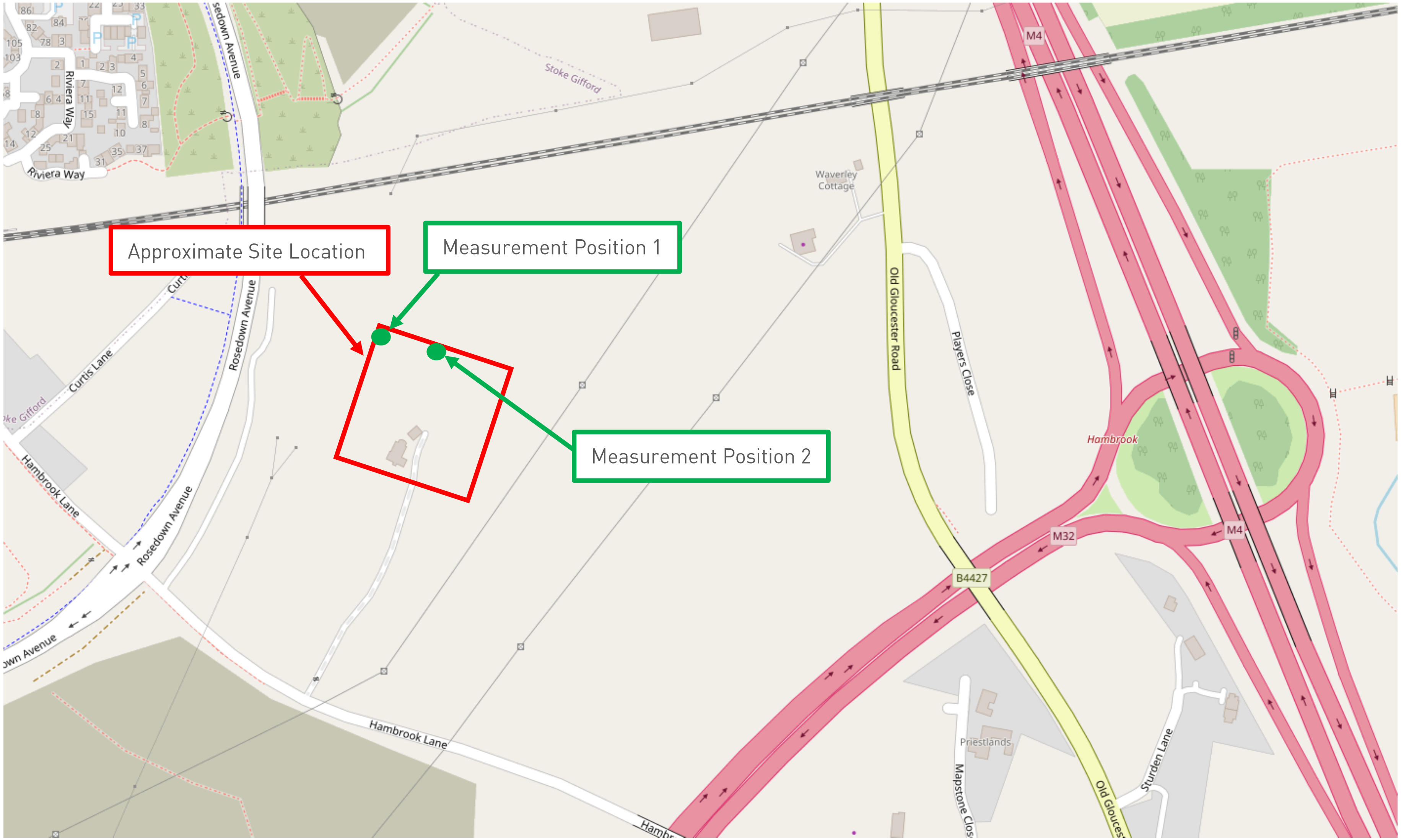


Address: Hoodlands, Bristol
Position: 1
Horizontal Perpendicular Axis



Address: Hoodlands, Bristol
Position: 2
Horizontal Perpendicular Axis





Hoodlands, Bristol
Site Plan
Project 10905

Figure 1
15 July 2021
Not to Scale

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