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BRIEF FOR CONSULTANCY:

To assess the results of vibration measurements undertaken during construction works, relative to the guidance given in BS 5228.

Construction Vibration Assessment
Elgin Academy

Technical Report No. R-5247B-DL4-UC
25 October 2010

PREPARED FOR:

Stewart Milne Developments
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For the attention of Mark Miller

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1.0 Introduction

1.1 We were instructed by Mark Miller of Stewart Milne Developments to undertake an assessment of vibration from construction activities at Elgin Academy.

1.2 The main sources of vibration were from piling and compacting activities. A plan of the site is included in Appendix A.

2.0 Criteria

2.1 BS 5228-2:2009 *"Code of practice for noise and vibration control on construction and open sites –Part 2: Vibration"* forms the most relevant guidance for the assessment of construction vibration, and gives the following background with regard to effects of vibration of the surrounding community and structures:

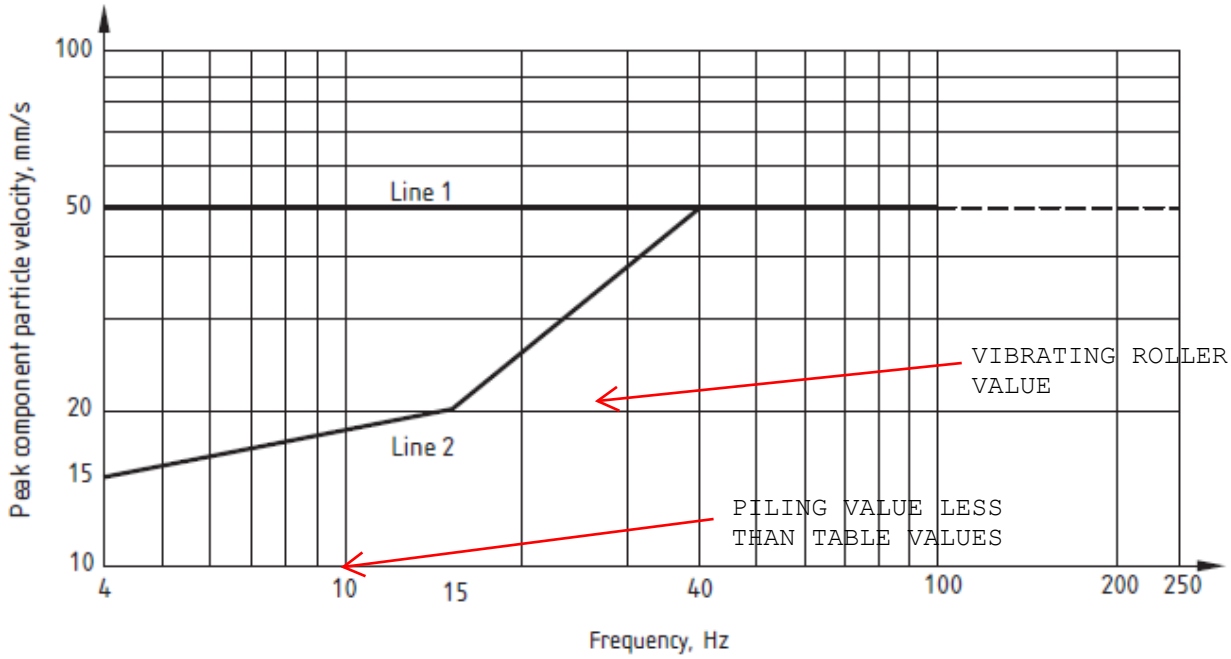
"Vibrations, even of very low magnitude, can be perceptible to people and can interfere with the satisfactory conduct of certain activities, e.g. delicate procedures in hospital operating theatres, use of very sensitive laboratory weighing equipment. Vibration nuisance is frequently associated with the assumption that, if vibrations can be felt, then damage is inevitable; however, considerably greater levels of vibration are required to cause damage to buildings and structures (see, for example, BS 7385-2)…"

And:

"Extensive studies carried out in the UK and overseas have shown that documented proof of actual damage to structures or their finishes resulting solely from well-controlled construction and demolition vibrations is rare. There are many other mechanisms which cause damage, especially in decorative finishes, and it is often incorrectly concluded that vibrations from construction and demolition sites are to blame.

In some circumstances, however, it is possible for the vibrations to be sufficiently intense to promote minor damage. Typically this damage could be described as cosmetic and would amount to the initiation or extension of cracks in plasterwork, etc., rather than the onset of structural distress. In more severe cases, falls of plaster or loose roof tiles or chimney pots can occur."

2.2 Figure B.1 of BS 5228-2, reproduced below, gives indicative values for the onset of minor cosmetic damage to buildings, relative to the vibration level at the base of the building. Line 1 is appropriate to industrial and heavy commercial buildings whilst Line 2 is relevant to residential and light commercial buildings.



3.0 Measurements

3.1 Vibration data has been collected by the piling and foundation engineers, Roger Bullivant Ltd. The monitoring equipment was located on the boundary wall at the upper level of the site and is shown on the site plan in Appendix A. The measurement data was presented to us in graphical form covering the following periods:

23/08/2010	11:45	to	17:30
25/08/2010	08:30	to	16:00
27/08/2010	08:00	to	16:00
02/09/2010	14:30	to	18:00
03/09/2010	08:30	to	18:30

3.2 Calibration certificates for the monitoring instrumentation are provided in Appendix B.

3.3 The data presents the vertical PPV values at the boundary location, 28 m from the closest property.

3.4 Vibration monitoring was undertaken during the most vibratory work, i.e. the piling and compacting exercises. The piling took place between 55 to 140 m from the monitoring location. The compacting took place between 3 to 150 m from the monitoring location, as shown on the site plan in Appendix A

3.5 Figures 1 to 5 show the results of vibration monitoring during the piling exercise.

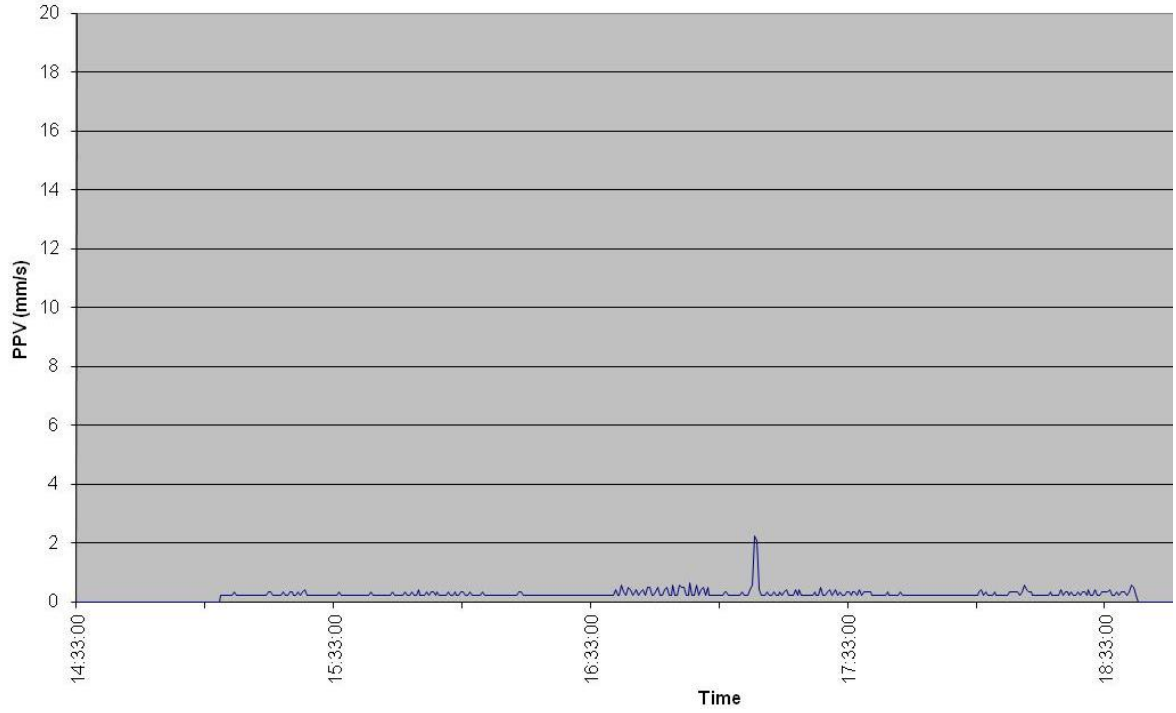


Figure 1. Vibration monitoring results, 02/09/2010

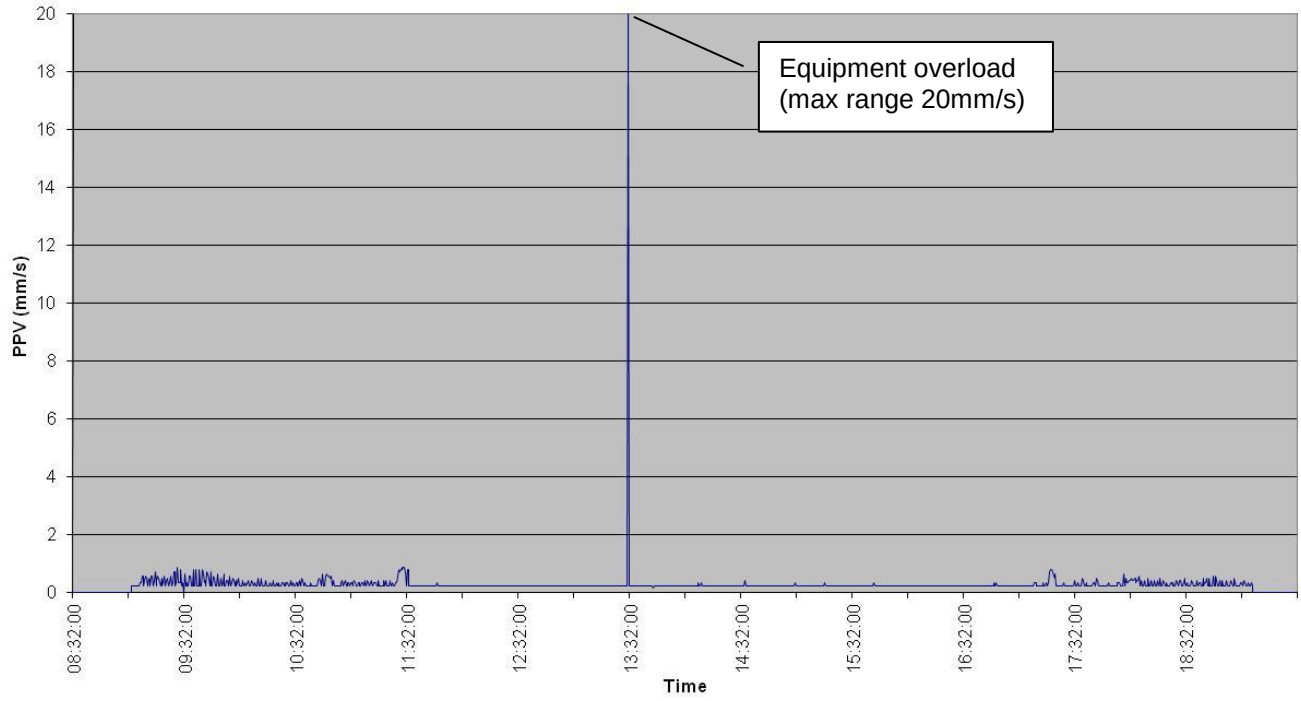


Figure 2. Vibration monitoring results, 03/09/2010

3.6 The peak measured at 13:00hr on 03/09/10 is not characteristic of vibration from piling activities, but is rather thought to be due to a member of the public interfering with the monitoring equipment during the lunchtime period.

3.7 The following figures detail the measured vibration levels from piling and compacting on the site. From the shapes of the graphs it is expected that vibration levels on 23/08/10 were dominated by piling, with vibration levels on 25/08/10 and 27/08/10 dominated by the vibrating roller.

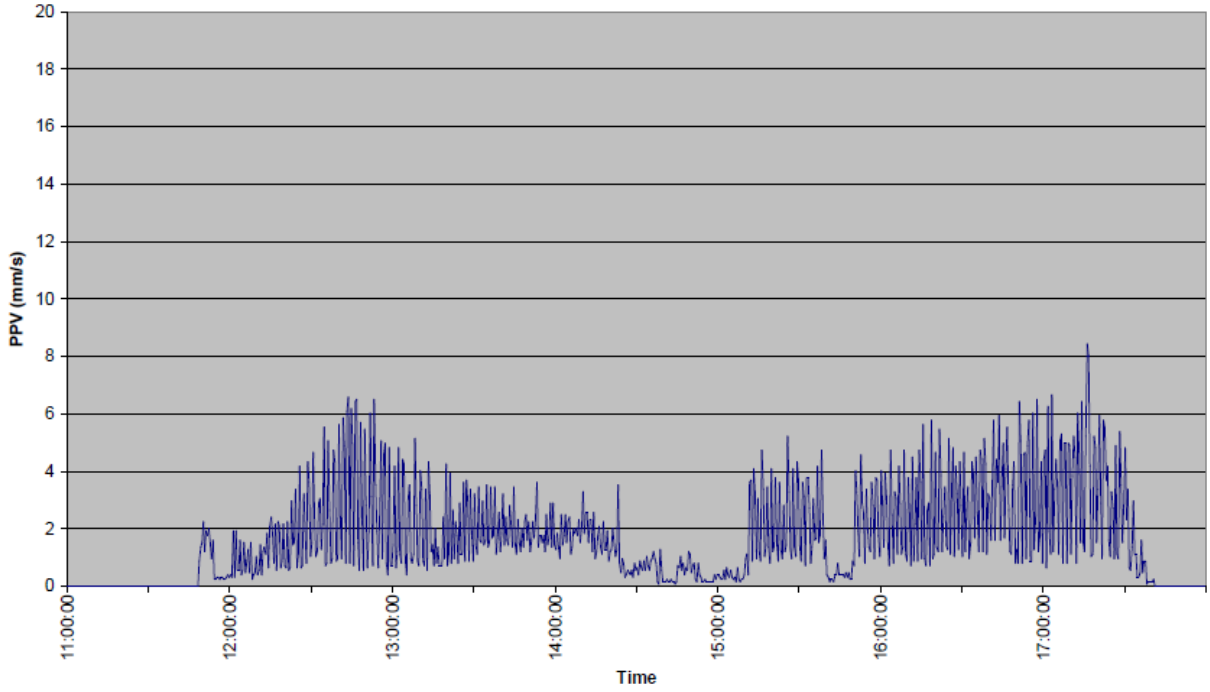


Figure 3. Vibration monitoring results, 23/08/2010

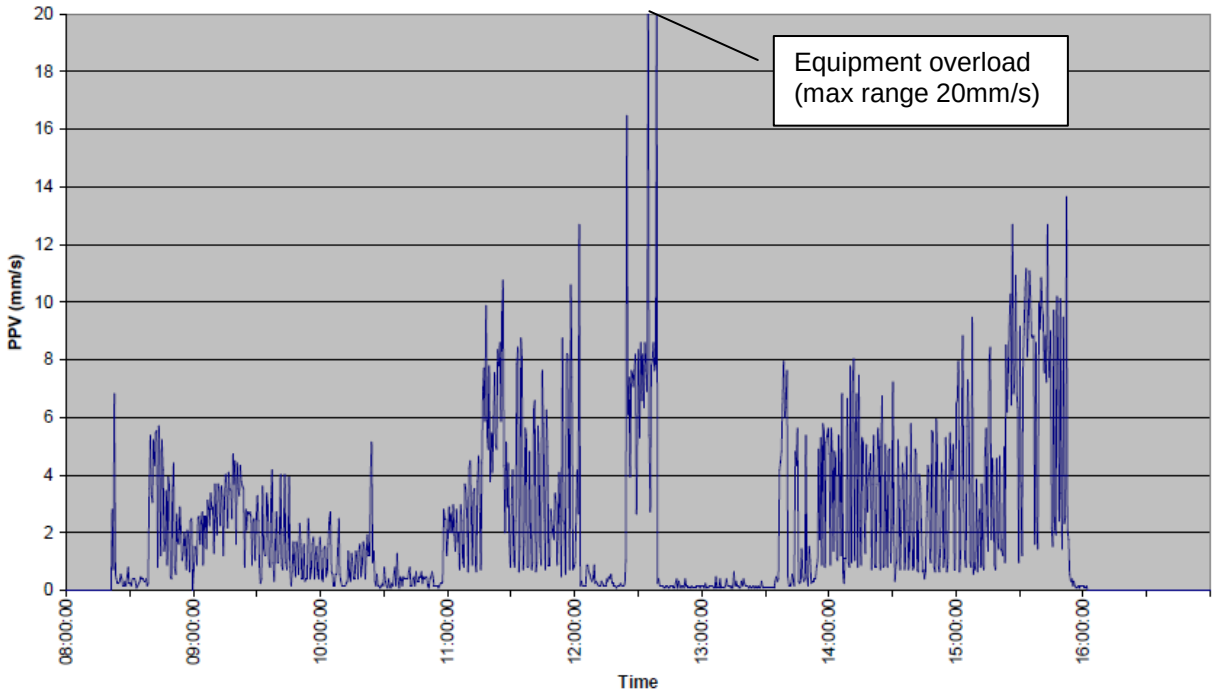


Figure 4. Vibration monitoring results, 25/08/2010

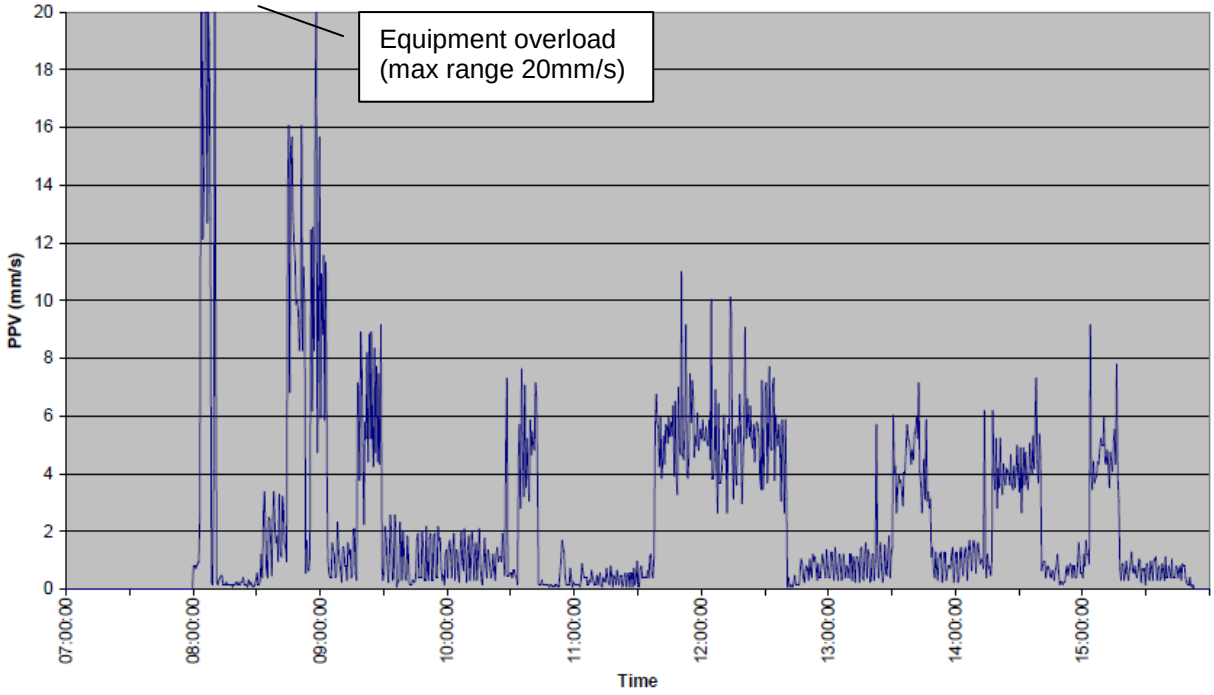


Figure 5. Vibration monitoring results, 27/08/2010

3.8 The highest recorded values are understood to have occurred when the compacting equipment was operating close to the monitoring location and will not be representative of vibration levels at the nearest residential properties. Overloading of the equipment occurred at this level, and as such alternative periods should be used for analysis.

4.0 Analysis

4.1 From analysis of all results, the piling operations are estimated to have caused vibration levels at the monitoring location of up to 8 mm/s (at around 17:20 hrs on 23/08/10). From site records, it is known that the piling rig at this time was located approximately 55 m from the monitoring location, and 88 m from the nearest residential property.

4.2 For analysis of the vibration from the compacting exercise, the highest recorded values caused overloading of the measurement equipment and therefore should not be used for analysis. It is considered that the highest reliably recorded vibration level from the compacting exercise was in the region of 14 mm/s (at around 15:55 hrs on 25/08/10). From site records, the centre of the compacting operations during this time was approximately 75 m from the monitoring location, and 58 m from the nearest residential property.

4.3 Table E.1 of BS 5228-2 provides empirical formulae for predicting groundborne vibration, from which it is possible to derive a distance correction for our calculations.

4.4 Equation 1 gives the derived distance correction factor for percussive piling:

$$v_{res,2} = v_{res,1}\left(\frac{r_1}{r_2}\right)^{1.3} \qquad (1)$$

Where,

$v_{res,1}$ is the peak particle velocity at the measurement location (mm/s);

$v_{res,2}$ is the peak particle velocity at the receiver location (mm/s);

r_1 is the distance between piling toe and measurement location (m);
r_2 is the distance between piling toe and receiver location (m).

4.5 Given a distance of 55 m between the piling toe and monitoring location, and a distance of 88 m between the piling toe and receiver location, the resultant peak particle velocity at the closest residential property as a result of piling activities is calculated to be **4.3 mm/s**. It should be noted that the dominant frequency range for vibration from piling is above 10 Hz. This level does not exceed Line 2 of Figure B.1 of BS 5228-2.

4.6 Equation 2 gives the derived distance correction factor for vibratory compaction:

$$v_{res,2} = v_{res,1}\left(\frac{x_1+L_d}{x_2+L_d}\right)^{1.5} \qquad (2)$$

Where,

$v_{res,1}$ is the peak particle velocity at the measurement location (mm/s);
$v_{res,2}$ is the peak particle velocity at the receiver location (mm/s);
x_1 is the distance between compaction and measurement location (m);
x_2 is the distance between compaction and receiver location (m);
L_d is the width of the vibrating roller drum (m);

4.7 Given a distance of 75 m between compacting and monitoring location, and a distance of 58 m between the compacting and receiver location, the resultant peak particle velocity at the closest residential property as a result of the vibrating roller with a drum width of 2.1 m (as per manufacturers' information) is calculated to be **20.9 mm/s**. It should be noted that manufacturers' data indicates the dominant frequency of the vibrating roller to be 28 Hz. This level does not exceed Line 2 of Figure B.1 of BS 5228-2 at the appropriate frequency.

5.0 Conclusion

5.1 We were instructed to undertake an assessment of vibration levels from construction activities at Elgin Academy.

5.2 Measurements of vibration were undertaken by the piling engineers.

5.3 The results of the measurements have been analysed and predictions made of the resulting vibration at the nearest residential properties.

5.4 The calculations show that vibration from construction activities is predicted to have been below the level which BS 5228-2 defines as the onset of minor cosmetic damage to buildings. It is therefore unlikely that damage (cosmetic or otherwise) will have been caused to nearby residential buildings due to construction related vibration, although some vibration may have been perceptible to inhabitants of the residential buildings.

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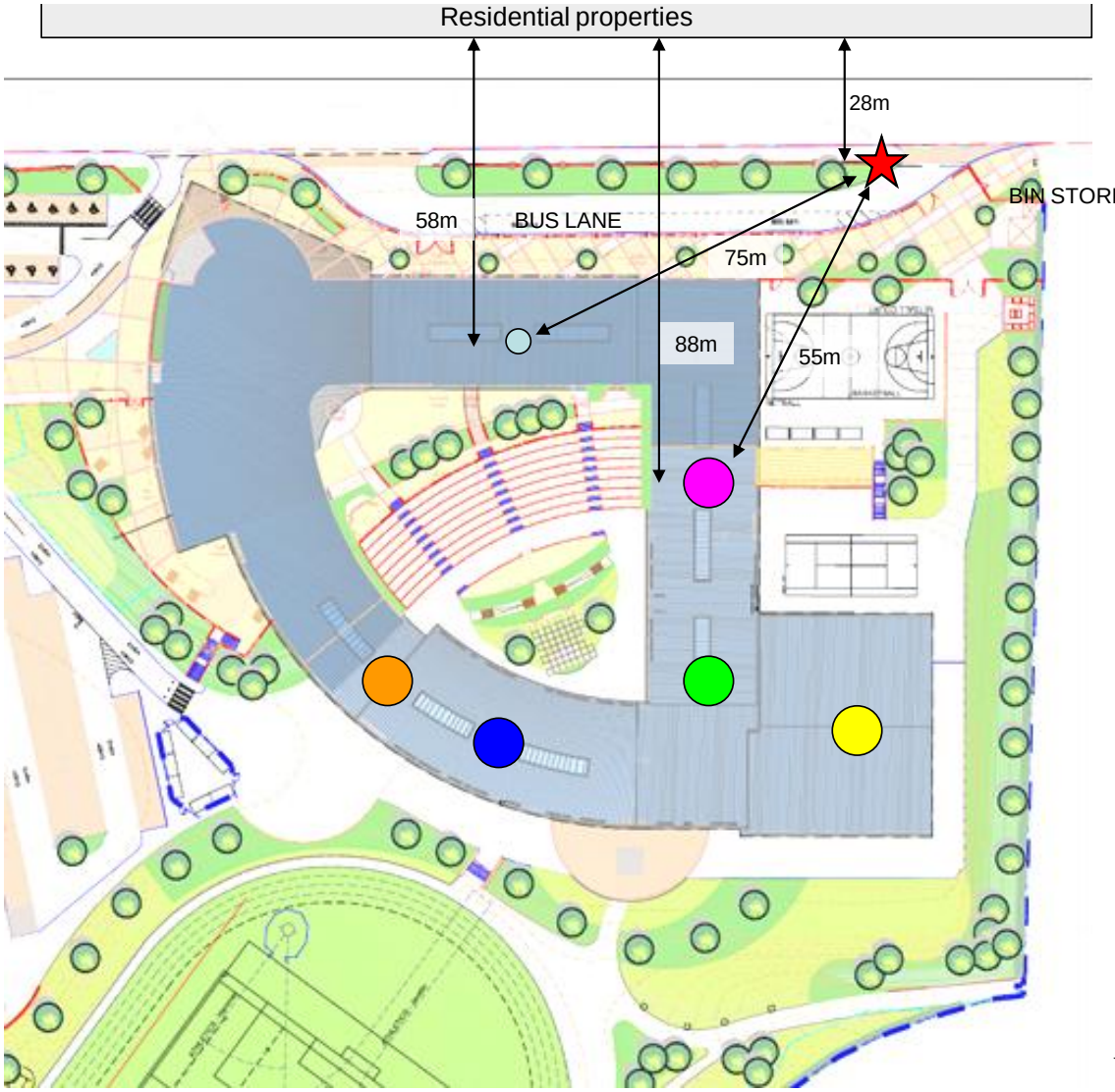
Appendix A: Site layout



- 23rd August 2010 – Profile Staff car park and dig out bus lane, grade and roll. 10am Piling work commenced. 50% East Retaining wall complete by end of working day.
- 25th August 2010 – Stone up bin store and roll. 10am Piling work to gym area.
- 27th August 2010 – Form sub base and roll to ground floor plate. 10am Piling complete to East zone.
- 2nd September 2010 – Form sub base and roll to ground floor plate. Piling West retaining wall
- 3rd September 2010 – Form sub base and roll to ground floor plate. Piling works complete by 12pm.
- Centre of compacting operations.
- Monitoring location.

Appendix B: Calibration certificates

CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: 0410577

CLIENT: Roger Bollivant

INSTRUMENT TYPE: V901

SERIAL NUMBER: 577

CALIBRATION DATE: 22/04/10

CALIBRATED BY: PJA

CALIBRATION ACCURACY:- @ 40Hz 10mm/s

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	\ %	X \ %
Peak Particle Velocity V	±5 %	\ %	Y \ %
Peak Particle Velocity T	±5 %	\ %	Z \ %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted \ dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY: [signature]

DATE: 22/4/10

THIS CERTIFICATE IS VALID FOR 12 MONTHS

The above calibration was carried out using equipment calibrated as follows:-
Genrad Sound Level Calibrator 1562-A, serial number U0 132, calibrated February 2010
ISO-TECH IFG 100 Oscillator, serial number 300351, calibrated June 2009
Monitran Vibration Meter, serial number 213608, calibrated June 2009
Mastech M92A Multimeter, serial number 20030907471, calibrated June 2009

THIS CALIBRATION IS TRACEABLE TO NATIONAL STANDARDS

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Ilkeston Road
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Derbyshire DE75 7DR
Tel: 01773 711211
Fax: 01773 711311
Email: vibrock@vibrock.com
Web: http://www.vibrock.com

VIBROCK

CALIBRATION CERTIFICATE

CALIBRATION CERTIFICATE NO.: 0310 1100

CLIENT: FUGRO GEOS LTD

INSTRUMENT TYPE: V901

SERIAL NUMBER: 1100

CALIBRATION DATE: 16TH MARCH 2010

CALIBRATED BY: D. LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X N/A %
Peak Particle Velocity V	±5 %	±5 %	Y N/A %
Peak Particle Velocity T	±5 %	±5 %	Z N/A %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY: [signature]

DATE: 16TH MARCH 2010

THIS CERTIFICATE IS VALID FOR 12 MONTHS

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