9 May 2014

Our ref J13235/HD/01

Geotechnical & Environmental Associates

Tyttenhanger House
Coursers Road
St Albans
AL4 0PG

tel 01727 824666
fax 01727 824777
email mail@gea-ltd.co.uk
web www.gea-ltd.co.uk

Dan Wagner
Flat 1
15 Wedderburn Road
London
NW3 5QS

Dear Mr Wagner

Re: GROUND MOVEMENT ANALYSIS FOR PROPOSED DEVELOPMENT AT FLAT 1, 15 WEDDERBURN ROAD, LONDON, NW3 5QS

Further to your instruction of 17 March 2014, we have now completed our analysis of ground movements associated with the proposed construction of a basement at the above site and this letter forms the report of our assessment.

The purpose of this assessment has been to determine the effects of the basement construction upon the neighbouring structures. In the formulation of our assessment we have referred to a Construction Method Statement (report ref 23569 rev B dated March 2014) prepared by Fluid Structures, which includes details of the excavation, temporary works and construction techniques to be adopted.

1.0 PROPOSED DEVELOPMENT SUMMARRY

It is proposed to demolish the existing garage and conservatory to allow for the construction of a new basement beneath the entire footprint of the existing building, which will also be extended slightly into the front and rear gardens.

The top of the proposed basement slab will extend to a level of about 74.10 m OD, with a deepened section for a swimming pool beneath the southeastern corner of the site, extending to a level of about 70.80 m OD and a ramp will be located in the northwestern corner of the site and will extend to a depth of 2.50 m, or to a level of about 77.50 m OD. Allowing for 500 mm thick slab, 150 mm Cordek and overdig gives a formation level of about 69.80 m OD for the swimming pool, roughly 76.50 m OD for the ramp and approximately 73.45 m OD for the remainder of the basement.

The basement excavation will vary in depth across the site, given the different ground levels and configuration of existing lower ground floor level, and will involve a 6.00 m deep excavation below the existing ground floor level in the central northern part of the site, where no basement currently exists, and a 6.00 m dig in the area of the proposed new swimming pool. The remainder of the existing lower ground floor level will be deepened by roughly 4.00 m, although in the area of the existing swimming pool it will be reduced to a 1.50 m deep excavation. The proposed layout and configuration of the basement are shown in more detail in the enclosed plans and sections provided by Clive Sall Architecture Limited.

Formation level for the proposed basement is likely to be within the Claygate Member although the deeper excavation for the swimming pool is likely to be just within the London Clay.

The Belsize New Tunnel is located approximately 20 m to the south of the southern boundary of the site, but is not considered to be of concern, given its distance and likely depth..

For the movement analysis the basement has been modeled as an irregular shaped box, which will be formed by a secant bored pile wall, followed by construction of a reinforced concrete box structure. It is assumed that suitable propping will be provided during the construction of the basement and in the permanent condition, such that the walls can be considered to be stiff for the purpose of the ground movement modelling.

2.0 GROUND CONDITIONS

GEA has previously undertaken a ground investigation (report ref J13235 Issue 2, dated 5 November 2013), which found that beneath a moderate to significant thickness of made ground, the Claygate Member was encountered overlying the London Clay, which was proved to the full depth investigated.

The made ground typically comprised a brown sandy clay with occasional fragments of brick and ash and generally extended to depths of between 1.00 m and 1.70 m (78.75 m OD and 75.71 m OD), although a greater thickness was encountered within the vicinity of existing foundations, which was not proved and extends to a depth of at least 2.10 m. The Claygate Member was found to extend to depths of between 8.00 m (71.50 m OD), 5.10 m (72.21 m OD) and 6.00 m (71.41 m OD) and initially comprises firm locally soft brown mottled orange-brown and greenish grey silty sandy clay with rare flint gravel, which extended to depths of between 4.30 m and 5.80 m (74.20 m OD and 72.91 m OD), overlying firm becoming stiff grey silty sandy clay. The underlying London Clay comprises firm becoming stiff grey silty fissured clay, with rare partings of grey silt and fine sand and rare fragments of shells, and was proved to the maximum depth investigated of 15.00 m (65.00 m OD). Desiccation of the clay was encountered at a single locality in close proximity to an existing tree and extended to a depth of about 2.0 m.

Groundwater was not encountered during drilling of Borehole Nos 1 or 2. A standing water level of 7.30 m (72.70 m OD) was however measured within Borehole No 1, upon completion of the drilling. Groundwater was encountered during drilling of Borehole No 3, from a depth of 1.32 m from within the made ground and significant groundwater inflows were noted from a depth of about 3.00 m to 10.00 m and resulted in poor recovery of the soils between these depths. Borehole No 3 was located roughly 1.0 m to the east of an existing drain and is thought to result from a leaking drain as the water as noted to be malodourous.

Perched water was also noted in Trial Pit Nos 1 and 2 at depths of 1.40 m (75.86 m OD) and 1.50 m (76.12 m OD) respectively, in the vicinity of the existing footings.

The table below shows the depths at which groundwater has been measured within the installed standpipes on four occasions to date.

Borehole No	Standpipe depth in m (m OD)	Depth to groundwater in m (m OD)			
		18/09/2013	27/09/2013	09/10/2013	01/04/2014
1	15.00 (65.00)	-	3.96 (76.04)	4.14 (75.86)	3.55 (76.45)
2	10.45 (66.86)	1.27 (76.04)	1.44 (75.87)	1.47 (75.84)	1.26 (76.05)
3	6.00 (71.41)	1.09 (76.32)	1.08 (76.33)	1.15 (76.26)	1.10 (76.31)

3.0 CONSTRUCTION SEQUENCE

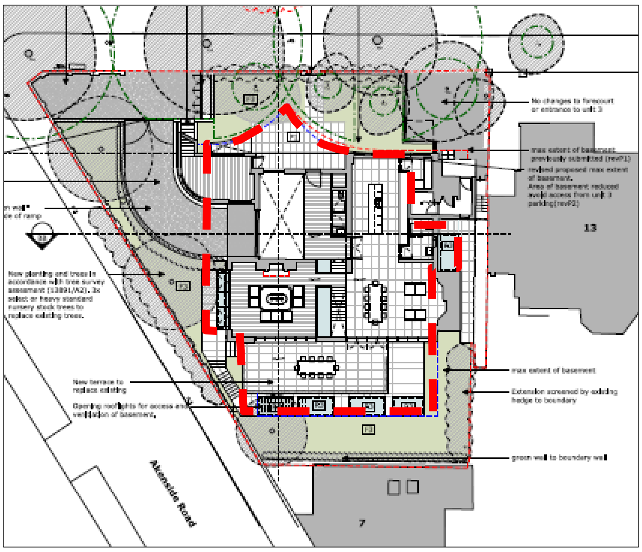
The Construction Method Statement (CMS) has been used to enable analysis of the ground movements around the basement both during and after construction.

Essentially the proposed works will be undertaken through top-down construction. As such there will be only minimal temporary works to the retaining walls since permanent capping beams, struts and slabs will be formed as excavation proceeds. This will reduce the number of construction stages to the piled retaining walls and therefore reduce the potential for wall movement during the transfer of loads from temporary to permanent props. The existing structure will, however, need to be supported throughout the works and transfer structures are proposed to transmit the existing building loads onto new piled foundations.

3.1 Pile Installation

The perimeter of the proposed basement will be relatively close to the site boundaries such that embedded retaining walls will be the only realistic method of forming excavation support.

The line of the proposed piled wall is indicated on the plan opposite, provided by Fluid Structures and annotated by GEA as a red dotted line.



It is envisaged that piling platforms will be formed at or about current ground levels and the use of crushed masonry and concrete from the demolition of the garage would minimise the need to import granular fill. Piling will therefore take place with the rig wholly within the site.

3.2 Support to Piled Walls

Following the installation of the bored pile wall and capping beams, permanent propping will be installed through the construction of reinforced concrete beams and slabs after which the basement excavation will proceed, level by level. The detail of the connection between piled wall and slabs will need to be finalised by the contractor but the levels selected and adopted in the outline pile design are considered reasonable for such a basement excavation.

When the proposed excavation depths have been reached for each level, the permanent works will be formed. The basement will comprise reinforced concrete walls with a drained cavity lining the inside of the bored pile wall. Reinforced concrete will be used for floor slabs and it is anticipated that heave protection will be installed beneath the lowest slabs.

The floor slabs will be constructed from the highest level first so that the slabs can be cast on the exposed formation and when each floor has achieved adequate strength, the excavation can be advanced until the frame is structurally complete.

4.0 RETAINING WALL DESIGN

It is recognised that the final retaining wall design is likely to be undertaken by the successful piling contractor and that it will be tied into elements of both temporary and permanent works undertaken by the principal contractor appointed for the construction. Plainly with planning permission not yet in place a contractor has not been appointed so a preliminary geotechnical design of the piled retaining walls has been undertaken by GEA. The design has been carried out to establish the most likely pile diameter and founding depths required for the basement and to estimate the movement of the retaining walls both in the short term during construction and also in the long term when different soil properties will govern wall behaviour.

4.1 Basis of Design

The design has been undertaken using the Wallap software (Version 6.05 Revision A42.B57.R48) produced and licensed by Geosolve and commonly used by piling contractors for their design of multi-propped pile retaining walls. This analysis has adopted the BS EN 1997 Eurocode 7 method of analysis although it is understood that some piling contractors may prefer to use the approach set out in CIRIA Report C580[1].

Observation of groundwater during the drilling of the boreholes and the subsequent monitoring of standpipes has indicated that the basement is likely to be formed below the prevailing groundwater level.

As part of the site investigation standpipes were installed and subsequent monitoring has measured groundwater at levels of between 76.45 m OD and 75.84 m OD. The proposed formation of the general basement has been taken as 73.45 m OD but locally deepened in the swimming pool area to 69.8 m OD. The excavation will therefore extend below the anticipated groundwater level. In order to prevent groundwater ingress from the Claygate Beds it is proposed that the piled retaining walls will be of secant construction and at this stage it is thought likely that a hard / firm wall will be adopted. In such a wall the 'female' piles are constructed from unreinforced weak concrete with all of the bending moments and shear forces resisted by the fully reinforced 'male' piles. On the assumption that a waterproof lining wall will be installed to face the secant wall, it may be that specialist piling contractors will consider that a hard / soft secant piled wall may be appropriate for the short term water resistance, where the female piles are constructed from a mix of cement, bentonite and sand.

The female piles have been assumed to provide no contribution to the structural strength of the wall and are present only to prevent ingress of fines and water. These piles do not therefore need to extend to the full depth of the male piles but will need to extend into impermeable strata, which on this site is the London Clay. The design is therefore based upon female piles generally extending to a level of 69.5 m OD. At such a toe level, piles will be formed with just over 1.0 m penetration into the London Clay although for the swimming pool area the female piles will extend to a level of 68.8 m OD, representing 1.0 m penetration below the maximum excavation level. Fluid Structures have proposed a limited headroom piling rig for the internal piles and this may be suitable for the deeper retaining wall piles as well.

The soil parameters adopted are those recommended within the GEA Ground Investigation report. The foundations of the adjacent structures of 13 Wedderburn Road and 7 Akenside Road have been modelled as surcharges with the loads imposed and their likely bearing depths having been estimated; this will be refined in due course. In addition, an assumed net loading intensity of 10 kN/m^2 has been taken for the adjacent roads and gardens to allow for road traffic and for construction plant and equipment on site.

At this stage the retaining walls have been designed for the Serviceability Limit State (SLS) in order to establish likely movements and toe levels to provide adequate factors of safety.

The detailed design within each case has been based on undrained soil parameters during temporary works and construction with long term drained soil parameters adopted for the long

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[1] Gaba, A, Simpson, B, Powrie, W and Beadman, D (2003) *Embedded retaining walls – guidance for economic design* CIRIA Report C580.

term permanent case with a reversion to at rest earth pressures. In order to present conservative calculations limited drained cohesion, c’, has been used in the calculations and an at-rest earth pressure coefficient of K_0 of 1.0 has been adopted for the Claygate Beds. The results of these runs are appended and comprise a summary analysis for each of the three walls assessed. These are considered to represent the most onerous cases and those that are critical in terms of the magnitude of wall deflection. The remaining load cases such as returns towards the site or alongside Akenside Road will yield lower bending moments and shear forces and probably require a slightly lesser embedded depth. However that refinement of design will be for the piling contractor to establish at a later stage.

4.2 Summary Results and Wall Proposal

The proposed secant wall comprises 450 mm diameter piles installed at 600 mm male to male and female to female centre to centre spacings. These spacings would allow each male pile to cut 150 mm into the adjacent female piles. The toe level of the female piles is proposed as 69.5 m OD or 68.8 m OD around the pool. The male piles would extend to levels of between 69.5 m OD at the front of the house to 64.5 m OD to the rear for wall stability. The pile sizes adopted keep wall deflections within sensible limits and the order of bending moments and shear forces generated are within those expected for the pile sizes quoted. Detailed reinforcement design would be undertaken by the piling contractor at a later stage.

A summary of the retaining wall designs and predicted movements is shown below but in essence, the calculations indicate that the section of piled wall surrounding the deepest part of the basement may be expected to deflect into the excavation by around 15 to 20 mm at the mid-point between props. In this regard the movement at that level could be reduced considerably by either stiffening the lining wall to provide a ‘ring beam’ prop or by increasing the stiffness of the wall using a larger diameter pile.

Wall Section	Male Pile Toe Level (m OD)	Pile Diameter (mm)	Pile Length (m)	Predicted Wall Deflection (mm)
North	69.5	450 Secant	10.8	10 - 15
South	65.0	450 Secant	12.8	15 - 20
East	64.5	450 Secant	13.3	15 - 20

5.0 GROUND MOVEMENTS

5.1 Methods of Analysis

An assessment of ground movements surrounding the excavation has been undertaken using the X-Disp computer program licensed from the OASYS suite of geotechnical modelling software from Arup. This program is commonly used within the ground engineering industry and is considered to be an appropriate tool for this analysis.

The X-Disp program has been used to predict ground movements likely to arise from the installation of the secant piled walls and then from the subsequent excavation of the basement. For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C580[2], which were derived from a number of historic case studies.

In addition to the above, a preliminary estimate has been made of the likely ground movements that would arise from heave of the underlying Claygate Member and London Clay due to unloading that will take place during excavation. This analysis has been carried out using the OASYS P-Disp software package (Version 19.2 Build 17) which estimates the likely ground movements based on the assumption that the soils behave elastically; this provides a reasonable

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[2] Gaba, A, Simpson, B, Powrie, W and Beadman, D (2003) *Embedded retaining walls – guidance for economic design* CIRIA Report C580.

approximation to soil behaviour at small strains. Undrained soil parameters have been used to estimate the potential short term movements, which include the "immediate" or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total long-term movement. At this site unloading of the underlying Claygate Member and London Clay will take place as a result of the basement excavation although a proportion of that unloading will be mitigated by the proposed basement raft loading. Whilst these loads are not known at present, it is understood that the development will still result in a net unloading of the soils, such that there would be a net uplift force on the basement slab. This force could be transferred into the retaining wall piles or indeed into a line of tension piles at basement level. This will depend upon the retaining wall design, the structural connection between slab and piles and the stiffness of the raft slab. On this basis the movements quoted are those that might be expected for unrestrained soil that is allowed to heave.

5.2 Models Used and Assumptions Made

For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C580[3], which were derived from a number of historic case studies. The ground movement curves for 'excavations in front of high stiffness' have been adopted as being considered most appropriate for the Claygate Member and London Clay. The magnitudes of ground differential movement predicted by the program have been assessed.

In addition, some of the neighbouring structures have been set as sensitive structures, requiring Building Damage Assessments. This includes;

- No 13 Wedderburn Road; located to the east of the site; and
- a building directly to the south of the site which appears to be No 7 Akenside Road.

The sensitive structures have been modelled as lines in the analysis and are the lines along which the damage assessment has been undertaken. For clarity these critical lines are shown on the attached plan. For the analyses it has been assumed that the neighbouring property to the east is at a level of about 78.71 m OD and the property to the south is at an elevation of roughly 77.70 m OD and both buildings are assumed to not have basements.

For the heave analysis, the elastic analysis requires values of soil stiffness at various levels to calculate displacements. Values of stiffness for the soils at this site are readily available from published data and well-established methods have been used to provide our estimates. This relates values of E_u and E', the drained and undrained stiffness respectively, to values of undrained cohesion as described by Padfield and Sharrock[4] and Butler[5] and more recently by O'Brien and Sharp[6]. Relationships of $E_u = 500\ C_u$ and $E' = 300\ C_u$ for the cohesive soils have been used to obtain values of Young's Modulus. More recent published data[7] indicates stiffness values of 750 x Cu for the London Clay and a ratio of E' to Cu of 0.75, but it is considered that the use of the more conservative values provides a sensible approach for a first analysis.

5.3 Wall Movements

The X-Disp analysis has been used to calculate the movements behind the walls resulting from pile installation and basement excavation. This includes the settlement of the ground (vertical movement) and the lateral movement of soil behind the wall (horizontal movement). The ground movements predicted for pile installation and subsequent basement excavation have also been combined.

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3 Gaba, A, Simpson, B, Powrie, W and Beadman, D (2003) *Embedded retaining walls – guidance for economic design* CIRIA Report C580.

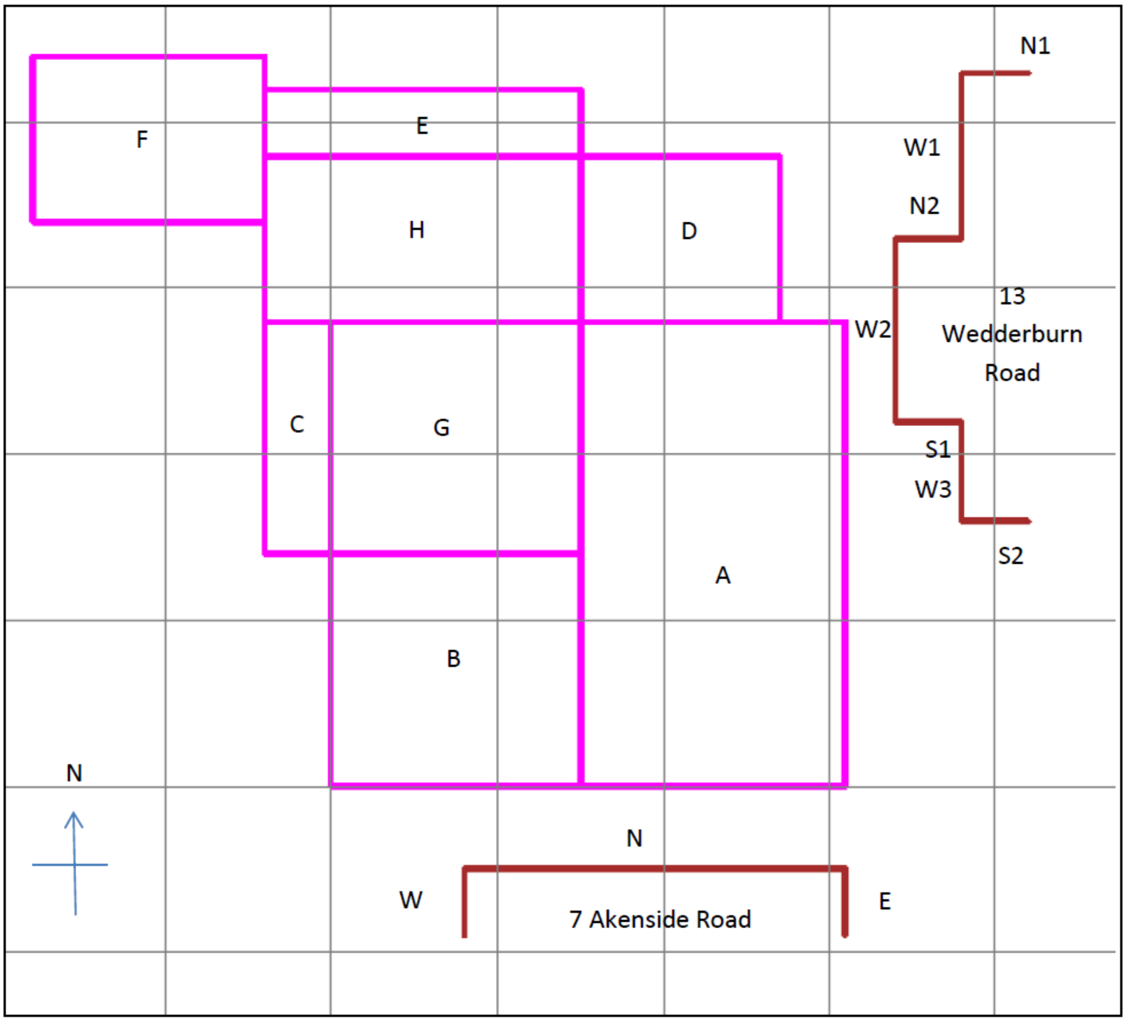
4 Padfield CJ and Sharrock MJ (1983) *Settlement of structures on clay soils.* CIRIA Special Publication 27

5 Butler FG (1974) *Heavily overconsolidated clays: a state of the art review.* Proc Conf Settlement of Structures, Cambridge, 531-578, Pentech Press, Lond

6 O'Brien AS and Sharp P (2001) *Settlement and heave of overconsolidated clays - a simplified non-linear method.* Part Two, Ground Engineering, Nov 2001, 48-53

7 Burland JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension.. CIRIA Special Publication 200

Due to the complexity of the levels within the new basement, the proposed basement has been divided into eight rectangles labelled Areas A to H, as shown on the plan below.



The predicted movements are summarised in the table below.

Phase of Works	Wall Movement (mm)	
	Vertical Settlement	Horizontal Movement
Pile Installation (secant wall)	14 to 16	14 to 20
Basement Excavation (excavation in front of high stiffness wall	8 to 12	16 to 20
Piling phase and excavation phase - combined movements	22 to 24	32 to 36
*Note: Horizontal movements from basement excavation have also been predicted using movements calculated within the retaining wall design using the WALLAP programme		

The analysis has indicated that the maximum vertical settlement that will result from pile installation is unlikely to exceed 16 mm with 14 mm to 20 mm of horizontal movement. The maximum vertical settlement that will take place behind the walls as a result of the basement excavation are unlikely to exceed 12 mm with 16 mm to 20 mm of horizontal movement.

The total vertical ground movements are not likely to exceed 28 mm of settlement, whilst the maximum horizontal movements are anticipated to between 30 mm to 40 mm.

The movements calculated are considered to represent a worst case scenario, particularly the horizontal movements, which are unlikely to be any greater than those predicted using WALLAP in section 4.2 above and will be further minimised due to control of the propping in the temporary works and a regime of monitoring.

5.4 Damage to Neighbouring Structures

The results of the combined movements resulting from both pile installation and basement excavation the building damage reports for sensitive structures predict damage to the adjacent properties would be either be negligible to very slight categories and the results are summarised in the table below.

Building Damage Assessment		
Sensitive Structure	**Elevation**	**Burland Scale**
No 7 Akenside Road	West	Category 0 (Negligible)
	North	Category 1 (Very Slight)
	East	Category 0 (Negligible)
No 13 Wedderburn Road	North wall 1	Category 0 (Negligible)
	West wall 1	Category 0 (Negligible)
	North wall 2	Category 0 (Negligible)
	West wall 2	Category 1 (Very Slight)
	South wall 1	Category 0 (Negligible)
	West wall 3	Category 0 (Negligible)
	South wall 2	Category 0 (Negligible)

On this basis, the damage that would inevitably occur as a result of such an excavation would fall within the acceptable limits.

5.5 Heave Movements

The proposed development comprises the refurbishment of the existing house, which will include deepening and extending the existing basement which will extend to depths of between 1.50 m and 6.00 m below existing ground floor level and lower ground floor level and formation level of the basement will be within the Claygate Member or London Clay. The proposed construction of the new basement will result in a variable unloading of roughly 27 kN/m^2, 45 kN/m^2, 72 kN/m^2 and 108 kN/m^2.

It is understood that it is proposed to adopt a raft which will reduce the net unloadings resulting from the basement excavation slightly. However, as these loads are not known at present the movements quoted are those that might be expected for unrestrained soil that is allowed to heave.

The strength of the soils is based on the results of the SPT and shear strength results from the cable percussion borehole carried out at the site as part of the ground investigation carried out by GEA.

A rigid boundary for the analysis has been set within the London Clay at a level of 25.00 m OD.

The basement footprint has been divided into a number of rectangles, as discussed in the preceding section, to take account of the different site levels and differing excavation depths. Details of the analysis together with full tabular results and output movement contour plots are included within the appendix.

The P-Disp analysis indicates that, by the time the basement construction is complete, up to 15 mm of heave is likely to have taken place at the centre of the proposed swimming pool excavation, reducing to less than 10 mm along the eastern and southern edges of this area. For the remainder of the basement area, short term heave movements are unlikely to exceed 10 mm, reducing to less than 5 mm at the edges of this area.

In the long term, following completion of the basement construction, a further 15 mm to 20 mm of heave is estimated as a result of long term swelling of the underlying Claygate Member in the area of the swimming pool with a further 12 mm of heave predicated in the remaining basement areas.

In order to mitigate the effects of heave on the new building, the basement boxes could be designed to transmit heave forces into the wall piles or onto tension piles within the basement. Alternatively, a void should be incorporated into the design of the basement floor slab to accommodate these potential long term movements. If a compressible material is used beneath the slab, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect potential heave pressures are typically taken to equate to around 50 % to 60 % of the total unloading pressure.

6.0 CONCLUSIONS

The analysis has concluded that the predicted damage to the neighbouring properties would be either 'Negligible' or 'Very Slight'. On this basis, the damage that would inevitably occur as a result of such an excavation would fall within the acceptable limits.

It is noted that the post excavation heave will go some way to mitigate the settlements expected following the piling and excavation and this analysis is therefore considered to represent a relatively conservative assessment.

The two phases of work, piling and subsequent excavation will in practice be separated by a number of weeks during which time construction of capping beams and pile curing will take place. This will provide an opportunity for the ground movements during and immediately after piling to be measured and the data acquired can be fed back into the design and compared with the predicted values. Such a comparison will allow the ground model to be reviewed and the predicted wall movements to be reassessed prior to the main excavation taking place so that propping arrangements can be adjusted if required.

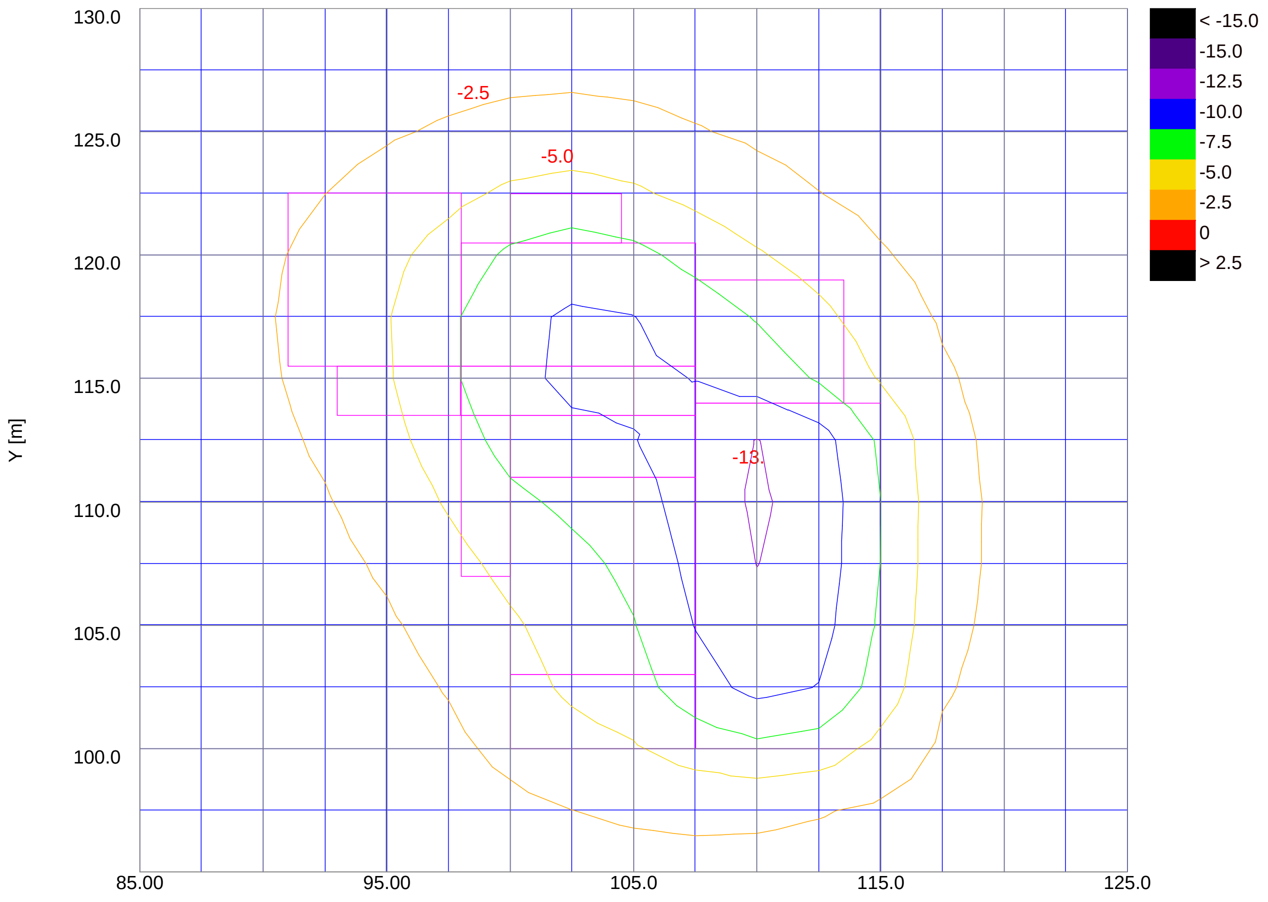
We trust that the foregoing comments are sufficient for your needs and we would be pleased to discuss the findings in more detail if required and to provide any additional assistance that may be necessary.

Yours sincerely
GEOTECHNICAL & ENVIRONMENTAL ASSOCIATES

Hannah Dashfield

pp. Martin Cooper

Settlement Contours : Grid 1 at 69.80m



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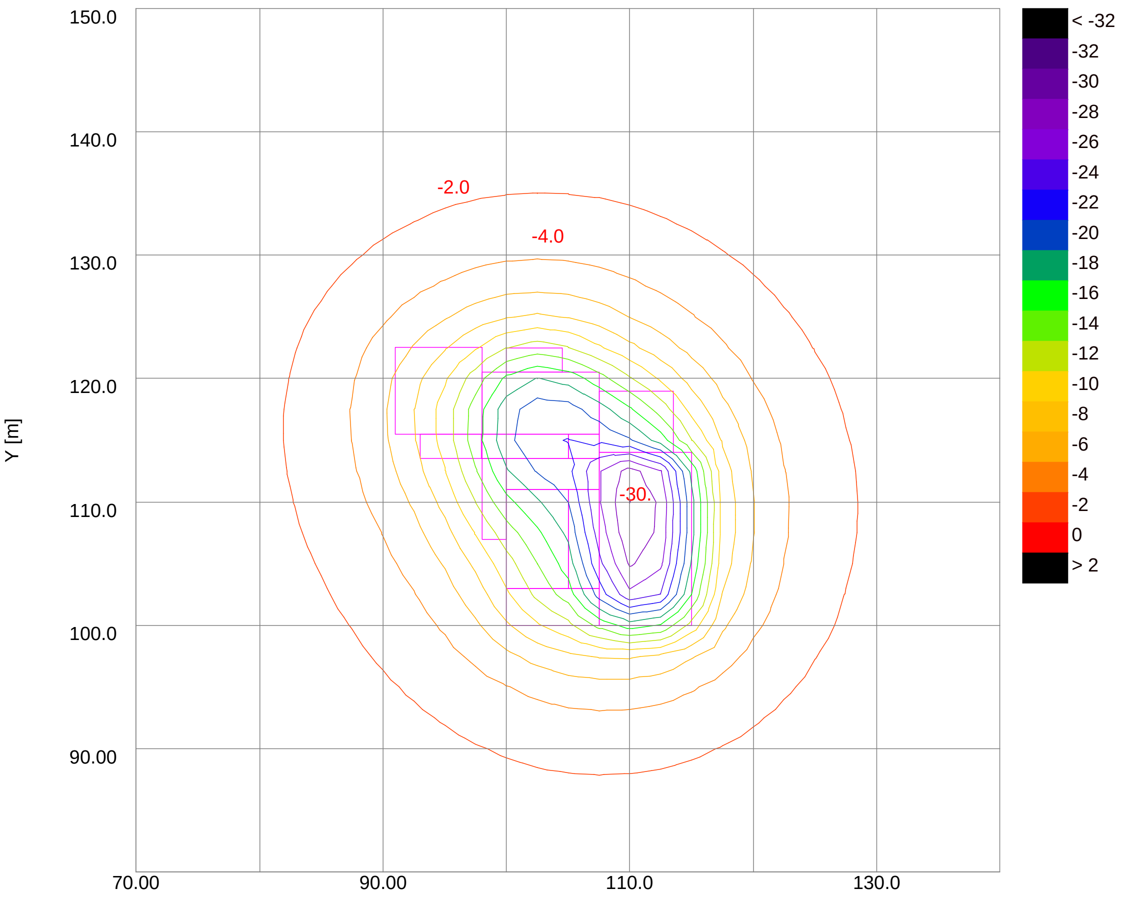
Oasys

Wedderburn Road

Total Heave (Short and Long term)

Job No.	Sheet No.	Rev.
J13235		
Drg. Ref.		
Made by HD	Date 08-May-2014	Checked

Settlement Contours : Grid 1 at 69.80m



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Contour Interval: 2mm

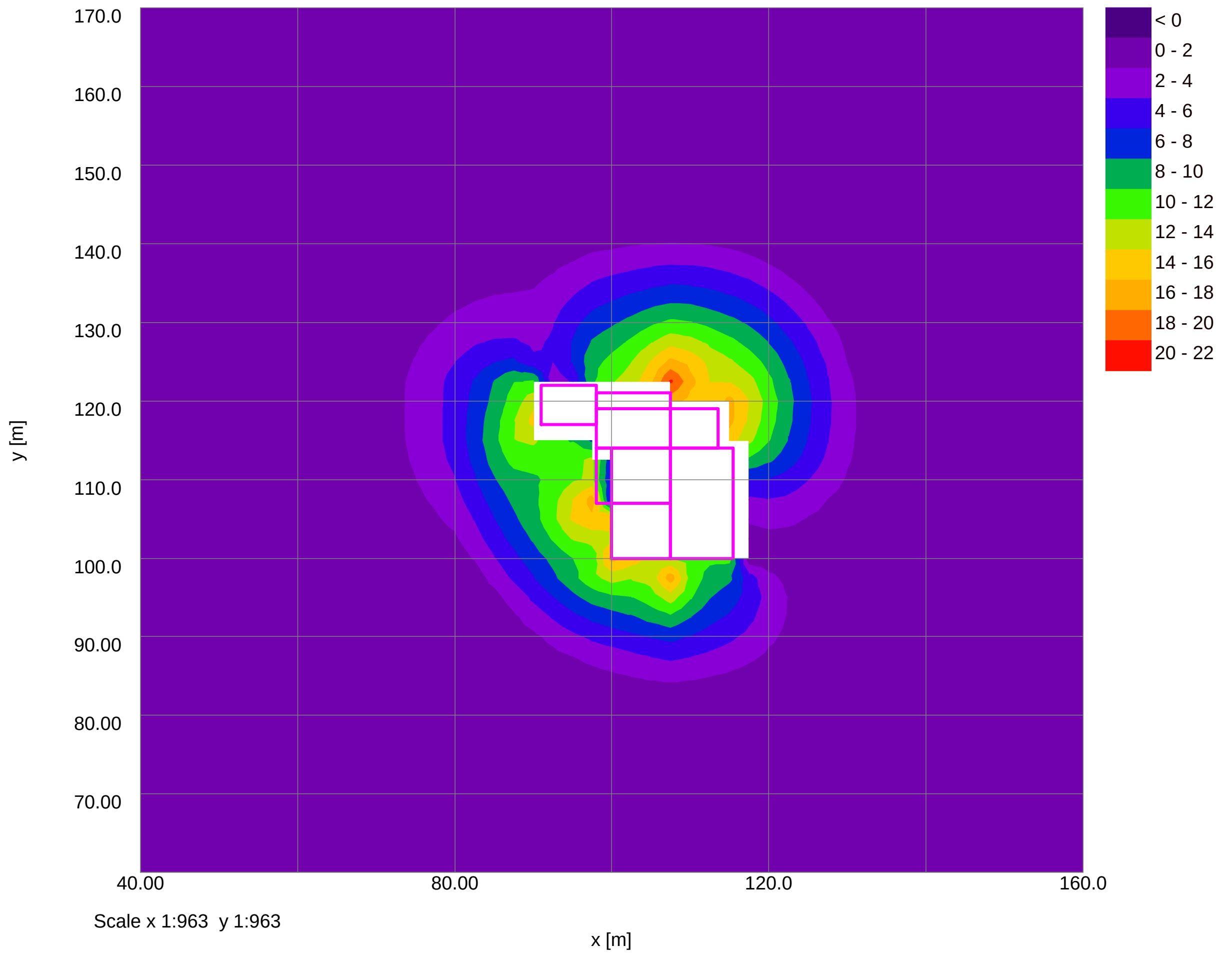
X [m]

Oasys

Wedderburn Road
Pile Installtion

Job No.	Sheet No.	Rev.
J13235		
Drg. Ref.		
Made by HD	Date 08-May-2014	Checked

Horizontal Displacement Contours: Grid 1 (level 77.400m) Interval 2mm



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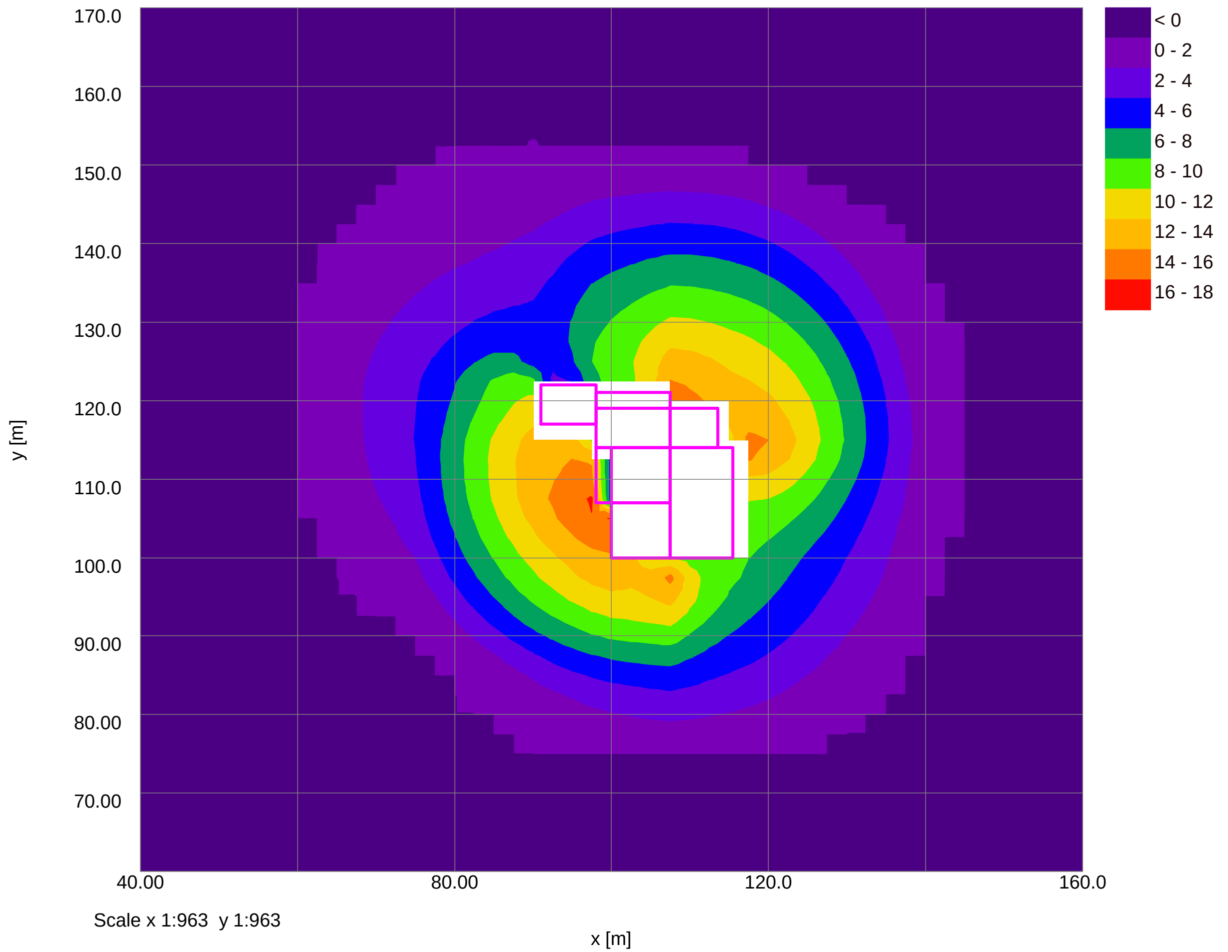
Oasys

Wedderburn Road

Pile Installtion

Job No.	Sheet No.	Rev.
J13235		
Drg. Ref.		
Made by HD	Date 08-May-2014	Checked

Vertical Settlement Contours: Grid 1 (level 77.400m) (Interval 2mm)



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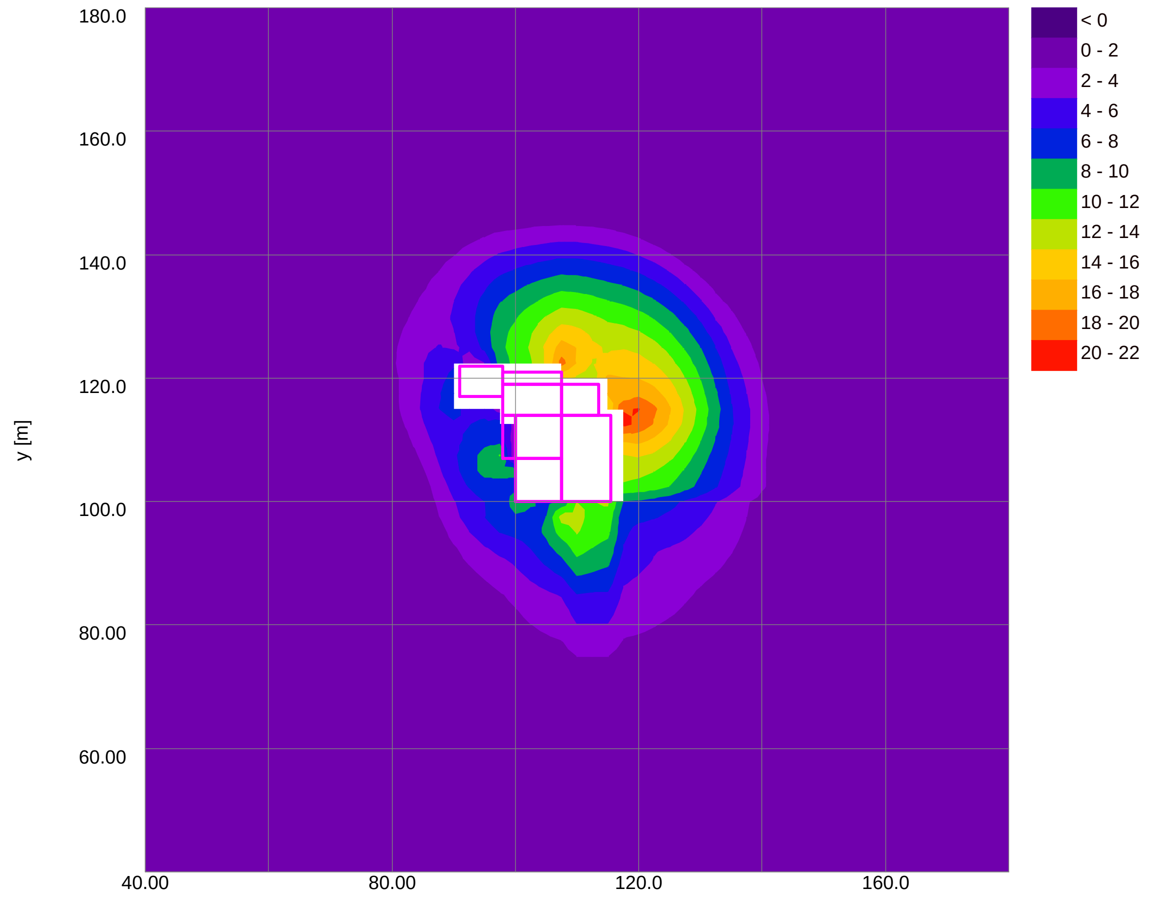
Oasys

Wedderburn Road
Basement Excavation

Job No.	Sheet No.	Rev.
J13235		
Drg. Ref.		
Made by HD	Date 08-May-2014	Checked

Horizontal Displacement Contours: Grid 1 (level 77.400m) Interval 2mm



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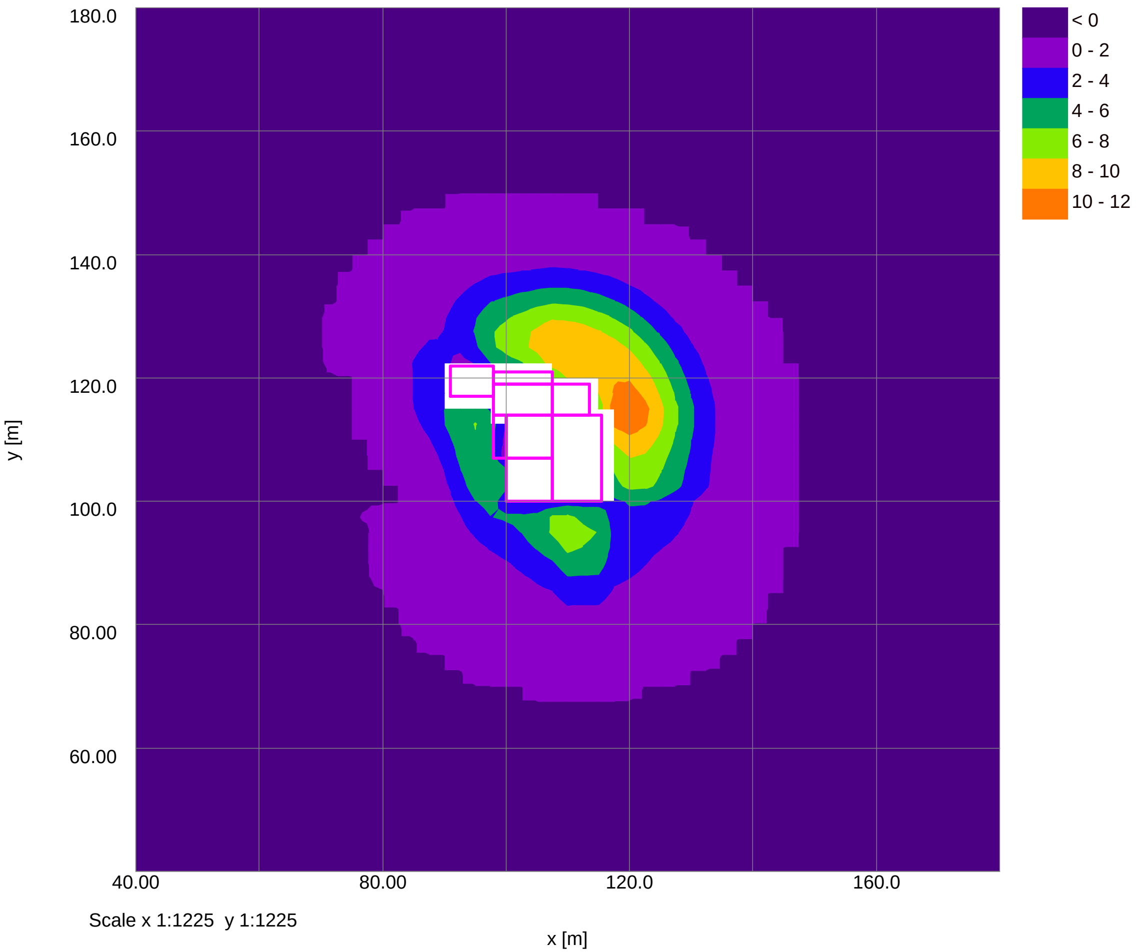
Oasys

Wedderburn Road
Basement Excavation

Job No.	Sheet No.	Rev.
J13235		
Drg. Ref.		
Made by HD	Date 08-May-2014	Checked

Vertical Settlement Contours: Grid 1 (level 77.400m) (Interval 2mm)



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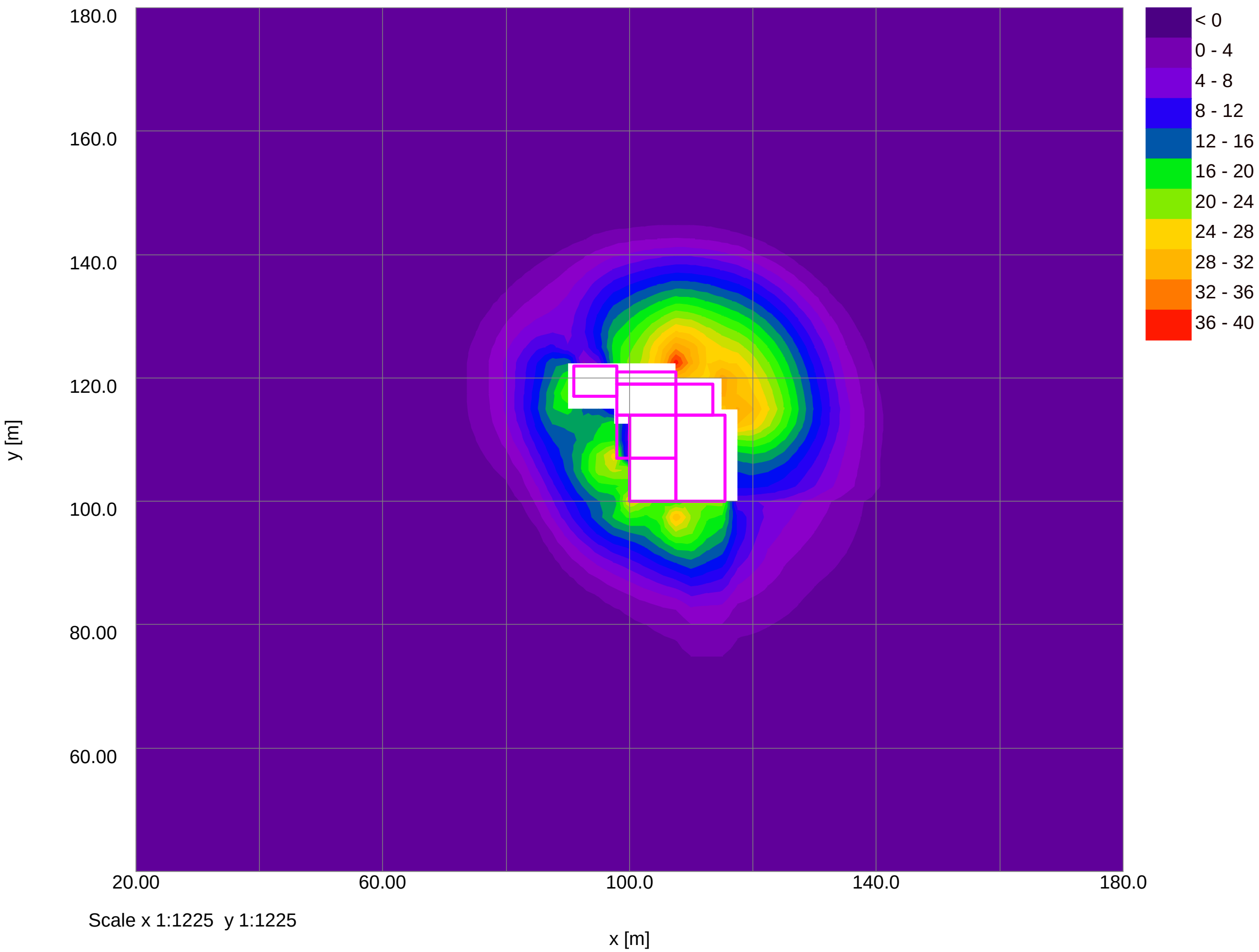
Oasys

Wedderburn Road

Combined Movements

Job No.	Sheet No.	Rev.
J13235		
Drg. Ref.		
Made by HD	Date 08-May-2014	Checked

Horizontal Displacement Contours: Grid 1 (level 77.400m) Interval 2mm



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Oasys

Wedderburn Road
Combined Movements

Job No.	Sheet No.	Rev.
J13235		
Drg. Ref.		
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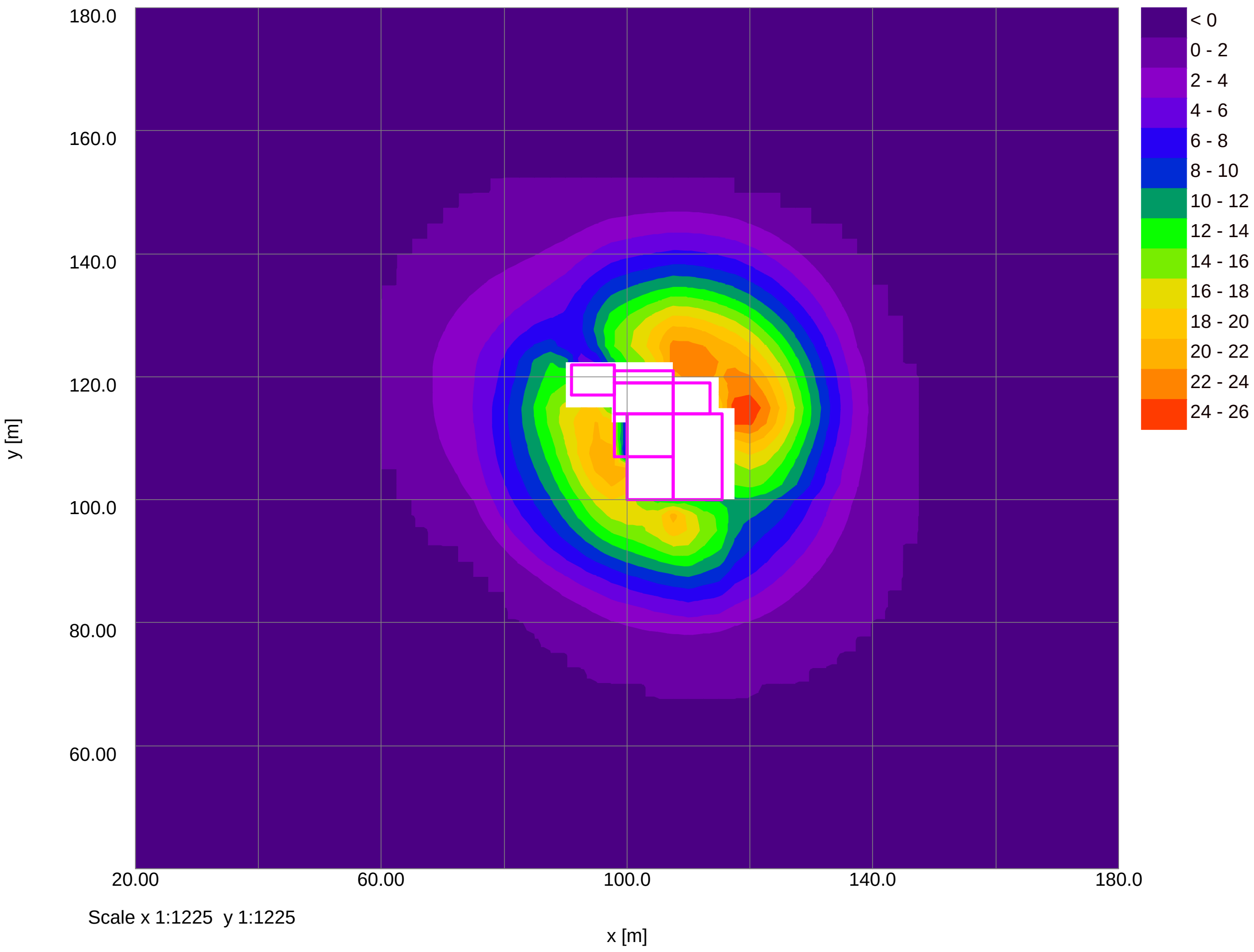
Vertical Settlement Contours: Grid 1 (level 77.400m) (Interval 2mm)



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Dist.	Coordinates x	y	z	Displacements x	y	Along the Line	Perpendicular to Line

Structure: Line 7 | Sub-structure: South wall 2 - 13 Wedderburn

Dist.	Coordinates x	y	z	Displacements x	y	Along the Line	Perpendicular to Line
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]
0.0	119.00000	108.00000	78.70000	-13.993	4.0456	-13.993	4.0456
0.33333	119.33333	108.00000	78.70000	-14.021	4.0147	-14.021	4.0147
0.66667	119.66667	108.00000	78.70000	-14.035	3.9721	-14.035	3.9721
1.0000	120.00000	108.00000	78.70000	-14.035	3.9193	-14.035	3.9193
1.3333	120.33333	108.00000	78.70000	-14.020	3.8579	-14.020	3.8579
1.6667	120.66667	108.00000	78.70000	-13.992	3.7890	-13.992	3.7890
2.0000	121.00000	108.00000	78.70000	-13.950	3.7139	-13.950	3.7139

Structure: Line 8 | Sub-structure: West - 7 Akenside

Dist.	Coordinates x	y	z	Displacements x	y	Along the Line	Perpendicular to Line
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]
0.0	104.00000	95.50000	77.00000	1.4484	7.5616	7.5616	-1.4484
0.50000	104.00000	96.00000	77.17500	1.3608	7.5697	7.5697	-1.3608
1.0000	104.00000	96.50000	77.35000	1.2190	7.5284	7.5284	-1.2190
1.5000	104.00000	97.00000	77.52500	1.1255	7.5467	7.5467	-1.1255
2.0000	104.00000	97.50000	77.70000	0.97589	7.5272	7.5272	-0.97589

Structure: Line 9 | Sub-structure: North - 7 Akenside

Dist.	Coordinates x	y	z	Displacements x	y	Along the Line	Perpendicular to Line
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]
0.0	104.00000	97.50000	77.00000	0.97589	7.5272	0.97589	7.5272
0.57500	104.57500	97.50000	77.03500	1.0931	7.7122	1.0931	7.7122
1.1500	105.15000	97.50000	77.07000	1.2360	8.0772	1.2360	8.0772
1.7250	105.72500	97.50000	77.10500	1.4199	8.8179	1.4199	8.8179
2.3000	106.30000	97.50000	77.14000	1.3587	9.8727	1.3587	9.8727
2.8750	106.87500	97.50000	77.17500	0.82557	11.187	0.82557	11.187
3.4500	107.45000	97.50000	77.21000	-0.35941	12.518	-0.35941	12.518
4.0250	108.02500	97.50000	77.24500	-1.3377	15.251	-1.3377	15.251
4.6000	108.60000	97.50000	77.28000	-1.8560	14.277	-1.8560	14.277
5.1750	109.17500	97.50000	77.31500	-2.0201	13.415	-2.0201	13.415
5.7500	109.75000	97.50000	77.35000	-1.9682	12.736	-1.9682	12.736
6.3250	110.32500	97.50000	77.38500	-1.8122	12.231	-1.8122	12.231
6.9000	110.90000	97.50000	77.42000	-1.6181	11.860	-1.6181	11.860
7.4750	111.47500	97.50000	77.45500	-1.4186	11.587	-1.4186	11.587
8.0500	112.05000	97.50000	77.49000	-1.2281	11.384	-1.2281	11.384
8.6250	112.62500	97.50000	77.52500	-1.0519	11.230	-1.0519	11.230
9.2000	113.20000	97.50000	77.56000	-0.94710	11.150	-0.94710	11.150
9.7750	113.77500	97.50000	77.59500	-0.85631	11.134	-0.85631	11.134
10.350	114.35000	97.50000	77.63000	-0.78266	11.179	-0.78266	11.179
10.925	114.92500	97.50000	77.66500	-0.72509	11.231	-0.72509	11.231
11.500	115.50000	97.50000	77.70000	-0.68162	7.8335	-0.68162	7.8335

Structure: Line 10 | Sub-structure: East - 7 Akenside

Dist.	Coordinates x	y	z	Displacements x	y	Along the Line	Perpendicular to Line
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]
0.0	115.50000	97.50000	77.00000	-0.68162	7.8335	-7.8335	-0.68162
0.50000	115.50000	97.00000	77.17500	-0.72905	7.7002	-7.7002	-0.72905
1.0000	115.50000	96.50000	77.35000	-0.76389	7.5722	-7.5722	-0.76389
1.5000	115.50000	96.00000	77.52500	-0.78586	7.4463	-7.4463	-0.78586
2.0000	115.50000	95.50000	77.70000	-0.79523	7.3202	-7.3202	-0.79523

Specific Building Damage Results - Vertical Displacements

Structure: Line 1 | Sub-structure: North wall 1 - 13 Wedderburn

Dist.	Coordinates x	y	z	Displacements z
[m]	[m]	[m]	[m]	[mm]
Vertical Offset 1				
0.0	121.00000	121.50000	78.70000	8.9004
0.50000	120.50000	121.50000	78.70000	9.1216
1.0000	120.00000	121.50000	78.70000	9.3105
1.5000	119.50000	121.50000	78.70000	9.4639

Dist. [m]	Coordinates x [m]	y [m]	z [m]	Displacements z [mm]
2.0000	119.00000	121.50000	78.70000	9.5793

Structure: Line 2 | Sub-structure: West wall 1 - 13 Wedderburn

Vertical Offset 1

Dist. [m]	Coordinates x [m]	y [m]	z [m]	Displacements z [mm]
0.0	119.00000	121.50000	78.70000	9.5793
0.50000	119.00000	121.00000	78.70000	9.7258
1.0000	119.00000	120.50000	78.70000	9.8702
1.5000	119.00000	120.00000	78.70000	10.020
2.0000	119.00000	119.50000	78.70000	10.178
2.5000	119.00000	119.00000	78.70000	10.346
3.0000	119.00000	118.50000	78.70000	10.437
3.5000	119.00000	118.00000	78.70000	10.538
4.0000	119.00000	117.50000	78.70000	10.654
4.5000	119.00000	117.00000	78.70000	10.791
5.0000	119.00000	116.50000	78.70000	10.953

Structure: Line 3 | Sub-structure: North wall 2 - 13 Wedderburn

Vertical Offset 1

Dist. [m]	Coordinates x [m]	y [m]	z [m]	Displacements z [mm]
0.0	119.00000	116.50000	78.70000	10.953
0.50000	118.50000	116.50000	78.70000	10.817
1.0000	118.00000	116.50000	78.70000	10.586
1.5000	117.50000	116.50000	78.70000	10.250
2.0000	117.00000	116.50000	78.70000	9.8026

Structure: Line 4 | Sub-structure: West wall 2 - 13 Wedderburn

Vertical Offset 1

Dist. [m]	Coordinates x [m]	y [m]	z [m]	Displacements z [mm]
0.0	117.00000	116.50000	78.70000	9.8026
0.55000	117.00000	115.95000	78.70000	9.9079
1.1000	117.00000	115.40000	78.70000	10.120
1.6500	117.00000	114.85000	78.70000	10.499
2.2000	117.00000	114.30000	78.70000	11.104
2.7500	117.00000	113.75000	78.70000	11.233
3.3000	117.00000	113.20000	78.70000	10.609
3.8500	117.00000	112.65000	78.70000	10.029
4.4000	117.00000	112.10000	78.70000	9.4983
4.9500	117.00000	111.55000	78.70000	9.0154
5.5000	117.00000	111.00000	78.70000	8.5774

Structure: Line 5 | Sub-structure: South wall 1 - 13 Wedderburn

Vertical Offset 1

Dist. [m]	Coordinates x [m]	y [m]	z [m]	Displacements z [mm]
0.0	117.00000	111.00000	78.70000	8.5774
0.33333	117.33333	111.00000	78.70000	8.9151
0.66667	117.66667	111.00000	78.70000	9.2058
1.0000	118.00000	111.00000	78.70000	9.4515
1.3333	118.33333	111.00000	78.70000	9.6545
1.6667	118.66667	111.00000	78.70000	9.8169
2.0000	119.00000	111.00000	78.70000	9.9409

Structure: Line 6 | Sub-structure: West wall 3 - 13 Wedderburn

Vertical Offset 1

Dist. [m]	Coordinates x [m]	y [m]	z [m]	Displacements z [mm]
0.0	119.00000	111.00000	78.70000	9.9409
0.50000	119.00000	110.50000	78.70000	9.5984
1.0000	119.00000	110.00000	78.70000	9.2730
1.5000	119.00000	109.50000	78.70000	8.9648
2.0000	119.00000	109.00000	78.70000	8.6735
2.5000	119.00000	108.50000	78.70000	8.3988
3.0000	119.00000	108.00000	78.70000	8.1403

Dist.	Coordinates x	y	z	Displacements z
[m]	[m]	[m]	[m]	[mm]

Structure: Line 7 | Sub-structure: South wall 2 - 13 Wedderburn

Dist.	Coordinates x	y	z	Displacements z
[m]	[m]	[m]	[m]	[mm]
Vertical Offset 1				
0.0	119.00000	108.00000	78.70000	8.1403
0.33333	119.33333	108.00000	78.70000	8.2535
0.66667	119.66667	108.00000	78.70000	8.3380
1.0000	120.00000	108.00000	78.70000	8.3951
1.3333	120.33333	108.00000	78.70000	8.4261
1.6667	120.66667	108.00000	78.70000	8.4325
2.0000	121.00000	108.00000	78.70000	8.4157

Structure: Line 8 | Sub-structure: West - 7 Akenside

Dist.	Coordinates x	y	z	Displacements z
[m]	[m]	[m]	[m]	[mm]
Vertical Offset 1				
0.0	104.00000	95.50000	77.00000	4.5580
0.50000	104.00000	96.00000	77.17500	4.5556
1.0000	104.00000	96.50000	77.35000	4.4946
1.5000	104.00000	97.00000	77.52500	4.4556
2.0000	104.00000	97.50000	77.70000	4.3482

Structure: Line 9 | Sub-structure: North - 7 Akenside

Dist.	Coordinates x	y	z	Displacements z
[m]	[m]	[m]	[m]	[mm]
Vertical Offset 1				
0.0	104.00000	97.50000	77.00000	4.3482
0.57500	104.57500	97.50000	77.03500	4.4192
1.1500	105.15000	97.50000	77.07000	4.5547
1.7250	105.72500	97.50000	77.10500	4.8444
2.3000	106.30000	97.50000	77.14000	5.2113
2.8750	106.87500	97.50000	77.17500	5.6635
3.4500	107.45000	97.50000	77.21000	6.1944
4.0250	108.02500	97.50000	77.24500	7.4528
4.6000	108.60000	97.50000	77.28000	7.0657
5.1750	109.17500	97.50000	77.31500	6.7330
5.7500	109.75000	97.50000	77.35000	6.4515
6.3250	110.32500	97.50000	77.38500	6.2131
6.9000	110.90000	97.50000	77.42000	6.0095
7.4750	111.47500	97.50000	77.45500	5.8333
8.0500	112.05000	97.50000	77.49000	5.6785
8.6250	112.62500	97.50000	77.52500	5.5388
9.2000	113.20000	97.50000	77.56000	5.4300
9.7750	113.77500	97.50000	77.59500	5.3503
10.350	114.35000	97.50000	77.63000	5.2990
10.925	114.92500	97.50000	77.66500	5.2586
11.500	115.50000	97.50000	77.70000	3.6259

Structure: Line 10 | Sub-structure: East - 7 Akenside

Dist.	Coordinates x	y	z	Displacements z
[m]	[m]	[m]	[m]	[mm]
Vertical Offset 1				
0.0	115.50000	97.50000	77.00000	3.6259
0.50000	115.50000	97.00000	77.17500	3.7792
1.0000	115.50000	96.50000	77.35000	3.8969
1.5000	115.50000	96.00000	77.52500	3.9805
2.0000	115.50000	95.50000	77.70000	4.0318

Specific Building Damage Results - All Segments

Structure: Line 1 | Sub-structure: North wall 1 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	2.0000	Sagging	0.0035137	0.0097017	0.010772	-167.11E-6	-442.42E-6	6454.6	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category

Structure: Line 2 | Sub-structure: West wall 1 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	0.52718	Sagging	20.178E-6	-0.13125	0.026250	0.0013350	-293.29E-6	63606.	0 (Negligible)
	2	0.52718	1.1725	Hogging	366.57E-6	-0.10004	0.020008	0.0010981	-316.01E-6	30827.	0 (Negligible)
	3	1.6997	1.5005	Sagging	0.0035415	-0.066765	0.013507	0.0011343	-337.74E-6	7404.8	0 (Negligible)
	4	3.2002	1.7998	Hogging	0.0019169	-0.023856	0.0048985	376.15E-6	-324.76E-6	9269.1	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: Line 3 | Sub-structure: North wall 2 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	2.0000	Sagging	0.010383	-0.093120	0.019561	0.0012886	896.77E-6	2187.8	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: Line 4 | Sub-structure: West wall 2 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	1.6983	Hogging	0.0099052	-0.0071012	0.0079255	0.0032749	-0.0011041	1808.8	0 (Negligible)
	2	1.6983	2.0218	Sagging	0.043520	-0.29004	0.063258	0.0046132	0.0011362	623.11	1 (Very Slight)
	3	3.7201	1.7799	Hogging	0.0034472	-0.040017	0.0082487	0.0013634	0.0010557	6324.7	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: Line 5 | Sub-structure: South wall 1 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	2.0000	Sagging	0.0095995	-0.028964	0.0082209	579.21E-6	-0.0010137	2330.6	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: Line 6 | Sub-structure: West wall 3 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	3.0000	Hogging	0.0025221	0.010039	0.010618	-275.28E-6	685.15E-6	14547.	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: Line 7 | Sub-structure: South wall 2 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0	1	0.0	2.0000	Sagging	0.0058390	0.0021810	0.0067984	-126.60E-6	-339.86E-6	3812.6	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Vertical Offset from Line for Vertical Movement	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement	Maximum Gradient of Vertical Displacement	Min. Radius of Curvature	Damage Category

Structure: Line 8 | Sub-structure: West - 7 Akenside

Vertical Offset from Line for Vertical Movement Calculations [m]	Segment	Start [m]	Length [m]	Curvature	Deflection Ratio [%]	Average Horizontal Strain [%]	Max. Tensile Strain [%]	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature [m]	Damage Category
0	1	0.0	2.0000	Sagging	0.0027396	-0.0017175	0.0022140	82.603E-6	214.75E-6	2748.9	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: Line 9 | Sub-structure: North - 7 Akenside

Vertical Offset from Line for Vertical Movement Calculations [m]	Segment	Start [m]	Length [m]	Curvature	Deflection Ratio [%]	Average Horizontal Strain [%]	Max. Tensile Strain [%]	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature [m]	Damage Category
0	1	0.0	3.3915	Hogging	0.012259	-0.035818	0.010370	0.0020651	-925.09E-6	1361.2	0 (Negligible)
	2	3.3915	1.7153	Sagging	0.062490	-0.10271	0.046349	0.0020651	-0.0021923	528.78	0 (Negligible)
	3	5.1068	4.7022	Hogging	0.0047039	0.024429	0.026107	-346.83E-6	578.87E-6	6638.1	0 (Negligible)
	4	9.8090	1.6910	Sagging	0.061611	0.010073	0.065489	-128.07E-6	0.0028393	165.90	1 (Very Slight)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Structure: Line 10 | Sub-structure: East - 7 Akenside

Vertical Offset from Line for Vertical Movement Calculations [m]	Segment	Start [m]	Length [m]	Curvature	Deflection Ratio [%]	Average Horizontal Strain [%]	Max. Tensile Strain [%]	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature [m]	Damage Category
0	1	0.0	2.0000	Sagging	0.0033851	0.025666	0.026697	-266.42E-6	-306.56E-6	6946.9	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

Specific Building Damage Results - Critical Values for All Segments within Each Sub-Structure

Structure: Line 1 | Sub-structure: North wall 1 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations [m]	Deflection Ratio [%]	Average Horizontal Strain [%]	Maximum Slope	Maximum Settlement [mm]	Max. Tensile Strain [%]	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging) [m]	Min. Radius of Curvature (Sagging) [m]	Damage Category
0	0.0035137	0.0097017	-442.42E-6	9.5793	0.010772	-167.11E-6	-442.42E-6	-	6454.6	0 (Negligible)

Structure: Line 2 | Sub-structure: West wall 1 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations [m]	Deflection Ratio [%]	Average Horizontal Strain [%]	Maximum Slope	Maximum Settlement [mm]	Max. Tensile Strain [%]	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging) [m]	Min. Radius of Curvature (Sagging) [m]	Damage Category
0	0.0035415	-0.13125	-337.74E-6	10.953	0.026250	0.0013350	-337.74E-6	9269.1	7404.8	0 (Negligible)

Structure: Line 3 | Sub-structure: North wall 2 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations [m]	Deflection Ratio [%]	Average Horizontal Strain [%]	Maximum Slope	Maximum Settlement [mm]	Max. Tensile Strain [%]	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging) [m]	Min. Radius of Curvature (Sagging) [m]	Damage Category
0	0.010383	-0.093120	896.77E-6	10.953	0.019561	0.0012886	896.77E-6	-	2187.8	0 (Negligible)

Vertical Offset from Line for Vertical	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement	Maximum Gradient of Vertical Displacement	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category

Structure: Line 4 | Sub-structure: West wall 2 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0	0.043520	-0.29004	0.0011362	11.231	0.063258	0.0046132	0.0011362	1808.8	623.11	1 (Very Slight)

Structure: Line 5 | Sub-structure: South wall 1 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0	0.0095995	-0.028964	-0.0010137	9.9409	0.0082209	579.21E-6	-0.0010137	-	2330.6	0 (Negligible)

Structure: Line 6 | Sub-structure: West wall 3 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0	0.0025221	0.010039	685.15E-6	9.9409	0.010618	-275.28E-6	685.15E-6	14547.	-	0 (Negligible)

Structure: Line 7 | Sub-structure: South wall 2 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0	0.0058390	0.0021810	-339.86E-6	8.4323	0.0067984	-126.60E-6	-339.86E-6	-	3812.6	0 (Negligible)

Structure: Line 8 | Sub-structure: West - 7 Akenside

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0	0.0027396	-0.0017175	214.75E-6	4.5580	0.0022140	82.603E-6	214.75E-6	-	2748.9	0 (Negligible)

Structure: Line 9 | Sub-structure: North - 7 Akenside

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0	0.062490	-0.10271	0.0028393	7.4474	0.065489	0.0020651	0.0028393	1361.2	165.90	1 (Very Slight)

Structure: Line 10 | Sub-structure: East - 7 Akenside

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Maximum Gradient of Horizontal Displacement Curve	Maximum Gradient of Vertical Displacement Curve	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0	0.0033851	0.025666	-306.56E-6	4.0318	0.026697	-266.42E-6	-306.56E-6	-	6946.9	0 (Negligible)

Specific Building Damage Results - Critical Segments within Each Structure

Structure Name	Parameter	Critical	Critical Start	End	Curvature	Maximum	Maximum	Max.	Min.	Min.	Damage Category

		Sub-Structure	Segment	[m]	[m]		Slope	Settlement [mm]	Tensile Strain [%]	Radius of Curvature (Hogging) [m]	Radius of Curvature (Sagging) [m]	
Line 1	Maximum Slope	North wall 1 - 13 Wedderburn	1	0.0	2.0000	Sagging	**442.42E-6**	9.5793	0.010772	-	6454.6	0 (Negligible)
	Maximum Settlement	North wall 1 - 13 Wedderburn	1	0.0	2.0000	Sagging	442.42E-6	**9.5793**	0.010772	-	6454.6	0 (Negligible)
	Max. Tensile Strain	North wall 1 - 13 Wedderburn	1	0.0	2.0000	Sagging	442.42E-6	9.5793	**0.010772**	-	6454.6	0 (Negligible)
	Min. Radius of Curvature (Hogging)		-	-	-	-	-	-	-	-	-	-
	Min. Radius of Curvature (Sagging)	North wall 1 - 13 Wedderburn	1	0.0	2.0000	Sagging	442.42E-6	9.5793	0.010772	-	**6454.6**	0 (Negligible)
Line 2	Maximum Slope	West wall 1 - 13 Wedderburn	3	1.6997	3.2002	Sagging	**337.74E-6**	10.477	0.013507	-	7404.8	0 (Negligible)
	Maximum Settlement	West wall 1 - 13 Wedderburn	4	3.2002	5.0000	Hogging	324.76E-6	**10.953**	0.0048985	9269.1	-	0 (Negligible)
	Max. Tensile Strain	West wall 1 - 13 Wedderburn	1	0.0	0.52718	Sagging	293.29E-6	9.7336	**0.026250**	-	63606.	0 (Negligible)
	Min. Radius of Curvature (Hogging)	West wall 1 - 13 Wedderburn	4	3.2002	5.0000	Hogging	324.76E-6	10.953	0.0048985	**9269.1**	-	0 (Negligible)
	Min. Radius of Curvature (Sagging)	West wall 1 - 13 Wedderburn	3	1.6997	3.2002	Sagging	337.74E-6	10.477	0.013507	-	**7404.8**	0 (Negligible)
Line 3	Maximum Slope	North wall 2 - 13 Wedderburn	1	0.0	2.0000	Sagging	**896.77E-6**	10.953	0.019561	-	2187.8	0 (Negligible)
	Maximum Settlement	North wall 2 - 13 Wedderburn	1	0.0	2.0000	Sagging	896.77E-6	**10.953**	0.019561	-	2187.8	0 (Negligible)
	Max. Tensile Strain	North wall 2 - 13 Wedderburn	1	0.0	2.0000	Sagging	896.77E-6	10.953	**0.019561**	-	2187.8	0 (Negligible)
	Min. Radius of Curvature (Hogging)		-	-	-	-	-	-	-	-	-	-
	Min. Radius of Curvature (Sagging)	North wall 2 - 13 Wedderburn	1	0.0	2.0000	Sagging	896.77E-6	10.953	0.019561	-	**2187.8**	0 (Negligible)
Line 4	Maximum Slope	West wall 2 - 13 Wedderburn	2	1.6983	3.7201	Sagging	**0.0011362**	11.231	0.063258	-	623.11	1 (Very Slight)
	Maximum Settlement	West wall 2 - 13 Wedderburn	2	1.6983	3.7201	Sagging	0.0011362	**11.231**	0.063258	-	623.11	1 (Very Slight)
	Max. Tensile Strain	West wall 2 - 13 Wedderburn	2	1.6983	3.7201	Sagging	0.0011362	11.231	**0.063258**	-	623.11	1 (Very Slight)
	Min. Radius of Curvature (Hogging)	West wall 2 - 13 Wedderburn	1	0.0	1.6983	Hogging	0.0011041	10.552	0.0079255	**1808.8**	-	0 (Negligible)
	Min. Radius of Curvature (Sagging)	West wall 2 - 13 Wedderburn	2	1.6983	3.7201	Sagging	0.0011362	11.231	0.063258	-	**623.11**	1 (Very Slight)
Line 5	Maximum Slope	South wall 1 - 13 Wedderburn	1	0.0	2.0000	Sagging	**0.0010137**	9.9409	0.0082209	-	2330.6	0 (Negligible)
	Maximum Settlement	South wall 1 - 13 Wedderburn	1	0.0	2.0000	Sagging	0.0010137	**9.9409**	0.0082209	-	2330.6	0 (Negligible)
	Max. Tensile Strain	South wall 1 - 13 Wedderburn	1	0.0	2.0000	Sagging	0.0010137	9.9409	**0.0082209**	-	2330.6	0 (Negligible)
	Min. Radius of Curvature (Hogging)		-	-	-	-	-	-	-	-	-	-
	Min. Radius of Curvature (Sagging)	South wall 1 - 13 Wedderburn	1	0.0	2.0000	Sagging	0.0010137	9.9409	0.0082209	-	**2330.6**	0 (Negligible)
Line 6	Maximum Slope	West wall 3 - 13 Wedderburn	1	0.0	3.0000	Hogging	**685.15E-6**	9.9409	0.010618	14547.	-	0 (Negligible)
	Maximum Settlement	West wall 3 - 13 Wedderburn	1	0.0	3.0000	Hogging	685.15E-6	**9.9409**	0.010618	14547.	-	0 (Negligible)
	Max. Tensile Strain	West wall 3 - 13 Wedderburn	1	0.0	3.0000	Hogging	685.15E-6	9.9409	**0.010618**	14547.	-	0 (Negligible)
	Min. Radius of Curvature (Hogging)	West wall 3 - 13 Wedderburn	1	0.0	3.0000	Hogging	685.15E-6	9.9409	0.010618	**14547.**	-	0 (Negligible)
	Min. Radius of Curvature (Sagging)		-	-	-	-	-	-	-	-	-	-
Line 7	Maximum Slope	South wall 2 - 13 Wedderburn	1	0.0	2.0000	Sagging	**339.86E-6**	8.4323	0.0067984	-	3812.6	0 (Negligible)
	Maximum Settlement	South wall 2 - 13 Wedderburn	1	0.0	2.0000	Sagging	339.86E-6	**8.4323**	0.0067984	-	3812.6	0 (Negligible)
	Max. Tensile Strain	South wall 2 - 13 Wedderburn	1	0.0	2.0000	Sagging	339.86E-6	8.4323	**0.0067984**	-	3812.6	0 (Negligible)
	Min. Radius of Curvature (Hogging)		-	-	-	-	-	-	-	-	-	-
	Min. Radius of Curvature	South wall 2 - 13 Wedderburn	1	0.0	2.0000	Sagging	339.86E-6	8.4323	0.0067984	-	**3812.6**	0 (Negligible)

Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Maximum Slope	Maximum Settlement	Max. Tensile Strain	Min. Radius of Curvature (Hogging)	Min. Radius of Curvature (Sagging)	Damage Category
				[m]	[m]			[mm]	[%]	[m]	[m]	
	(Sagging)											
Line 8	Maximum Slope	West - 7 Akenside	1	0.0	2.0000	Sagging	**214.75E-6**	4.5580	0.0022140	-	2748.9	0 (Negligible)
	Maximum Settlement	West - 7 Akenside	1	0.0	2.0000	Sagging	214.75E-6	**4.5580**	0.0022140	-	2748.9	0 (Negligible)
	Max. Tensile Strain	West - 7 Akenside	1	0.0	2.0000	Sagging	214.75E-6	4.5580	**0.0022140**	-	2748.9	0 (Negligible)
	Min. Radius of Curvature (Hogging)		-	-	-	-	-	-	-	-	-	-
	Min. Radius of Curvature (Sagging)	West - 7 Akenside	1	0.0	2.0000	Sagging	214.75E-6	4.5580	0.0022140	-	**2748.9**	0 (Negligible)
Line 9	Maximum Slope	North - 7 Akenside	4	9.8090	11.500	Sagging	**0.0028393**	5.3473	0.065489	-	165.90	1 (Very Slight)
	Maximum Settlement	North - 7 Akenside	2	3.3915	5.1068	Sagging	0.0021923	**7.4474**	0.046349	-	528.78	0 (Negligible)
	Max. Tensile Strain	North - 7 Akenside	4	9.8090	11.500	Sagging	0.0028393	5.3473	**0.065489**	-	165.90	1 (Very Slight)
	Min. Radius of Curvature (Hogging)	North - 7 Akenside	1	0.0	3.3915	Hogging	925.09E-6	6.1404	0.010370	**1361.2**	-	0 (Negligible)
	Min. Radius of Curvature (Sagging)	North - 7 Akenside	4	9.8090	11.500	Sagging	0.0028393	5.3473	0.065489	-	**165.90**	1 (Very Slight)
Line 10	Maximum Slope	East - 7 Akenside	1	0.0	2.0000	Sagging	**306.56E-6**	4.0318	0.026697	-	6946.9	0 (Negligible)
	Maximum Settlement	East - 7 Akenside	1	0.0	2.0000	Sagging	306.56E-6	**4.0318**	0.026697	-	6946.9	0 (Negligible)
	Max. Tensile Strain	East - 7 Akenside	1	0.0	2.0000	Sagging	306.56E-6	4.0318	**0.026697**	-	6946.9	0 (Negligible)
	Min. Radius of Curvature (Hogging)		-	-	-	-	-	-	-	-	-	-
	Min. Radius of Curvature (Sagging)	East - 7 Akenside	1	0.0	2.0000	Sagging	306.56E-6	4.0318	0.026697	-	**6946.9**	0 (Negligible)

Specific Building Damage Results - All Combined Segments

Structure: Line 1 | Sub-structure: North wall 1 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

No structures have segments combined.

Structure: Line 2 | Sub-structure: West wall 1 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

No structures have segments combined.

Structure: Line 3 | Sub-structure: North wall 2 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

No structures have segments combined.

Structure: Line 4 | Sub-structure: West wall 2 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

Vertical Offset from Line for Vertical	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category

No structures have segments combined.

Structure: Line 5 | Sub-structure: South wall 1 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

No structures have segments combined.

Structure: Line 6 | Sub-structure: West wall 3 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

No structures have segments combined.

Structure: Line 7 | Sub-structure: South wall 2 - 13 Wedderburn

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

No structures have segments combined.

Structure: Line 8 | Sub-structure: West - 7 Akenside

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

No structures have segments combined.

Structure: Line 9 | Sub-structure: North - 7 Akenside

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

No structures have segments combined.

Structure: Line 10 | Sub-structure: East - 7 Akenside

Vertical Offset from Line for Vertical Movement Calculations	Combined Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max. Tensile Strain	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]	

No structures have segments combined.