Addendum Ground Movement Assessment Report

Site	5 Highfields Grove London N6 6HN
Client	Novus Finitor (UK) Ltd
Date	January 2015
Our Ref	GMA/4957

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14th January 2015

Our Ref: GMA/4957

Dear Sirs,

Addendum to Report on Basement Impact Assessment
5 HIGHFIELDS GROVE, LONDON, N6 6HN

This addendum is supplementary to, and should be read in conjunction with, our Basement Impact Assessment report, Ref. BIA4957

1. Heave/Settlement Assessment

1.1 Basement Geometry and Stresses:

1.1.1 Analyses of vertical ground movements (heave or settlement) have been undertaken using PDISP software in order to assess the potential magnitudes of movements which may result from the changes of vertical stresses caused by excavation of the two basements. These preliminary analyses have simplified the complex stress regime between these basements, the bearing piles and the ground.

1.1.2 Figure D1 (see Appendix) illustrates the layout of the proposed foundations, including bearing piles, based on Elite Designers' Drg No's 2014-207-01 and 2014-207-02. The two plans provided by Elite with hand-annotated load takedown data are also appended.

1.1.3 The levels of the underside of the basement slabs were calculated using the finished floor levels on drawings by Yeates Design and structural slab details provided by Elite Designers, as described in paragraph 3.2 of the BIA report. These gave approximate excavation levels as follows:

- Basement 1: 44.45m ASD except for the linking corridor to the garage where Yeates' Drg No.548/P/014A showed that the FFL is lowered 27.5cm, giving an excavation level of 44.18m ASD.
- Basement 2: 46.4m ASD.

1.1.4 The excavation depths required for these basements were unusually variable owing to the variations in ground levels around the property. As a result more, smaller zones have been used, and, where appropriate, the excavation depth in each zone has been calculated using the average ground level over the zone.

1.1.5 Table 3 presents the co-ordinates used to input the main elements of the basement's geometry into PDISP based on the illustration in Figure D2, together with the net changes in vertical pressure for the short-term and long-term conditions/stages of basement construction, as listed in paragraph 1.3.1 below.

1.1.6 Stress changes typically extend to a depth equal to twice the width of the loaded or unloaded area, below which depth the changes are usually assumed to be negligible. The dimensions (measured from Elite's drawings) and maximum depths of significant stress reductions from excavation of the basements are:

Basement 1 (main part):
Dimensions: 8.415m by 7.87m (or 11.16m including the en-suite)
Maximum depth of significant stress reductions: approx 17m below slab.

Basement 2:
Dimensions: 3.09m below the house, to a maximum of 5.14m at eastern end
Maximum depth of significant stress reductions: approx 3m to 10.5m below slab.

1.1.7 The pile foundations could be designed to fully isolate Basement 2 from these stress changes, whereas that is unlikely to be economic for Basement 1. The piles will however reduce the load from the basement acting on the upper part of the soils below formation level.

Table 3: Coordinates and net bearing pressure for PDISP

ZONE	Centroid		Dimensions		Angle with	Net change in vertical pressure (kPa)	
#	Xc(m)	Yc(m)	X(m)	Y(m)	X-Axis	Stages 1 to 3	Stage 4
1	12.804	8.832	2.628	3.810	0.0000	-78.85	-78.85
2	11.158	7.927	0.665	1.999	0.0000	-80.75	-80.75
3	10.369	7.927	0.913	1.399	0.0000	-42.75	-42.75
4	10.369	9.495	0.913	1.737	0.0000	-42.75	-42.75
5	10.369	10.890	0.913	1.054	0.0000	-53.20	-53.20
6	10.369	11.780	0.913	0.726	0.0000	-54.15	-54.15
7	9.340	12.426	2.970	0.565	0.0000	-54.15	-54.15
8	6.826	12.426	2.058	0.565	0.0000	-39.90	-39.90
9	4.854	12.426	1.887	0.565	0.0000	-37.05	-37.05
10	3.430	12.426	0.960	0.565	0.0000	-34.20	-34.20
11	1.496	12.426	2.908	0.565	0.0000	-30.40	-30.40
12	1.475	10.081	2.950	0.565	0.0000	-30.40	-30.40
13	3.430	9.495	0.960	1.737	0.0000	-34.20	-34.20
14	3.430	7.816	0.960	1.620	0.0000	-32.30	-32.30
15	3.296	6.752	0.691	0.509	0.0000	-32.30	-32.30
16	4.538	5.702	2.702	0.912	-45.2039	-32.30	-32.30
17	5.543	4.574	0.509	0.563	0.0000	-34.20	-34.20

Table 3 (Cont'd): Coordinates and net bearing pressure for PDISP							
ZONE	Centroid		Dimensions		Angle with	Net change in vertical pressure (kPa)	
#	Xc(m)	Yc(m)	X(m)	Y(m)	X-Axis	Stages 1 to 3	Stage 4
18	6.826	4.683	2.058	0.781	0.0000	-36.10	-36.10
19	8.884	4.683	2.057	0.781	0.0000	-38.95	-38.95
20	10.369	4.683	0.913	0.781	0.0000	-40.85	-40.85
21	10.369	6.150	0.913	2.154	0.0000	-41.80	-41.80
22	9.601	13.999	2.448	2.582	0.0000	-57.00	-57.00
23	9.445	16.215	2.761	1.850	0.0000	-57.00	-57.00
24	8.884	11.253	2.057	1.780	0.0000	-47.50	-47.50
25	6.826	11.253	2.058	1.780	0.0000	-41.80	-41.80
26	4.854	11.253	1.887	1.780	0.0000	-37.05	-37.05
27	3.430	11.253	0.960	1.780	0.0000	-34.20	-34.20
28	1.480	11.253	2.940	1.780	0.0000	-30.40	-30.40
29	4.854	9.495	1.887	1.737	0.0000	-34.20	-34.20
30	6.826	9.495	2.058	1.737	0.0000	-38.00	-38.00
31	8.884	9.495	2.057	1.737	0.0000	-41.80	-41.80
32	4.854	7.927	1.887	1.399	0.0000	-34.20	-34.20
33	6.826	7.927	2.058	1.399	0.0000	-38.00	-38.00
34	8.884	7.927	2.057	1.399	0.0000	-40.85	-40.85
35	8.884	5.760	2.057	2.935	0.0000	-39.90	-39.90
36	6.826	5.760	2.058	2.935	0.0000	-37.05	-37.05
37	4.854	7.117	1.887	0.221	0.0000	-33.25	-33.25
38	4.922	6.881	1.750	0.250	0.0000	-33.25	-33.25
39	5.047	6.631	1.500	0.250	0.0000	-33.25	-33.25
40	5.172	6.381	1.250	0.250	0.0000	-33.25	-33.25
41	5.272	6.131	1.050	0.250	0.0000	-32.30	-32.30
42	5.394	5.881	0.807	0.250	0.0000	-32.30	-32.30
43	5.547	5.631	0.500	0.250	0.0000	-32.30	-32.30
44	5.647	5.381	0.300	0.250	0.0000	-32.30	-32.30

Table 3 (Cont'd): Coordinates and net bearing pressure for PDISP							
ZONE	Centroid		Dimensions		Angle with X-Axis	Net change in vertical pressure (kPa)	
#	Xc(m)	Yc(m)	X(m)	Y(m)		Stages 1 to 3	Stage 4
45	25.531	13.608	0.610	0.728	0.0000	-68.40	-68.40
46	26.771	13.608	1.870	0.728	0.0000	-68.40	-68.40
47	28.011	13.608	0.610	0.728	0.0000	-68.40	-68.40
48	28.011	9.808	0.610	6.872	0.0000	-68.40	-68.40
49	28.011	5.705	0.610	1.335	0.0000	-68.40	-68.40
50	32.711	4.722	9.490	0.630	0.0000	-61.75	-61.75
51	38.075	4.722	1.238	0.630	0.0000	-61.75	-61.75
52	38.075	2.532	1.238	3.751	0.0000	-57.95	-57.95
53	38.075	0.328	1.238	0.656	0.0000	-53.20	-53.20
54	32.739	1.149	9.571	0.549	-9.2479	-53.20	-53.20
55	27.837	1.998	0.350	0.605	0.0000	-57.00	-57.00
56	27.089	2.566	1.847	0.532	0.0000	-57.95	-57.95
57	26.636	3.181	0.941	0.698	0.0000	-57.95	-57.95
58	26.636	4.380	0.941	1.699	0.0000	-61.75	-61.75
59	26.176	5.687	0.679	0.915	0.0000	-68.40	-68.40
60	25.531	5.687	0.610	0.915	0.0000	-68.40	-68.40
61	25.531	9.694	0.610	7.100	0.0000	-68.40	-68.40
62	26.771	9.694	1.870	7.100	0.0000	-68.40	-68.40
63	27.111	5.687	1.191	0.915	0.0000	-68.40	-68.40
64	27.406	5.133	0.600	0.192	0.0000	-61.75	-61.75
65	27.536	4.722	0.860	0.630	0.0000	-61.75	-61.75
66	32.281	3.969	10.350	0.877	0.0000	-61.75	-61.75
67	32.281	3.181	10.350	0.698	0.0000	-57.95	-57.95
68	32.734	2.519	9.444	0.626	0.0000	-57.95	-57.95
69	33.206	2.081	8.500	0.250	0.0000	-57.00	-57.00
70	33.956	1.831	7.000	0.250	0.0000	-55.10	-55.10
71	34.656	1.581	5.600	0.250	0.0000	-54.15	-54.15
72	35.431	1.331	4.050	0.250	0.0000	-53.20	-53.20
73	36.181	1.081	2.550	0.250	0.0000	-53.20	-53.20
74	37.006	0.831	0.900	0.250	0.0000	-53.20	-53.20

1.2 Ground Conditions:

1.2.1 The ground profile was based on the site-specific ground investigation by Chelmer Site Investigations, as presented in Sections 7 and 8.1 of the BIA report, together with the desk study information.

1.2.2 The short-term and long-term geotechnical properties of the soil strata used for the PDISP analyses are summarised in Table 4. They were based on the findings of CSI's investigation and data from previous projects.

Table 4: Soil parameters for PDISP analyses

Strata	Level (m ASD)	SPT, N	Short term, undrained Young's Modulus, Eu (MPa)	Long term, drained Young's Modulus, E' (MPa)
SAND/ Soft CLAY	46.4 43.75	(20) (20)	40 40	40 40
Stiff, sandy, silty CLAY (Claygate Fm/ London Clay Fm)	43.75/ 41.2 17.5		50 150	30 90

Where:
For granular soils:
Eu = E' = 2 * N
For CLAY:
Undrained shear strength, Eu = 50 + 3.75 z
Drained Young's Modulus, E' = 0.6 Eu
where z = depth below the top of the stratum.

1.3 PDISP Analyses:

1.3.1 Three dimensional analyses of vertical displacements have been undertaken using PDISP software and the basement geometry, loads/stresses and ground conditions outlined above in order to assess the potential magnitudes of ground movements (heave or settlement) which may result from the vertical stress changes caused by excavation of the basement. PDISP analyses have been carried out as follows:

- Stages 1 & 2 – Construction of piles, retaining walls and bulk excavation to formation level – Short-term condition
- Stage 3 – Construction of basement slab, probably combined with Stages 1 & 2 – Short-term (undrained) conditions
- Stage 4 – As Stage 3, except – Long-term (drained) conditions

1.3.2 In this case, with the self-weight of the basement structures fully supported on piles (and minimal/no load from any superstructure) the proportion of load carried at each level cannot easily be quantified. Thus, a worst case scenario has been analysed with no reduction of the gross unloading.

1.3.3 The results of the analyses for Stages 1-3 and Stage 4 are presented as contour plots on the appended Figures D3 & D5 for Basement 1, and Figures D4 & D6 for Basement 2.

1.4 Heave Assessment and associated Recommendations

1.4.1 As noted in the BIA report, excavation of the basement will cause immediate elastic heave in response to the stress reduction, followed by long term plastic swelling as the over-consolidated clays at depth take up groundwater. The soft and firm clays (and the loose sands) recorded above depths of 5.5-6.0m are not expected to undergo any such swelling so have been modelled as a granular material. The rate of plastic swelling in the over-consolidated clays will be determined largely by the availability of water and as a result, given the low permeability of the clays in the Claygate Member/London Clay Formation, can take decades to reach full equilibrium. The structures of these basements, including the lengths, diameters and sleeving details (if any) of the piles, will need to be designed so as to enable them to accommodate the swelling displacements/pressures developed underneath them, taking into account the piled structures above.

1.4.2 The pile foundations are unlikely to isolate fully Basement 1 from the heave in the underlying clays and while Basement 2 could be fully isolated this may not be the most cost-effective solution. The soft/loose condition of the soils recorded above 5.5-6.0m bgl may compress in response to the underlying heave, and thus help to isolate the basements from the underlying heave; however this cannot be relied upon. Use of CellCore of other suitable compressible material beneath the 'underpins' and basement slabs should therefore be considered, unless it can be shown that the proposed basements and the existing piled structures can accommodate the likely pressures which the clays might develop.

1.4.3 The piled slab for Basement 1 should be extended beneath the outbuilding in order to avoid the risk of differential movement between the outbuilding and the rest of the structure.

1.4.4 The ranges of predicted short-term and long-term movements for each of the main walls are presented in Tables 5 & 6 below for Basements 1 & 2 respectively.

Table 5: Summary of predicted displacements – Basement 1		
Location	**Stages 1 - 3** **(Figure D3)**	**Stage 4** **(Figure D5)**
Entrance/kitchen (West)	1 – 3mm Heave	2 – 5mm Heave
Corridor to garage (North)	2 – 5mm Heave	3 – 7mm Heave
En-suite (East)	3 – 6mm Heave	4 – 8mm Heave
Main central part of basement	2 – 5mm Heave	4 – 8mm Heave

Table 6: Summary of predicted displacements – Basement 2		
Location	**Stages 1 – 3** **(Figure D4)**	**Stage 4** **(Figure D6)**
Corridor and store beneath house	2 – 5mm Heave	4– 8mm Heave
Main part of basement beyond south wall of house	2 – 5mm Heave	4 – 8mm Heave

1.4.5 The analyses indicated that only modest heave movements are likely to develop beneath the piled basements, despite the fact that a worst case scenario has been analysed with no allowance for any load from the self-weight from the basement structures and no allowance for any restraining influence of friction on the pile shafts. The actual displacements are therefore expected to be smaller than these values, with the possible exception only of Basement 2 **if** it is isolated fully from the ground movements in the 6-10m depth of soils below the basement slab.

1.4.6 All the short term elastic heave is likely to have occurred before the basement slab is cast, so only the post-construction incremental heave may be relevant to the slab design, dependant on the construction sequence used. The maximum predicted heave beneath both basement slabs post-construction is therefore likely to be further reduced as a result.

- END -

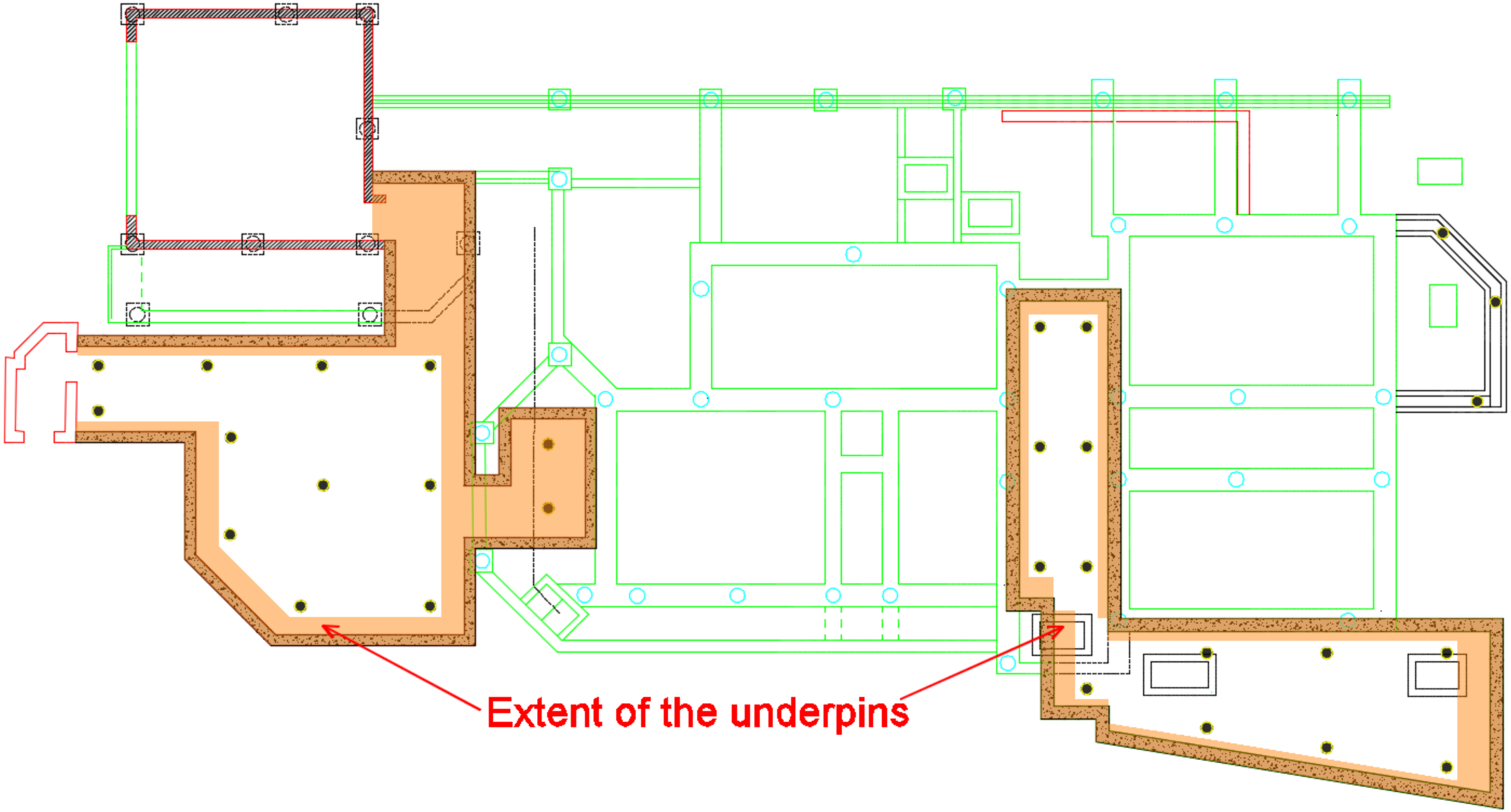

Figure D1. Layout of the proposed basement foundation plan

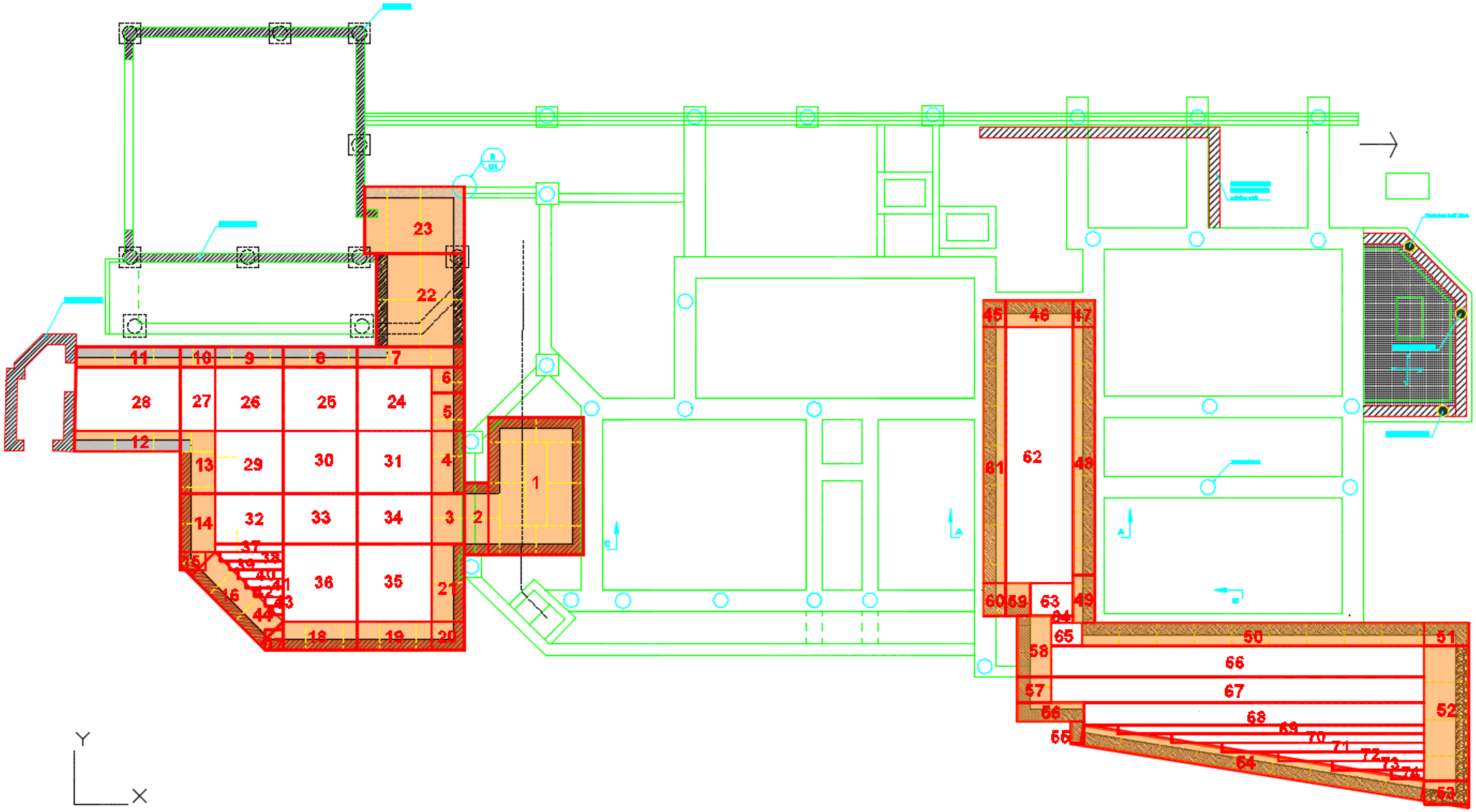

Figure D2. Detail of geometry introduced to PDISP

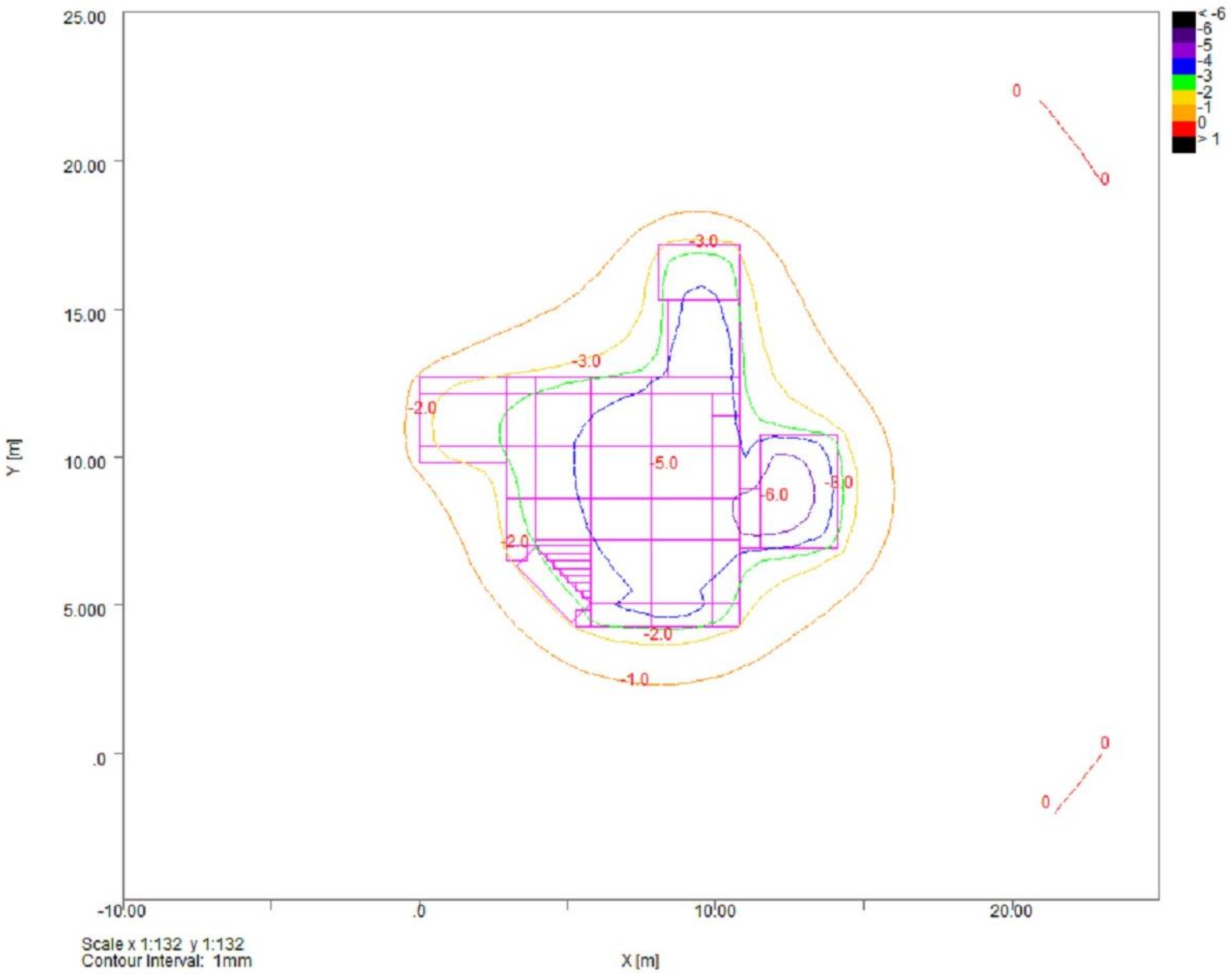

Figure D3. Short term (Stages 1-3) heave assessment contour for Basement 1 near the garage

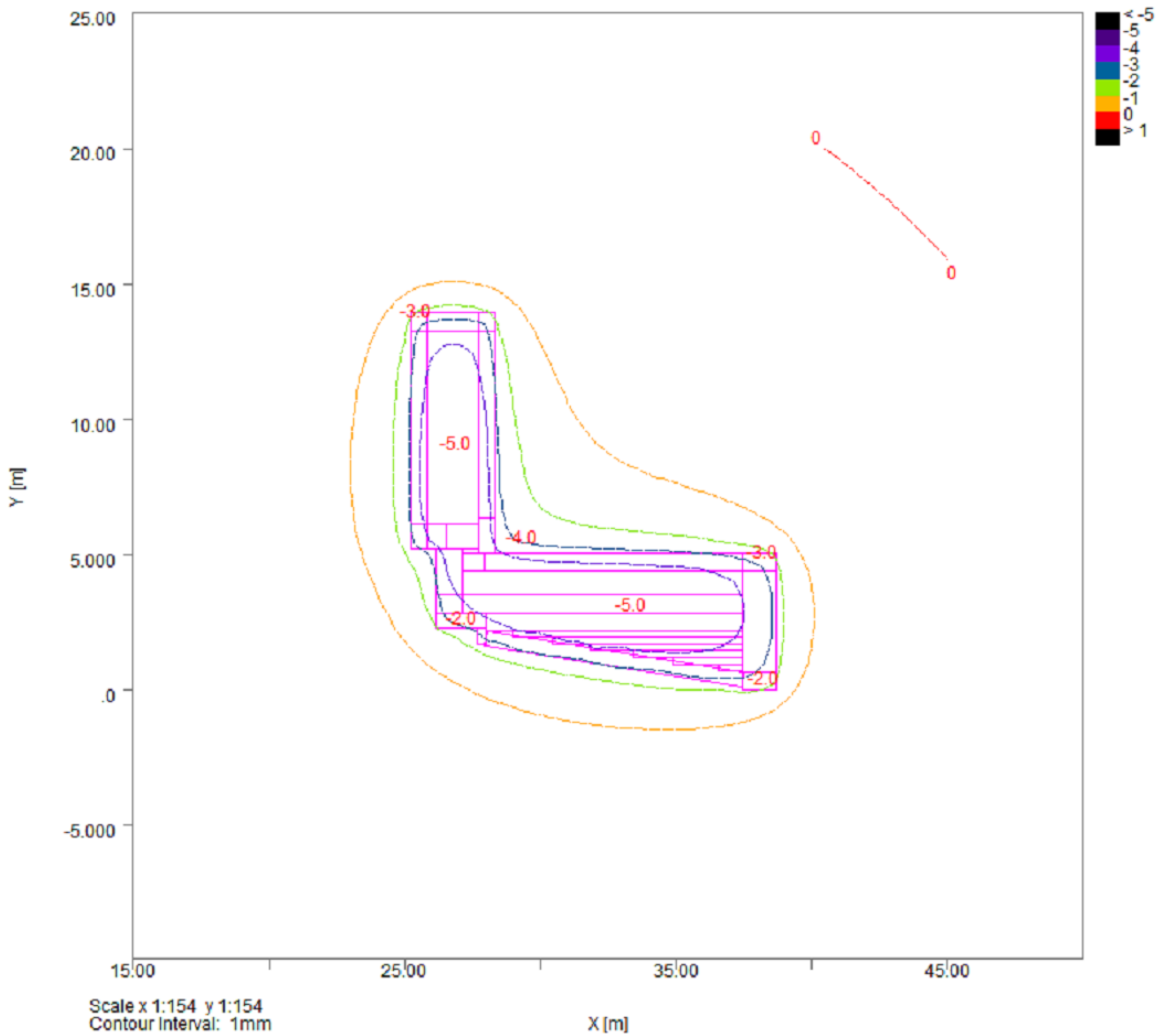

Figure D4. Short term (Stages 1-3) heave assessment contour for Basement 2, partially beneath the house

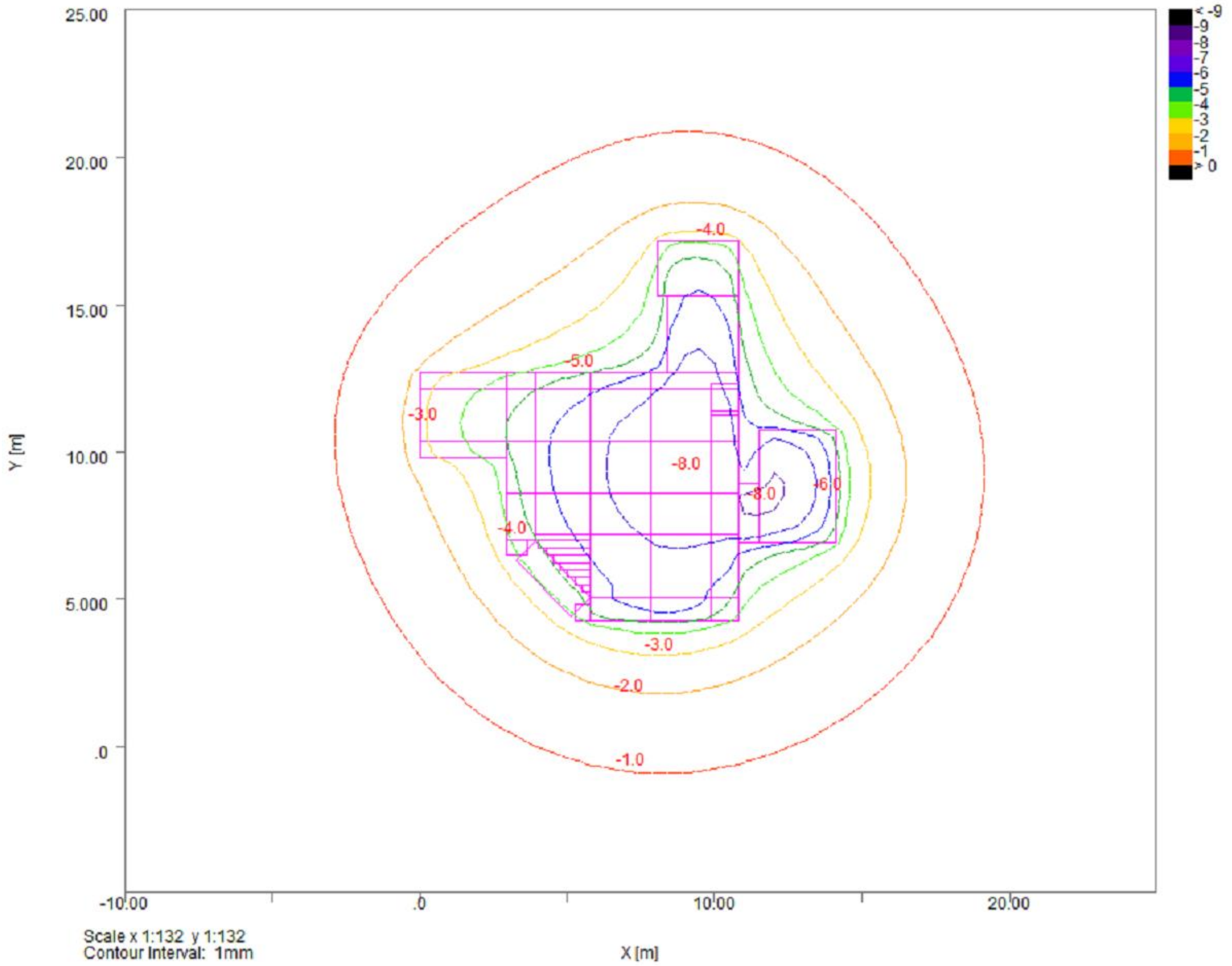

Figure D5. Long term (Stage 4) heave assessment contour for Basement 1 near the garage

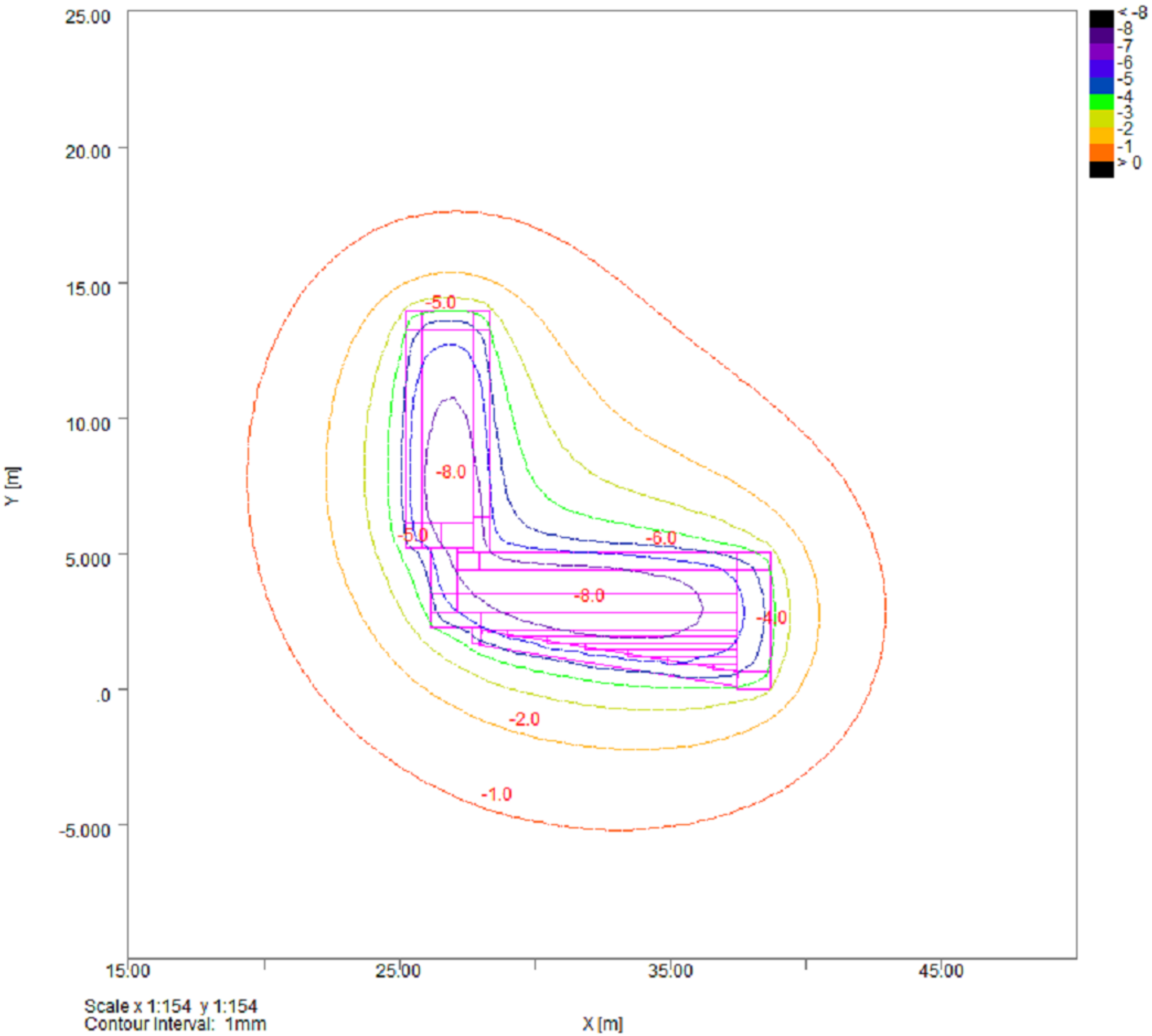

Figure D6. Long term (Stage 4) heave assessment contour for Basement 2, partially beneath the house