the treatment but they will need to provide documentation to prove that this has been carried out. Alternatively, the treatment can be carried out by an approved contractor. The Environment Agency has issued a position paper[14] which states that in certain circumstances, segregation at source may be considered as pre-treatment and thus excavated material may not have to be treated prior to landfilling if the soils can be segregated onsite prior to excavation by sufficiently characterising the soils insitu prior to excavation.

The above opinion with regard to the classification of the excavated soils is provided for guidance only and should be confirmed by the receiving landfill once the soils to be discarded have been identified.

The local waste regulation department of the Environment Agency (EA) should be contacted to obtain details of tips that are licensed to accept the soil represented by the test results. The tips will be able to provide costs for disposing of this material but may require further testing.

In view of the potential classification of the made ground as a hazardous waste it may be beneficial to consider more testing in an attempt to reduce the classification, although an analysis of the potential cost savings should be carried out to determine whether this is cost-effective.

14 Environment Agency 23 Oct 2007 *Regulatory Position Statement Treating non-hazardous waste for landfill - Enforcing the new requirement*

Part 3: GROUND MOVEMENT ASSESSMENT

This section of the report comprises an analysis of the ground movements arising from the proposed basement and foundation scheme discussed in Part 2 and the information obtained from the investigation, presented in Part 1 of the report.

9.0 INTRODUCTION

Consideration is being given to the demolition of the existing building and subsequent construction of a six-storey mixed residential and retail building, including a single level basement. It is understood that the new basement will extend to a depth of roughly 4.5 m. The reinforced concrete retaining walls will be excavated and constructed following the demolition of the house.

The sides of an excavation will move to some extent regardless of how they are supported. The movement will typically be both horizontal and vertical and will be influenced by the engineering properties of the ground, groundwater level and flow, the efficiency of the various support systems employed during retaining wall construction and the efficiency or stiffness of any support structures used.

9.1 Basis of Ground Movement Assessment

9.1.1 Nearby Sensitive Structures

A plan showing the proposed basement and nearby sensitive structures at Nos 18 to 22 Haverstock Hill is shown below.

Sensitive structures relevant to this assessment include the Salvation Army Citadel, Haverstock School, Chalk Farm station and the adjacent depot. Observations during the site walkover suggested Nos 4 to 8 Haverstock Hill had recently been demolished and it was noted that the new building is to be supported by means of bored pile foundations such that the building has not been considered within this analysis.

The heights of neighbouring houses have been estimated from observation and from drawings provided by the consulting engineers. Where the depths of foundations or the heights of buildings are not known due to restricted access, these dimensions have been assumed. The heights and basement depths of each of the nearby sensitive structures are summarised in the table below. All building heights and foundations depths are taken relative to a ground level of 32.0 m OD.

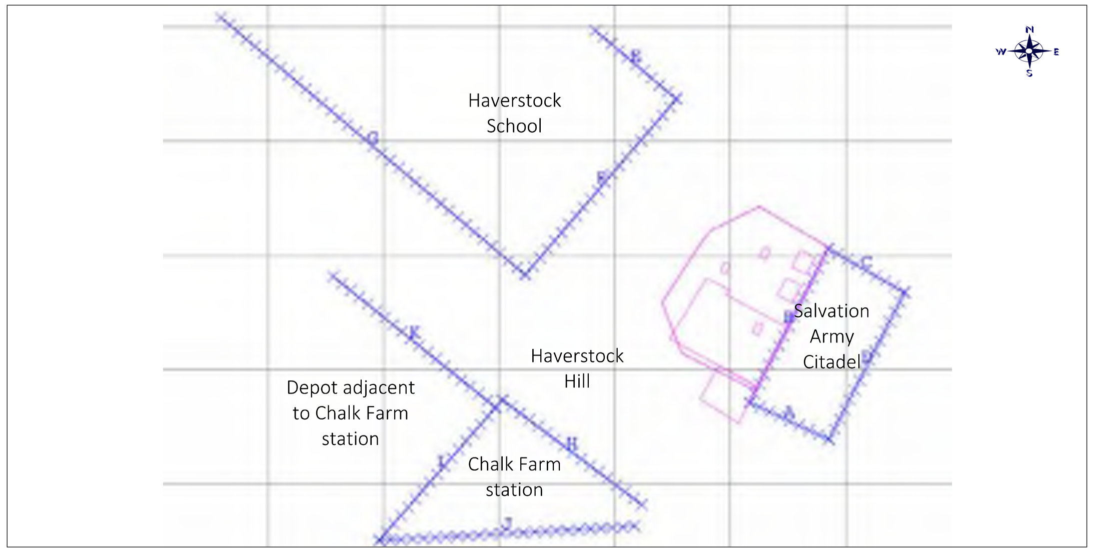
Sensitive Structure	Structure Reference	Depth below Ground level of foundations (m)	Height of building above ground level (m)
Salvation Army Citadel	A to D*	0.5	6.0
Haverstock School	E to G	0.5	7.0
Chalk Farm station	H to J	1.2	7.9
Depot adjacent to Chalk Farm station	K	0.5	7.0

** Sensitive structure 'B' is a party wall and a proposed underpin level of 27.49 m OD has been adopted.*

The following drawings have been referred to, where relevant, to model the sensitive structures and proposed excavation.

Drawing Reference	Drawing Title
E0563-EEE-00-B1-DR-S-1099 P01, dated 23/03/18	Proposed Basement Plan
E0563-EEE-00-GF-DR-S-1100 P01, dated 23/03/18	Proposed Ground Floor Plan
E0563-EEE-00-ZZ-DR-S-2001 P01, dated 23/03/18	Overall Sections Sheet 1
E0563-EEE-00-XX-DR-S-9033 P-1, dated 09/03/18	Construction Sequence Sheet 1
E0563-EEE-00-XX-DR-S-9034 P-1, dated 09/03/18	Construction Sequence Sheet 2
Print2391_1973858	FindMaps location plan

The diagram below details the sensitive structures in relation to the proposed excavation.



9.1.2 Construction Sequence

The following sequence of operations has been assumed to enable analysis of the ground movements around the proposed basement both during and after construction.

In general, the sequence of works for basement construction will comprise the following stages.

1. Demolition of the existing structure, including removal of the existing spread foundations;

2. Construction of reinforced concrete retaining walls to perimeter of proposed basement and construction of underpin beneath party wall with Salvation Army Citadel. It is assumed the retaining walls will be formed in a 'hit and miss' sequence using a trench box excavation, commonly sheet lined, shored and strutted; all temporary shoring and propping to be inspected by a suitably qualified person; and

3. Construct new reinforced concrete slabs and excavate the new basement in a sequence that provides full restraint to the head and base of the wall, casting floor and basement raft to provide propping as the excavation proceeds. Temporarily retain and strengthen the new retaining walls with sufficient propping and walling beams. Construct new raft foundation. Construct new building.

The retaining walls will be adequately laterally propped and sufficiently dowelled together, and the concrete will be cast and adequately cured prior to excavation of the basement and removal of the formwork and supports. It is assumed that the corners of the excavation will be locally stiffened by cross-bracing or similar and that the new retaining walls will not be cantilevered at any stage during the construction process. It is assumed that adequate temporary propping of the new retaining walls, particularly at the top level, will occur at all times prior to the construction of permanent concrete floor slabs.

The detail of the support provided to adjacent walls is beyond the scope of this report at this stage and the structural engineer will be best placed to agree a methodology with the retaining wall contractor once appointed.

When the final excavation depths have been reached the permanent works will be formed, which are likely to comprise reinforced concrete walls with a drained cavity lining the inside of the retaining walls. Reinforced concrete will be used for the proposed floor slabs. Following this, the proposed raft slab will be constructed at basement depth and the temporary props will be removed.

9.2 Ground Movements

9.2.1 Movements within the Excavation (Heave)

Model Used

At this site, unloading of the London Clay will take place as a result of the proposed basement excavation and the reduction in vertical stress in the short term will cause heave to take place. 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 movement, which includes long term swelling that will continue for a number of years.

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 we have used a well-established method to provide our estimates. Published data[15] indicates stiffness values of 750 x Cu for the London Clay and a ratio of E' to Eu of 0.75, and it is considered that this provides a sensible approach. The strength profile of the underlying clay has been extrapolated from the ground investigation and a design line of 7.0z + 30 has been adopted for this analysis.

Demolition of the existing building will result in an unloading of around 50 kN/m^2 at a level of 30.22 m OD and 12.5 kN/m^2 at a level of 30.80 m OD for the main building and shop frontage of No 18 respectively. The levels at which the unloading occurs has been calculated from section drawings provided by the consulting engineers.

The proposed basement excavation will result in a short term unloading of around 90 kN/m^2 and is assumed to act at a proposed formation level of 27.49 m OD, which includes a proposed raft excavation of 0.65 m.

Localised excavations for lift pits and attenuation tanks are shown on the plan overleaf and an unloading of 45 kN/m^2 at a level of 25.29 m OD are assumed in these areas.

In the long term, a new uniformly distributed pressure of 60 kN/m^2 is assumed to act at a level of 27.49 m OD and includes the proposed dead load and 30 % of the proposed live load.

9.2.2 Ground movements resulting from basement excavation

Model Used

The X-Disp program has been used to predict ground movements likely to arise from the construction of the proposed basement. Published data for ground movements associated with underpinned retaining walls and the subsequent excavation of a new basement is limited compared to other types of retaining wall. The analysis of potential ground movements associated with the underpinned basement, as a result of unloading of the underlying soils has been carried out using the Oasys P-Disp software package and is based on the assumption that the soils behave elastically, which provides a reasonable approximation to soil behaviour at

15 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

small strains. The movements predicted by the P-Disp assessment have been imported into the X-Disp model and a combined model and building damage assessment was completed. X-Disp uses the movement curves for embedded retaining walls contained within CIRIA C760[16] and this approach is considered to be conservative.

The soil parameters used in the P-Disp assessment are tabulated below.

Stratum	Depth range (m)	Level range (m OD)	Eu (MPa)	E' (MPa)
Made Ground	GL to 1.0	32.0 to 31.0	10.0	10.0
London Clay	1.0 to 47.0	31.0 to -15.0	22.5 to 264.0	16.87 to 198.0

A rigid boundary for the analysis has been set at the base of the London Clay at roughly 47 m below ground level, where the closest deep BGS borehole record (ref TQ28SE1490) indicates that the base of this formation is likely to be present.

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction parallel with the orientation northwest-southeast, whilst the y-direction is parallel with the orientation of northeast-southwest. Vertical movement is in the z-direction. Wall lengths of less than 10 m have been modelled as 1 m long structural elements, while walls greater than 10 m in length have been modelled as 2 m elements to reflect their greater stiffness. The full outputs of all the analyses can be provided on request and samples of the output movement contour plots are included within the appendix.

Results

The predicted movements are based on the worst case of the individually analysed segments of 'hogging' and 'sagging' and these are summarised in the table below. It should be noted that the combined effect of segments acting together typically improves the resultant movements and the values below are therefore deemed to be conservative. The diagram in Section 9.1 details the relevant sensitive structures in relation to the proposed excavations.

The results are tabulated below and have been presented to the degree of accuracy required to allow predicted variations in ground movements around the structures to be illustrated, but may not reflect the anticipated accuracy of the predictions.

Short Term Movements

Sensitive Structure	Structure Reference	Vertical Movement (Settlement) (mm)	Horizontal Movement (mm)
Salvation Army Citadel	A	3	4
	B	9	< 1
	C	4	7
	D	< 1	2
Haverstock School	E to G	< 1	< 1
Chalk Farm station	H to J	< 1	< 1
Depot adjacent to Chalk Farm station	K	< 1	< 1

16 Gaba, A, Hardy, S, Powrie, W, Doughty, L and Selemetas, D (2017) *Embedded retaining walls – guidance for economic design* CIRIA Report C760

Total Movements

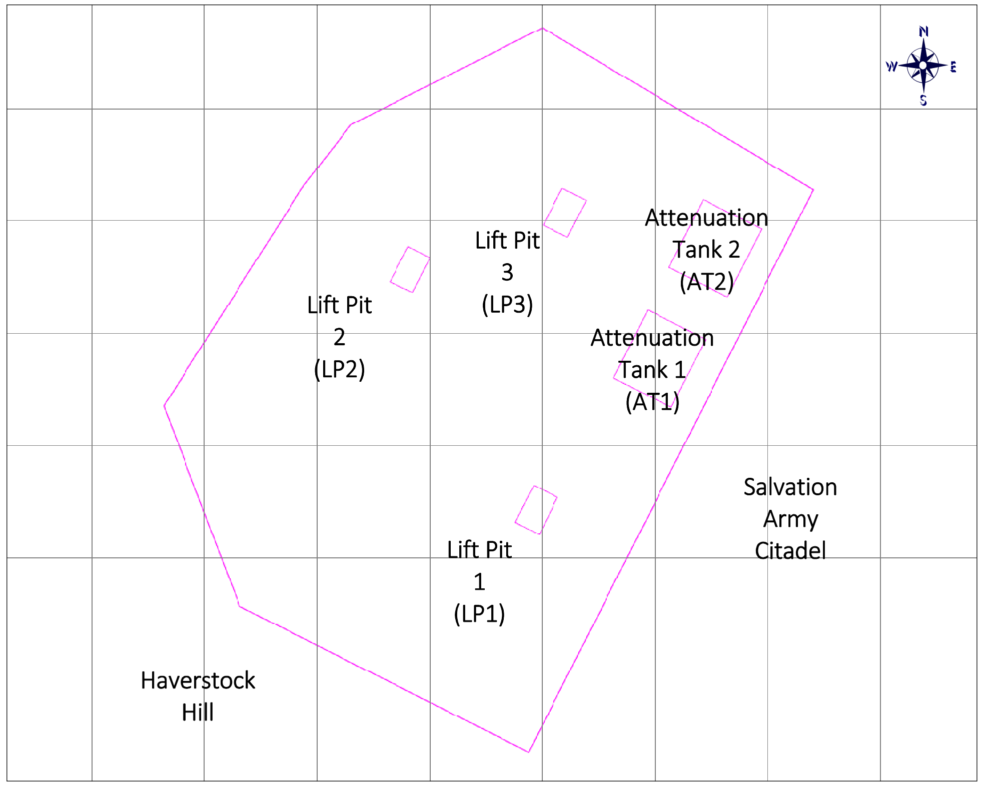
Sensitive Structure	Structure Reference	Vertical Movement (Settlement) (mm)	Horizontal Movement (mm)
Salvation Army Citadel	A	5	4
	B	10	< 1
	C	4	7
	D	< 1	2
Haverstock School	E to G	< 1	< 1
Chalk Farm station	H to J	< 1	< 1
Depot adjacent to Chalk Farm station	K	< 1	< 1

The analysis has indicated that the maximum vertical settlements and horizontal movements that will result from the demolition of the existing building, new retaining wall construction, including underpinning, are likely to be up to around 10 mm. Furthermore, the analysis has indicated that the maximum vertical settlements and horizontal movements that will result from the excavation are around 10 mm or less.

Results

The P-Disp analysis indicates that, by the time the basement construction is complete, between around 5 mm to 10 mm of heave is likely to have taken place at the centre of the proposed excavation, reducing to around 5 mm to 6 mm at the edges. In the long term, additional movements at the centre of the basement are likely to be around 5 mm to 10 mm and will occur in the long term over many years.

The results of the P-Disp analysis can be used to indicate the likely impact of the proposed basement construction beyond the site boundaries; about 5 m away from the excavation a total movement of around 5 mm to 10 mm is predicted. Movements outside the excavation will be constrained to a certain extent by the presence of the new retaining walls.



A void or layer of compressible material may need to be incorporated into the design 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 30 % to 40 % of the total unloading pressure.

9.3 Building Damage Assessment

In addition to the above assessment of the likely movements that will result from the proposed development, the neighbouring buildings are considered to be sensitive structures, requiring Building Damage Assessments, on the basis of the classification given in Table 6.4 of C760[1].

All structures are shown on the plan in Section 9.1.

9.3.1 Damage to Neighbouring Structures

The movements resulting from the basement construction have been estimated using the X-Disp modelling software to carry out an assessment of the likely damage to adjacent properties. The results are summarised for the combined wall installation and basement excavation in the table overleaf.

The heave movements have been incorporated into the underpin retaining wall predicted movements. The analysis can therefore be considered as conservative, as these movements are likely to have a mitigating effect on the downward settlement predicted by X-Disp.