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Gondar Gardens Report

Basement Impact Assessment – Land Stability

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Prepared for:
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1 INTRODUCTION

The purposes of this report is asses the impact of the proposed basement development at the Former Gondar Gardens Reservoir site in accordance with Camden Planning Guidance Document 'Basement and Lightwells CPG4', this report however only deals with the issues of Land Stability and effects on adjoining structures and therefore should be read in conjunction with other reports which deal with other issues which CPG4 requires to be addressed.

In accordance with CPG4 a slope stability screening review was undertaken and it was concluded that a Basement Impact Assessment was required.

2 SITE HISTORY

The site is located in Gondar Gardens, London. The site comprises a former Thames Water buried reservoir structure constructed on circa 1890 located within a residential area of West Hampstead near Shoot Up Hill. The overall site is rectangular in shape and approximately 1.2ha.

It is of note that the existing reservoir does not extend beneath the site to the extent to the east.

The national grid reference for the approximate centre of the site is 524840E 185310 N.

The site is bounded on 3 sides by residential dwellings and on the remaining side by Gondar Gardens.

The existing reservoir structure is a masonry structure and formed from arched perimeter walls braced with profile buttresses. The roof structure is formed from barrel vaulted arches supported on cruciform masonry columns.

The existing reservoir was partly constructed into the natural ground profile and then adjacent ground levels were raised to cover the structure.

3 DEVELOPMENT PROPOSALS

The development proposals are to develop the front portion of the site which fronts Gondar Gardens. The proposals will incorporate the existing buried reservoir structure as a basement in part, and require additional excavations to form new sections of lower ground and basement structure, mainly to the front elevation and adjacent to 1-6 Chase Mansions. Adjacent structures are very close to the proposed new retaining structures and particular attention needs to be paid to protection of the adjacent third party assets. Lateral support will need to be provided prior to commencement of excavation.

To the rear of the frontage scheme the proposal is to demolish the existing reservoir roof structure retaining the perimeter masonry arched walls and buttresses. Between the retained buttresses a crushed fill material will be placed to form sloped banks down to the enhanced landscaped habitat area of the former reservoir structure.

The scheme proposals in the general arrangement drawings, sections and details are shown on drawings SK110 P3, SK120 P3, SK130 P3, SK200 P3, SK210 P2 and SK220 P2 a copy of these are contained within Appendix A.

Within the frontage scheme there are requirements to remove the current buttresses which brace the vertical perimeter masonry arches. It is intended to construct new reinforced vertically spanning RC walls in front of the arches sequentially.

These will span between the basement floor, lower ground and ground floors of the new reinforced concrete framed development with the RC floor plates acting as diaphragms transferring lateral loads across the floor plates which will either be resisted by forces in opposing directions or by the core walls to the development. During construction temporary works may be required utilising diagonal temporary propping to provide lateral support to the walls.

Once the walls are constructed, the void between the rear of the new RC wall and the existing masonry arch will be in filled with a foamed concrete. Once the arches are supported via the new RC lining walls the buttresses will be demolished and completed to form a continuous concrete box, a proposed detail of which is shown on drawing SK200 P3.

Where excavations are required to form lower ground and basement areas retaining structures will be required. These structures will be simple vertical retaining structures which provide lateral support.

The proposed building will be founded at depth on piles into the London Clay to minimise the risks of differential settlement due to the different founding levels.

It is currently assumed that for the areas of retaining structure that are non vertically load bearing–these will be constructed using either Permanent Sheet Piles or Contiguous Piles which are then faced with a concrete lining wall.

Where the retaining walls need to support both vertical and horizontal loads then contiguous piles will be utilised.

4 ASSESSMENT OF SITE GEOLOGY

The British Geological Survey Sheet 256 (1:50,000 Scale), drift edition, indicates that the geology of the site comprises the London Clay formation.

Due to the presence of the buried reservoir structure, Made Ground and reworked London Clay are likely to be present on the site.

No mining, quarrying or land reclamation activities are recorded as having taken place within 2km of the site.

These inferred conditions have been generally confirmed by the intrusive investigation undertaken by RSK report ref 23283-1(00) dated December 2009, a copy of which is included within Appendix C.

5 GEOTECHNICAL PARAMETERS

This section describes the materials encountered beneath the site and presents material parameters and properties considered appropriate for this preliminary geotechnical design. Where possible these properties were based on results obtained from testing samples, however only one borehole has been carried out on site and hence testing data is limited. Therefore in general empirical correlations based on the available data for all exploratory holes on the site have been used to derive design parameters. The general ground conditions for the site are summarised in Table 5.1. The exploratory logs for the site as provided by the site investigation contractor, RSK, are included in Appendix C.

Table 5.1 General ground conditions for site at Gondar Gardens

Strata	Depth Top Encountered (m bgl)	Depth Bottom Encountered (m bgl)	Thickness range (m)
Made Ground	0.0	0.5 to >4	0.5 to >4
Weathered London Clay	0.5 to 2.2	8.8	8.3
Unweathered London Clay	8.8	>20	>11.2

5.1 Made Ground

5.1.1 *Material Description*

Made Ground was encountered in all boreholes with thickness ranging from 0.5 to at least 4m. The extent of the Made Ground was not proven in PH4 or PH5. The Made Ground is generally described as silty sandy clay with fine to coarse gravel, stone and fragments of concrete, brick and roots to depths of up to 1m, under which it is generally described as remoulded firm to stiff brown silty clay with occasional gravel, occasional pockets of sand and occasional fragments of brick and roots. This is likely to be reworked London Clay associated with construction of the reservoir. PH3 and PH7 show a layer of sand and gravel with stone 0.1m to 0.3m in thickness at a depth of 0.3m to 0.8m bgl.

5.1.2 *Material Properties*

16 No. SPT tests (using both open and solid modes) were carried out within the Made Ground. The N values ranged from 5 to 18, with an average value of 9.

The parameters derived for this material are summarised in Table 5.2, below.

Table 5.2 Derived parameters for Made Ground

Material	Cu (kPa)	E (MPa)	φ' (°)	c' (kPa)
Made Ground	35	12.2	20	0

5.2 Weathered London Clay

5.2.1 *Material Description*

Weathered London Clay was encountered in all exploratory holes on the site except PH4 and PH5. The top of the stratum was encountered between 0.5 and 1.9 m bgl.
The base of the stratum was encountered in BH1 only, at a depth of 8.8m bgl. The material is generally described as firm becoming stiff and very stiff brown occasional mottled grey silty CLAY with occasional fine to medium gravel and occasional pockets of sand. Due to the presence of tree roots, the clay within PH1, PH2, PH3 and PH7 is considered to have been desiccated during dry seasons in the past to about 3.0mbgl.

Due to the presence of gravel and pockets of sand, it is possible that some reworking of the material has taken place at the time of the construction of the reservoir.

5.2.2 *Material Properties*

13 No. SPT tests (using both open and solid modes) were carried out within the Weathered London Clay. The N values ranged from 11 to 31, with an average value of 18.

4 No. Atterberg Limit tests were carried out within the Weathered London Clay. The plasticity index values ranged from 42% to 48%.

3 No. Unconsolidated Undrained Triaxial Compression tests were carried out within the Weathered London Clay. All tests were undertaken on samples from BH1, and therefore indicate properties at one location only. The undrained shear strength values ranged from 78kPa to 110kPa.

The parameters derived for this material, considering in situ and laboratory data, are summarised in Table 5.3, below.

Table 5.3 Derived parameters for Weathered London Clay

Material	Cu (kPa)	E (MPa)	φ' (°)	c' (kPa)
Weathered London Clay	60	21	22	0

5.3 Unweathered London Clay

5.3.1 *Material Description*

Unweathered London Clay was encountered in BH1 at a depth of 8.8m bgl. The base of the stratum was not proven. The material is described as stiff grey silty CLAY with occasional fine gravel and occasional pockets of sand.

5.3.2 *Material Properties*

4 No. SPT tests were carried out within the Unweathered London Clay. The SPT N values ranged from 20 to 32, with an average value of 24.

4 No. Unconsolidated Undrained Triaxial Compression tests were carried out within the Unweathered London Clay. All tests were undertaken on samples from BH1, and therefore indicate properties at one location only. The undrained shear strength values ranged from 144kPa to 215kPa.

The parameters derived for this material, considering in situ and laboratory data, are summarised in Table 5.4, below.

Table 5.4 Derived parameters for Unweathered London Clay

Material	Cu (kPa)	E (MPa)	φ' (°)	c' (kPa)
Unweathered London Clay	95	33.2	22	0

5.4 Groundwater

Groundwater seepage was encountered at a depth of 13m bgl in BH1. Groundwater was not encountered in any other locations.

No groundwater monitoring has been carried out. The level of the groundwater table is therefore unknown and will vary seasonally.

Basements are typically designed to survive ground water levels at the surrounding ground level. Whilst it may be considered unlikely to occur, this is s sensible safety precaution to ensure that catastrophic failure does not occur to the substructure of the development.

5.5 Ground model assumed for analysis of basement retaining wall

The ground model for the basement retaining wall at the Gondar Gardens edge of the site has been based the nearest exploratory holes; BH1, PH1, PH2 and PH7. The exploratory holes located further from the proposed basement retaining wall show a much greater thickness of Made Ground. The potential effect of a greater thickness of Made Ground on the design of the retaining wall should be considered during detailed design.

The material properties have been adopted as detailed above based on all exploratory holes within the site. Only one borehole has been undertaken and testing is very limited, particularly below 4m bgl (the extent of the probe holes). All parameters have therefore been derived by empirical correlations and should be validated for detailed design.

The adopted ground model is summarised in Table 5.5, below.

Table 5.5 Ground model and material parameters for analysis of basement retaining wall

Material	Depth to top of strata (m bgl)	Thickness of strata (m)	Cu (kPa)	E (MPa)	φ' (°)	c' (kPa)
Made Ground	0.0	2.2	35	12.2	20	0
Weathered London Clay	2.2	6.6	60	21	22	0
Unweathered London Clay	8.8	-	95	33.2	22	0

5.6 Engineering Interpretation

This section assesses the predicted lateral wall movements of the proposed retaining walls and ground movements behind these walls at five cross-section locations (A-A, B-B, C-C, D-D and E-E). These cross-sections and their locations are shown in on the scheme proposals contained within appendix A.

The lateral movements of the proposed retaining walls and the ground movements and potential damage to structures behind the walls have been assessed using the methods set out in CIRIA

C580 Section 2.5.2 and Section 2.5.4. The method within CIRIA C580 for predicting ground movements behind the walls is an empirical method based on field measurements from case histories of retaining walls installed in stiff clay. Estimates of lateral movements of the wall based on its stiffness are obtained from a chart in CIRA C580 which is based on results of finite element analysis rather than the empirical data used to predict movements in the ground behind the walls. Although these two methods within CIRIA C580 use data from different sources, the results for the lateral movements of the wall and the settlements of the ground behind it should be compatible provided that a system of appropriate stiffness has been chosen.

Predicted ground movements and lateral wall deflections have been estimated by using the CIRIA C580 methods outlined above. The deflections and settlements have then been compared to check that the results obtained are of a similar magnitude, indicating that the system stiffness proposed is appropriate to the predicted movements.

The effect of vertical loading on the retaining walls has not been assessed as this is not considered as part of the CIRIA C580 approach. The vertical loading may cause some localised additional vertical settlement. However, this is likely to be small when compared to the settlements due to installation of the wall and excavation in front of the wall. Some additional pile length may be required at appropriate locations to support the vertical loads. This should be assessed further at the detailed design stage at appropriate locations.

All predicted deflections and settlements and suggested pile lengths and diameters are the result of a preliminary assessment only and shall be confirmed during detailed design.

5.7 Design assumptions

All proposed retaining walls have been assumed to be contiguous bored pile walls of moderate to high system stiffness.

Dimensions used for the analysis have been taken from preliminary architects' drawings and plans.

It has been assumed that all proposed retaining walls will be installed from the reduced ground level prior to any excavation taking place in front of the retaining walls. Where there are two separate walls (upper and lower), it has been assumed that both walls have been installed from the reduced ground level and that the lower wall has been cut to its final level following excavation in front of the upper wall.

Loading on the proposed retaining walls from the existing structures is not considered as part of the CIRIA C580 assessment. These loads should be considered during the detailed design stage.

Detailed design shall also include an assessment of any settlements which may affect the adjacent structures as a result of the loading from the proposed building and its foundations. These settlements are likely to be small compared to the settlements resulting from the retaining walls.

5.8 Analysis of wall behaviour (based on CIRIA C580)

Assessments have been made of the wall movements and the effects of ground movements on the adjacent assets using the empirical approaches outlined above.

The assumed behaviour of the wall as defined in CIRA C580 will be used to set the performance specification for the detailed design of the retaining structure.

Detailed design calculations which demonstrate compliance will be submitted during the detailed design phase.

5.8.1 *Ground settlements*

The predicted ground movements have been estimated using the empirical methods set out in CIRIA C580 Section 2.5.2. It is not possible to predict ground movements accurately without good ground data and significant time spent on analyses, and the below values are estimations only based on field measurements of previously constructed walls in stiff clay. The magnitude of ground movements due to installation is largely dependent on the quality of workmanship and large local ground movements can be expected where construction problems are encountered.

All walls have been assumed to be contiguous bored pile walls. Moderate to high support stiffness has been assumed as it has been considered that the ground floor and lower ground floor will act as props at the top of the upper and lower walls respectively. Where light wells are present, careful consideration should be given during detailed design to the system stiffness and buttresses or props across the light wells may be required to avoid the use of larger diameter piles.

The embedded length of the retaining walls has been assumed to be 2.5 times the retained height to provide a high factor of safety and hence better performance.

All ground movements are conservatively quoted are at ground level, as exact foundation depths of the adjoining buildings are unknown. Settlements at the founding level of 1-6 Chase Mansions and 1-6 St Elmo Mansions and hence settlements of this building should be less than those quoted.

Cross-section drawings showing the sections described below are presented in Appendix A.

Section A-A

The ground movements under 1-6 Chase Mansions due to installation of the piles and due to excavation in front of the retaining wall have been estimated using Figure 2.8 and Figure 2.11 of CIRIA C580.

The removal of existing material to the proposed reduced ground level will cause settlements to 1-6 Chase Mansions. To give a conservative estimate of the potential ground movements due to the reduction of the ground level as well as the installation of and excavation in front of the wall, it has been assumed that the retained height of the wall includes the thickness of the removed material.

The estimated ground movements are summarised inTable 5.7, below.

Table 5.6 Approximate Ground Movements Behind Wall at Section A-A

Horizontal Distance from Wall to Near Edge of 1-6 Chase Mansions (m)		1.95
Approximate Predicted Ground Surface Movements at Near Edge of 1-6 Chase Mansions (mm)	Horizontal	9 to 12
	Vertical	7 to 9

Ground movements at the far edge of 1-6 Chase Mansions at this cross-section location are less than 5mm.

Section B-B

The ground movements under 1-6 Chase Mansions and 1-6 St Elmo Mansions due to installation of the piles and due to excavation in front of the retaining walls have been estimated using Figure 2.8 and Figure 2.11 of CIRIA C580.

The removal of existing material to the proposed reduced ground level will cause settlements to 1-6 Chase Mansions and 1-6 St Elmo Mansions. To give a conservative estimate of the potential ground movements due to the reduction of the ground level as well as the installation of and excavation in front of the wall, it has been assumed that the retained height of the upper wall includes the height of the material removed.

The retained height assumed for the lower wall is equal to the actual retained height as the movements due to the removal of the upper material has already been considered during the assessment of the outer wall. It is currently proposed to install the piles for the lower wall from the reduced level, prior to excavation in front of the outer wall. The piles will be cut to the correct level when the excavation takes place. The total pile length assumed for movements due to installation has included this additional height.

To calculate the total ground movements beneath the structure, the estimated movements from each wall have been superposed. Any interaction effects that may exist between the two walls have not been considered.

The estimated ground movements are summarised in Table 5.7, below.

Table 5.7 Approximate Ground Movements Behind Upper Wall at Section B-B

Horizontal Distance from Upper Wall to Near Edge of 1-6 Chase Mansions (m)		0.9
Horizontal Distance from Lower Wall to Near Edge of 1-6 Chase Mansions (m)		5.8
Approximate Ground Surface Movements at Near Edge of 1-6 Chase Mansions due to installation of and excavation in front of Upper Wall (mm)	Horizontal	10 to 15
	Vertical	7 to 10
Approximate Ground Surface Movements at Near Edge of 1-6 Chase Mansions due to installation of and excavation in front of Lower Wall (mm)	Horizontal	7 to 10
	Vertical	7 to 8
Approximate Total Predicted Ground Surface Movements at Near Edge of 1-6 Chase Mansions (mm)	Horizontal	17 to 25
	Vertical	14 to 18

Ground movements at the far edge of 1-6 St Elmo Mansions are negligible.

The estimated ground movements presented above are a conservative estimate as they do not consider interaction between the two walls. Detailed design is likely to show movements lower than those estimated at this stage.

Section C-C

The ground movements under the Gondar Gardens road and footpaths due to installation of the piles and due to excavation in front of the retaining walls have been estimated using Figure 2.8 and Figure 2.11 of CIRIA C580.

The removal of existing material to the proposed reduced ground level will cause settlements to Gondar Gardens. To give a conservative estimate of the potential ground movements due to the reduction of the ground level as well as the installation of and excavation in front of the wall, it has been assumed that the retained height of the upper wall includes a 1m thick layer of removed material.

The retained height assumed for the lower wall is equal to the actual retained height as the movements due to the removal of the upper material has already been considered during the assessment of the outer wall. It is currently proposed to install the piles for the lower wall from the reduced level, prior to excavation in front of the outer wall. The piles will be cut to the correct level when the excavation takes place. The total pile length assumed for movements due to installation has included this additional height.

To calculate the total ground movements beneath the structure, the estimated movements from each wall have been superposed. Any interaction effects that may exist between the two walls have not been considered.

The estimated ground movements are summarised in Table 5.8, below.

Table 5.8 Approximate Ground Movements Behind Upper Wall at Section C-C

Horizontal Distance from Upper Wall to Near Edge of Gondar Gardens Footpath (m)		0.6
Horizontal Distance from Lower Wall to Near Edge of Gondar Gardens Footpath (m)		6.1
Approximate Ground Surface Movements at Near Edge of Gondar Gardens Footpath due to installation of and excavation in front of Upper Wall (mm)	Horizontal	10 to 15
	Vertical	6 to 10
Approximate Ground Surface Movements at Near Edge of Gondar Gardens Footpath due to installation of and excavation in front of Lower Wall (mm)	Horizontal	6 to 10
	Vertical	6 to 8
Approximate Total Predicted Ground Surface Movements at Near Edge of Gondar Gardens Footpath (mm)	Horizontal	16 to 25
	Vertical	12 to 18

Ground movements at the far edge of the Gondar Gardens road and footpaths are less than 5mm, which are considered negligible.

The estimated ground movements presented above are considered to be a conservative estimate as they do not consider interaction between the two walls. Detailed design is likely to show movements lower than those estimated at this stage.

Section D-D

The ground movements under the Gondar Gardens road and footpaths due to installation of the piles and due to excavation in front of the retaining wall have been estimated using Figure 2.8 and Figure 2.11 of CIRIA C580.

The removal of existing material to the proposed reduced ground level will cause settlements to Gondar Gardens. To give a conservative estimate of the potential ground movements due to the reduction of the ground level as well as the installation of and excavation in front of the wall, it has been assumed that the retained height includes a 1m thick layer of removed material.

The estimated ground movements are summarised in
Table 5.9, below.

Table 5.9 Approximate Ground Movements Behind Wall at Section D-D

Horizontal Distance from Wall to Near Edge of Gondar Gardens Footpath (m)		1.5
Approximate Total Predicted Ground Surface Movements at Near Edge of Gondar Gardens Footpath (mm)	Horizontal	9 to 12
	Vertical	7 to 9

Ground movements at the far edge of the Gondar Gardens road and footpaths are less than 5mm, which are considered negligible.

Section E-E

The ground movements under the Gondar Gardens road and footpaths due to installation of the piles and due to excavation in front of the retaining wall have been estimated using Figure 2.8 and Figure 2.11 of CIRIA C580.

The removal of existing material to the proposed reduced ground level will cause settlements to Gondar Gardens. To give a conservative estimate of the potential ground movements due to the reduction of the ground level as well as the installation of and excavation in front of the wall, it has been assumed that the retained height includes a 1.5m thick layer of removed material.

The estimated ground movements are summarised in Table 5.10, below.

Table 5.10 Approximate Ground Movements Behind Wall at Section E-E

Horizontal Distance from Wall to Near Edge of Gondar Gardens Footpath (m)		4.3
Approximate Total Predicted Ground Surface Movements at Near Edge of Gondar Gardens Footpath (mm)	Horizontal	16 to 20
	Vertical	13 to 16
Approximate Total Predicted Ground Surface Movements at Far Edge of Gondar Gardens Road and Footpaths (mm)	Horizontal	8 to 10
	Vertical	7 to 8

As the lower ground floor of the proposed building will act as a prop mid-way down the wall as well as the ground floor acting as a prop at the top of the wall, it is likely that movements will be closer to the lower end of the ranges given above.

5.8.2 *Impact on adjacent structures - effects of potential ground movement and comment on stability of existing foundations*

The effects of the estimated ground movements presented in Section 5.8.1 on the adjacent structures have been assessed using Figure 2.18 and Box 2.5 of CIRIA C580. This method assigns a damage category to the adjacent structure based on the deflection ratio and the horizontal strain across the structure, assuming that the structure is of negligible stiffness.

Section A-A

At this cross-section location, 1-6 Chase Mansions is separate from the adjacent 1-6 St Elmo Mansions. As no elevation data is available for the rear of the building, it has been assumed that the height of the structure is the same as the height at the front of the building. It has been assumed that the ground behind the retaining walls and the ground underneath 1-6 Chase Mansions is flat and is at the same level as the ground directly behind the retaining wall. The building at 1-6 Chase Mansions has been assumed to be of negligible stiffness.

The settlements estimated in Section 5.8.1 imply that for 1-6 Chase Mansions a damage category of 1 to 2 applies at the location of this cross-section.

The description from CIRIA C580 of the typical damage for Damage Category 1 is as follows:

"Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection."

The description from CIRIA C580 of the typical damage for Damage Category 2 is as follows:

"Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly."

This assessment of the damage category is based on conservative estimates of the ground movements and assumes that the structure has negligible stiffness.

The ground movements used in this assessment are at ground level. Settlements at the founding level of 1-6 Chase Mansions and hence settlements of this building should be less. It is therefore likely that the actual damage to the structure will be less than that described above.

Section B-B

At this cross-section location, 1-6 Chase Mansions is joined to the adjacent 1-6 St Elmo Mansions. It has been assumed that the ground behind the retaining walls and the ground underneath 1-6 Chase Mansions and 1-6 St Elmo Mansions is flat and is at the same level as the ground directly behind the retaining wall. 1-6 Chase Mansions and 1-6 St Elmo Mansions have been assumed to be acting as a single building of negligible stiffness.

Although the ground movements at the far side of 1-6 St Elmo Mansions are negligible, the method assesses strain and deflection across the whole building, therefore the damage category assigned applies to both 1-6 Chase Mansions and 1-6 St Elmo Mansions. A detailed damage assessment could be undertaken at the detailed design stage to further investigate the soil-structure interaction and the extent and location of likely damage to 1-6 Chase Mansions and 1-6 St Elmo Mansions if this is considered necessary.

The settlements estimated in Section 5.8.1 imply that for 1-6 Chase Mansions and 1-6 St Elmo Mansions a damage category of 2 applies as described for Section A-A, above.

This assessment of the damage category is based on conservative estimates of the ground movements and assumes that the structure has negligible stiffness. The ground movements used in this assessment are at ground level. Settlements at the founding level of 1-6 Chase Mansions and 1-6 St Elmo Mansions and hence settlements of this building should be less. It is therefore likely that the actual damage to the structure will be less than that described above.

Section C-C

It has been assumed that the ground behind the retaining walls and the ground underneath the Gondar Gardens road and footpaths is flat and is at the same level as the ground directly behind the retaining wall. The roads and footpaths have been assumed to be acting as a single structure of negligible stiffness.

The CIRIA C580 method for assessment of damage category is for assessment of buildings. For the purposes of assigning a category to the Gondar Gardens road for this assessment, the method has been used with the highest structure length to height ratio (L/H=4) given within CIRIA C580.

The settlements estimated in Section 5.8.1 imply that for the Gondar Gardens road and footpaths a damage category of 2 applies as described for Section A-A, above.
As the road and pavements will be built from more flexible material than a brittle masonry structure and the road is a flexible thin layer and not a fully three-dimensional building, it is unlikely that significant cracking of the road surface will occur. Should any cracking occur, local repairs to the footpath and roadway may be required. Services are unlikely to be affected.

This assessment of the damage category is based on conservative estimates of the ground movements. It is therefore likely that the actual damage to the structure will be less than that described above.

Section D-D

It has been assumed that the ground behind the retaining walls and the ground underneath the Gondar Gardens road and footpaths is flat and is at the same level as the ground directly behind the retaining wall. The roads and footpaths have been assumed to be acting as a single structure of negligible stiffness.

The CIRIA C580 method for assessment of damage category is for assessment of buildings. For the purposes of assigning a category to the Gondar Gardens road for this assessment, the method has been used with the highest structure length to height ratio (L/H=4) given within CIRIA C580.

The settlements estimated in Section 5.8.1 imply that for the Gondar Gardens road and footpaths a damage category of 1 to 2 applies as described for Section A-A, above.

As the road and pavements will be built from more flexible material than a brittle masonry structure and the road is a flexible thin layer and not a fully three-dimensional building, it is unlikely that significant cracking of the road surface will occur. Should any cracking occur, local repairs to the footpath and roadway may be required. Services are unlikely to be affected.

This assessment of the damage category is based on conservative estimates of the ground movements. It is therefore likely that the actual damage to the structure will be less than that described above.

Section E-E

It has been assumed that the ground behind the retaining walls and the ground underneath the Gondar Gardens road and footpaths is flat and is at the same level as the ground directly behind the retaining wall. The roads and footpaths have been assumed to be acting as a single structure of negligible stiffness.

The CIRIA C580 method for assessment of damage category is for assessment of buildings. For the purposes of assigning a category to the Gondar Gardens road for this assessment, the method has been used with the highest structure length to height ratio (L/H=4) given within CIRIA C580.

The settlements estimated in Section 5.8.1 imply that for the Gondar Gardens road and footpaths a damage category of 2 applies as described for Section A-A, above.

As the road and pavements will be built from more flexible material than a brittle masonry structure and the road is a flexible thin layer and not a fully three-dimensional building, it is unlikely that significant cracking of the road surface will occur. Should any cracking occur, local repairs to the footpath and roadway may be required. Services are unlikely to be affected.

This assessment of the damage category is based on conservative estimates of the ground movements. It is therefore likely that the actual damage to the structure will be less than that described above.

Existing Foundations of Adjacent Structures

It has been assumed that the foundations of 1-6 Chase Mansions are at the same distance behind the proposed retaining walls as the existing outer wall of the building that they support. No light wells can been seen, indicating that it is unlikely that any existing basement structures beneath 1-6 Chase Mansions and 1-6 St Elmo Mansions are present.

Loading on the proposed retaining walls from the existing structures is not considered as part of the CIRIA C580 assessment. For costing purposes, the proposed piles could be increased to one pile size larger to allow for the additional loading on the walls, but this should be assessed fully during detailed design.

Detailed design shall also include an assessment of any settlements which may affect the adjacent structures as a result of the loading from the proposed building and its foundations. These settlements are likely to be small compared to the settlements resulting from the retaining walls. The final design should develop a construction sequence that will limit damage in the adjacent assets to category 2 or as agreed with the asset owners.

5.8.3 *Deflection based on preliminary assumptions of adopted wall stiffness*

The predicted lateral wall movement can be estimated using Figure 2.13 of CIRIA C580.

System stiffness is defined as $\rho_s = EI / (\gamma_w h^4)$ where EI is the Young's modulus multiplied by the second moment of area of the wall section, γ_w is the bulk unit weight of water and h is the average vertical prop spacing.

For the lateral wall movements presented below, it has been assumed that each wall is propped at the top and that there is a prop half way down the retained height of each wall, with the exception of Section E-E, where it has been assumed that the wall has been propped at intervals of 0.25 times the retained height. All permanent structures shall be constructed to provide adequate stiffness prior to any temporary propping being removed. Assumed prop spacings are for the purposes of this preliminary assessment only and shall be further assessed during detailed design. At sections where two retaining walls are proposed, the upper wall shall be propped to a point beyond the lower wall. If the use of props is not considered desirable, it is likely that larger pile diameters than those presented below will be required in order to achieve an adequate system stiffness.

Approximate lateral movements have been calculated for pile diameters of 300mm, 450mm and 500mm. These diameters are indicative only and final pile diameters shall be confirmed during the detailed design stage. The wall deflections calculated are of a similar order of magnitude to the ground movements calculated in Section 5.2.1, indicating that an appropriate system stiffness can be achieved subject to detailed design.

Young's modulus E has been assumed to be equal to 15000MPa.

A factor of safety of at least 2.0 against basal heave has been assumed. This is a conservative estimate and it is likely that a factor of safety of at least 3 will be achieved, further reducing the estimated movements.

Section A-A

At section A-A, the approximate expected maximum lateral wall movements have been estimated as shown in Table 5.12, below. The movements of the ground behind the wall will decrease with distance from the wall.

Table 5.11 Predicted Lateral Movements for Propped Upper Wall at Section A-A

Pile Diameter (mm)	Retained Height (m)	Approximate Maximum Lateral Wall Movement (mm)
300	2.6	10
450		7
500		7

Section B-B

At section B-B, the approximate expected maximum lateral wall movements have been estimated as shown in Table 5.12 and
Table 5.13, below. The movements of the ground behind the wall will decrease with distance from the wall.

Table 5.12 Predicted Lateral Movements for Propped Upper Wall at Section B-B

Pile Diameter (mm)	Retained Height (m)	Approximate Maximum Lateral Wall Movement (mm)
300	3.0	10
450		9
500		8

Table 5.13 Predicted Lateral Movements for Propped Lower Wall at Section B-B

Pile Diameter (mm)	Retained Height (m)	Approximate Maximum Lateral Wall Movement (mm)
300	3.6	17
450		12
500		11

Although the estimated values for the maximum lateral wall movements for the lower wall appear high, the values are very conservative as the interaction between the two walls has not been considered. During detailed design it is likely that these values will be significantly reduced.

Section C-C

At section C-C, the approximate expected maximum lateral wall movements have been estimated as shown in Table 5.14 and
Table 5.15, below.

Table 5.14 Predicted Lateral Movements for Propped Upper Wall at Section C-C

Pile Diameter (mm)	Retained Height (m)	Approximate Maximum Lateral Wall Movement (mm)
300	3.0	10
450		9
500		8

Table 5.15 Predicted Lateral Movements for Propped Lower Wall at Section B-B

Pile Diameter (mm)	Retained Height (m)	Approximate Maximum Lateral Wall Movement (mm)
300	3.1	13
450		9
500		9

Although the estimated values for the maximum lateral wall movements for the lower wall appear high, the values are very conservative as the interaction between the two walls has not been considered. During detailed design it is likely that these values will be significantly reduced.

Section D-D

At section D-D, the approximate expected maximum lateral wall movements have been estimated as shown in Table 5.12, below. The movements of the ground behind the wall will decrease with distance from the wall.

Table 5.16 Predicted Lateral Movements for Propped Upper Wall at Section D-D

Pile Diameter (mm)	Retained Height (m)	Approximate Maximum Lateral Wall Movement (mm)
300	3	10
450		9
500		8

Section E-E

At section E-E, the approximate expected maximum lateral wall movements have been estimated as shown in Table 5.12, below. The movements of the ground behind the wall will decrease with distance from the wall.

It has been assumed that the wall has been propped at intervals of 0.25 times the retained height. If the lateral movements need to be further reduced, additional props will be required. The lower ground floor slab will act as a permanent prop and will reduce lateral movements. It shall be ensured that the permanent structure (including the lower ground floor slab and the stairwell present at this location) have been constructed to adequate stiffness before temporary propping is removed.

Table 5.17 Predicted Lateral Movements for Propped Upper Wall at Section E-E

Pile Diameter (mm)	Retained Height (m)	Approximate Maximum Lateral Wall Movement (mm)
300	5.8	23
450		17
500		15

6 MONITORING REQUIREMENTS

In the interests of all affected parties it is recommended that a monitoring program be designed and implemented. In conjunction with this and prior to undertaking works on site it is proposed to undertake a full condition survey, including a photographic survey of 1-6 Chase Mansions, 1-6 St Elmo Mansions, 1-6 South Mansions and Gondar Gardens to record the existing condition of the buildings and road.

Vertical and horizontal movement targets shall be placed at the top of the retaining walls. Up to four inclinometers may also be required within the piles at Sections A-A and B-B.

Settlement targets shall be placed on the side of 1-6 Chase Mansions adjacent to the site and along the Gondar Gardens road at intervals of 5m.

Prior to construction, three sets of baseline readings shall be taken from all targets. Monitoring of all targets and inclinometers shall be undertaken throughout construction at a frequency dependant on the activities taking place on the site at a given time.

Movements observed during construction should be compared with predicted movements for the same stage of the construction. Deviations of observed measurements from the predicted movements should be referred back to the designer for assessment and a decision on actions required.

A further two sets of monitoring are recommended within the first year of completion of works as some long term settlements due to the proposed building may occur.

APPENDIX A - Substructure Scheme Proposal Drawings

APPENDIX B - Topographical Survey Drawings

APPENDIX C - RSK Site Investigation Report