Project

Residential Development at Milltown Park, Sandford Road, Dublin 6

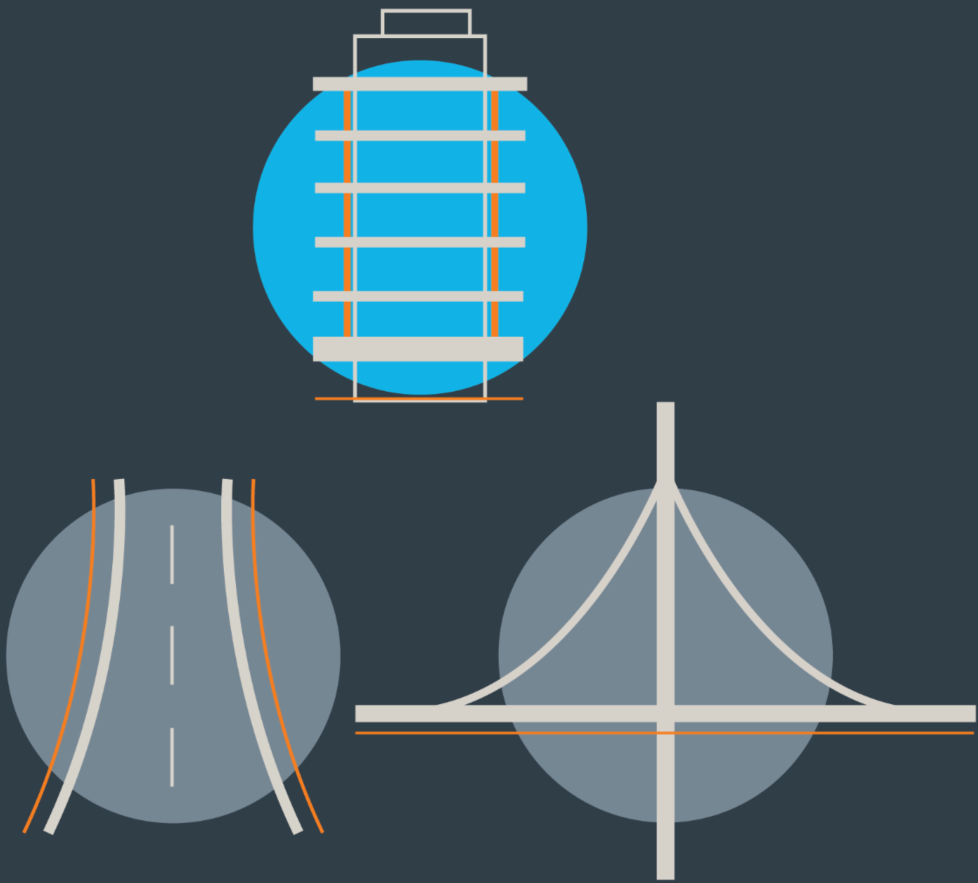
Report Title

Basement Impact Assessment

Client

Sandford Living Limited

STRUCTURES



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Project Number: 190226

Report Title: Basement Impact Assessment

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Table of Contents

1 INTRODUCTION

1.1 Structure of Report

This Basement Impact Assessment has been prepared for Sandford Living Ltd (part of Ardstone Capital Group) in respect of a proposed planning application for the development of 671 No. Apartments and associated amenities on the former Jesuit site at Milltown Park located between Sandford Road and Milltown Road in Ranelagh, Dublin 6. The development proposals include the following:

• Local Amenities

• Provision of New Site Access on Milltown Road

• 344 No. Car Parking Spaces (295 No. at basement level & 49 No. at surface level).

• Extensive Cycle Parking Spaces

This Basement Impact Assessment has been approached to address the key criteria with regard to both the temporary and permanent conditions. The permanent context of the new basement is addressed in the following core document. The temporary condition to occur during the basement excavation and construction is covered in Byrne Looby's '*Basement Impact Assessment Report'* (*Rep. No. B1694-GEO-R001*) in Appendix B of this report which details the key aspects of (i). incremental, progressive ground movement and (ii). an assessment of the hydrogeological characteristics of the site considering the new basement.

1.2 Description of Development

Sandford Living Limited intend to apply for planning permission for development of 671 No. Apartments on a site of c. 4.26 hectares at Milltown Park, Sandford Road, Dublin 6, D06 V9K7.

The site is bounded by Sandford Road to the North East and Milltown Road to the South East. The proposed development structures are however buffered from the road boundary by retained parkland. A handful of listed buildings are located across Sandford Road from the existing entrance gate to Milltown Park. They are Protected Structures RPS No's 7458, 7459, 7460 & 7461, comprising four semi-detached period houses fronting onto Sandford Road to the north east. Also, the closest of a row of houses along St. James's Terrace at no. 2 Clonskeagh Road which is Protected Structure RPS No 1909. The nearest protect structures are at least ≈70m away from the proposed basement structure.

The proposed development comprises the following:

- Provision of 671 No. Apartments in 7 no. blocks + Tabor House varying in height from 2 to 10 storeys
- Communal Amenities (including a creche, lounges, library and co-working space)
- Provision of New Site Access on Milltown Road. Sandford Road will be a secondary access to the site.
- 344 No. Car Parking Spaces (295 No. in the single level basement and 49 No. at ground level)
- Extensive Cycle Parking Spaces (three quarters in the basement with separate two-way bicycle ramp access and the rest at ground level)
- Provision of plant and ancillary services at basement level
- Hard and soft landscaping and all associated site works necessary to facilitate the development.

The proposed development has a gross floor area of 54,871 sq m above ground over a basement measuring 10,607 sq m.

1.3 Proposed Development

The proposed residential development comprises nine blocks four of which are over the single level basement. The residential scheme of 671 housing units. The development is augmented with a creche and resident services and amenities. The proposed development will include public and communal open spaces. The existing tree belt which is currently overgrown and unusable will be opened up for residents and the wider community to enjoy, providing a public woodland walk linking south to north entrances and retained and refurbished historic structures representing the historic use of Milltown Park as a religious and educational institutional sanctuary from the urban impetus. Building height ranges from two storeys to ten storeys. Communal gardens, terraces and roof gardens intersperse throughout the blocks. Private balconies and terraces punctuate all external elevations, save for the retained historic structures Tabor House and the Chapel.

1.3.1 Basement

With reference to **1.2 'Description of Development'** (above) – The main basement is a single level structure in two separate zones, Basement 1 beneath Blocks B & C with a floor level of +16.88mOD and Basement 2 beneath Blocks A2 & A1 with a floor level of +16.88mOD to +14.55mOD respectively. The main basement has capacity for 295 no. car parking spaces of the 344 total provided, with a top of car ramp level of +20.80mOD, three quarters of all bicycle parking racks including parking for cargo bikes, plant, services, bin storage, waste compactor and other storage areas for residents' support facilities.

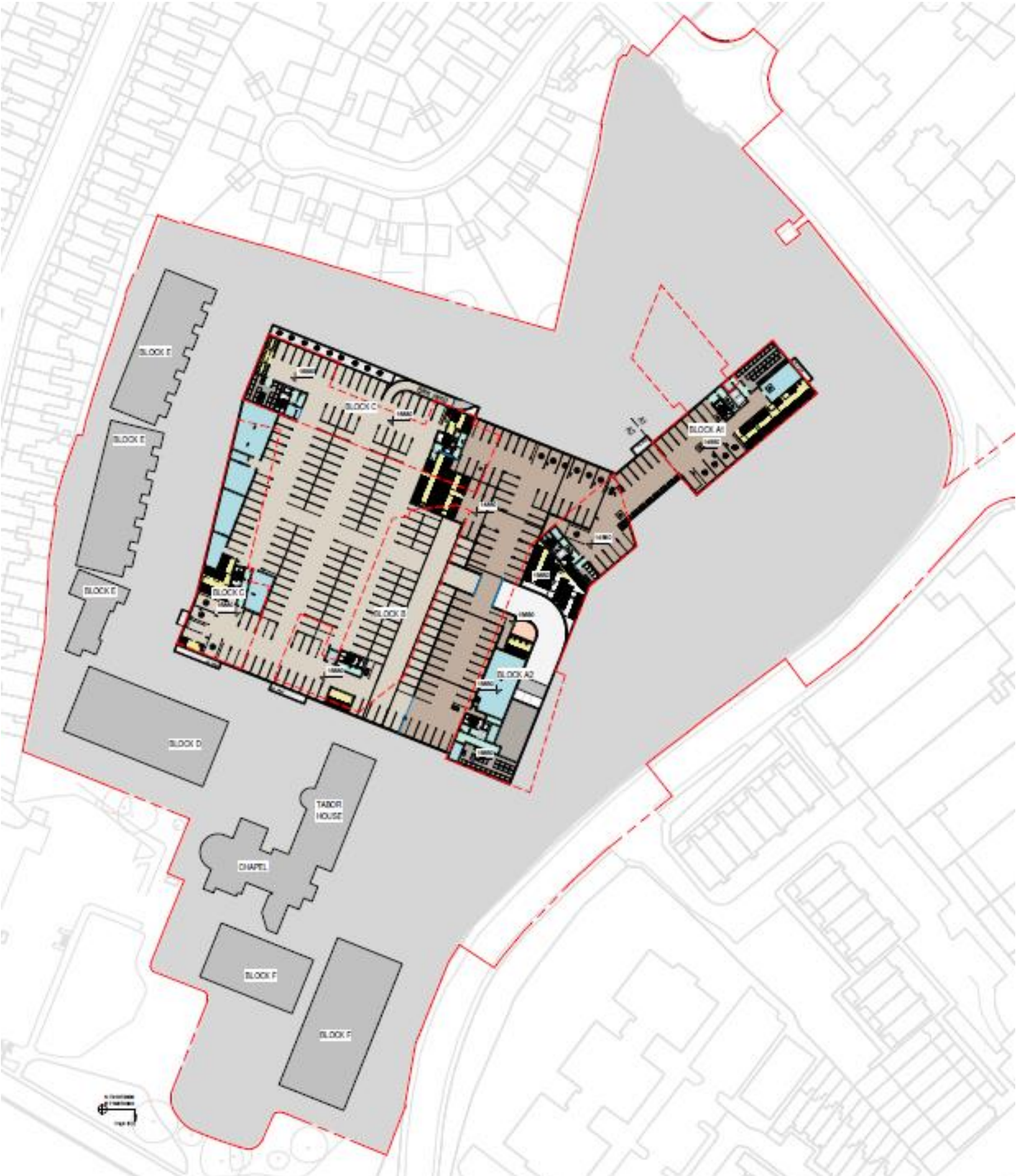


Figure 1 – Site plan and basement layout (OMP Architects)

1.3.2 Block A

Block A is notionally split into two sub blocks A1 and A2 separated by a three-storey high archway with apartments on the link bridge above the gap. Block A sits on a transfer slab at ground level to enable the main basement no. 2 car park layout below. Block A1 contains 94 apartments with the northeast corner extending up to 10 storeys above ground.

Block A2 contains 140 apartments with the southwest corner rising to 8 storeys. The main car park is accessed via a ramp into the basement in the southeast corner of this block alongside an ESB substation and switch-room, and bicycle parking lockups.

Figure 2 - Site Plan with Block references

1.3.3 Block B/C

Blocks B and C form a perimeter block surrounding a central courtyard space all above the main basement no. 1 car park facility. The podium deck and transfer slab at ground level facilitate the car parking flow and column layout below. Blocks B and C are connected across the courtyard passage via linkages at ground and upper levels.

Block B contains 91 apartments with the resident amenties and ESB substation, switch rooms up to part 7 storeys in height.

Block C contains 163 apartments up 8 storeys in part height.

1.3.4 Block D

Block D is a standalone block containing 39 apartments with no amenities or basement structure beneath.

1.3.5 Block E

Block E is made up of 14 triplex structures each containing a 2-bedroom ground floor apartment and a 3-bedroom duplex above giving a total of 28 residential units.

1.3.6 Block F

Block F is another standalone block containing 92 residential units, and a creche.

1.3.7 Tabor House

Tabor House is an existing 19th century 7 bay, 4 storey structure forming part of the conglomerate of original buildings housing the Jesuit institutional activities. It is one of two buildings which will be retained along with the Chapel building. Tabor House will be retrofitted with 24 individual studio and one bed apartments.

Figure 3 - Existing Buildings nomenclature

1.3.8 The Chapel

The Chapel building will be repurposed for communal and community amenities with a new glazed feature entrance. The Chapel and Tabor House will form a focal point on arrival into the main hub of the development off the new Milltown Road entrance gate showcasing the existing feature retained buildings.

Figure 4 – Composition of Development (above ground level context – Site Layout Plan by O'Mahony Pike Arch.).

2 THE SITE

2.1 Site Description

The development at Milltown Park, Sandford Road, Dublin 6 is on a site of circa 4.3 hectares. The site is located at approximate Irish Grid Reference O 17004 31212 and occurs within the Pembroke-Rathmines ward of Dublin City Council.

The site is bounded by Sandford Road to the North East turning the corner on Milltown Road which bounds it to the East and South East following along the existing stone wall and tree belt which disconnects the site and obscures it from the local area beyond. The North-West and West of the site is bounded by the rear gardens of residential houses in Norwood Park and Cherryfield Avenue Lower and Upper. To the South the site is bounded by the Jesuits residential and administrative accommodation and their access off Milltown Road.

Figure 5 – Site location adjacent to Gonzaga College, to the North West of Clonskeagh Hospital and south of Muckross Park College in the Ranelagh area of Dublin 6 (Google Maps).

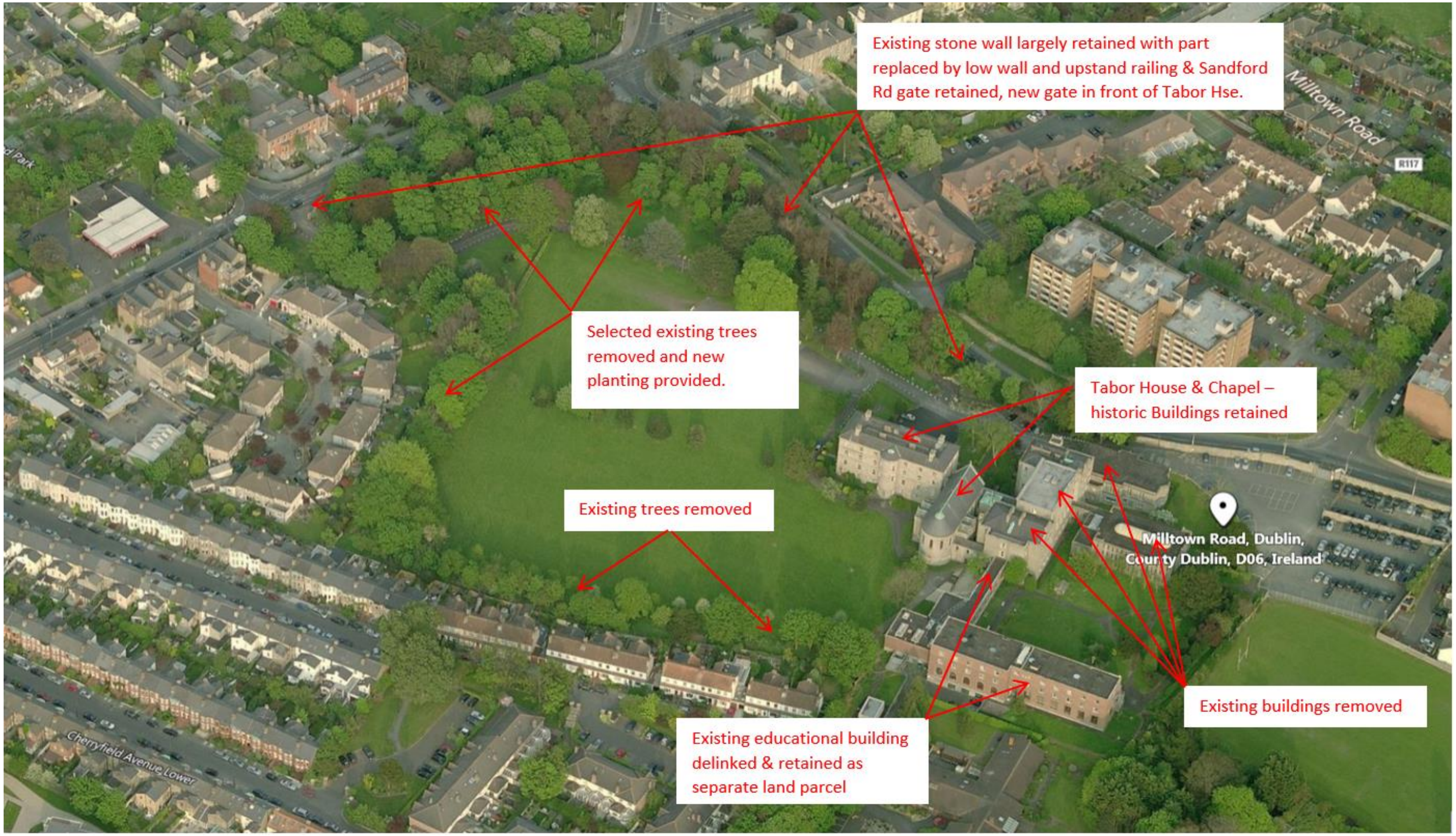


Figure 6 – Site with existing notable features

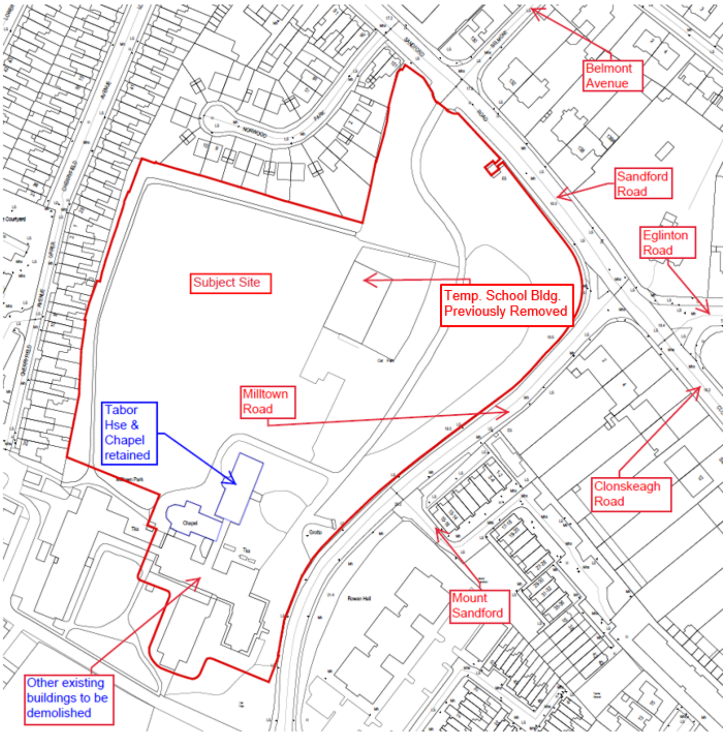


Figure 7 – Site location with local surrounding properties.

2.2 Geology/Ground Conditions

2.2.1 Desk Study

Initial studies relating to the ground conditions used the information available from the Geological Survey of Ireland such as geological data, archive borehole logs and site investigations obtained from www.gsi.ie .

The area is indicated as being underlain with Dark-grey to black Calp Limestone and of the 'Lucan Formation' which comprises 'dark-grey to black, fine-grained, occasionally cherty, micritic limestones that weather paler, usually to pale grey. There are rare dark coarser grained calcarentic limestones, sometimes graded, and interbedded dark-grey calcar'.

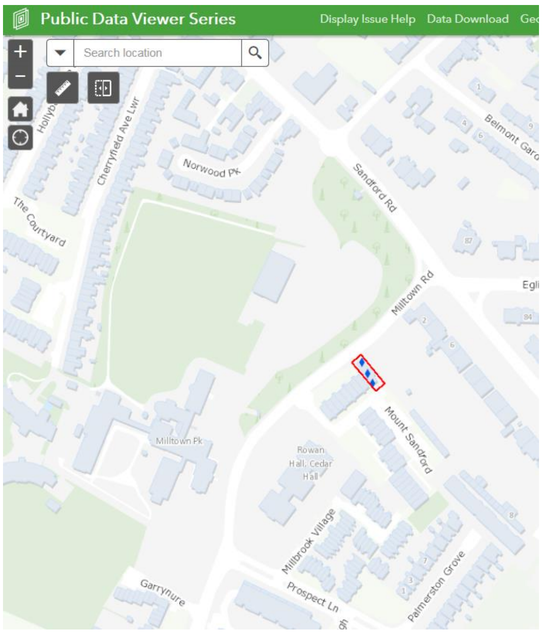


Figure 8 – Plan of local archive boreholes and associated ground investigations (Geological Survey of Ireland) – noting 3 no. boreholes within a site centrally to the East and South of the eastern boundary wall.

Other that the three boreholes dating from 1980 as shown in Figure 8 above there are no other nearby archive borehole logs and site investigations in close proximity to the Milltown Park site. These boreholes note the following stratification;

Stratum	Depth Below Ground
Fill/Made Ground	0-1.3m
Brown Gravelly Silty Clay	1.3-3.8m
Glacial Till	3.8-7.5m

2.2.2 Site Specific Ground Investigation

A site investigation was carried out at the Milltown Park site between January and June 2020. The overall SI works consisted of the following (with reference to plan arrangement of exploratory locations in Figure 9 below):

- Carry out 11 No. Trial / Foundation Inspection Pits to determine existing foundation details,
- Carry out 3 No. Soakaways to determine a soil infiltration value to BRE digest 365,
- Carry out 14 No. Window Sample Boreholes to recover soil samples,
- Carry out 13 No. Dynamic Probes to determine soil strength/density characteristics,
- Carry out 16 No. Cable Percussion boreholes to a maximum depth of 8m BGL,
- Carry out 5 No. Rotary Core follow on boreholes to a maximum depth of 20m BGL,
- Carry out 9 No. Plate Load tests to determine CBR Value,
- Carry out 1 No TRL probe to determine CBR Value,
- Installation of 7 No. Groundwater monitoring wells,
- Geotechnical & Environmental Laboratory testing,
- Report with recommendations.

The related ground investigation report; *'Milltown Park Sandford – DBFL – Ground Investigation Report – October 2020'* (Ref. 9338-12-19) by Ground Investigations Ireland notes the following;

Sequence of strata:

- Topsoil/surfacing
- Made Ground
- Cohesive deposits
- Granular Deposits (Rarely encountered)
- Bedrock

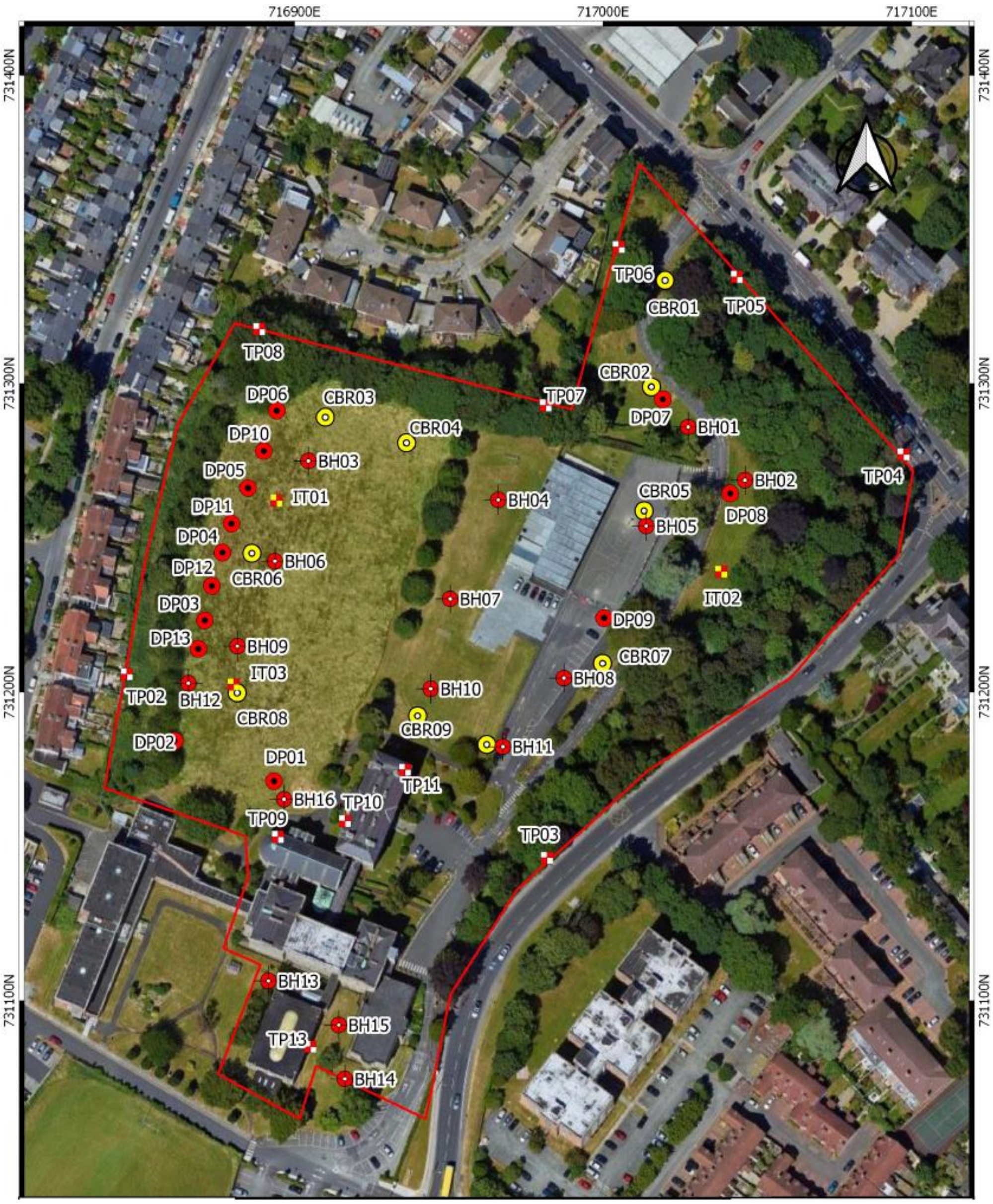


Figure 9 - Site Plan indicating agreed exploratory holes, trial pits & dynamic probe locations.

The typical stratification associated with the site investigations is as follows:

Stratum	Depth Below Ground (m)
Topsoil	0.2 – 0.4
Made Ground	0.5 – 1.0
Light brown slightly sandy slightly gravelly CLAY with occasional cobbles	0.5/1.0 – 2.2/2.6
Very stiff dark grey/black slightly sandy slightly gravelly CLAY with occasional cobbles	2.2/2.6 – 9.0 / 18.45
Bedrock	below 9.0 / 18.45

2.2.3 Recommendations from Site Specific Ground Investigation

The ground investigation report by Ground Investigations Ireland made the following key recommendations in respect of foundation typology and excavations during basement/construction works:

- An allowable bearing capacity of 200 kN/m² is recommended for conventional strip or pad foundations on the stiff or very stiff dark grey/back cohesive deposits encountered at a depth of between 2.0m and 2.6m BGL on the northern part of the site. On the western part of the site where the 3 storey structures are proposed a bearing capacity of 100 kN/m² is achievable at depths of between 1.2m and 1.5m BGL.

- For the area of the proposed basement a bearing capacity of 350 kN/m2 would be achievable at 4 m below ground level in the very stiff dark grey Clay, however a settlement assessment should be carried out to ensure the structure can deal with the potential settlement, total and differential due to this increased loading.
- Short term temporary excavations in the cohesive deposits will remain stable for a limited time only and will require to be appropriately battered or the sides supported if the excavation is below 1.25m BGL or is required to permit man entry.
- Excavations in the Made Ground, or soft Cohesive Deposits will require to be appropriately battered or the sides supported due to the low strength of these deposits.
- Uplift and tension loading due to hydrostatic and Clay heave shall be incorporated into both the foundation and basement slab design.
- Excavations in the upper cohesive deposits are expected to be excavatable with conventional excavation equipment.

2.3 Hydrology & Hydrogeology

Please refer to the study carried out by Byrne Looby in respect of Hydrology & Hydrogeology as per section 4 of Appendix B of this overall document.

2.4 Contamination

Based on the chemical analysis of the subsoil sampled collected across the site the site is free of contamination.

The black boulder clay underlying the site due to naturally occurring level of the metal selenium has been classified as either Category B2 or C if it is to be excavated and removed from site as waste material. This is not indicative of contamination of the material. The remainder of the material sampled can be considered to be inert and meet the Category A criteria.

Nearby sites requiring clean fill material will be contacted to investigate reuse opportunities for clean and inert material, if required. If any of the material is to be reused on another site as by-product (and not as a waste), this will be done in accordance with Article 27 of the EC (Waste Directive) Regulations (2011). EPA approval will be obtained prior to moving material as a by-product. However, it is not currently anticipated that Article 27 will be used.

The material sampled is suitable from an environmental impact perspective for removal from site as a by-product in line with Article 27 of the European Communities (Waste Directive) Regulations 2011. The material may only be declared a by-product if all four by-product conditions are met.

a) further use of the soil and stone is certain,
b) the soil and stone can be used directly without any further processing other than normal industrial practice,
c) the soil and stone is produced as an integral part of a production process, and
d) further use is lawful in that the soil and stone fulfils all relevant requirements for the specific use and will not lead to overall adverse environmental or human health impacts.

Reference shall be made in this regard to the 'Environmental Assessment Report' by Ground Investigations Ireland (June 2020).

3 THE PROPOSED DEVELOPMENT & CONSTRUCTION METHODOLOGIES

The proposed development comprises seven new build, multi-storey, residential blocks of between three and ten storeys (Blocks A1, A2, B, C, D, E, and F) in height above ground level with a single storey basement beneath Blocks A, B and C as well as the refurbishment of the existing four storey historic structure (Tabor House) and the Chapel building in the original Jesuit enclave in the south west extremity of the site.

3.1.1 Superstructure

The six new-build blocks (Blocks A, B, C, D, E, and F) comprise precast concrete hollowcore slabs on masonry reinforced concrete walls with constituent 275mm thick slabs supported by perimeter and partitioned loadbearing walls. Each block is braced by the loadbearing cross wall arrangement save for the ten-storey tower structure at the northern end of Block A1 which is braced by a combination of RC core walls and shear walls to resist lateral forces and affects.

It is currently considered that the structure of each block shall be constructed on a floor-by-floor cycle, however this shall be open to discussion with the main contractor with potential efficiencies associated with methodologies such as jump or slip forming of core walls worth consideration subject to pending supply and programme deliberations.

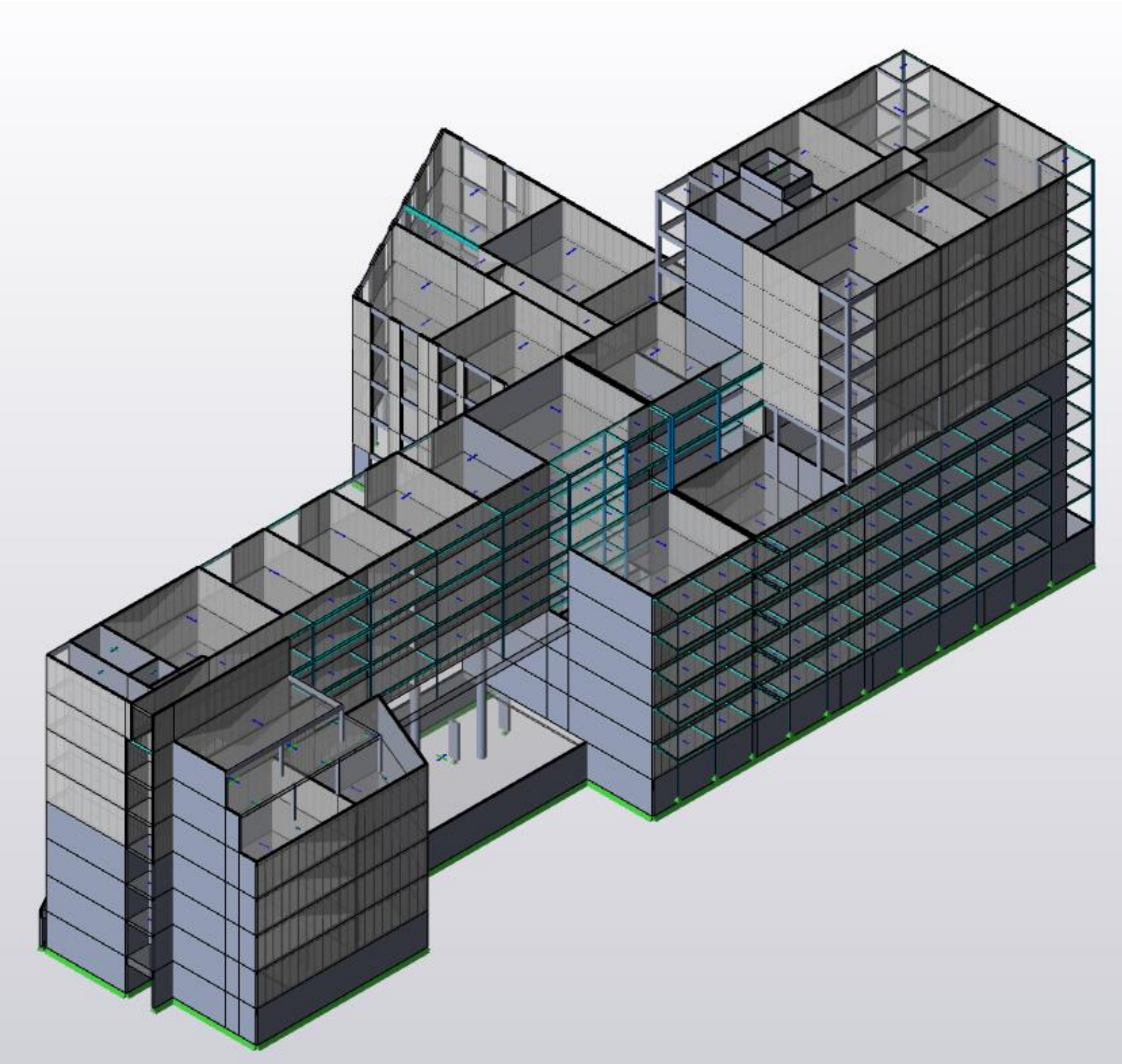


Figure 10 – Block A1 including 10 storey north tower (view from south).

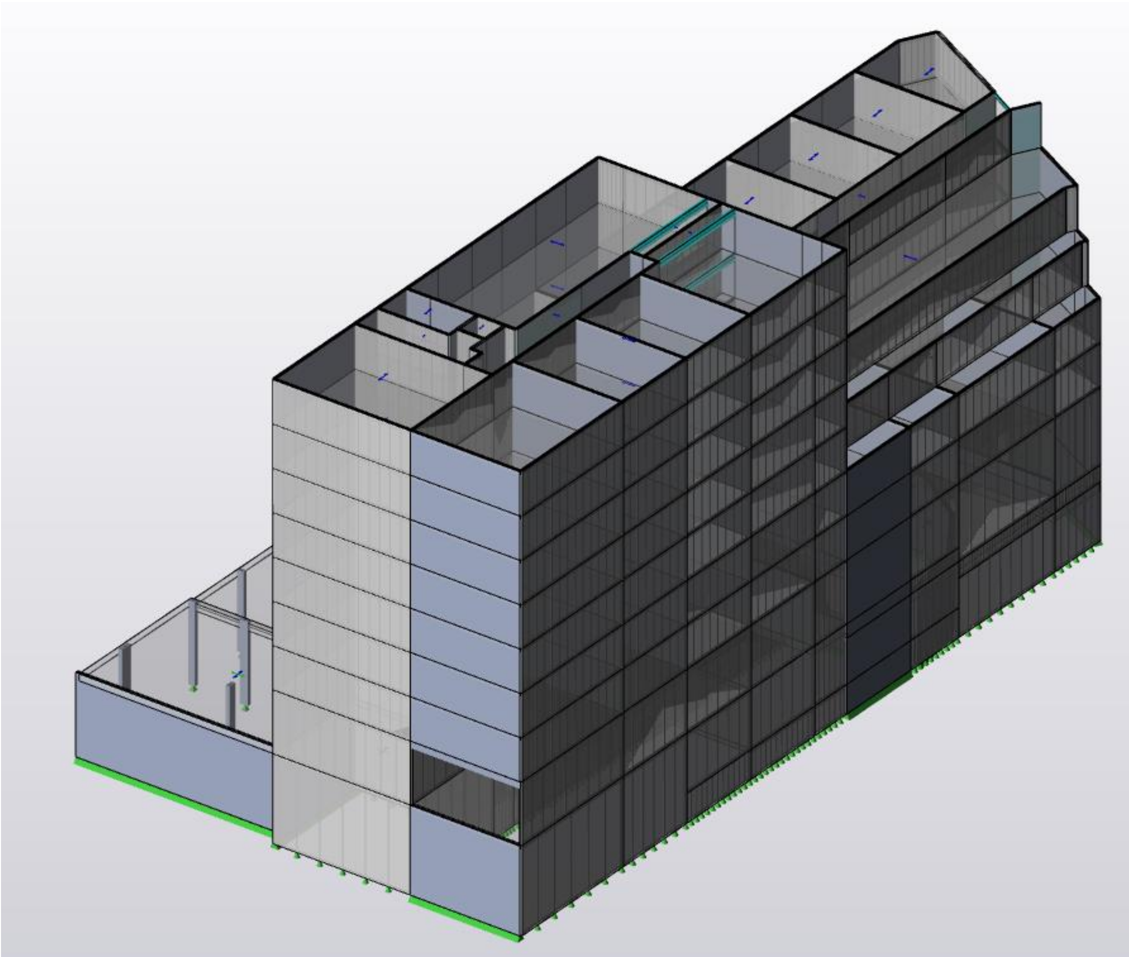


Figure 11 – Block A2 precast slabs on masonry / RC cross wall construction above ground floor level (view from south)

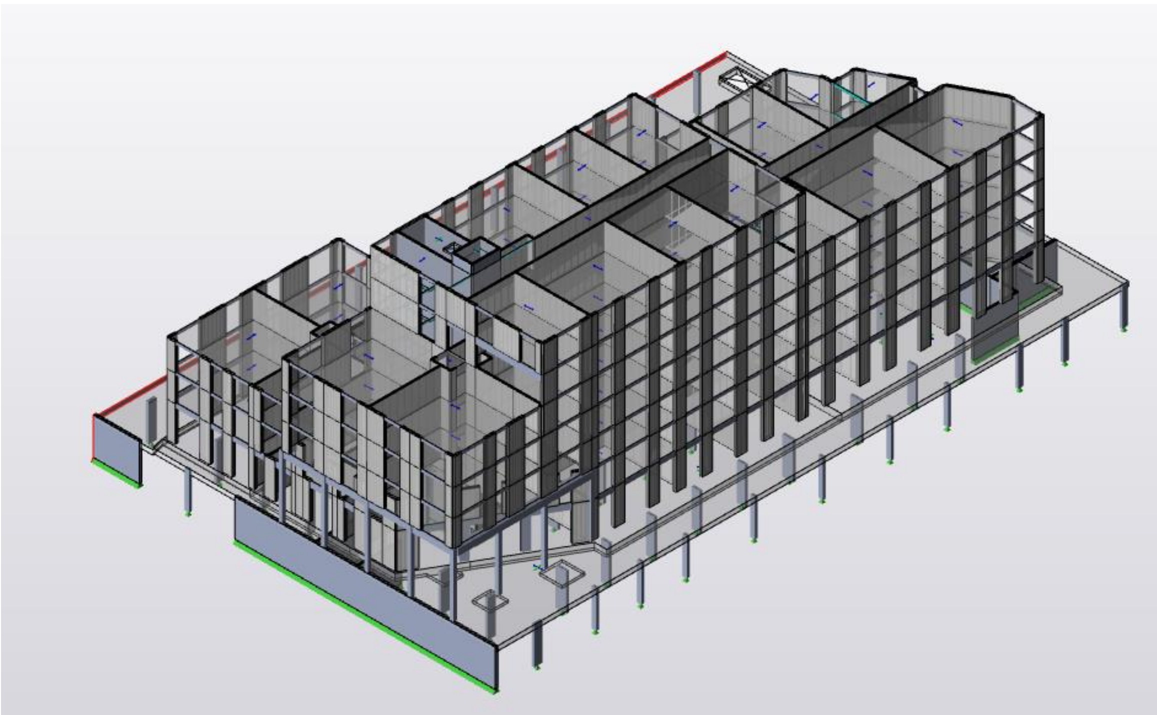


Figure 12 – Blocks B precast slabs on masonry / RC cross wall construction above ground / podium level transfer slab (view from southeast).

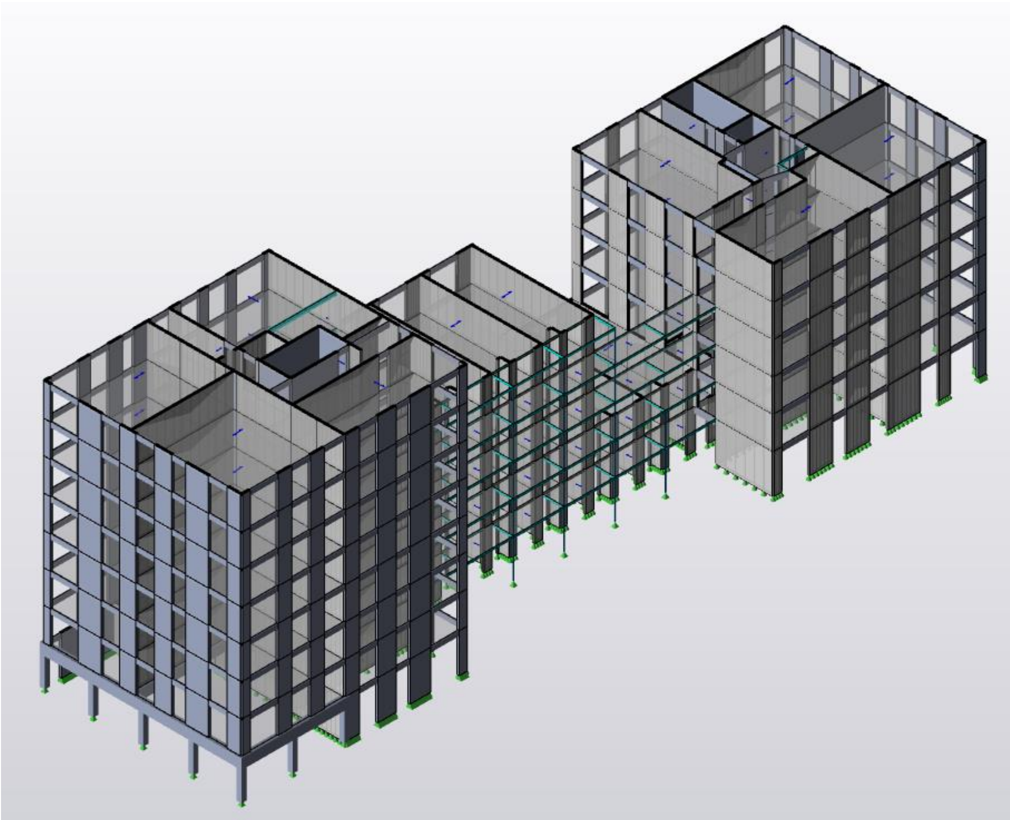


Figure 13 – Blocks C northern wing superstructure with precast slabs on masonry / RC cross wall construction (view from northeast)

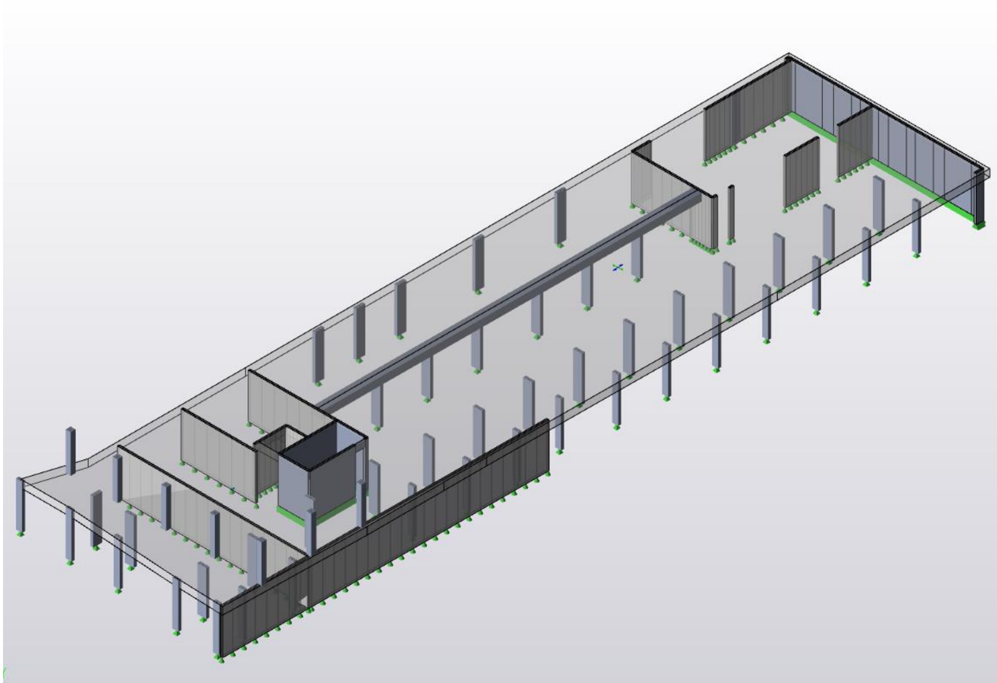


Figure 14 – Blocks C northern wing substructure ground level transfer slab on RC columns and walls (view from northeast)

Between each of the blocks over the basement plan envelope, an ≈500mm thick podium slab shall serve to support soft and hard landscaping build-up and traffic live loading associated with fire tender and access and maintenance equipment. The podium slab is broken by permanent movement joints to mitigate against adverse effects due to expansion/contraction and due to potential differential movement between adjacent blocks of varying height.

3.1.2 Basement Structure

The basement shall house car-parking, bicycle parking, bins, services, and plant rooms. The associated broad basement formation level is approximately 16.2mOD under Basement area 1 and from approximately 16.0mOD to 13.6mOD (below the basement slab with allowance for blinding to adequately seal the excavation and prevent undue deterioration of clays between excavation and construction) which necessitates the excavation of approximately 4-5.5m of made ground/clay relative to the existing ground levels across the site.

3.1.3 Temporary Slope Batter

The basement construction methodology proposed is cut and cover. The initial bulk excavation phase of the existing topsoil, made ground, and clay to formation level is facilitated using a side slope battered back at the appropriate angle of repose as determined by site investigation for temporary stability. Deflection monitoring and/or removable sheet piling will be utilised in discreet areas where proximity to retained trees or buildings dictates.

The subsequent second phase involves the construction of the 300mm thick reinforced concrete basement ground bearing slab, then the 300mm thick RC perimeter retaining walls and finally the RC ground transfer slabs / 550mm thick RC podium slab which will permanently brace the walls once the soil for retention is backfilled.

The RC retaining walls are designed to span vertically between the basement and ground slabs as laterally restraining diaphragms to the top and bottom of the walls. The RC retaining walls are designed to resist (i). active ground pressures according to retained height (ii). inherent hydrostatic pressure taking due cognisance for increase in ground water level due to climate change and/or in the accidental scenario of an adjacent, burst water main and (iii). Appropriate outboard live load surcharges associated with the surrounding access roads, walkways, fire tender access and landscaping including retained trees and preserved structures.

3.1.4 Basement Slab

The 300mm thick basement slab is designed as a ground bearing slab with enlarged pad and strip foundations supporting the wall and column loads from the superstructure above and to resist the following loading conditions:

- Condition 1: Downward characteristic dead and live loading appropriate to function as a car park, plant rooms, water tanks, etc.
- Condition 2: Upward hydrostatic pressure (with allowance for climate change and local burst water main) and clay heave pressure.

3.1.5 Foundations

The foundations shall consist of 0.5-2.0m deep pad and strip footings transferring dead, live and wind loads from the columns, core and shear walls to the stiff boulder clay substrate.

Foundations are dropped to lower levels under lift cores to facilitate requirement for lift pits. Cores are not located adjacent to perimeter retaining walls within the context of the proposed main basement.

4 BASEMENT CONSTRUCTION SEQUENCE

The basement excavation/construction sequence shall be executed as per the following:

1. Excavate to basement formation level forming slope batters,
2. Form, fix reinforcement and cast reinforced concrete pad and strip footings,
3. Install basement internal sub-slab drainage including pumping chamber and petrol interceptor,
4. Install tanking membrane,
5. Form, fix reinforcement and cast reinforced concrete basement slab,
6. Erect vertical formwork for 300mm basement to ground level reinforced concrete retaining walls, columns and lift, stair, shear walls,
7. Install reinforcement and cast basement to ground level reinforced concrete retaining walls, columns and lift, stair, shear walls,
8. Form, fix reinforcement and cast reinforced concrete ground slab,
9. Basement 'box' construction complete.

Please refer to the following figures in respect of the basement construction sequence

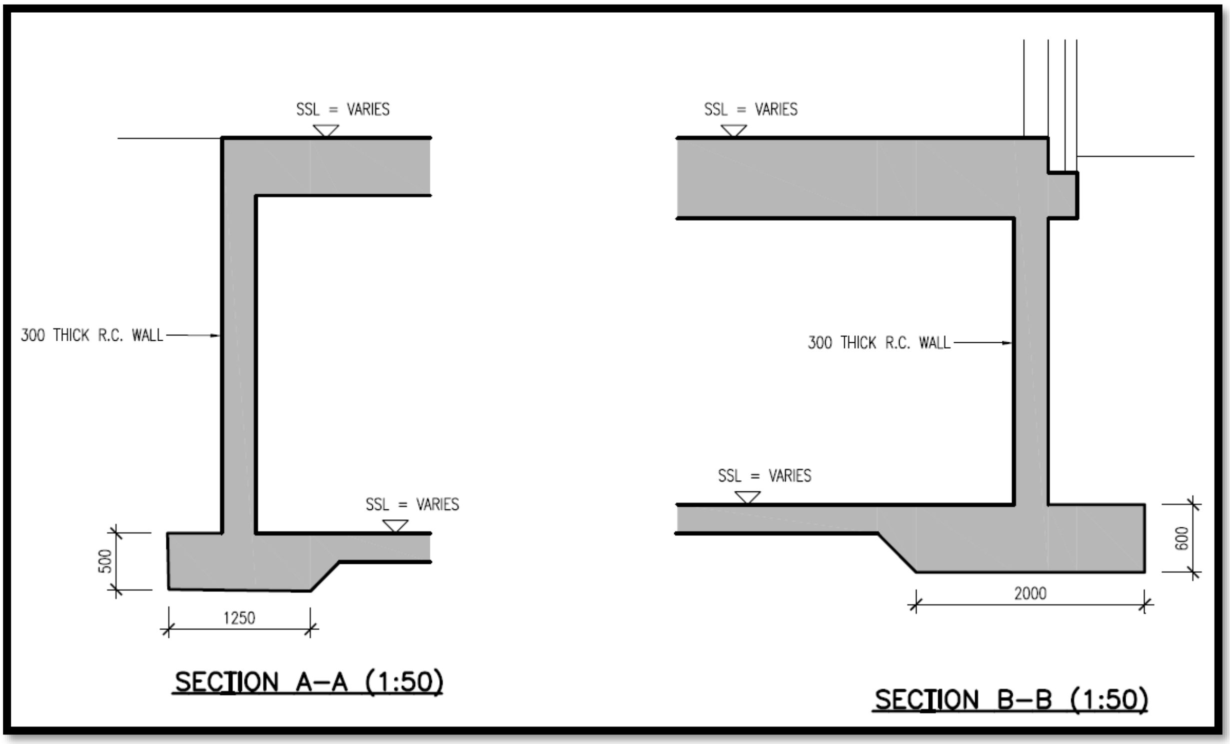


Figure 15 – Sample section through basement external boundary at podium and external wall in permanent condition.

5 BASEMENT IMPACT ASSESSMENT

The following risk assessment follows guidance as provided in '*Basement Development Policy Document – Version 1.1*' – January 2020 by Dublin City Council so as to demonstrate that a basement/underground development is consistent with the planning and development policies for the area and that the proposed basement will not unduly impact upon the environment, including the water environment, biodiversity, adjacent structures, etc.

The process of basement impact assessment is a staged process as follows:

- Stage 1: Screening – to identify areas for study.
- Stage 2: Scoping – to identify data required for detailed study.
- Stage 3: Site investigation and study – which provides the relevant, applicable data.
- Stage 4: Impact assessment – which compares the present situation with the proposed/future condition.
- Stage 5: Review and decision making – the proposed solution (by the developer) and the final assessment (by the planning authority).

6 STAGE 1 – SCREENING

The following utilises the flow chart method of assessment from Appendix E of the London Borough of Camden Geological, Hydrogeological and Hydrological Study:

6.1 Surface Flow & Flooding Screening

	Question	Response
1.	Is the site within the catchment of local ponds, lakes, rivers?	Yes – The closest surface water feature is the River Dodder which is located approximately 500m to the south east of the site. The site is situated within the Dodder Lower Surface Water Body Catchment (IE_EA_09_587). The surface water report indicates the status of the water body is 'Poor'. The risks for the catchment are diffuse source of contamination.
2.	As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	No - The surface water run-off from the site will be equal or less than the existing condition using an attenuation tank to store and slow release surface water.
3.	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	Yes - The site will increase the proportion of the site which is hard surfaces.
4.	Will the proposed basement result in changes to the profile of the inflows (instantaneous and long-term) of surface water being received by adjacent properties or downstream watercourses?	No - The site will not increase the profile of surface water to the sewer as it is designed to utilise SUDs technology to prevent an increase in surface water load compared to the prior existing development.
5.	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No - The site utilises SUDs technology to manage peak surface water loads.
6.	Is the site in an area known to be at risk from surface water flooding or is it at risk from flooding, for example because the proposed basement is below the static water level of a nearby surface water feature?	No - The site is not within an area identified as being of flood risk or near a static water feature.

6.2 Subterranean/Groundwater Flow Screening

	Question	**Response**
1.	Is the site located directly above an aquifer?	Yes - The Lucan Formation has been classified by the GSI as a Locally Important Aquifer which is moderately productive in local zones (LI). The Eastern River Basin District (ERBD) Management Plan identifies that the groundwater body (GWB) beneath the site is part of the Dublin Urban Groundwater Body (IE_EA_G_005).
2.	Will the proposed basement extend beneath the water table surface?	Yes, As per the site investigation groundwater monitoring indicates a ground water level of 0.77m to 1.43m BGL.
3.	Is the site within 100m of a watercourse, well (used/disused) or potential spring line?	No.
4.	Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	Yes - The proposed development is on largely undeveloped land and will therefore alter the hard area of the site.
5.	As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and/or SUDS)?	No - The development is not designed to discharge water into the ground as the soil infiltration rate is not suitable. SuDS and attenuation will be used for retention only.
6.	Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond or spring line?	No - There are no local ponds or spring lines.

6.3 Slope Stability Screening

	Question	Response
1.	Does the existing site include slopes, natural or manmade, greater than 7º? (approximately 1 in 8)	No – Falls on the site are very shallow of the order of 1:55.
2.	Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7º?	No – The proposed development does not change slopes at the property boundary.
3.	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7º?	No – The surrounding area has no embankments and the streets are of a shallow gradient.
4.	Is the site within a wider hillside setting in which the general slope is greater than 7º?	No – The surrounding area is similarly flat.
5.	Is the Clay the shallowest strata at the site?	No – The underlying Clay is overlain by 0.2-1.0m of Topsoil and/or Made Ground across the site.
6.	Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	Yes – Some selected trees will be felled to facilitate development however in the main the large existing tree belts are preserved with a large amount of replacement planting proposed.
7.	Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	No.
8.	Is the site within 100m of a watercourse or a potential spring line?	No.
9.	Is the site within an area of previously worked ground?	No – most of the site is undeveloped land however there are areas of pre-existing development related to the historic buildings to the south of the site or the temporary school building now removed to the centre of the site which remains an area of hardstanding.
10.	Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	No – The site is not within an aquifer. The basement will occur below the water table as indicated by the site investigation; however the depth of basement does not penetrate the clays which act as an aquitard protecting the limestone aquifer at depth underlaying the site.
11.	Is the site within 5m of a highway or pedestrian right of way?	Yes – the site is bounded by roads on 2 sides (North-East and South-East).
12.	Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	No – even though the new basement will be deeper than surrounding residential accommodation the basement is setback approximately 30 – 60m from neighbouring buildings which makes the differential insignificant.
13.	Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No.

7 STAGE 2 – SCOPING

Scoping is required where any of the answers to the array of questions in the screening exercise were answered “yes” or “unknown”. Those parameters are taken forward and considered in more detail. The scoping stage aims to define the scope of investigation required in order to provide the information necessary to make an assessment of the impact of the issues identified.

7.1 Potential Impacts

The potential impacts identified by the Stage 1 – Screening Exercise (undertaken in accordance with the LBC guidance) are summarised in the following table:

Surface Flow & Flooding	
Screening Flowchart Question	Potential Impact
Is the site within the catchment of local ponds, lakes, rivers?	Yes – The closest surface water feature is the River Dodder which is located approximately 500m to the south east of the site. The site is situated within the Dodder Lower Surface Water Body Catchment (IE_EA_09_587). The surface water report indicates the status of the water body is ‘Poor’. The risks for the catchment are diffuse source of contamination. SuDS features and silt and hydrocarbon interceptors plus settlement within attenuation tanks de-risk the contamination sources.
Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	Yes - The site will increase the proportion of the site which is hard surfaces. However, in accordance with the GDSDS (Greater Dublin Strategic Drainage Study) the outflow from the site will be throttled and attenuated to greenfield flow rates and the drainage design includes SuDS measures such as green roofs and landscaped podiums which reduce the runoff rates.
Subterranean (Groundwater) Flow	
Screening Flowchart Question	Potential Impact
Is the site located directly above an aquifer?	Yes - The Lucan Formation has been classified by the GSI as a Locally Important Aquifer which is moderately productive in local zones (Ll). The Eastern River Basin District (ERBD) Management Plan identifies that the groundwater body (GWB) beneath the site is part of the Dublin Urban Groundwater Body (IE_EA_G_005).
Will the proposed basement extend beneath the water table surface?	Yes – the ground water level of 0.77m to 1.43m BGL.
Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?	Yes - The proposed development is on largely undeveloped land and will therefore alter the hard area of the site. However, there are areas of pre-existing development related to the historic buildings to the south of the site or the temporary school building now removed to the centre of the site which remains an area of hardstanding.
Slope Stability	
Screening Flowchart Question	Potential Impact
Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?	Yes – Some selected trees will be felled to facilitate development however in the main the large existing tree belts are preserved with a large amount of replacement planting proposed.
Is the site within 5m of a highway or pedestrian right of way?	Yes – the site is bounded by roads on 2 sides (North-East and South-East). However, the basement is setback ≈30m from the road with an excavation depth of approximately 4.0m to 4.8m to formation level and assuming a conservative soft ground slope batter of 30° would result in a 7m plan length of slope leaving at least 23m of undisturbed ground to the road.

8 STAGE 3 – SITE INVESTIGATION, STUDY & MONITORING

To provide appropriate local context and decision making, several studies have been commissioned and completed in conjunction with geotechnical specialists which are listed below and available under separate cover:

1. 190226-REP-003 – 'Site Specific Flood Risk Assessment' – DBFL Consulting Engineers (Enclosed as a separate report).
2. 9338-12-19 – 'Ground Investigation Report' – Ground Investigations Ireland (Refer to Appendix 10A of the EIAR).
3. 9338-12-19 – 'Environmental Assessment Report' – Ground Investigations Ireland (Refer to Appendix 10B of the EIAR).
4. B1694-GEO-R001 – 'Basement Impact Assessment Report' – Byrne Looby Partners (Refer to Appendix B of this report).

9 STAGE 4 – IMPACT ASSESSMENT & MITIGATION MEASURES

During development and upon completion of the proposed project, the site will see several changes and this chapter defines their impact.

The screening and scoping processes have allowed for a number of potential impacts to be identified and the information required to quantify their impact. Now that studies and investigations are complete these impacts may be properly quantified.

9.1 Surface Flow and Flooding

1. Is the site within the catchment of local ponds, lakes, rivers?

   Yes – The closest surface water feature is the River Dodder which is located approximately 500m to the south east of the site. The site is situated within the Dodder Lower Surface Water Body Catchment (IE_EA_09_587). The surface water report indicates the status of the water body is 'Poor'. The risks for the catchment are diffuse source of contamination. SuDS features and silt and hydrocarbon interceptors plus settlement within attenuation tanks de-risk the contamination sources.

   The DBFL Infrastructure Design Report (190226-rep-002) considers the surface water quality impact as follows:

   - The GDSDS (Greater Dublin Strategic Drainage Study) requires interception storage to be incorporated into surface water drainage design in order to limit discharge of sediment and pollutants into the downstream surface water drainage network and receiving water courses. This interception storage is designed to capture surface water run-off from rainfall depths of 5mm (and up to 10mm if possible). Run-off rates from the site are controlled by flow control devices.
   - Surface water management proposals for the development also incorporate the following impact reduction measures;
     - Surface water network designed in accordance with GDSDS requirements.
     - Incorporates SUDS features e.g. green roofs, drainage reservoir (drainage board) on the podium slab over basement, permeable paving in parking areas at the front of duplex units (i.e. treatment / filtration provided within the stone reservoir beneath permeable paved driveways) and tree pits with overflow to conventional road gullies.
     - Surface water attenuation (i.e. treatment / filtration provided within the granular surround of the Stormtech Chambers) in conjunction with a final Class 1 fuel / oil separator prior to discharge to the downstream surface water network.

2. Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?

   Yes – The site will increase the proportion of the site which is hard surfaces. However, in accordance with the GDSDS the outflow from the site will be throttled and attenuated to greenfield flow rates and the drainage design includes SuDS measures such as green roofs and landscaped podiums which reduce the runoff rates.

   The DBFL Infrastructure Design Report (190226-rep-002) considers the increase in hard surfaces and restricts the allowable outflow to the greenfield runoff rate of 2.00 l/sec/ha sizing the attenuation storage volume accordingly to protect the site from flooding under the 1:100 yr intensity storm with 20% allowance for climate change and surface flow paths to roads considered for storms exceeding this pluvial volume.

9.2 Subterranean/Ground Water Flow

1. Is the site located directly above an aquifer?

Yes - The Lucan Formation has been classified by the GSI as a Locally Important Aquifer which is moderately productive in local zones (Ll). The Eastern River Basin District (ERBD) Management Plan identifies that the groundwater body (GWB) beneath the site is part of the Dublin Urban Groundwater Body (IE_EA_G_005).

As the stiff clays overlaying the bedrock are an aquitard which prevent pluvial recharge of the ground water so there is no impact on the aquifer of changes in the proportions of hard surfaces.

2. Will the proposed basement extend beneath the water table surface?

Yes – Ground water levels of 0.77m to 1.43m BGL were measured. The basement will extend into the stiff clays. Groundwater levels would be expected to vary with the tide, time of year, rainfall, nearby construction, and other factors. For this reason, standpipes were installed in BH02 and BH07 to allow the equilibrium groundwater level to be determined and to monitor ground water levels and flows on a continuous basis moving forward into pending construction. The groundwater monitoring is included in Appendix A of this report for ease of reference.

Any net uplifting forces due to hydrostatic pressure to the underside of the basement structure will be resisted by dewatering operations until such stage as sufficient dead load from the superstructure has been constructed to counteract any uplift pressures. Retaining walls will be designed to consider hydrostatic lateral forces. The criteria applied in the design of the basement also takes cognisance of the inherent pressure head due to ground water. With reference to the hydrogeological and hydrological assessment as per Appendix B, it is highlighted that the new basement shall extend down into the stiff clays underlying the site which has a low porosity to transfer ground water through. The proposed basement development is also highly unlikely to block inherent groundwater flows.

3. Will the proposed basement development result in a change in the proportion of hard surfaced/paved areas?

Yes – The proposed development is on largely undeveloped land and will therefore alter the hard area of the site. However, there are areas of pre-existing development related to the historic buildings to the south of the site or the temporary school building now removed to the centre of the site which remains an area of hardstanding. As above the stiff clays overlaying the bedrock are an aquitard which prevent pluvial recharge of the ground water so there is no impact on the aquifer of changes in the proportions of hard surfaces.

9.3 Slope Stability

- **Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained?**

  Trees will be removed but replaced with new planting to facilitate development and some large existing tree are preserved, all in order to enhance open space and opening a public route through the mature woodland creating a natural buffer to the East of the site. The goal is to retain trees where possible to uphold the sites natural biodiversity and character. In particular the arborist has assessed and graded the existing trees with particular focus put on protection of grades A + B which are deemed to be of high and moderate quality and value capable of making significant contribution to the area for 40 and 20 years respectively. The architecture has responded to the existing tree belt resulting in some movement of the buildings and opening up key view lines into the site.

  The construction methodology of the basement will respond to the protection of tree roots where proximity necessitates.

- **Is the site within 5m of a highway or pedestrian right of way?**

  The site is bounded by roads on 2 sides (North-East and South-East). However, the basement is setback 30m from the road with an excavation depth of 4.0m to 4.8m to formation level and assuming a conservative soft ground slope batter of 30° would result in a 7m plan length of slope leaving at least 23m of undisturbed ground to the road which mitigates any impact on the surrounding public roads and paths.

10 STAGE 5 – REVIEW & DECISION MAKING

The proposed basement and its construction has been carefully considered to take account of its surroundings which have largely dictated the selection of the various described systems according to the design performance required of them in use – high water table, adjacent roads and buildings.

During construction, the basement is planned to be formed of a conventional new reinforced concrete retaining wall on all sides with ground temporarily graded back within the extent of the site. Deflection monitoring and/or removable sheet piling will be utilised in discreet areas where proximity to retained trees or buildings dictates. Monitoring systems associated with both ground movement and the occurrence of ground water will be in place throughout the construction phase of the project. Any initial or permanent ground water shall be removed through pumping as required to facilitate the basement construction phase – for which a license shall be been obtained with Dublin City Council/Irish Water.

10.1 Surface Flow and Flooding

The site drainage design including SuDS systems and attenuated flows will protect the site and surrounding watercourses from flooding for high intensity storms with additional capacity for climate change impacts. Beyond this the routing of surface flows has been considered to further protect properties.

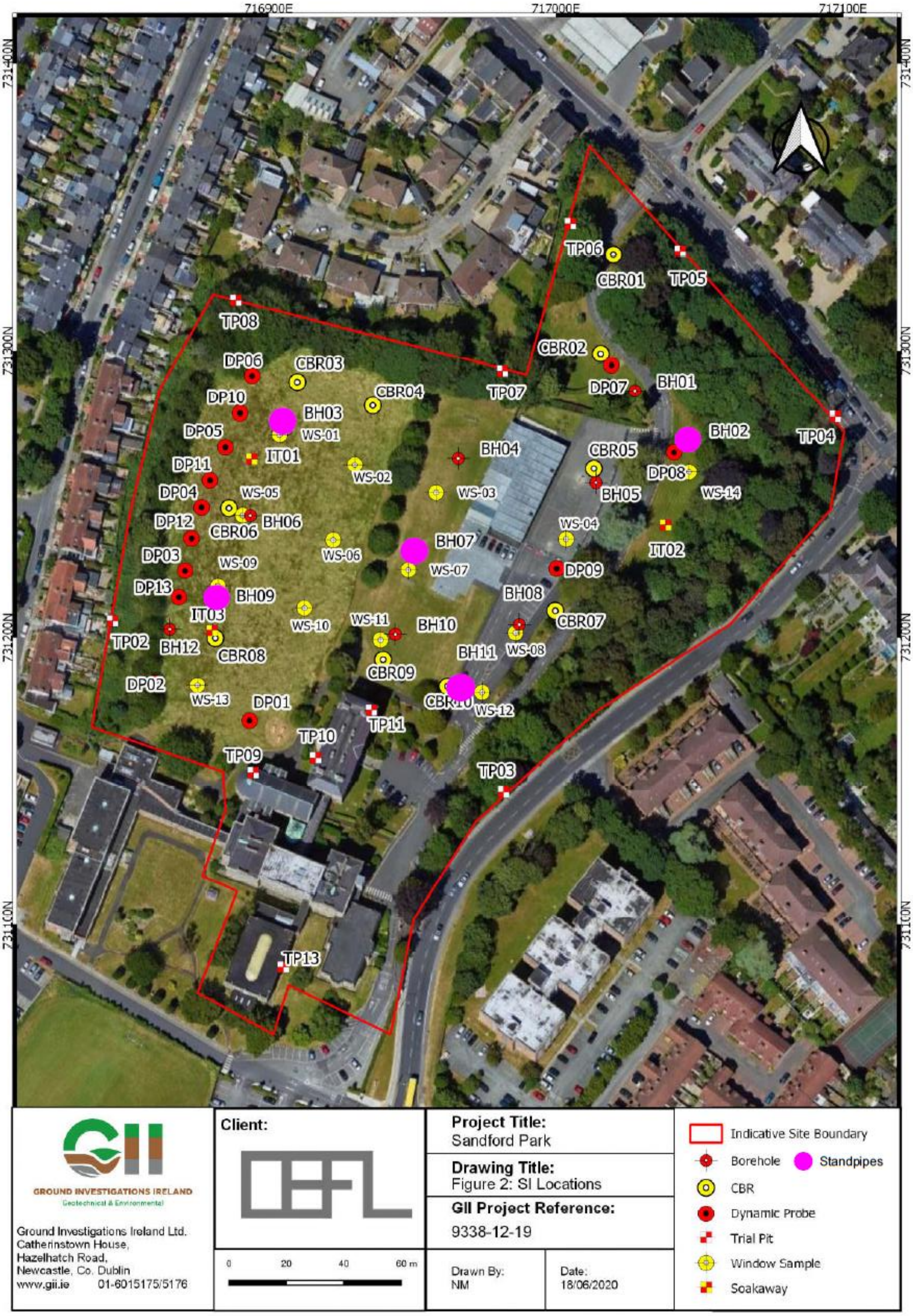
10.2 Subterranean/Ground Water Flow

The new basement shall not have an adverse effect on existing ground water regime as the basement extends into the low porosity boulder clays.

10.3 Slope Stability

As noted in Appendix B, ground movement analysis appropriate to the proposed basement structure and associated sequence of construction indicates that only minute/acceptable levels of movement shall occur during the basement construction and excavation where it is of any concern to the proposed retained existing structures. Ongoing monitoring of movement shall be implemented as noted.

11 APPENDIX A –GROUNDWATER MONITORING – STANDPIPES LOCATION & RESULTS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GROUND INVESTIGATIONS IRELAND
Geotechnical & Environmental
Ground Investigations Ireland Ltd.
Catherinstown House,
Hazelhatch Road,
Newcastle, Co. Dublin
www.gii.ie 01-6015175/5176
Client:
DBFL
0 20 40 60 m
Project Title:
Sandford Park
Drawing Title:
Figure 2: SI Locations
GII Project Reference:
9338-12-19
Drawn By:
NM
Date:
18/06/2020
Indicative Site Boundary
Borehole
Standpipes
CBR
Dynamic Probe
Trial Pit
Window Sample
Soakaway

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Web: www.gii.ie

GROUNDWATER MONITORING

Sandford Park Miltown

BOREHOLE	DATE	TIME	GROUNDWATER (m BGL)	Comments
BH02	04/06/2020	17:15	1.31	
BH02	09/06/2020	16:15	1.37	
BH03	05/06/2020	14:58	7.00	
BH03	09/06/2020	15:50	7.25	
BH07	05/06/2020	14:37	1.47	
BH07	09/06/2020	16:06	1.50	
BH09	05/06/2020	15:20	7.50	
BH09	09/06/2020	15:25	7.74	
BH11	05/06/2020	15:55	1.40	
BH11	09/06/2020	16:11	1.50	

Ground Investigations Ireland. Groundwater Monitoring Results

GROUND INVESTIGATIONS IRELAND
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Web: www.gii.ie

GROUNDWATER MONITORING

Sandford Park Miltown

BOREHOLE	DATE	TIME	GROUNDWATER (m BGL)	Comments
BH02	23/10/2020	09:05	0.77	
BH03	23/10/2020	08:50	6.30	
BH07	23/10/2020	08:52	1.37	
BH09	23/10/2020	08:47	6.69	
BH11	23/10/2020	09:00	1.10	
BH14	23/10/2020	08:35	1.43	
BH16	23/10/2020	08:45	1.22	

Ground Investigations Ireland. Groundwater Monitoring Results

12 APPENDIX B – BASEMENT IMPACT ASSESSMENT REPORT (GROUND MOVEMENT & HYDROGEOLOGICAL ASSESSMENT)

IRELAND • UK • UAE • BAHRAIN • KSA

BYRNELOOBY

DBFL Consulting Engineers

Milltown Park, Dublin 6

Basement Impact Assessment Report

Report No. B1694-GEO-R001

24 August 2021

Revision 08

W W W . B Y R N E L O O B Y . C O M

Document Control

Document: Basement Impact Assessment Report

Project: Milltown Park, Dublin 6

Client: DBFL Consulting Engineers

Report Number: B1694-GEO-R001

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Document Checking:

Revision	Revision/ Review Date	Details of Issue	Authorised		
			Prepared By	Checked By	Approved By
00	20 May 2020	Information	ATA & NP	MR	JB
01	12 June 2020	Information	ATA & NP	MR	MR
02	17 June 2020	Information	ATA & NP	MR	MR
03	31 July 2020	Information	ATA & NP	MR	MR
04	12 March 2021	Information	ATA & NP	MR	MR
05	23 March 2021	Information	ATA & NP	MR	MR
06	24 March 2021	Information	ATA & NP	MR	MR
07	08 April 2021	Information	ATA & NP	MR	MR
08	24 August 2021	Information	ATA & NP	MR	MR
Disclaimer: Please note that this report is based on specific information, instructions and information from our Client and should not be relied upon by third parties.					

Contents

1 Introduction

1.1 Introduction

The site for assessment is the Milltown Park located at the intersection of Milltown Road and Sandford Road in Ranelagh, Dublin 6. The site is primarily a Greenfield site with a small footprint of low rise buildings occupying its south-eastern section as shown in Figure 1.1 below. The site area is circa 4.26ha in area and is located in the local authority area of Dublin City Council (DCC).

Figure 1.1 - Site location and approximate site boundary (Source: Google Earth)

1.2 Report Objectives

It is intended to lodge an SHD planning application with An Bord Pleanala within the first half of 2021. At the time of planning this development, planning applications which include a basement were required to carry out a Basement Impact Assessment (BIA). DCC also notes that the applicants shall have regard to the – Dublin City Council 'Basement Development Policy Document – Version 1.0'. However, the BIA order was subsequently removed after a judicial review order due to lack of public consultation prior to implementation.

This report has been prepared by ByrneLooby on behalf of its client, DBFL Consulting Engineers to assess the impact of the proposed development.

In order to achieve the objectives of the report, the following were undertaken:

1. Desktop study to provide a brief outline on the site particularly focussing on previous site use, nearby basements and its location;
2. Carry out a ground movement assessment and hydrogeological assessment associated with the construction of the basement structure; and
3. Provide recommendation for further works (if required).

1.3 Proposed Development

The client intends to develop the site as a residential development with underground basement for car parking. The site's existing level around the proposed basement ranges between 17.9mOD and 21.0mOD (Malin Head). The basement finished floor level (FFL) will range between 14.55 to 16.85mOD for the basement, hence the dig level for the basement will vary between 4.0 to 4.8mBGL. The basement will occupy approximately 20% of the full footprint of the site and has been setback by more than 0.5m away in all directions from the red line boundary of the site as shown in Figure 1.2.

Figure 1.2: Basement footprint of the proposed development (Source: O' Mahony Pike Architects)

1.4 Basement Construction Sequence

The basement is proposed to be constructed and formed using the open cut excavation method. The construction sequence is expected to follow a traditional sequence of:

1. Excavate to the proposed formation level of the basement (c. 4.0 to 4.8m BGL).

2. Construct the permanent works basement substructure in the following sequence:

a) Construct basement floor slab

b) Construct RC liner walls

c) Construct ground floor slab, and backfill around the basement as necessary.

1.5 Education and Experience of author(s)

The report was completed by Ahmed Thamer Ahmed, Geo-Environmental Engineer and Nick Peters, Senior Project Engineer and was reviewed by Maurice Ryan, Associate Director with ByrneLooby.

Ahmed has obtained a Bachelor of Engineering (Civil) from Malaysia and a Master in Engineering (Environmental) degree from Trinity College Dublin, with specialisation in geo-environmental engineering; and has six years' experience in ground/contaminated land investigations in Ireland. Ahmed has been involved in numerous brownfield redevelopment projects in the Dublin Docklands. Ahmed also has scoped, designed and supervised hydrogeological investigations to inform groundwater dewatering design for shallow and deep basements construction.

Nick Peters, Senior Project Engineer carried out the ground movement assessment analysis within this report. Nick has 9 years of experience in Geotechnical Engineering and holds a Master of Engineering (Civil) from Heriot Watt University, UK. Nick is also a Chartered Engineer with the Institution of Civil Engineers (ICE) and is a Registered Ground Engineering Professional (RoGEP).

Maurice Ryan, Associate Director with ByrneLooby reviewed and regularly provided input into the preparation of this report and the overall project design. Maurice has an extensive 13 years' experience in Geotechnical Engineering and holds a Bachelor of Engineering (Civil and Environmental) from University College Cork and a Master in Engineering (Advanced Geotechnical Engineering) from the University of Surrey, United Kingdom. Maurice is also a Registered Ground Engineering Specialist with Engineers Ireland/Institution of Civil Engineers (ICE).

1.6 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the information supplied at the time of writing this report. Any information used have been assumed by ByrneLooby to be accurate and valid. Ground movement values and hydrogeology findings presented in this report are considered predictions and should be verified and confirmed at detailed design stage following final selection of construction methodologies and details.

1.7 References

The following is a non-exhaustive list of technical papers and guidance documents referenced in the body of the report and used in the assessment:

CIRIA C760 (formally C580) Guidance on Embedded Retaining Wall Design

Dublin City Council Basement Development Guidance Document Version 1.1. http://www.dublincity.ie/main-menu-services-planning/construction-basements-and-basement-impact-assessment-bia

Geological Survey of Ireland's (GSI) online geotechnical map viewer. www.gsi.ie;

Long, M. and C. O. Menkiti (2007). "Geotechnical properties of Dublin Boulder Clay." Geotechnique (57)7: 595-611;

Misstear, B.R., Brown, L., Daly, D., 2009 Hydrogeology Journal, Methodology for making initial estimates of groundwater recharge from groundwater vulnerability mapping;

Metro North Railway Order Application – An Bord Pleanála Further Information Request, Item 19 Groundwater and Hydrogeology, Pages 18-34, 2010.

National Mounments Service Historic Environment Viewer. http://webgis.archaeology.ie/historicenvironment/

National Planning Application Map Viewer. https://housinggovie.maps.arcgis.com/apps/webappviewer/index.html?id=9cf2a09799d74d8e9316a3d3a4d3a8de

Ordnance Survey Ireland Geohive mapviewer. http://map.geohive.ie/mapviewer.html

Skipper, J., B. Follet, et al. (2005). "The engineering geology and characterization of Dublin Boulder Clay." Quarterly Journal of Engineering Geology and Hydrogeology 38: 171 – 187;

2 Desktop Study

2.1 Nearby Land Use

The site's surrounding land use is urban. There are no major industrial/manufacturing operations present nearby to the site which might indicate that soil and groundwater contamination might have taken place. Table 2.1 below shows the breakdown of land use surrounding the site.

Table 2.1- Adjacent Land Uses

Boundary	Land Use
North	Residential Properties.
South	Irish Jesuit building, Residential Properties and further 500m south is the River Dodder.
East	Residential Properties and further to the south-east is the Clonskeagh Hospital.
West	Residential and Commercial Properties.

2.2 Site History

An overview of the site history was obtained through the review of publicly available extracts of historical Ordnance Survey of Ireland (OSI). The years 1837-1842 displayed by the 6" OSI map show the site to be shown as a park as shown in Figure 2.1 below. The 25" Historical maps (1888-1913) show that a chapel have been built in the southern portion while the northern portion also appear to be occupied by a park.

The majority of the site remained undeveloped at least until 2013, a temporary school building, car parking, drop-off/pick up area and external play area were present on site until late 2019. The school building have been removed from site.

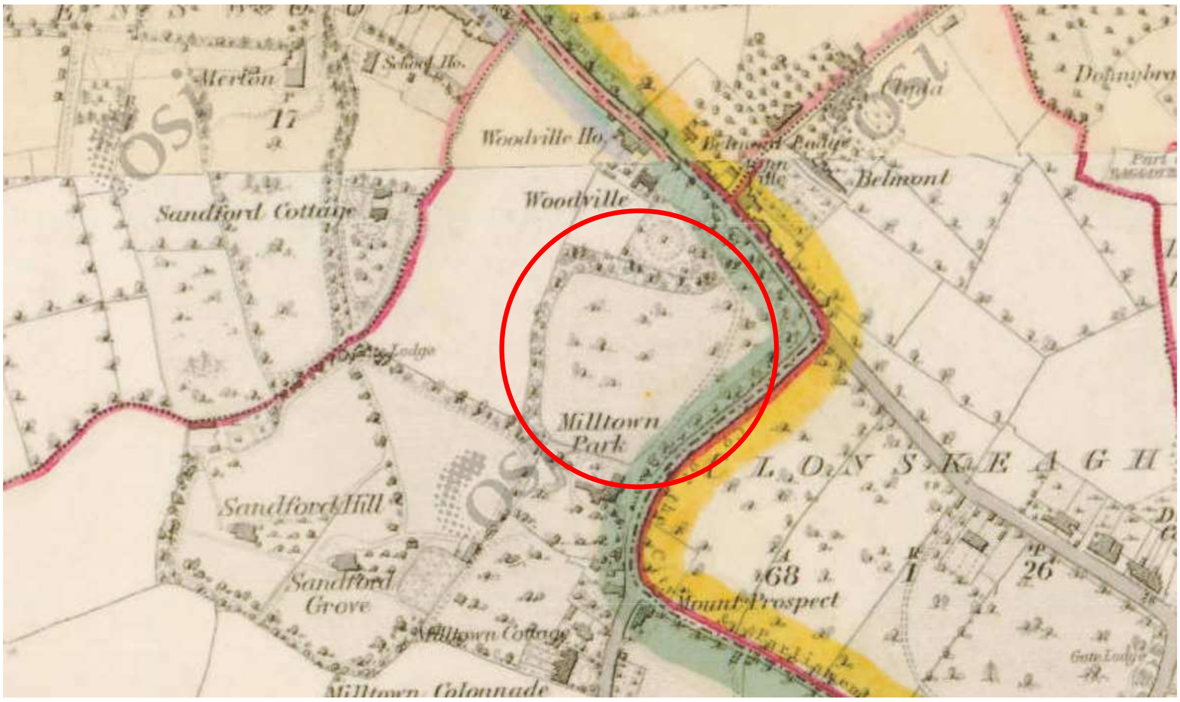

Figure 2.1 - Approximate location of the site on the1888-1913 25 inch OS Map (Source: Ordnance Survey Ireland)

2.3 Protected Structures

DCC's current Record of Protected Structures (Volume 3 of the 2016-2022 Dublin City Development Plan) came into force on the 21st October 2016. The record was accessed to identify nearby protected structures. The nearest protected structures are 4No. houses located at the East of the intersection of Belmont Avenue and Sandford Road to the north-east of the site, 2No. houses (No. 87 & No. 89 Sandford Road) to the north of the site and properties located on Clonskeagh Road (St James' Tce) to the East of the site (No. 2 – No.24 Clonskeagh Road). The site does not directly abut any protected structure and the proposed basement is at least 90m away from any protected structure. Some houses along Anna Villa, Sandford Road, Milltown Road, Clonskeagh Road and Beechwood Road are also protected structures.

2.4 Nearby basements

As required by the DCC basement guidance, ByrneLooby investigated the presence of existing nearby basements of which none were identified. The national planning application map viewer was accessed to identify permitted development with basements which might interact with the proposed basement. The nearby planning applications to the site are shown in Figure 2.2 below, the site is highlighted in yellow. Upon querying the planning applications surround the site, all of the other approved planning permissions comprises of prefabricated classrooms addition to existing schools, refurbishment, minor extensions and/or change of use. The interaction between the proposed basements is further discussed in Section 4.4 of this report.

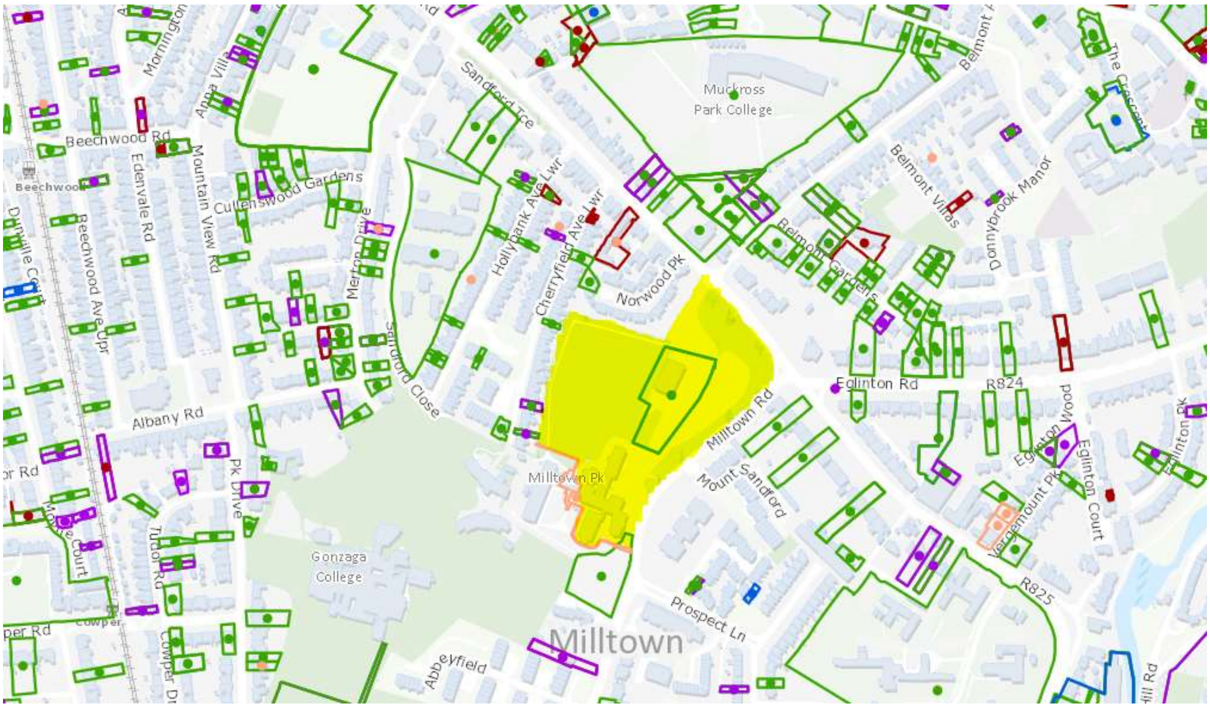

Figure 2.2 Nearby Permitted Developments (Source: MyPlan.ie)

2.5 Geology and Nearby Ground Investigations (GI)

The Geological Survey of Ireland (GSI) mapviewer shows the site to be underlain by Calp Limestone which is described as dark-grey to black, fine-grained, occasionally cherty, micritic limestones that weather paler, usually to pale grey. There are rare dark coarser grained calcarenitic limestones, sometimes graded, and interbedded dark-grey calcar.

The GSI's Geotechnical viewer which contain records for nearby ground investigations (GI) carried out across Ireland was consulted. The most relevant GI is Milltown Road (20m south to the site) as shown in Figure 2.3 which included the drilling of 3No. cable percussion boreholes. The boreholes showed that the ground comprised of 0.3-1.2m of made ground which is underlain by glacial till described as Sandy Gravelly Clay (Dublin Boulder Clay). The boulder clay thickness ranged between 5.9-7.4m, the upper 2m of the boulder clay was noted to be brown and had lower Standard Penetration Test (SPT) N value than deeper black layer. All 3No. boreholes terminated at depth of around 6.5-7.5mBGL.

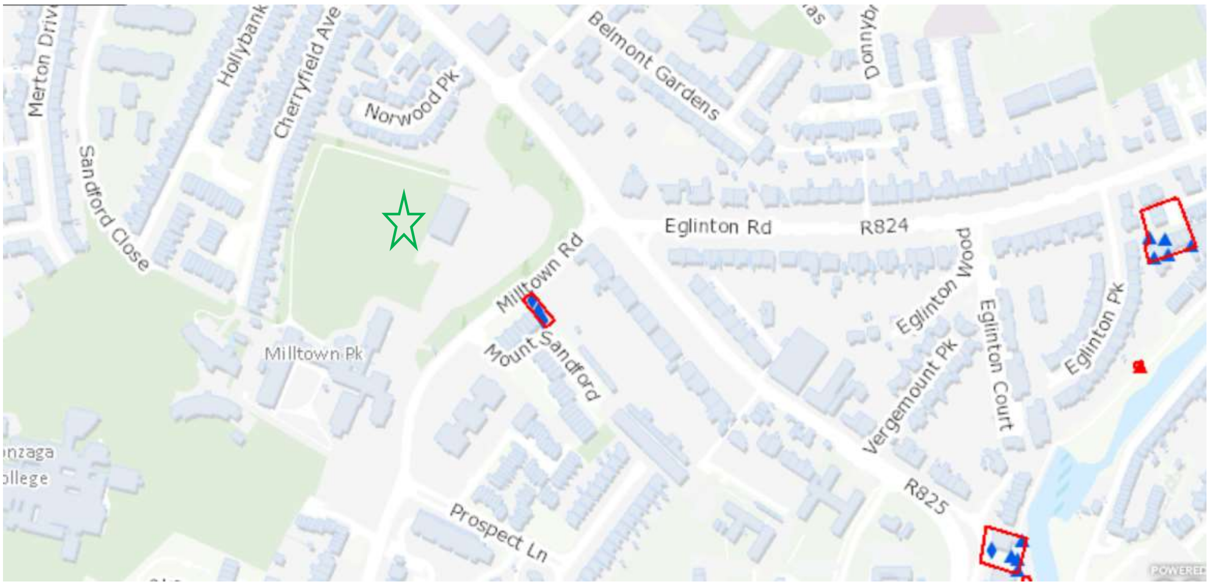

Figure 2.3: Nearby ground investigations to the site (Source: GSI Geotechnical viewer)

3 Ground Conditions

3.1 Ground Investigation

A ground investigation was carried out throughout January to October 2020 and comprised of the following:

- 16No. Cable Percussion boreholes to a maximum depth of 8m;
- 5No. rotary follow on boreholes on the cable percussion boreholes to a maximum depth of 20mBGL;
- 14No. window sample boreholes;
- 11No. trial/foundation pits to determine existing foundation details;
- 3No. soakaway pits;
- 13No. Dynamic probes; And
- 9No. Plate Load tests to determine CBR value.

3.2 Ground Profile

The geology of the site based on intrusive investigations carried out across the site were as follows:

- TOPSOIL;
- In some locations, a thin layer of Made Ground comprising of 'brown sandy gravelly CLAY with construction and demolition waste namely concrete and plastic fragments'. The maximum thickness of Made Ground during the investigation was 1.0m and the minimum thickness was 0.1m;
- Underneath the Made Ground, a glacial till layer is present and it can be described as 'Soft to Stiff light brown mottled grey sandy gravelly CLAY with occasional cobbles (Dublin Boulder Clay)'. This layer was encountered from depths of 0.5mBGL to 2.2mBGL during the investigation; and
- Underneath the brown sandy gravelly CLAY is 'very stiff grey to dark grey sandy gravelly CLAY with occasional boulders' (Dublin Boulder Clay). This layer was encountered from minimum depth of 2.2 and a maximum depth of 2.6mBGL; And
- Bedrock is LIMESTONE. The rotary core follow on boreholes encountered top of rock at a minimum depth of 9.0mBGL and a maximum depth of 18.5mBGL.

3.3 Ground Model & Characteristic Soil Parameters

The table below presents the ground model adopted for the purposes of this assessment. This is considered a site-wide model which is a best representative model of the whole site and is considered appropriate for the type of assessment completed.

Table 3.1: Design Ground / Ground Model

Strata	Depth to Top (m)	Elevation to Top (m)	Thickness (m)
Made Ground	0	+ 20.8-18.2	0.5
Firm to Stiff Sandy Gravelly CLAY	0.5	+ 20.3-17.7	1.7
Stiff to Very Stiff Sandy Gravelly CLAY	2.2-2.6	+ 18.6-18.2	7-17
Bedrock	Expected circa 9.0 to 18.45	+11.45 -/+ 1.2	-

More detailed ground models may be used at detailed design stage and following the completion of the rotary core drilling (e.g. specific ground models and stratigraphy levels for wall design at a given elevation).

As noted above, for undertaking a ground movement assessment, the most important properties of the soil are vertical stiffness (E', E_u). A number of authors and publications present correlations relating stiffness of overconsolidated clays to undrained shear strength. CIRIA C760 presents correlations for drained and undrained stiffness modules with Jamiolkowski et al. (1979) and Stroud & Butler (1975) also proposing relationships of Eu/Cu and E'/Cu to Plasticity Index.

Relationships of E_u = 500-600 C_u have been used for undrained modulus with the drained modulus (E') taken as 60% of this value. For soils with PI less than 30, the E_u/C_u relationship can be as high as 1000. E_u = 500 C_u has been taken here as a conservative approach. E' = 2N (MPA) is typically considered for granular soils and has been attributed for the GRAVEL.

In addition to the standard correlations above, a number of papers, namely '*Retaining Walls in Dublin Boulder Clay, Ireland*' by Long, Brangan, Menkiti, Looby and Casey in which a detailed study of retaining walls in Dublin Boulder Clay was conducted (2013) and *'Geotechnical properties of Dublin Boulder Clay'* by Long and Menkiti (2007) were consulted in the selection of parameters for the firm to stiff Clays.

Based on the above, the following characteristic soil parameters have been chosen for the various strata.

Table 3.2 Characteristic Soil Parameters

Strata	γ (kN/m^3)	SPT N Value	C_u (kPa)	E′ (MPa)	E_u (MPa)
Made Ground	18	10	-	20	-
Soft/Firm to Stiff Sandy Gravelly CLAY	19	6-27	100	40	60
Very Stiff Sandy Gravelly CLAY	19	33-50	225	90	135

For the purposes of the ground movement analysis, rock has been considered incompressible.

4 Hydrogeology

4.1 Geology and Hydrogeology of Dublin

Limestone bedrock from the Carboniferous age (365-325 million years ago) underlie circa 65% of the island of Ireland. This part of Dublin city is underlain by the Lucan formation which is classified by the GSI as a Locally Important (LI) aquifer which is moderately productive in local zones only as shown in Figure 4.1 below. In general, permeability in the Lucan Formation is low (1m/day). The flow of groundwater in rock aquifers is dependent on the network of fractures and its properties such as density of fracture, direction, length, width and the connectivity between the network of fractures, Fractures length can vary accordingly from few metres to hundreds of metres (Comte et al., 2012). When fractures are present in rocks it will change the flow pattern of groundwater because the water is trapped inside the fractures and hence it moves along the direction of the fracture and also fractured rock aquifer characteristics such as transmissivity and storage will differ greatly depending on the length and width of the fracture.

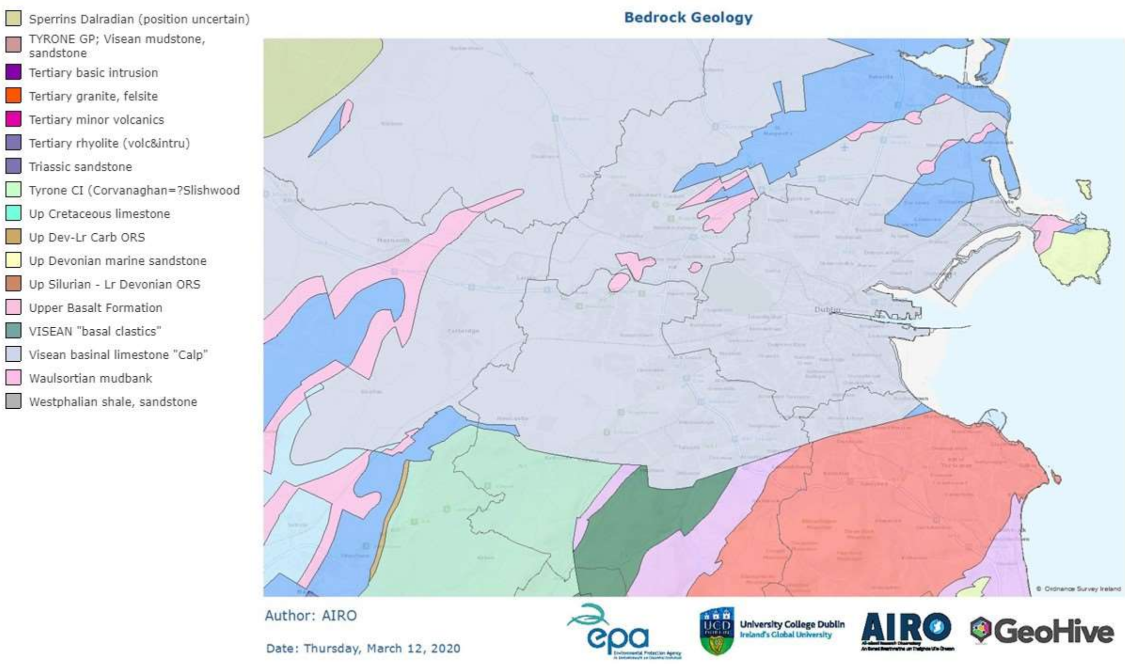

Figure 4.1: Bedrock Geology (Source: Geological Survey of Ireland)

Some 10,000 years ago, when a layer of ice of 1km thickness covered majority of the Leinster region, a low permeability lodgement till was formed at the base of this ice sheet due to the grinding action of the ice sheet on the bedrock. This layer of low permeability sandy gravelly clay (Dublin Boulder Clay) is present almost everywhere in the Dublin region and range in thickness from 20m in some parts to being absent near the Heuston Station and Smithfield area. A layer of glacial-fluvial Sand and Gravel can be found in Dublin city along the channels/floodplains of the River Liffey, Dodder and Camac. In addition, some unconnected

Sand and Gravel lenses can be found within the boulder clay, their lateral and vertical extent is also limited.

Groundwater flow in the bedrock is confined (artesian to semi-artesian) by the layer of low permeability clay present above it in the Dublin region. The boulder clay hence acts as a protective layer to the bedrock from surface activities such as contamination and oil spills and also limits the amount of rainfall that can end up recharging the groundwater in the bedrock (Misstear, Brown and Daly, 2009).

4.2 Findings of Detailed Assessment For Former Metro North Station Boxes on Groundwater Levels

The impact of deep basements construction within the city centre of Dublin has not been studied/investigated thoroughly, however, a small number of major developments such as the former Metro North (also known as MetroLink today) were requested by An Bord Pleanala (ABP) to appoint a hydrogeologist to carry out a study on the potential impact of its proposed underground station boxes on surrounding groundwater flow and/or levels. The former alignment of Metro North passes within areas which had low permeability geology (Made Ground over Dublin Boulder Clay over Limestone bedrock) and it also crosses areas where there are layers of alluvial deposits above the Dublin Boulder Clay such as in Parnell Square area. The proposed underground station boxes for the Metro North had an average dimension of 25m deep, 30m wide and 165m long. Professor William Powrie from University of Southampton, UK was appointed to carry out the study and his conclusions were as follows:

1. Where basements are founded in Low permeability tills such as Sandy Gravelly CLAY (Dublin Boulder Clay), there are no impact on groundwater regime since it is evident that there is very little water flow in these low permeability horizons regardless of their porosity;

4.3 Impact of the proposed development on the groundwater regime

The proposed basement is approximately 150m in length and 120m in width, the finished floor level for the basement of the development will be at circa 14.55-16.88mOD for the basement, the basement will be founded within the boulder clay. The construction of the basement will result in the excavation of the thin layers of Topsoil and Made Ground and about 3-4m of boulder clay. The boulder clay has very limited ability to transmit groundwater due to its low permeability characteristic and is an aquitard/aquiclude rather than an aquifer. Throughout the ground investigation, the vast majority of the cable percussion boreholes did not encounter groundwater strikes and where encountered it was within the boundary of the brown and dark grey boulder clay which is a known occurrence in the Dublin boulder clay.

The proposed basement is not likely to impede/block groundwater flow as it will be founded within the boulder clay

4.4 Cumulative Impact of Nearby Basements

There are no new basements proposed within the immediate vicinity of the site. It is therefore concluded that groundwater flow impediment scenarios C1 and D1 illustrated in the DCC guidance document (see Figure 4.1) are not applicable and the likely scenario for this proposed basement is B1.

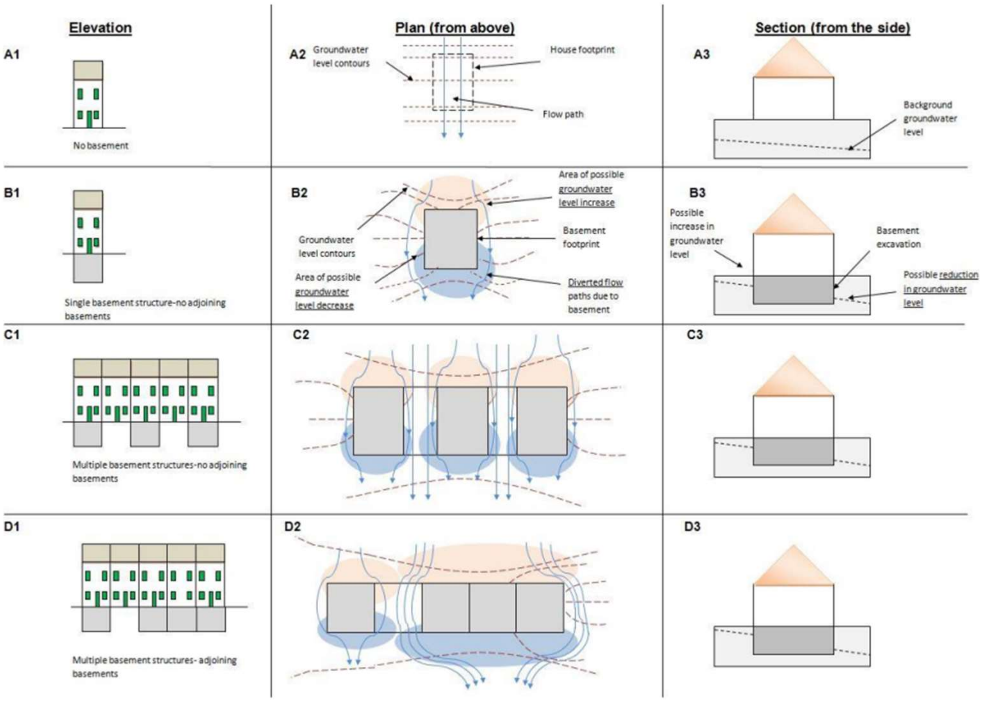

Figure 4.1: cumulative effects of basement construction on groundwater

4.5 Temporary Groundwater control

During the basement excavation, pumping of water might be required to keep the excavation dry. The source of water will likely be surface water runoff accumulating within the excavation footprint, minimal pumping arrangement will suffice.

5 Ground Movement Assessment

5.1 Basis of Assessment

5.1.1 Mechanisms Explored

ByrneLooby have completed a preliminary ground movement assessment associated with the proposed basement structure. The basement will be excavated to approx. 4.8m deep and will be formed on the stiff to very stiff CLAY strata. This assessment is considered preliminary. The following mechanisms of movements have been assessed:

1. Ground Movements within Basement (Heave & Settlement)

   The ground movements within the basement are as a result of the unloading on the formation soils will generate ground movement, which could affect adjacent foundations. Stress relief will initially cause short-term heave following which the soils will be subject to structural loading from the substructure. This mechanism considers the existing stress conditions, stress and weight of soil removed and design loads from new structural slab and pad/strip foundations. Short-term movements (i.e. heave) are associated with undrained conditions. The long-term movements are associated with drained conditions.

2. Ground Movements surrounding Basement

   It is proposed to construct the basement using open cut excavation techniques. ByrneLooby have carried out an assessment of ground movements based on ground movements caused by the lateral deflection of an embedded retaining wall which are based on default values within CIRIA C760, which were derived from a number of historic case studies. No ground movements caused by the installation of the embedded retaining wall have been included in the assessment. As it is proposed to construct the basement using open cut techniques, the assessment is considered conservative. Around critical wall sections embedded retaining walls will be required. Along these elevations, ground movements from embedded retaining wall installation have also been included.

5.1.2 Software Used

The assessment of ground movements within and surrounding the excavation has been undertaken using the X-Disp and P-Disp computer programs licensed from the OASYS suite of geotechnical modelling software. These programs are commonly used within the ground engineering industry and are considered to be appropriate tools for this analysis.

The analysis of potential ground movements within the excavation, 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 small strains.

The X-Disp program has been used to predict ground movements likely to arise from the construction of the proposed basement. This includes the settlement of the ground (vertical movement) and the lateral movement of soil caused by the excavation (horizontal movement).

5.2 Ground Movements within Basement (Heave)

5.2.1 Input Information

The soils at formation level of the basement will be subject to stress relief during excavation, as approximately 4.8m of overburden is to be removed from the basement excavation. It is envisaged that the reduction in vertical stress in the short term will cause heave or elastic rebound 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.

The subsequent reloading of the soils due to structural loading applied from pad/strip foundations is likely to give rise to potential settlement over the longer term. Drained parameters have been used to provide an estimate of the total long term movement.

As noted above, a vertical movement assessment has been undertaken using OASYS Limited PDisp analysis software. P-Disp assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness (E_u and E’) for each stratum.

P-Disp assumes perfectly flexible loaded areas and as such tends to overestimate movements in the centre of loaded areas and underestimate movements around the perimeter.

The following loading has been considered for the basement:

- As above the proposed excavation of the new basement will result in a maximum unloading stress reduction of approximately 96kN/m^2. An unloading value of 96kN/m^2 was taken as a representative to assess effects of short-term heave.
- DBFL have outlined a column layout for a portion of the basement. To simplify the model a UDL of 350kN/m^2 has been applied across the full basement footprint. Based on this, the net pressure (i.e. loading minus uplift pressure) has been applied as 254kN/m^2.

For the purpose of this analyses, the basement have been assumed as a box with the extremity corners defined by x and y coordinates.

5.2.2 Results

The P-Disp (internal displacement) results have been summarised below for the long and short-term conditions.

<u>Short-term Conditions</u>

A contour plot showing the variation of short-term movement due to unloading across the basement footprint is presented in the figure below.

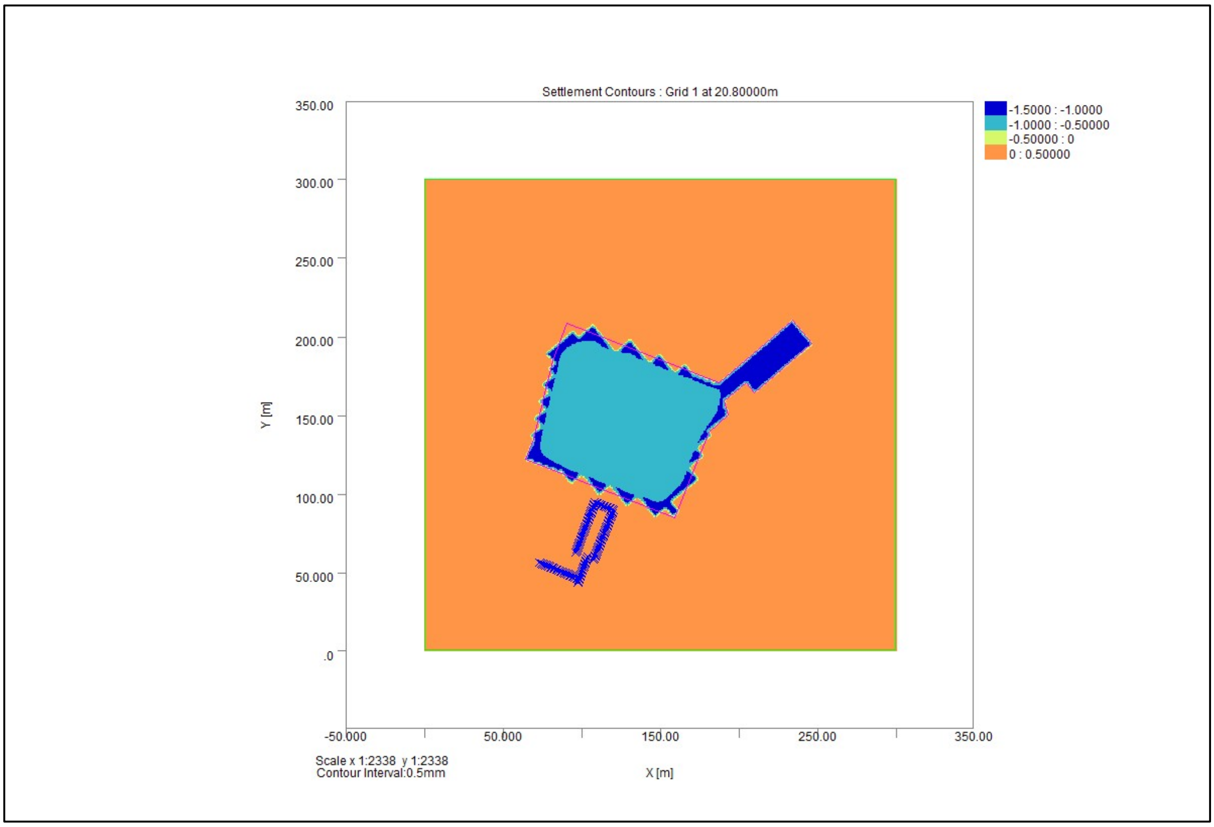

Figure 5.1: Short-term Ground Movement Contour Plot (Internal Movements)

The P-Disp analysis indicates that approximately up to 1.5mm of heave is likely to take place in the basement.

Long Term Conditions

For long term conditions, a net loading has been applied (i.e. unloading plus structural loading) with drained conditions. The results are shown in the Figure below.

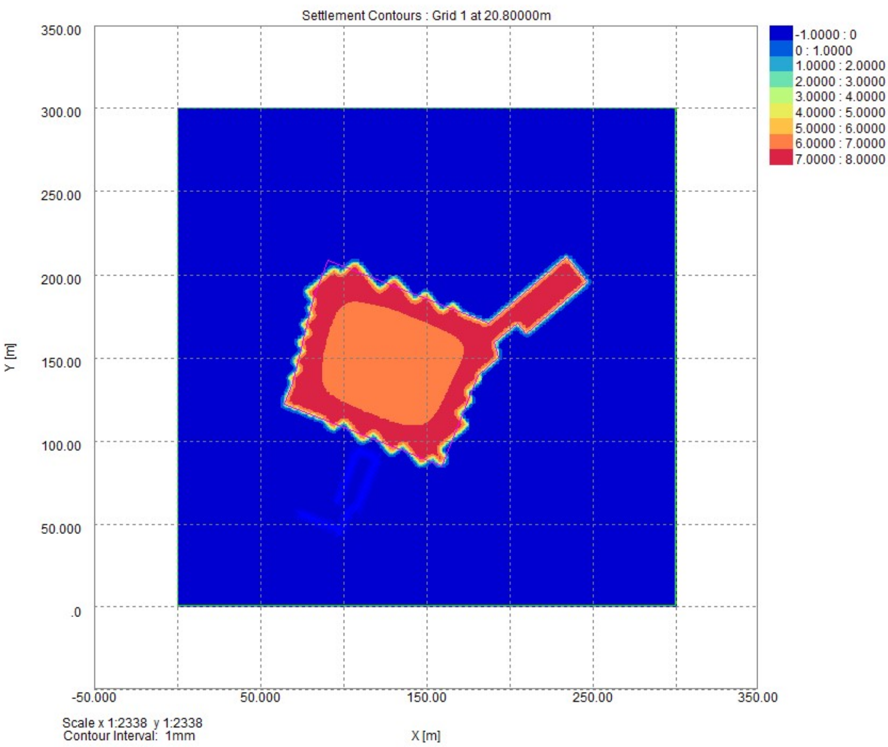

Figure 5.2: Long-term Ground Movement Contour Plot (Internal Movements)

As per the Figure above, the maximum predicted vertical settlement has been calculated as up to 8mm in the centre of the basement.

Ground movement associated with the basement excavation externally to the basement itself has been assessed in the section below.

5.3 Ground Movements Surrounding Basement

5.3.1 Input Information

For the X-Disp analysis, the ground movements used are the default values within CIRIA C760, which were derived from a number of historic case studies. Although, an open cut excavation is proposed to construct the basement, the ground movements curves for 'excavations in front of a low stiffness wall in stiff clay' have conservatively been used, as referenced in CIRIA C760. A number of sections have been modelled as an embedded retaining wall due to the proximity of adjacent buildings. The nearest adjacent structures assessed in the analysis are:

- Tabor House (Denoted Structure 'A')

All other nearby structures are considered outside the zone of influence from the site (i.e. a sufficient distance for the movements as a result of the proposed basement construction to reduce to negligible values) and as such, have not been included in the assessment.

The structures outlined above have been modelled as lines in the analysis and are the lines along which the damage assessment has been undertaken. These lines are expected to be sensitive at their foundation level, which have been taken as 0.55m bgl. The height of the structures has been estimated.

5.3.2 Results

The ground movements used in the assessment are summarised in the table below which in turn have been used to complete a Damage Impact Assessment of the adjacent properties. As an open cut excavation is proposed to form the basement, the movements detailed in the table below are considered conservative.

The movements detailed in the table below are extreme values and occurred immediately behind the embedded retaining wall. It is important to note that they are not settlement or movement values at specific foundation locations. Movements generally decrease away from the embedded retaining wall with extrapolated values used for the Damage Impact Assessment (see Section 5.4).

Table 5.1: Results of Ground Movement Analysis

Phase of Works		Max Ground Surface Movement Immediately Adjacent to Wall	
		Vertical Movement (mm)	Horizontal Movement (mm)
Excavation Movements – Main Basement	Low Stiffness System*	17	19

** Movements have been based on CIRIA C760 Figure 6.15.*

A Damage Impact Assessment for the above movements with respect to the surrounding structures has been completed in the next section.

5.4 Damage Impact Assessment

In addition to the above assessment of the likely movements that will result from the proposed development, a Damage Impact Assessment of the neighbouring structures has been completed based on the classifications given in Table of 6.4 of CIRIA report C760 (formally C580).

These classifications, which have been extracted and shown in the table below, are based on method of damage assessment outlined by Burland et al (1977), Boscardin and Cording (1989) and Burland (2001).

Table 5.2: Table 6.4 of CIRIA C760: Classification of visible damage to walls (after Burland et al, 1977, Boscardin and Cording, 1989, and Burland, 2001.

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain, ε_{lim} (%)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible	<0.1	0.0 to 0.05
1 Very slight	**Fine cracks that can easily be treated during normal decoration.** Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection	<1	0.05 to 0.075
2 Slight	**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.	<5	0.075 to 0.15
3 Moderate	**The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable lining. Repointing of external brickwork and possibly a small amount of brickwork to be replaced.** Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5 to 15 or a number of cracks >3	0.15 to 0.3
4 Severe	**Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows.** Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Services pipes disrupted.	15 to 25, but also depends on number of cracks	>0.3
5 Very severe	**This requires a major repair, involving partial or complete rebuilding.** Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	Usually >25, but depends on numbers of cracks	

The cumulative movements (Short Term Unloading and Excavation Movement) is shown in Figure 5.3.

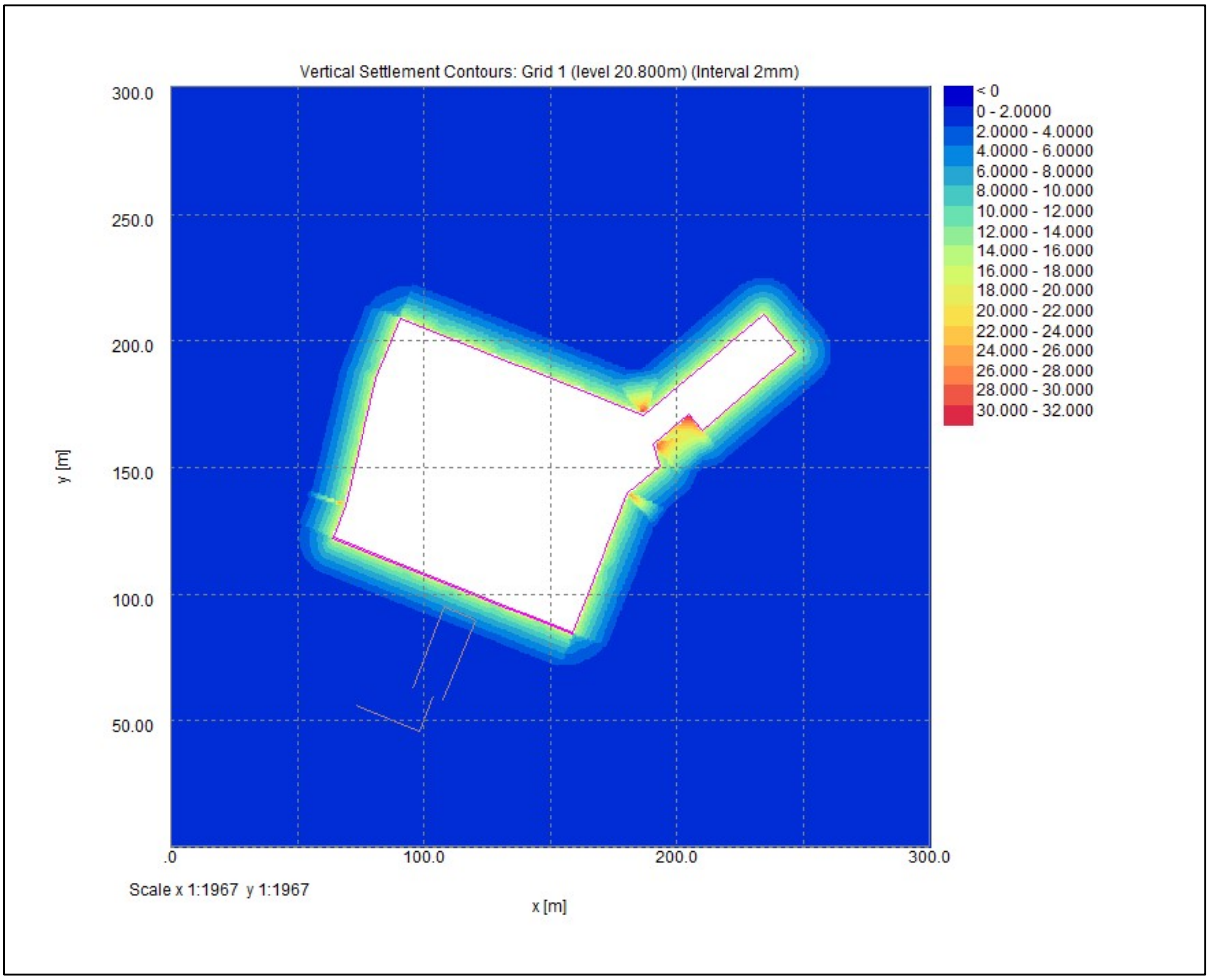

Figure 5.2: Cumulative Vertical Movement

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

Table 5.3: Results of Damage Impact Assessment

Structure Ref	Structure Description	Elevation / Line	Category of Damage (Table 5.1 above)
A	Tabor House 1	A1	Category 2 – Slight.
	Tabor House 2	A2	Category 0 – Negligible.
	Tabor House 3	A3	Category 2 – Slight.

As shown in the table, Tabor House falls within a Category 2 – Slight Damage Category which, as per Table 5.2, equates to damage that is considered to be aesthetic and non structural.

This may be reduced to a Category 0 - Negligible should a localised high stiffness (propped) embedded retaining wall be constructed along this section. Due to the proximity of Tabor House, required working space and excavation depth at this section a temporary retaining wall may be required.

Alternatively, a monitoring programme may be implemented whereby target points are installed on Tabor House, with movements monitored and contingency measures implemented should movements exceed trigger levels.

6 Conclusion

ByrneLooby have carried out a ground movement analysis to assess the impact of ground movements formed by the basement construction on adjacent structures. The only buildings considered within the zone of influence of the basement's construction is Tabor House to the south of the basement. Based on the movements caused by the unloading of the formation soils, permanent structural loading and the excavation works, a damage category of slight has been calculated for Tabor House. The empirical ground movement curves have been based on 'excavations in front of a low stiffness wall in stiff clay'. This may be reduced to a damage category of negligible should a localised high stiffness (propped) embedded wall be constructed along this section. Alternatively, a monitoring programme may be implemented whereby movements are monitored and contingency measures implemented should movements exceed trigger levels.

ByrneLooby have also assessed the impact of the basement excavation and construction on the groundwater regime beneath and surrounding the site. The basement will be formed using the open cut excavation method (no embedded piled retaining wall needed) and will be founded within the boulder clay. The method of basement construction in conjunction with the geology within which it is to be founded indicate that the impact on groundwater will be negligible.

A1