Basement Impact Assessment for Royal Liver

Royal Liver

Report No. C56-1423-AYE-GEO-RP001

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[1] Introduction

[1.1] Scope of the Report

Ayesa has been requested by DBFL Consulting Engineers to complete the Basement Impact Assessment (BIA) for the amendments to the permitted redevelopment of the Royal Liver Retail Park (ABP ref. PL295.307804 and DCC reg ref. 4436/23). Planning permission was granted on 15th February 2024 for the redevelopment of the Royal Liver Assurance Retail Park to provide a mixed-use development which includes for the provision of a significant basement. The basement is mainly constructed mainly as Vehicle parking. This application is being made to amend the granted permission including amendments (reduction) to the existing permitted basement as part of the latest planning application. The proposed development is located at Old Naas Road, Dublin 12.

As part of Dublin City Council's (DCC) Dublin City Development Plan 2022 - 2028, a Basement Impact Assessment (BIA) shall accompany all planning applications that incorporate a basement structure. This report complies with the requirements of DCC's Basement Impact Requirements. It provides information on the ground and groundwater conditions at the site to assess the impact of the proposed basement on the groundwater regime and neighbouring structures.

The purpose of the Basement Impact Assessment (BIA) is to identify potential short- and long-term impacts, inform as to whether a proposed basement structure is acceptable and identify appropriate mitigating measures that can be integrated into the development.

[1.2] Proposed Development

The development will consist of amendments to a previously permitted mixed-use development (DCC Reg. Ref.: 4238/19; ABP Ref. PL29S.307804, as amended by DCC Ref.: 4436/23 and DCC Reg. Ref.: 5050/26). The proposed amendments relate solely to the permitted Blocks B1, B2, C1, C2, D1 & D2 (identified as Phase 2). No amendments are proposed to any other permitted blocks.

The amendments are as follows:

1. The proposed alterations result in an overall increase of 2 no. units increasing the total overall units from 1196 to 1198. The proposed amended residential development of Block B1, B2, C1, C2, D1 & D2 will consist of a total of 635 no. residential apartments (an increase from 633 no. as permitted), which includes 38 No. Studios, 269 No. 1-Bed, 288 No. 2-Bed- 4-Person and 40 No. 3-Bed- 5-Person, units as follows:
    - Alteration of Block B1 from a permitted 11-12-storey building providing for 90 no. apartment units to a 10-storey building providing for 107 no. apartments.
    - Alteration of Block B2 from a permitted 10 storey building providing for 90 no. apartment units to a 10-storey building providing for 89 no. apartments.
    - Alteration of Block C1 from a permitted 10-storey building providing for 171 no. apartment units to a 10-storey building providing for 144 no. apartments.
    - Alteration of Block C2 from a permitted 10-storey building providing for 89 no. apartment units to a 10-storey building providing for 98 no. apartments.

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- Alteration of Block D1 from a permitted 9-storey building providing for 87 no. apartment units to a 9-storey building providing for 123 no. apartments.
- Alteration of Block D2 from a permitted 8-storey building providing for 106 no. apartment units to an 8-storey building providing for 74 no. apartments.

2. The reconfiguration of internal layouts of each of the blocks has resulted in the minor shift in the block footprints. The permitted podium between Block B2 and Block C1 is removed with additional public realm and connection to the south proposed. The block amendments result in amendments to permitted communal amenity space with the removal of roof terraces on Blocks C1, C2 and D1 and amendment to roof terraces on Block B1 and B2.
3. Façade modifications are proposed to respond to the revised internal layouts including minor relocation of windows, balconies etc. and a revised approach to the Naas Rd frontage.
4. Alteration of the permitted uses and facade at ground floor level and removal of permitted BTR tenant amenity spaces located in Blocks B1, B2, C1 & C2 to provide for a ground floor level that includes:
    - **Blocks B1-B2**: 1 no. retail/café/restaurant unit, 1 no. café unit, 1 no. community unit, a creche (relocated from Block D1) and associated cycle parking, plant areas and entrances.
    - **Block C1-C2-D1-D2**: 1 no. retail unit, 2 no. retail/cafe/restaurant units, own door residential units, undercroft parking and associated cycle parking, plant areas and entrances.
5. Alterations to the permitted undercroft and basement parking areas under Blocks B1, B2, C1, C2, D1 & D2 to include for alterations to permitted layouts of car parking, cycle parking, plant, waste stores and substation locations.
6. Amendment of Condition 3 (a) of the parent permission (DCC Reg. Ref.: 4238/19; ABP Ref. PL29S.307804) relating to the Build to Rent (BTR) covenant, and its removal as it relates to Blocks B1, B2, C1, C2 & D1.

[1.3] Site Location and Description

The proposed development site is located in the suburb of Inchicore to the southwest of Dublin city centre. Planning permission (Planning Application ref. 4436/23) was granted on 15h February 2024 for the redevelopment of the Royal Liver Assurance Retail Park to provide a mixed-use development.

The site is presently occupied by a retail park consisting of 2no. sizeable retail unit buildings and a carpark area. The site is bounded by the Old Naas Road to the north, the R810 Naas Road to the south, the R112 Kylemore Road to the west and a retail unit to the east. The surrounding area is predominantly commercial development.

The site is generally flat, with elevation of +41.0mOD to +42.0mOD. The site location and plan view of the basement are presented in Figure 1-1 and Figure 1-2.

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Figure 1-1 Site Location (Ref: Google Maps)

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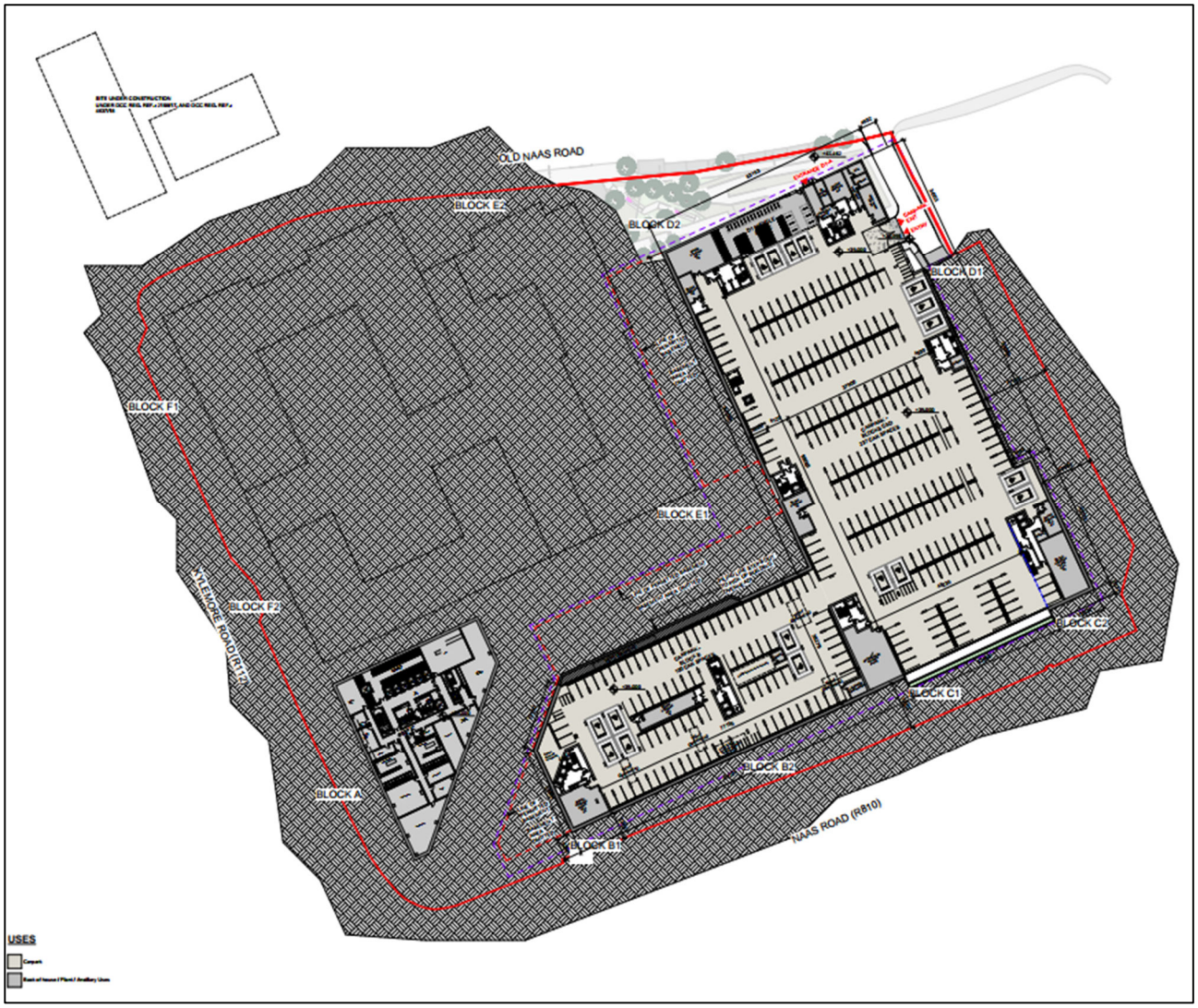


Figure 1-2 Proposed Revised Basement Plan (Ref: PRL-HJL-ZZ-B1-DR-A-0010A-P1)

[1.4] Report Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the ground investigations and surveys completed. The results of the work should be viewed in the context of the range of data sources consulted and the number of locations where the ground was sampled and tested. No liability can be accepted for information relating to other data sources or conditions not revealed by sampling or testing.

The ground movement assessment and hydrogeological findings presented in this report are considered predictions. They should be verified and confirmed at detailed design stage following final selection of construction methodologies and details.

Groundwater monitoring has been completed as part of the site-specific ground investigation. However, such monitoring should be completed over an extended period to record any seasonal variations in groundwater level.

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[2] Desktop Survey

[2.1] General

Ayesa has consulted a comprehensive range of online information resources to complete the desk study of the development site. Among these include the Geological Survey Ireland (GSI), Ordnance Survey Ireland (OSI), National Inventory of Architectural Heritage (NIAH) and National Planning Application Database (NPAD).

[2.1.1] Bedrock Geology

The Geological Survey Ireland (GSI) Spatial Resources Bedrock Geology Map indicates that the site is underlaid by the Lucan Formation (LU) dating back to the Carboniferous period. This formation is comprised of 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, which are sometimes graded and interbedded dark grey calcar. This can be described as dark limestone and shale (calp). The beds are predominantly fine-grained distal turbidites in the north Dublin Basin. The formation is intermittently exposed on the coast between Rush and Drumanagh Head and ranges from 300m to 800m in thickness.

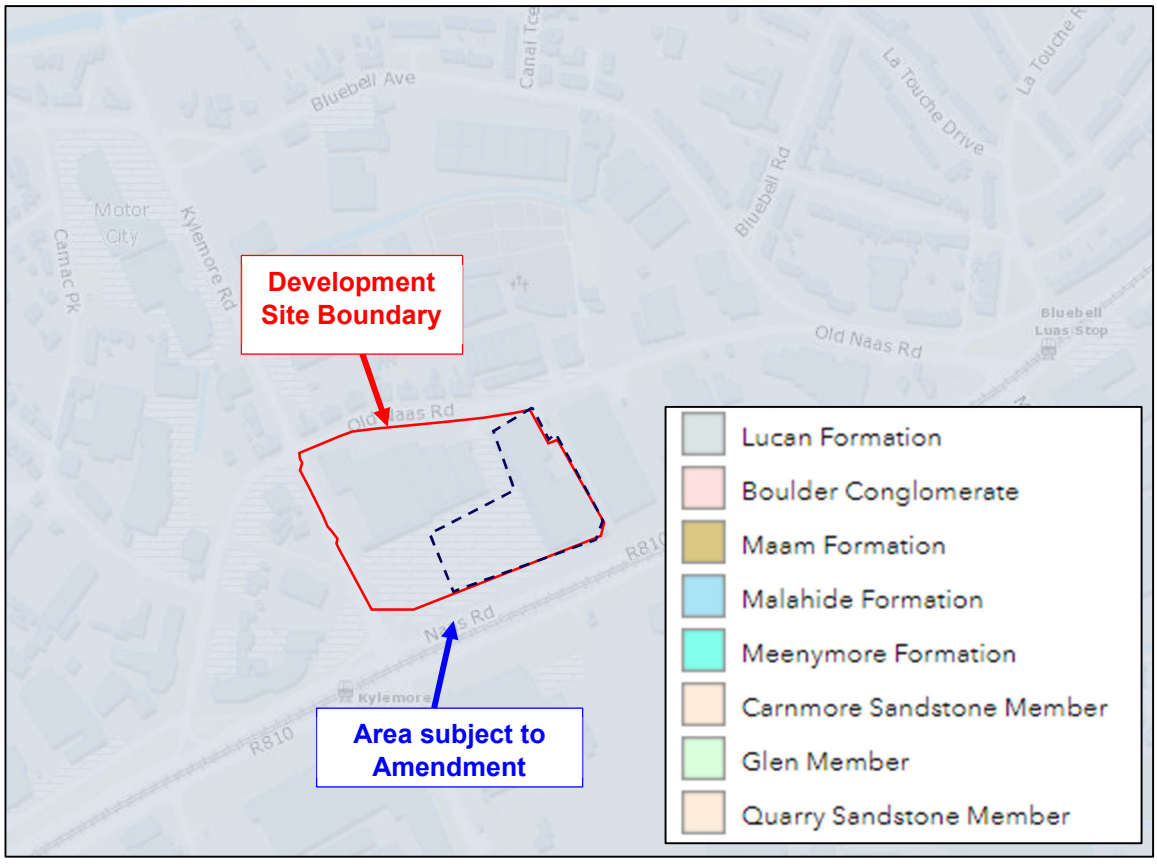


Figure 2-1 Bedrock Lithology (Ref: GSI)

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[2.1.2] Bedrock Depth

The GSI GeoUrban map indicates that bedrock can be expected between 5 and 10m depth Below Ground Level (BGL), as shown in Figure 2-2.

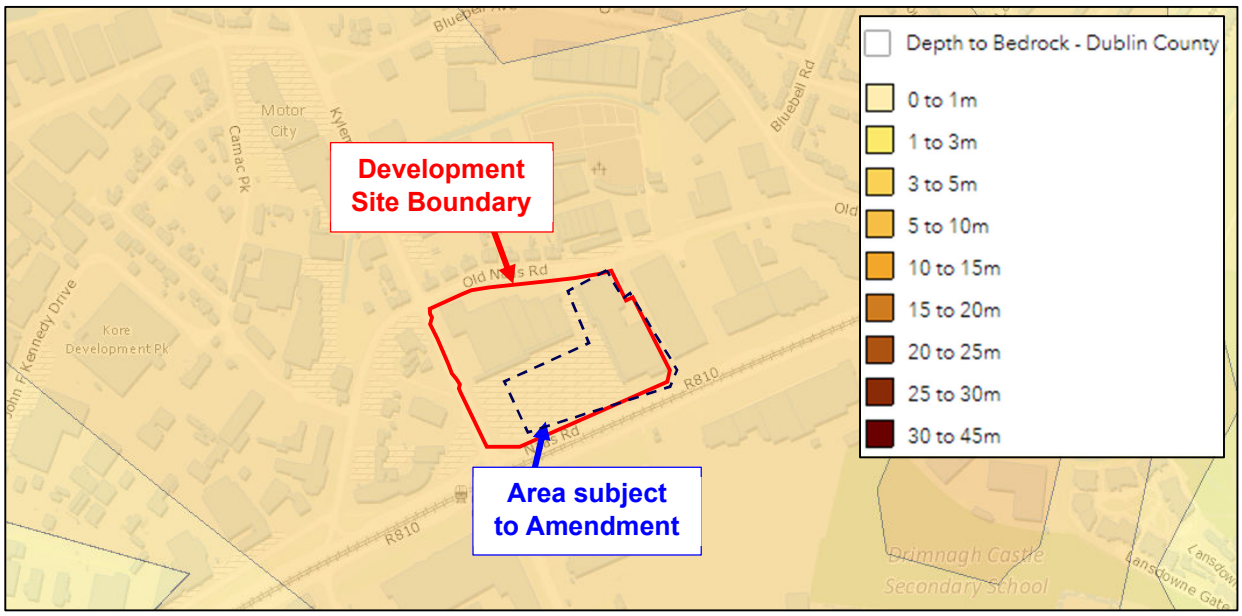


Figure 2-2 Depth to Bedrock Map (ref. GSI)

[2.1.3] Quaternary Sediments

The Geological Survey Ireland (GSI) Spatial Resources Quaternary Sediments Map depicts the site as being underlain by Till derived from limestones (TL). The site also borders an area of Urban Soils (Urban). The extents of the Quaternary Sediments are shown in Figure 2-3 below.

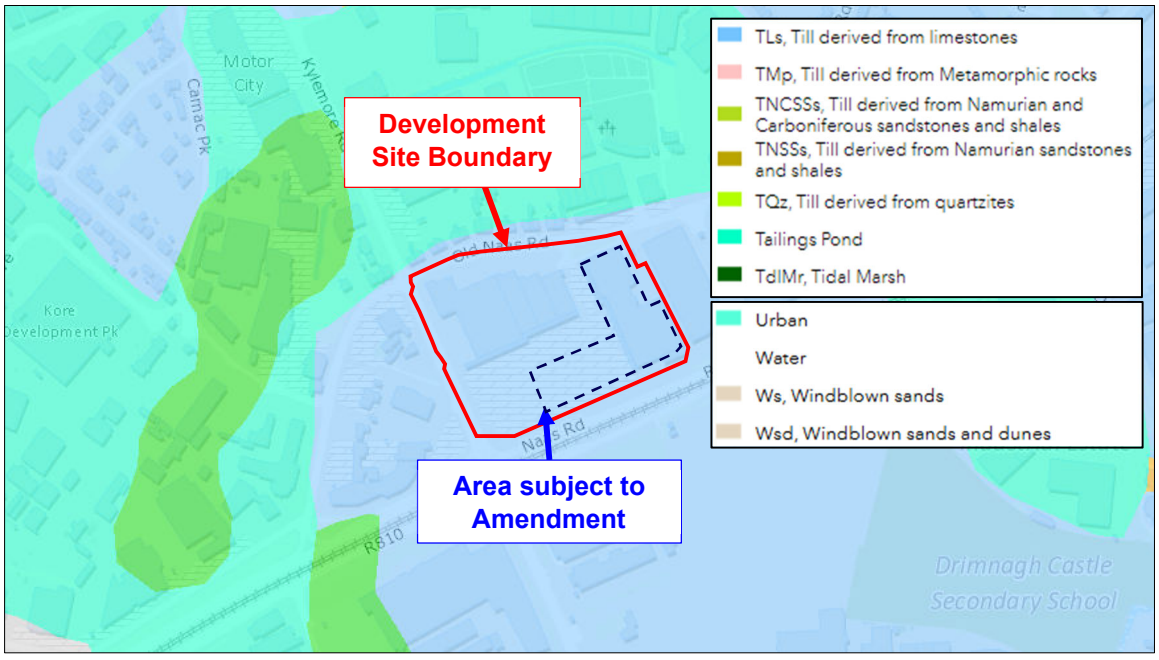


Figure 2-3 Quaternary Sediment (ref. GSI)

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[2.1.4] Groundwater

The subsoil is described as Made Ground of low permeability (L). The area is designated as moderate vulnerability (M).

The subsoil permeability and vulnerability maps are shown in Figure 2-4 and Figure 2-5 below.

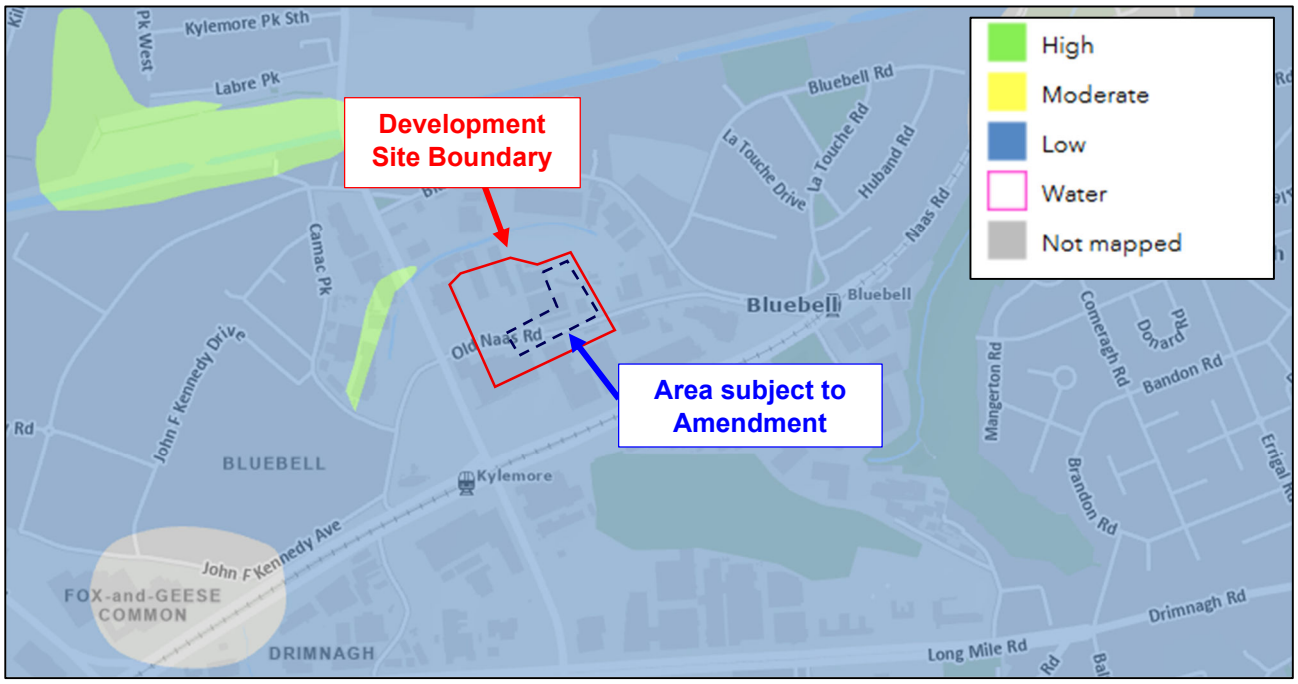


Figure 2-4 Subsoil Permeability Map (Ref: GSI)

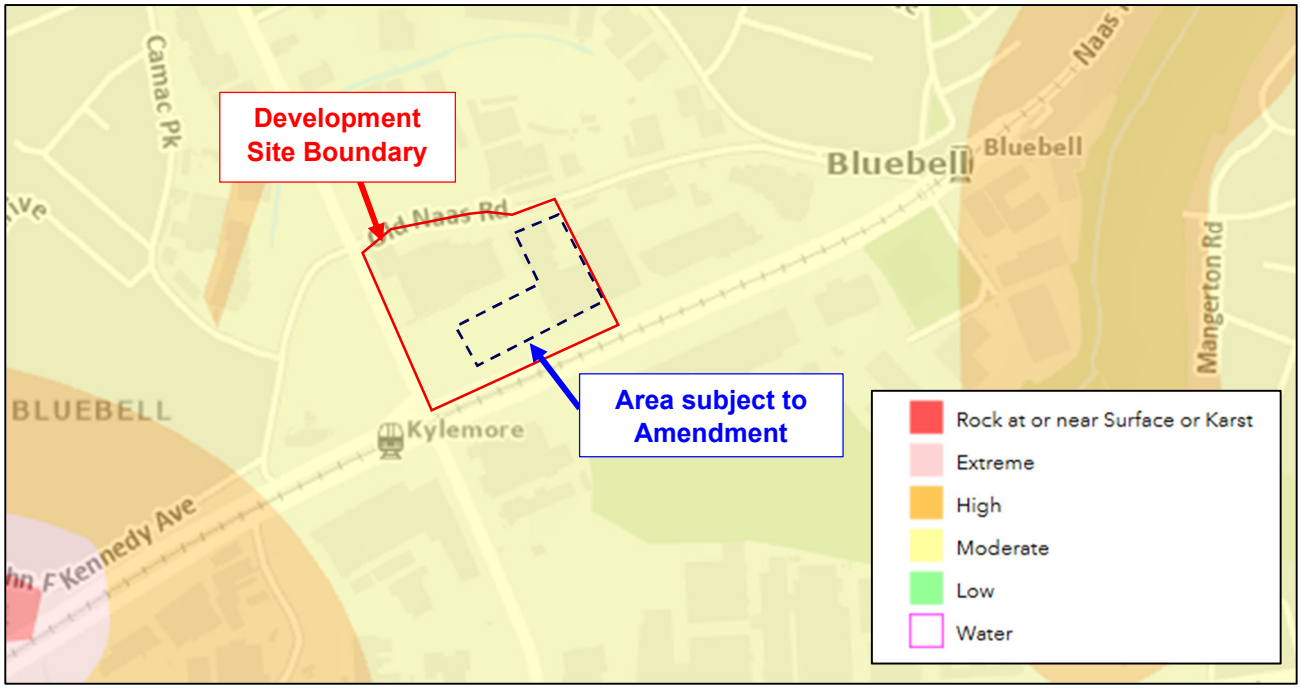


Figure 2-5 Subsoil Vulnerability Map (Ref: GSI)

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The Geological Survey Ireland (GSI) Spatial Resources Aquifer Map for the area indicates that the site is located within a locally important (LI) aquifer in which the bedrock is moderately productive only in local zones. It is designated as moderate vulnerability. The subsoil description is that of made ground and low permeability. The area has a hydrogeological setting code of 3m, a recharge coefficient of 20%, an average recharge rate of 70mm/year, an average recharge range of 51-100mm/year and a maximum recharge capacity of 200mm/year.

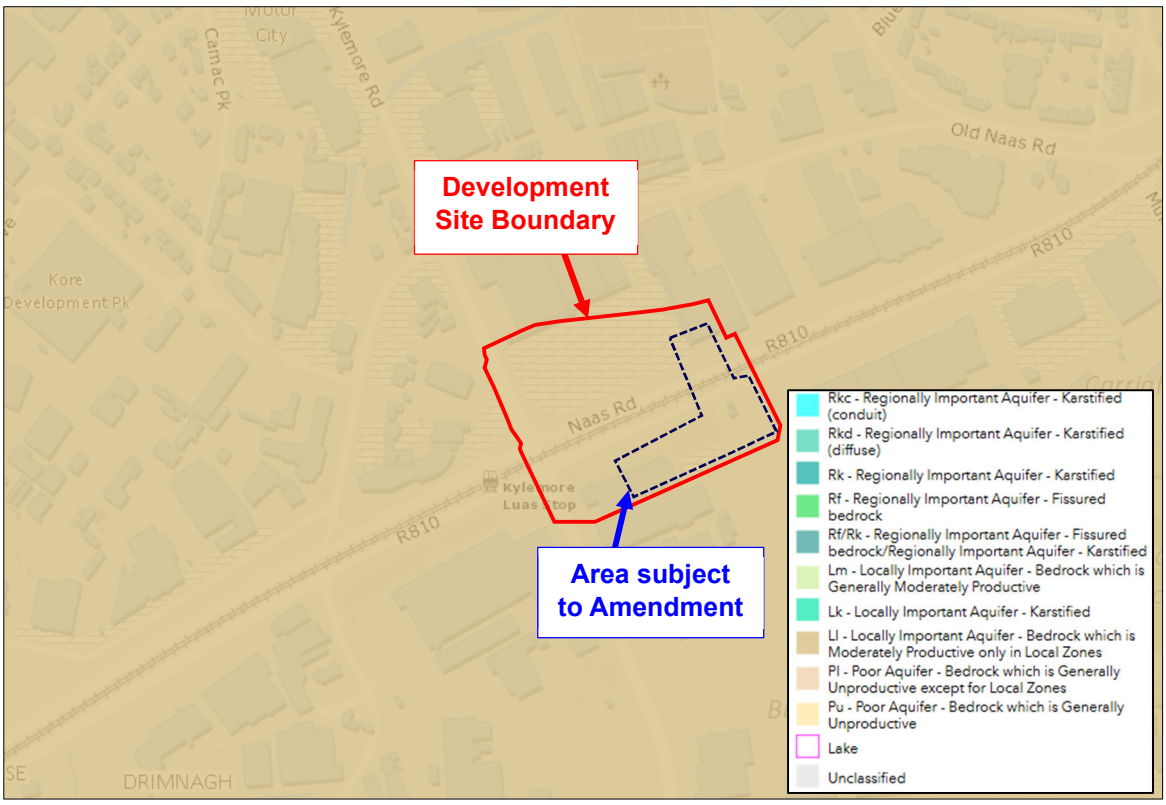


Figure 2-6 Bedrock Aquifer Map (ref. GSI)

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[2.2] Historical Ground investigation

The GSI website has been consulted to determine any historical ground investigations undertaken in the vicinity of the site. The locations of these are demarcated in Figure 2-7.

The following historical ground investigations in the proximity of the development site were obtained from the GSI spatial resources:

a. *Site Investigation Report for J.J Smith (Report ID 570): -*

This report was prepared for J J Smith by the Cementation Co. Ltd for an office development in June 1969. The report contains detailed report of 3no. detailed geotechnical borehole logs. No groundwater table was encountered during the ground investigation. The ground profile consists of 6.0m thick Made ground followed by 3.0m thick boulder clay. The bedrock was encountered at 9.0mBGL

b. *Site Investigation Report for Honda Site Naas Road (Report ID 5510): -*

This report was prepared for Honda by IGSL for a commercial development in June 2003. The report contains detailed report of 5no. detailed geotechnical borehole logs. The groundwater table was struck at 4.0mBGL. The ground profile consists of 0.25m of CONCRETE, 4.0m to 5.0m thick MADE GROUND, 1.2m to 2.8m thick Soft to Firm sandy Peaty Clay and 3.0m thick Stiff to Hard Sandy Gravelly Clay with boulders.

c. *Site Investigation report for KML Consulting Engineers (Report ID 957): -*

This report was prepared for KML Consulting Engineers by Joseph McCullough and Partners for a commercial development on 25th September 1990. The report contains detailed report of 6no. detailed geotechnical borehole logs. No groundwater table was encountered during the borehole investigation. The ground profile consists of 3.0m to 7.0m Made Ground followed by Firm to Stiff/Hard Silty Sandy Clay. Strong Limestone bedrock was encountered between 7.0mBGL to 10.0mBGL.

d. *Site Investigation report for McInerney's Warehouse (Report ID 413): -*

This report was prepared for McInerney's Warehouse by Cementation Co. Ltd. for an office development in July 1971. The report contains detailed report of 5no. detailed geotechnical borehole logs. No groundwater table was encountered during the borehole investigation. The ground profile consists of 4.0m to 7.0m Made Ground (mixed stoney clay fill) followed by Firm to Stiff/Hard Silty Sandy Clay. Strong Limestone bedrock was encountered between 5.5mBGL to 7.0mBGL.

e. *Site Investigation report for Joseph McCullough (Report ID 754): -*

This report was prepared for Joseph McCullough by Irish Soil Laboratories Ltd. for an office development in February 1980. The report contains detailed report of 11no. detailed geotechnical borehole logs. Groundwater table was encountered between 5.5mBGL to 7.0mBGL during the borehole investigation. The ground profile consists of 5.5m thick layer of Made Ground followed by 1.5m to 3.0m thick Firm to Stiff Silty Stoney Clay. The Limestone bedrock was encountered between 11mBGL to 13mBGL.

f. *Site Investigation report for O'Sheas Garage (Report ID 617): -*

This report was prepared for O'Sheas Garage by Site Investigation Ltd. in January 1972. The report contains detailed report of 5no. detailed geotechnical borehole logs. Groundwater table was encountered between 3.0mBGL during the borehole investigation. The ground profile

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consists of 0.5m thick layer of Made Ground followed by Firm to Stiff Silty Stoney Clay. The Limestone bedrock was encountered around 3.0mBGL.

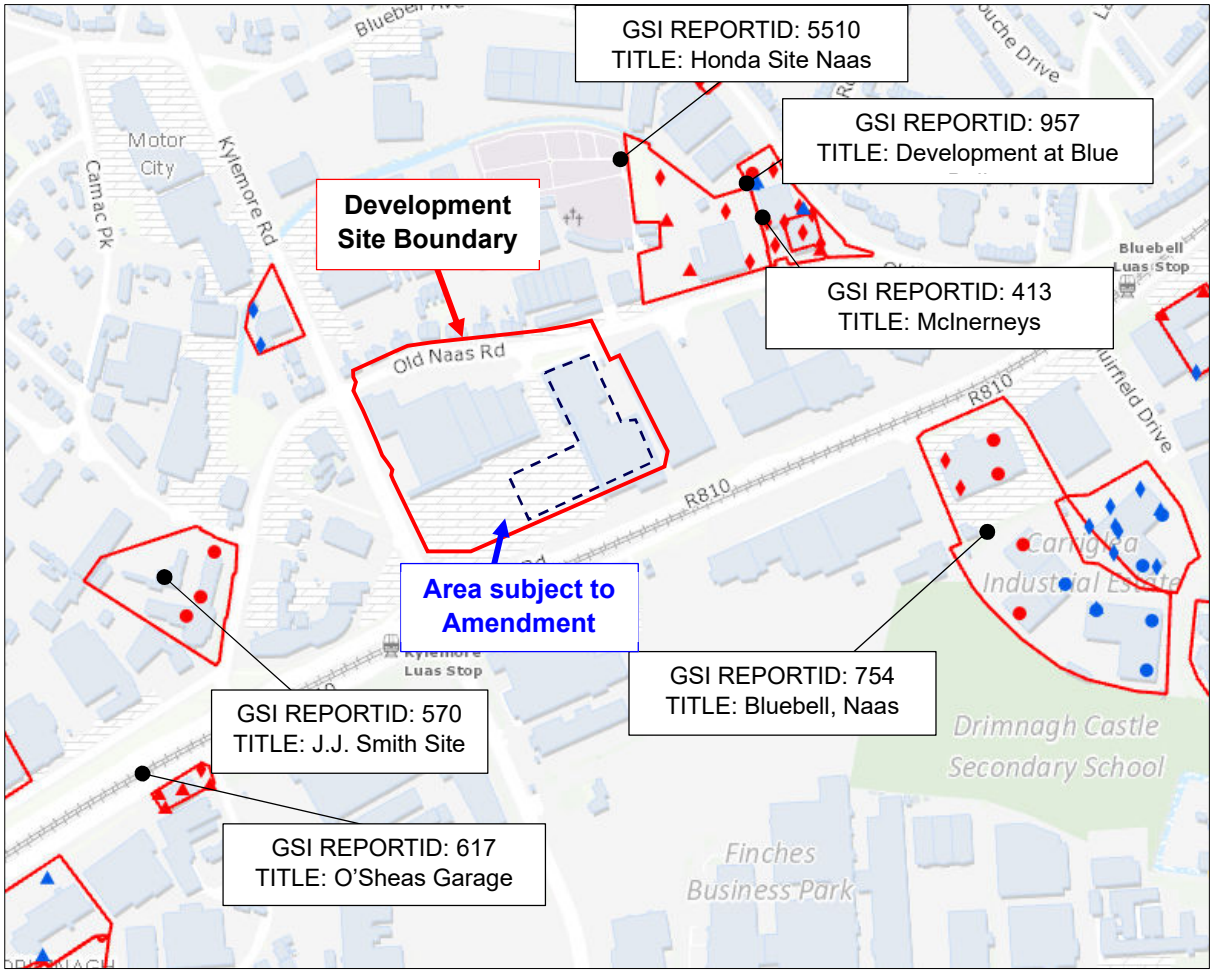


Figure 2-7: Historical ground investigations from GSI map viewer (ref. GSI)

[2.3] Adjacent Structures

The site is located in an area of predominantly high-density commercial developments of cultural and historical significance. The permitted development site is bounded by the Old Naas Road, R810 Naas Road and R112 Kylemore Road. The functional land use of the area in the immediate vicinity is predominantly retail development. The following builds are nearby the site:

1. A building materials supplier (Brooks Timber & Building Supplies) occupies the land to the immediate east of the development site.
2. Royal Liver Assurance Retail Park
3. Costa Coffee Shop
4. Circle K Westway
5. McDonald's Restaurant

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6. VHI Hospital

7. Mini Skip Hiring Office

8. The Bluebell Mills Apartments and Bluebell Cottages form a residential area located to the north of the site along the Old Naas Road.

The locations of the adjacent structures relative to the development site are displayed in Figure 2-8.



Figure 2-8 Surrounding Buildings (Ref: - Google Map)

[2.4] Protected Structures

The National Inventory of Architectural Heritage (NIAH) online resources were consulted to identify protected structures in the vicinity of the site. Multiple protected structures were located close to the site. They are as follows: -

i. Mercedes Benz Factory: - The factory, located at 265m Southwest of the site, is currently used as office. The factory was constructed circa 1950 comprising central square-plan tower with stepped corners flanked by projecting five-bay blocks with curved corners, in turn flanked by fourteen-bay blocks. The building is categorised as Regional Architectural Interest.

ii. Bluebell Cemetery: - The graveyard, located 150m Northeast of the site, is an eclosed irregular-plan graveyard, consisting of early graveyard with thirteenth-century church to south, extended to north 1905. The graveyard is categorised as Archeological, Architectural, Historical and Social Interest.

iii. Medieval Church: - The church is located at 150m Northeast of the site in the Bluebell Cemetary. This church was in use in 1547 (Ball 1906, 133). The Book of Reference to the Down Survey (1655-6) mentions the ruins of an old chapel (Simington 1945, 292).

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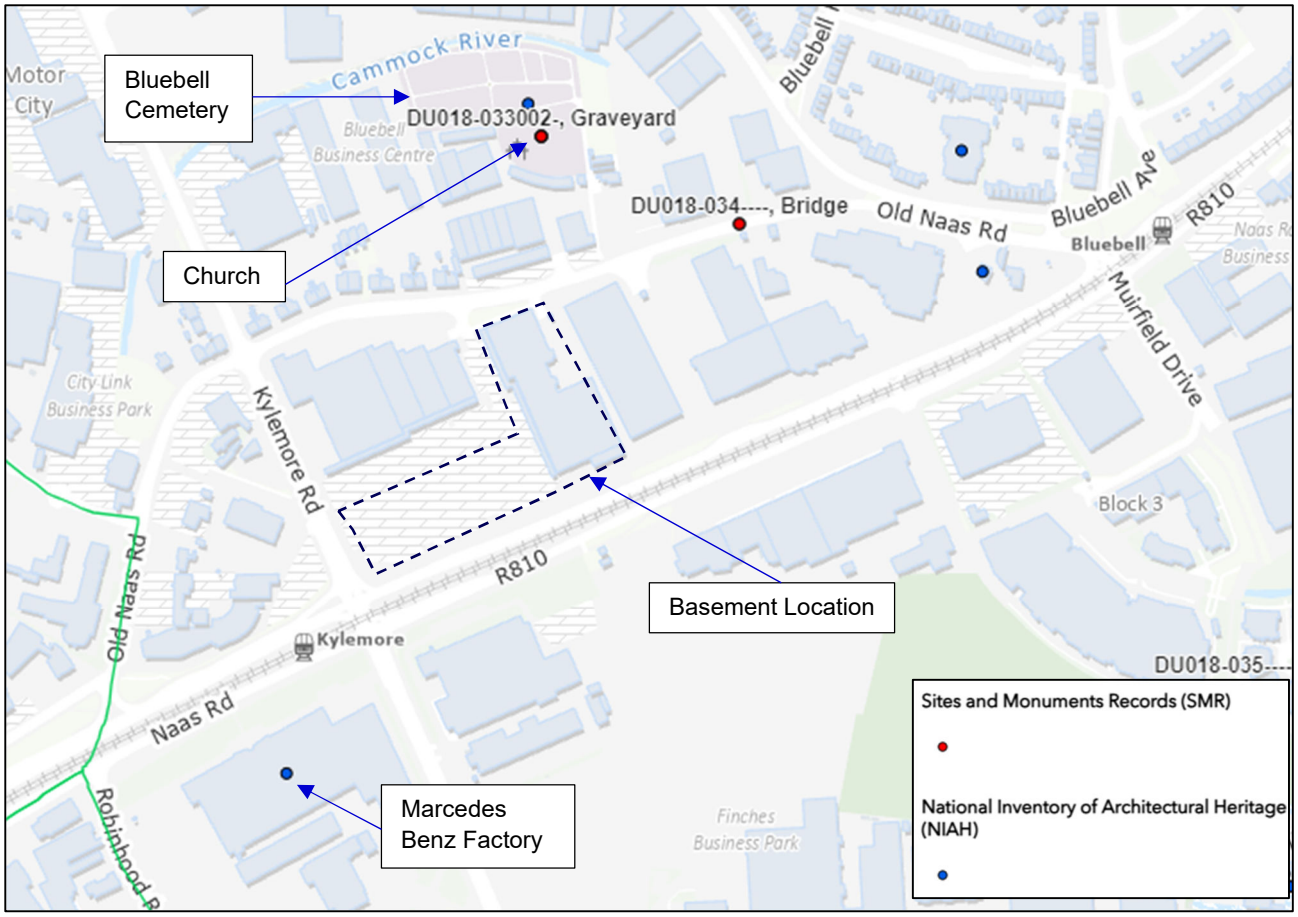


Figure 2-9 Historical Structures (Ref: GSI)

[2.5] Nearby Basements

Ayesa has investigated the presence of existing and proposed basements nearby. The National Planning Application Database (NPAD) was accessed to identify developments with basements / substructures, which might interact with the proposed basement. The relevant planning applications in the vicinity of the site from 2010 onwards are indicated in Figure 2-10 and detailed as follows:

Planning Applications Number 3404/20: -

The building is located next to the proposed site at 8-14 Old Naas Road Cottages, Bluebell, Dublin 12. The permission was granted on 5th January 2021. Retention permission and planning permission is sought for alterations and completion of previously approved development (Reg. Ref. 2158/17). Retention permission is sought for the following:

- 2 no. additional as-built floors of residential development Block A and Block B to provide an additional 16 no. units with associated balconies/terrace area in Block A (12 no. 2-bed units, 3 no. 1-bed units and 1 no. studio)
- Additional 10 no. units with associated balconies/terrace area in Block B (3 no. 3-bed units, 6 no. 2-bed units, 1 no. 1-bed units).

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Planning permission is sought for completion of the development and all ancillary works necessary to facilitate the development. The proposed development will result in the overall scheme extending to 8 storeys over basement level comprising 103 no. residential units, each with associated balconies/terrace area; 88 no. vehicle parking spaces, (comprising 79 no. car parking spaces, 4 no. accessible parking spaces and 5 no. motorcycle parking spaces); 127 no. bicycle spaces (103 no. spaces at basement level and 24 no. spaces at surface level). The development proposed for retention is identical to that approved under Planning Reg. Ref. 4637/18.

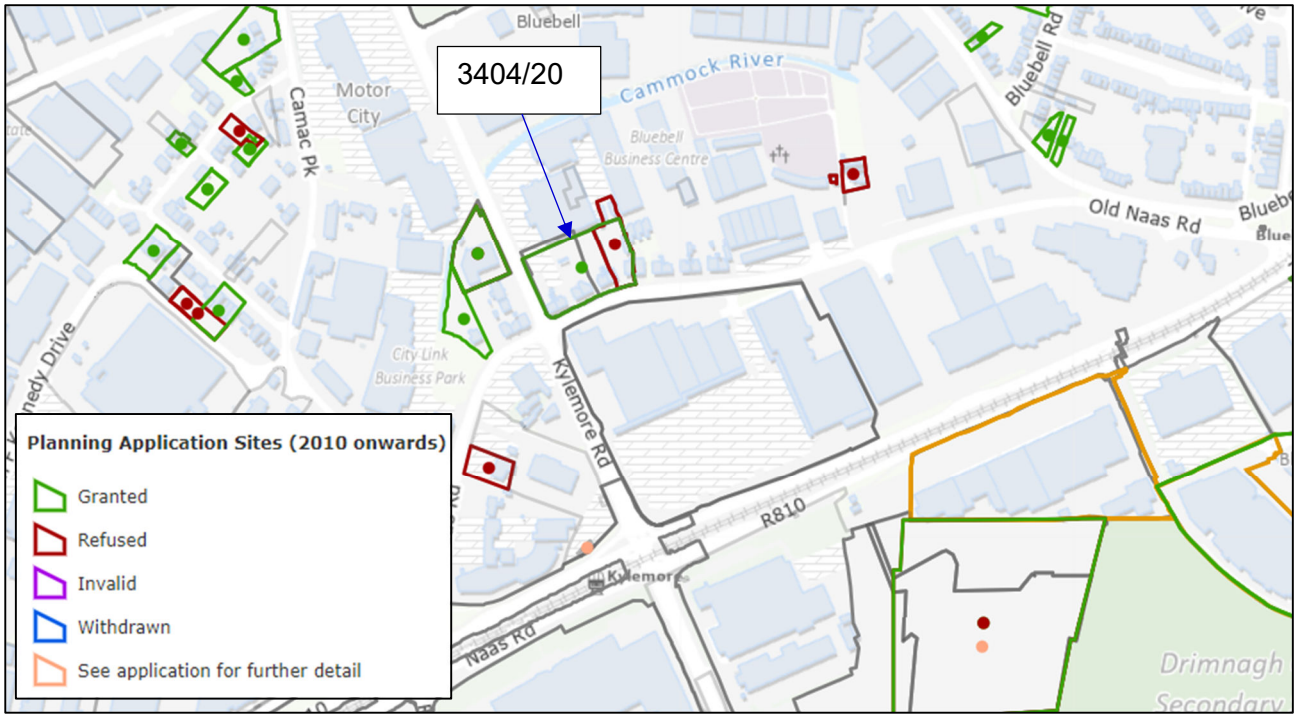


Figure 2-10 Nearby Basements (Ref: NAPD GIS)

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[3] Ground Conditions

[3.1] Ground Investigation

As site specific ground investigation was conducted by Ground Investigation Ireland in August 2019:

Project Title: Royal Liver Retail Park, Naas Road

Project Number: 8622-03-19

Document Title: Ground Investigation Report

Issue Date: 12 August 2019 (Rev. A)

A site investigation was undertaken by GII, on the instructions of Shorevale Investments Ltd, during the period of June to July 2019, and comprised the following:

- 11no. cable percussion boreholes to a maximum depth of 5.1m BGL
- 4no. rotary core boreholes to a maximum depth of 12.1m BGL
- Installation of 2no. groundwater monitoring wells
- Geotechnical and environmental laboratory testing

The locations are demarcated in Figure 3-1 below.

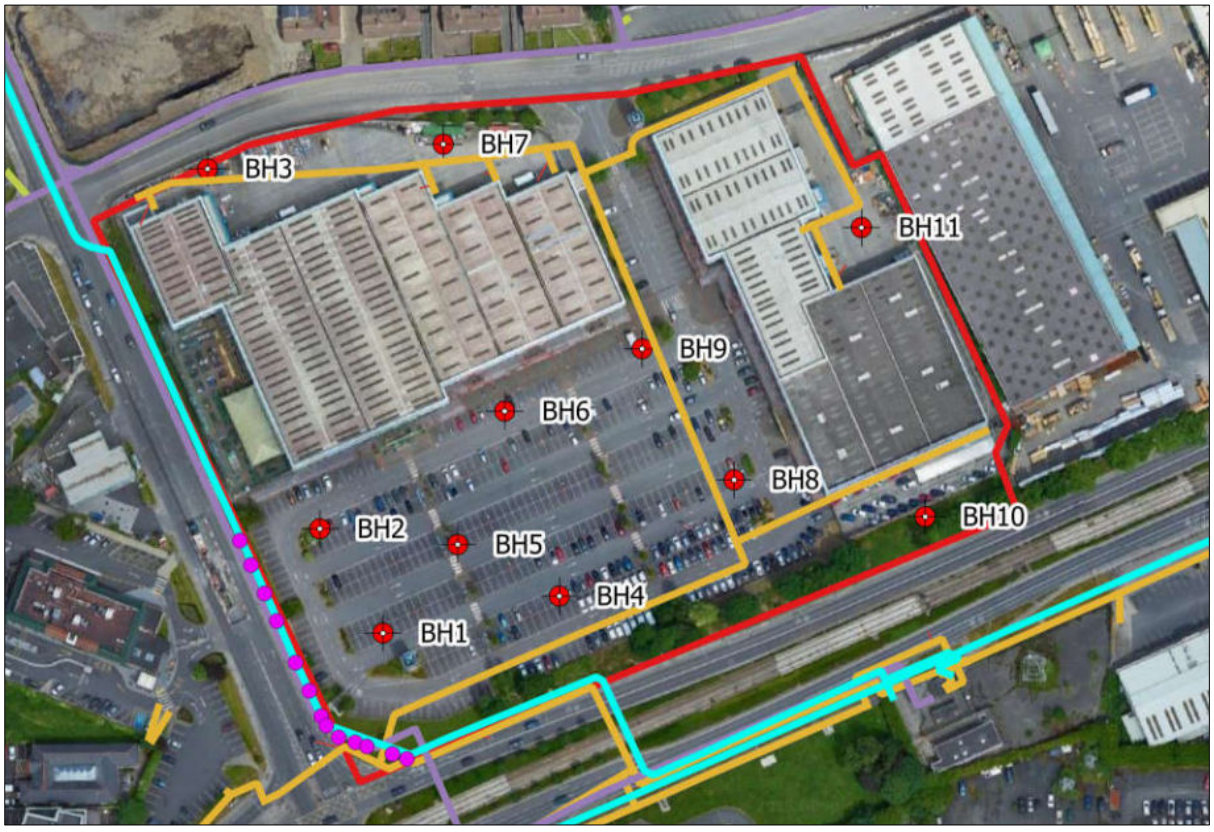


Figure 3-1 Borehole Locations (Ref: GII Report 8622-03-19)

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[3.2] Ground Profile

The soil descriptions were limited to driller notes in certain cases. The general ground conditions encountered were as follows:

- **MADE GROUND:** The thin surficial layer consisted of tarmacadam or concrete in certain areas. The underlying MADE GROUND material was comprised of grey, slightly sandy, angular, fine to coarse Gravel with occasional angular to sub-rounded cobbles and rootlets. The Sand component ranged from fine to coarse.

- **Firm to stiff to very stiff gravelly CLAY:** This progressed to a layer of brown to dark grey, firm to very stiff, slightly sandy, gravelly CLAY with occasional sub-angular to sub-rounded cobbles and rare sub-angular and sub-rounded boulders. The Sand component ranged from fine to coarse, while the Gravel component was sub-angular to sub-rounded and fine to coarse.

- **GRAVEL / SAND**: In certain areas of the site, the CLAY layer was interspersed by a layer of granular material consisting of brown, medium dense, very clayey fine to coarse SAND and angular to rounded, fine to coarse GRAVEL with angular to rounded cobbles.

- **LIMESTONE BEDROCK:** The bedrock layer consisted of light grey, partially weathered, weak to medium strong, very fine to fine-grained LIMESTONE with rare calcite veins and a black, thick clay band. This contained 2no. fracture sets, which were closely to medium spaced and undulating rough. This was interbedded with black, weak, fine-grained Mudstone laminations and rare pyrite in places.

The ground model has been taken from the boreholes and outlined in Table 3-1.

Table 3-1: Ground Model

Strata	Depth to top (m BGL)	Elevation (m OD)	Thickness (m)
MADE GROUND	0.0	+41.24 to +42.14	0.1 to 2.2
Firm to stiff gravelly CLAY	0.1 to 2.2	+39.05 to +41.42	0.8 to 6.4
Medium Dense Gravel *	1.5 to 3.0	+38.62 to +40.13	0.0 to 1.3
LIMESTONE Bedrock	4.5 to 9.1	+32.42 to +37.54	-

**Presence of these granular material deposits in BH03, BH07 and BH10 in northwestern and southeastern periphery of the site.*

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[3.3] Standard Penetration Tests (SPT)

In-situ SPT testing has been carried out in the boreholes completed by GII. The SPT 'N' values have been plotted against depth to aid in determining suitable soil parameters. The SPT 'N' Plot is shown in Figure 3-2 below.

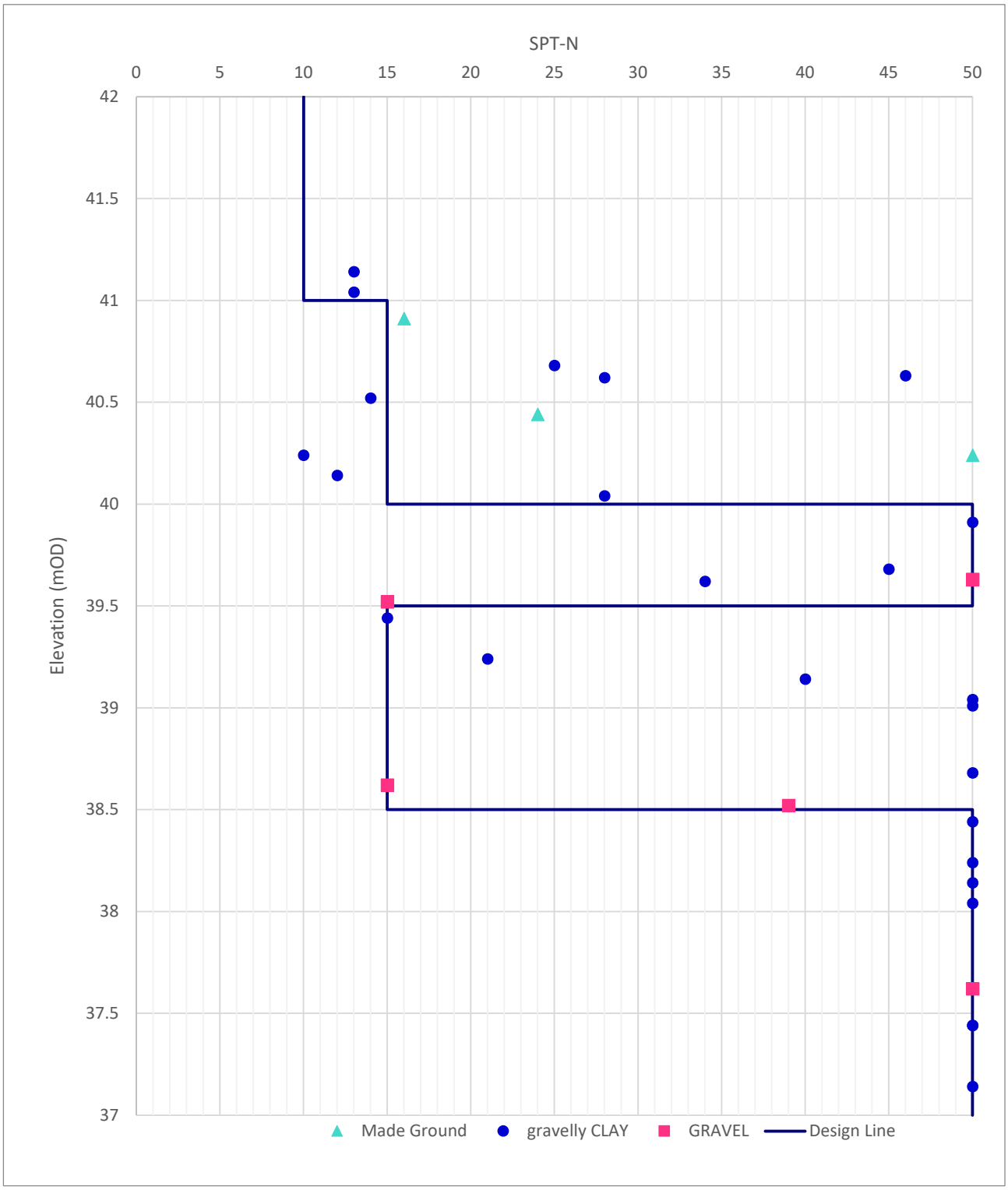


Figure 3-2 SPT-N Profile

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[3.4] Soil Parameter Determination

Based on the interpretation of the ground investigation data and various published correlations as described above, the characteristic soil parameters have been chosen as follows:

Table 3-2 Characteristic Soil Parameters

Stratum	SPT (N)	Density (γ) (kN/m³)	Angle of Friction φ' (°)	Undrained		Drained		UCS (MPa)
				C_u (kPa)	E_u (MPa)	C' (kPa)	E' (MPa)	
Made Ground	10	18	30	-	-	-	10	-
Firm Gravelly Clay	15	19	31	75	25	-	45	-
Stiff Gravelly Clay	50	21	33	250	150	-	95	-
Medium Dense Gravel	15	19	33	-	-	-	30	-
Limestone Bedrock	-	24	40	-	-	-	200	10

**The design parameters adopted in the assessment are based on the most recent site investigation, desk study, information from historical site investigations in adjacent sites and typical soil parameters in Dublin City Centre as outlined above.*

[3.5] Groundwater

Standpipes were installed in BH01 and BH10 for groundwater monitoring. Groundwater monitoring was carried out on 1 August 2019, and the measured groundwater depths range 1.30m and 3.16m BGL. In addition, groundwater was encountered at 2.2mBGL to 4.8mBGL during the ground investigation works. Ayesa has carried out the assessment based the groundwater level at 1.0m BGL, which is considered conservative.

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[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. The fracture lengths 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.

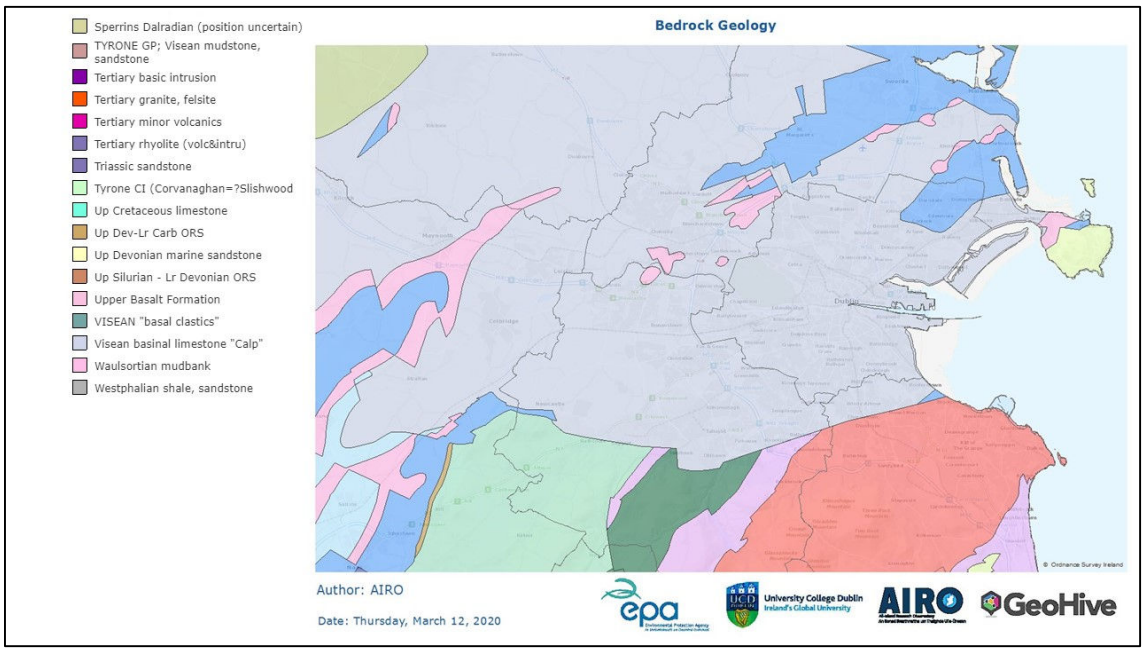


Figure 4-1 Bedrock Geology (Source: Geological Survey of Ireland)

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).

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[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:

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 of the Royal Liver Retail Park in this amended application is approximately 200m long by 130m in width, with the finished floor level of the basement will be approximately +38.6m OD, with excavation depth approximately 4.0m. The construction of the basement will likely within the Made Ground, and gravelly CLAY. The Made Ground and gravelly CLAY layers has very limited ability to transmit groundwater due to its low permeability characteristic and is an aquitard/aquiclude rather than an aquifer. The proposed basement is not likely to impede/block groundwater flow.

[4.4] Bedrock Aquifers

Given the low permeability of the overburden tills, underlying joints and crevices in bedrock become critical pathways for groundwater flow. Disturbing these are therefore expected to influence the groundwater regime.

GeoUrban map made available by GIS was consulted and indicates that bedrock is expected to be between 5 and 10m BGL at this site. It is thus not expected that the proposed basement is to encroach onto existing bedrock levels and is subsequently not expected to disturb the bedrock aquifer regime.

[4.5] Groundwater Extractions/Well Data

Groundwater well records for the area were obtained from GSI spatial resources database and detailed in Figure 4-2. A total of 7no. wells have been identified at approximate distances between 1km to 1.5km radius of the site. The yield class of all the wells are classified as good to excellent. The wells are being in use for industrial usage.

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Table 4-1 Summary of Wells

GSI ID	Well Type	Drill Date	Distance from Site (kM)	Depth (m)	Yield Class	Use
2923SEW008	Borehole	29/12/1899	0.64	54.9	Excellent	Industrial
2932SEW019	Borehole	23/05/1991	1.40	155	Good	Industrial
2932SEW020	Borehole	28/05/1991	1.23	165	Good	Industrial
2932SEW025	Borehole	27/11/1990	1.30	79.2	Moderate	Industrial
2923SEW026	Borehole	15/10/1985	1.00	66.7	Excellent	Industrial
2923SEW031	Borehole	01/08/1949	1.34	41.1	Good	Industrial
2923SEW035	Borehole	04/01/1996	1.19	3.3	-	Unknown

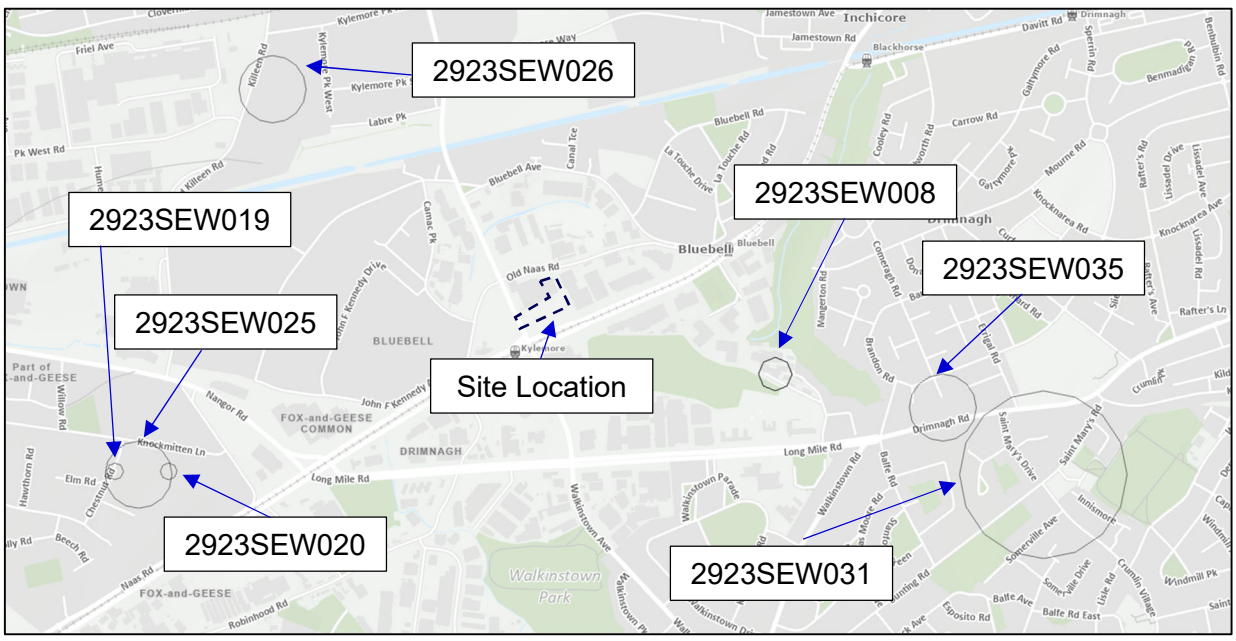


Figure 4-2 Groundwater Extractions/ Well Data (Ref: GSI)

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[4.6] Groundwater Flow

Groundwater within the Dublin City Centre area is reported to flow in a general eastward direction and either contributes to the various rivers flowing within the Dublin area or discharges directly into the sea at Dublin Bay. Figure 4-3 below illustrates the general direction of groundwater flow in this west-to-east direction, which mirrors the direction of flow of the River Liffey.

Although the site in question is to the north and outside the extents of the map displayed in Figure 4-3 below, the groundwater flow lines would also likely indicate a northwest-to-southeast groundwater flow direction.

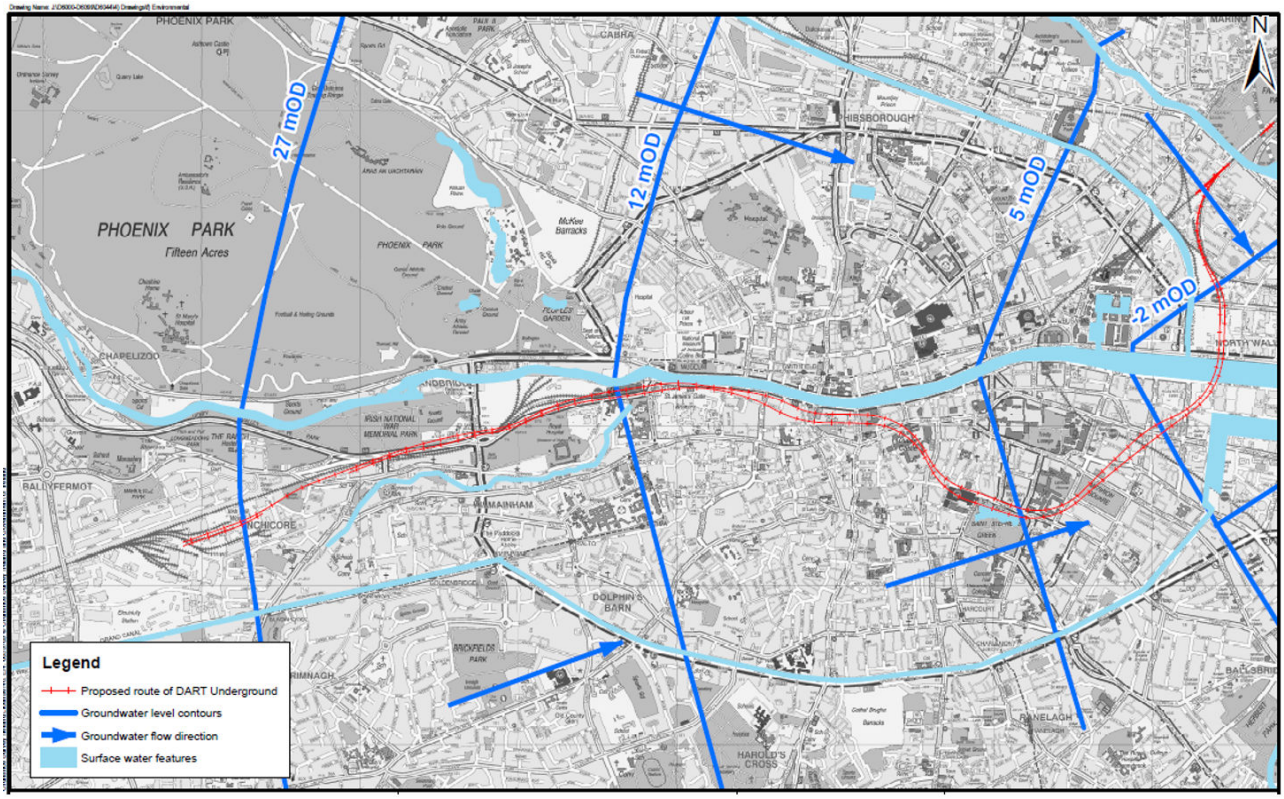


Figure 4-3 Groundwater Level Contours and Flow Lines in Dublin City Centre (excerpt from Environmental Impact Statement for DART Underground)

[4.7] Karst features

A review of the GSI online karst map was completed to determine if any localised karst features were recorded close to the site. No karst features such as caves, valleys or swallow holes were noted within the area, and this agrees with Farrell and Wall (1990) who suggest that minimal solution cavitation and weathering of the Dublin limestone is due to its argillaceous (fine grained) component. Farrell and Wall (1990), while recognizing that the bedrock surface would have undergone weathering to some extent, state that the weathered zone is generally limited to less than 1m, within the upper layer of the bedrock.

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[4.8] Cumulative Impact of Nearby Basements

As detailed above a number of basements are present adjacent to the proposed site. Scenario C1 will thus be applicable. However, based on the extent of the basements on site, depth to bedrock and the low permeability ground conditions, the increased impact is considered nominal.

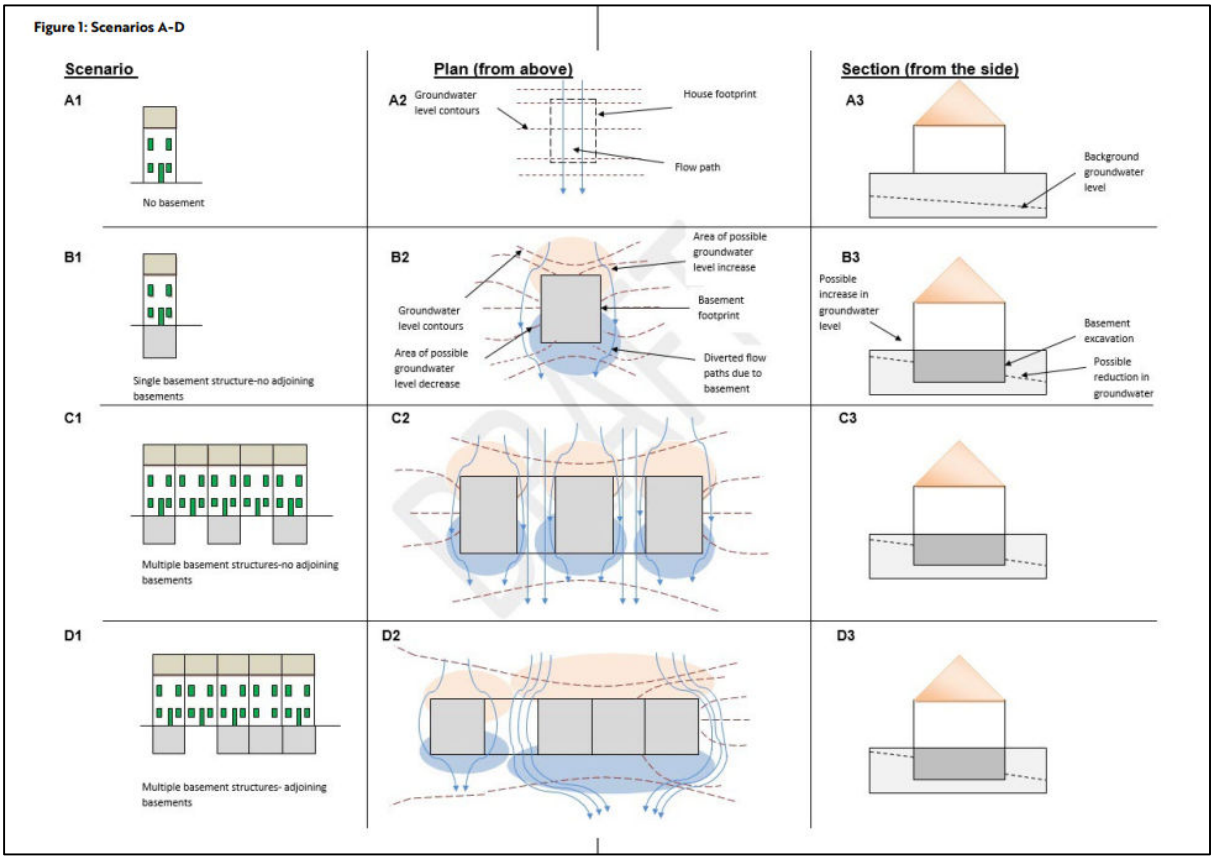


Figure 4-4: Cumulative effects of Basement Construction on Groundwater (ref. Dublin City Development Plan Appendix 9 – Figure 1)

[4.9] 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.

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[5] Ground Movement Assessment

[5.1] General

Ayesa has completed a preliminary ground movement assessment of the proposed basement substructure. This substructure will be founded within the Made Ground and Firm Clay stratum. The excavation depth is approximately 4mBGL It is proposed to form the basement using open cut excavation techniques where possible.

The excavation down to formation level will likely be feasible by adopting open cut excavation techniques with the side sloped at 1:1.5 in the temporary case during construction.

Ayesa has completed an assessment of the ground movements based on that of the excavation in front of a low stiffness wall (CIRIA C760 Table 6.2; CIRIA C760 Fig. 6.15 (b) as the open cut excavation approach has been adopted. These were derived from several historic case studies. Using this ground movement curve is considered conservative.

The following assumptions are made: -

Northern, Southern, Eastern, and Western elevation with open cut excavation

- Battering the slope at 1:1.5 profile of the excavation around the perimeter of the proposed basement footprint is assumed;
- Excavation depth of 4.0m is assumed, with existing ground level of +42.0mOD and formation level of +38.0mOD.
- Surcharge of 20kPa is assumed for the public road / construction site;
- Groundwater is lowered 0.5m below the excavation level in the temporary case (during construction of the basement).
- Following completion of the basement, the ground is backfilled back up to the finished ground level, dewatering of the site is discontinued and the water level is taken as +41.0mOD.

[5.2] Construction Stages

The following construction sequence has been assumed in the analysis of the proposed basement excavation and construction:

1. Carry out bulk excavation works for proposed basement formation level. Excavation batters are at 1:1.5 profile. Includes lower groundwater table 0.5m below the formation level during construction of the works.
2. Construct permanent basement slab.
3. Construct basement RC liner walls.
4. Construction ground floor slab and remaining superstructure.
5. Stop dewatering the excavation.
6. Long term soil and groundwater conditions and apply full foundation loads.

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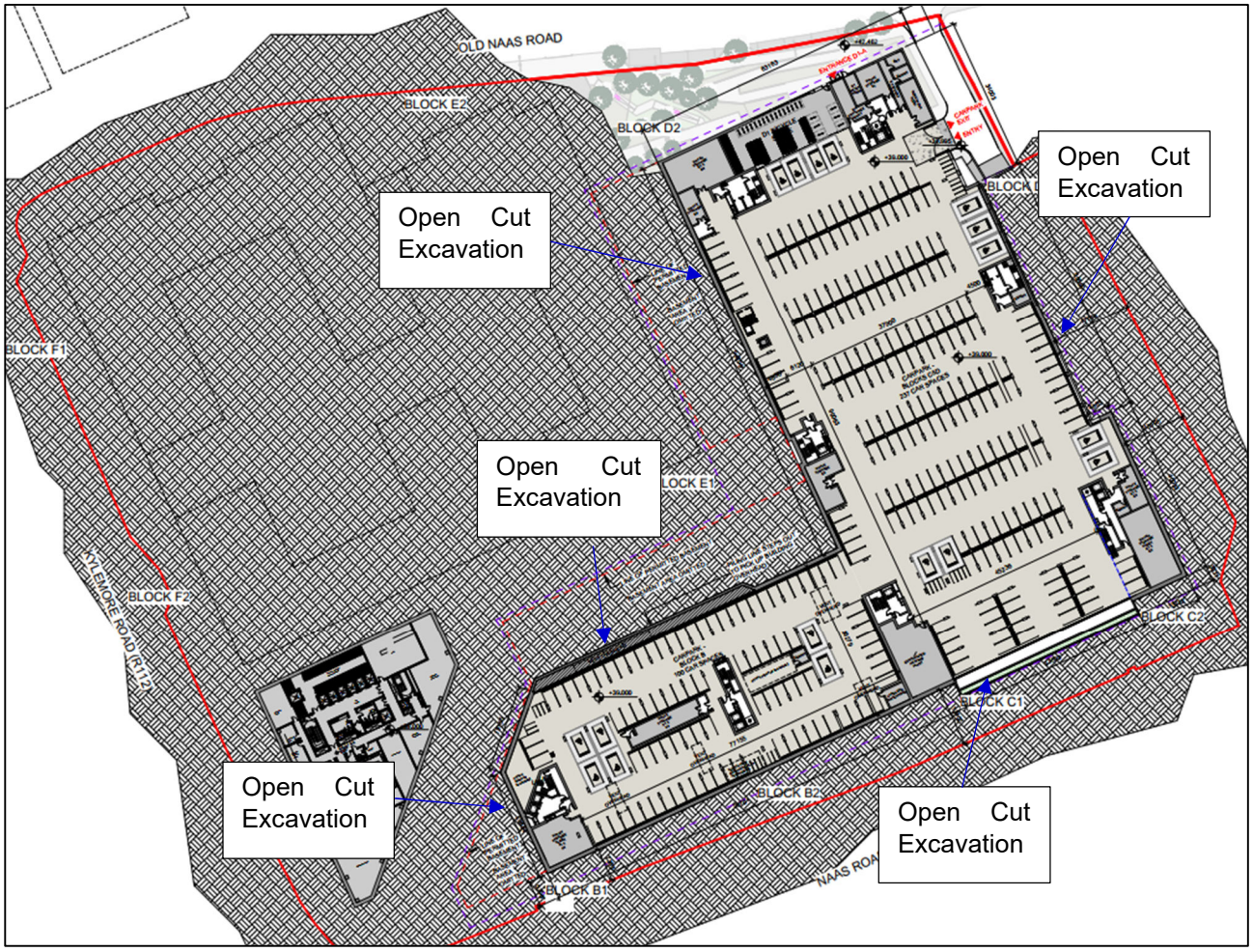


Figure 5-1 Proposed Location of Pile Wall and Open Cut Excavation

[5.3] Software

The assessment of ground movements within and surrounding the excavation area has been completed by means of the geotechnical modelling software application OASYS XDisp. It is commonly used within the ground engineering industry and considered to be an appropriate tool for this analysis. The XDisp software has been used to predict ground movements likely to arise from the construction of the proposed basement.

[5.4] Adjacent Structure

It is expected that the basement will be excavated using the following techniques:

- It is expected that most of the proposed basement will be excavated using open cut excavation techniques where there is adequate clearance (approx. 6m) between the basement edge and the boundary line.
- At some local areas, where the basement is close to the boundary line/structure, an embedded retaining wall will likely be required to facilitate the basement excavations. These

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have been accounted for in the ground movement and damage assessment carried out as part of the BIA by using the excavation in front of a low stiffness wall ground movement curve.

Based on the information in the desk study as discussed in Section [2.3], there is no evidence available to suggest that immediately adjacent buildings have any basement and the foundation is likely to consist of foundation pads and a ground floor slab with the slab cast approximately at ground level. However, the XDisp model has conservatively been modelled as strip foundations, so ground movements have been assessed at existing ground level.

It should be noted that the basement proposed to the east of the subject site and adjacent to Brooks Timber & Building Supplies is permitted under planning ref. 4238/19 and is not subject to any amendment as part of the subject application.

Pre-existing ground movement curves in accordance with CIRIA 760 were used to model the proposed development and the adjacent buildings in the XDisp model. This facilitated the assessment of the ground movement and impact on neighbouring buildings. The movement curves utilised for the analysis were those of “excavation in front of low stiffness wall in stiff clay” for the initial stage of the basement construction.

The plan view of the adjacent structures is shown in in the following page in Figure 5-2.

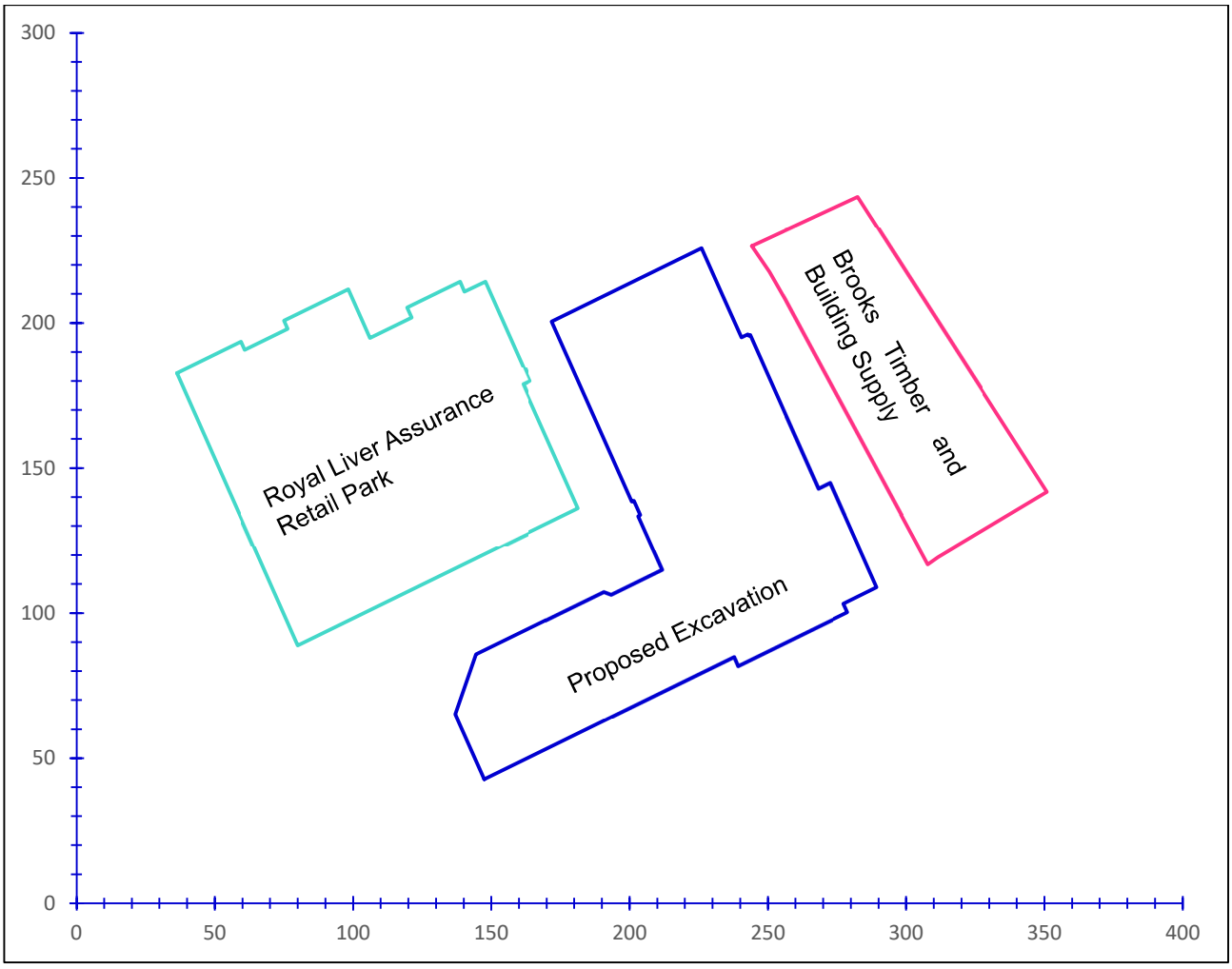


Figure 5-2 Adjacent structures to the excavation

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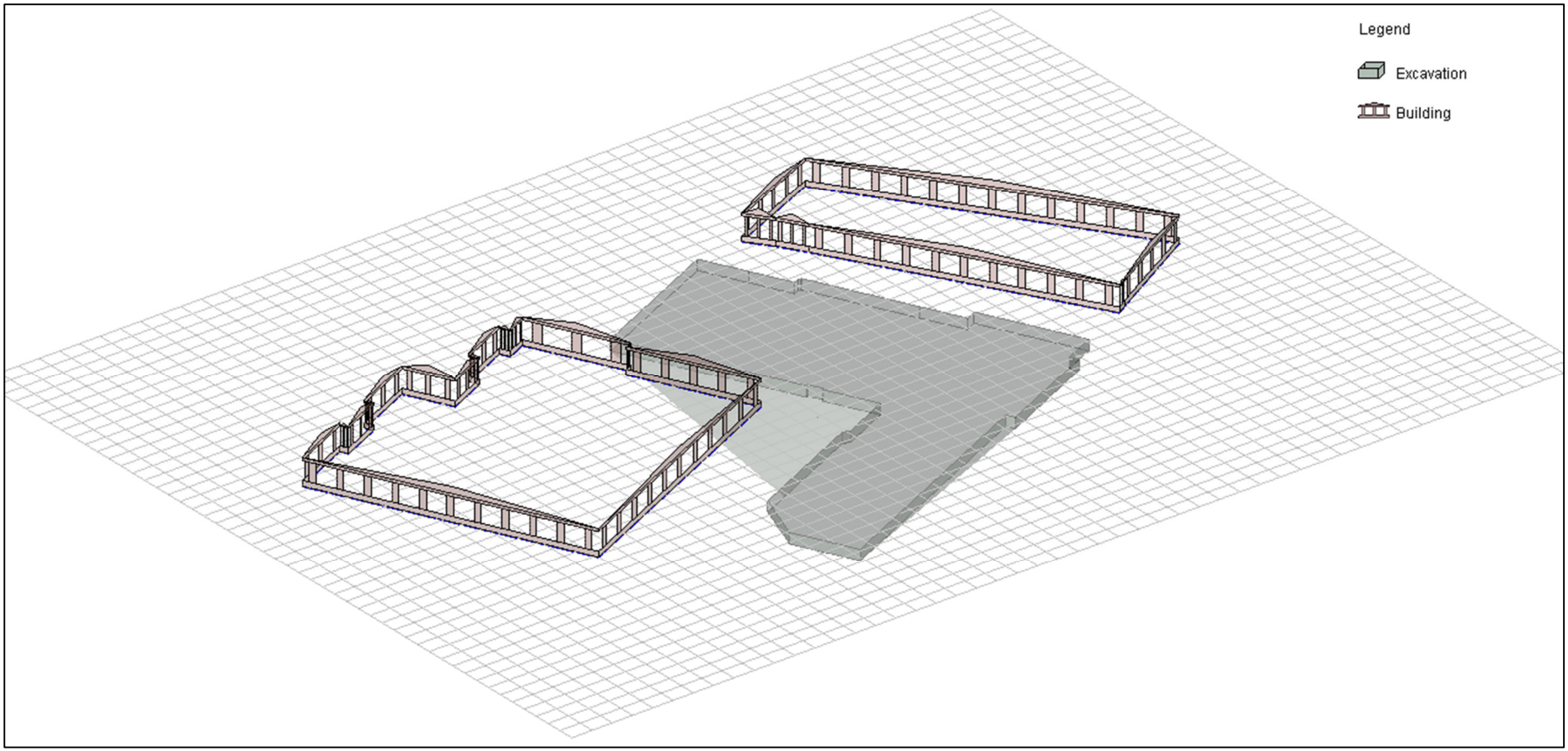


Table 5-1 XDisp Input

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[5.5] Damage Impact Assessment

[5.5.1] General

A damage impact assessment of the neighbouring structures has been completed based on the classifications stated in Table 6.4 of CIRIA report C760 (formally C580). These classifications have been extracted and shown in Table 5-2 below. They are based on the 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) & 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	

[5.5.2] XDisp Output

The maximum settlement was found to be between 26mm to 28mm around the corners of the excavation. The general settlement ranged from 10mm to 14mm surrounding the excavation. As outlined above, this is considered conservative based on the proposal to form the basement using open cut techniques. The building damage category is shown in Figure 5-4.

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Table 5-3 Building Damage

Building	Building Name	Damage Category
Building 1	Royal Liver Assurance Retail Park	No Sensitivity
Building 2	Brooks Timber and Building Supply	No Sensitivity

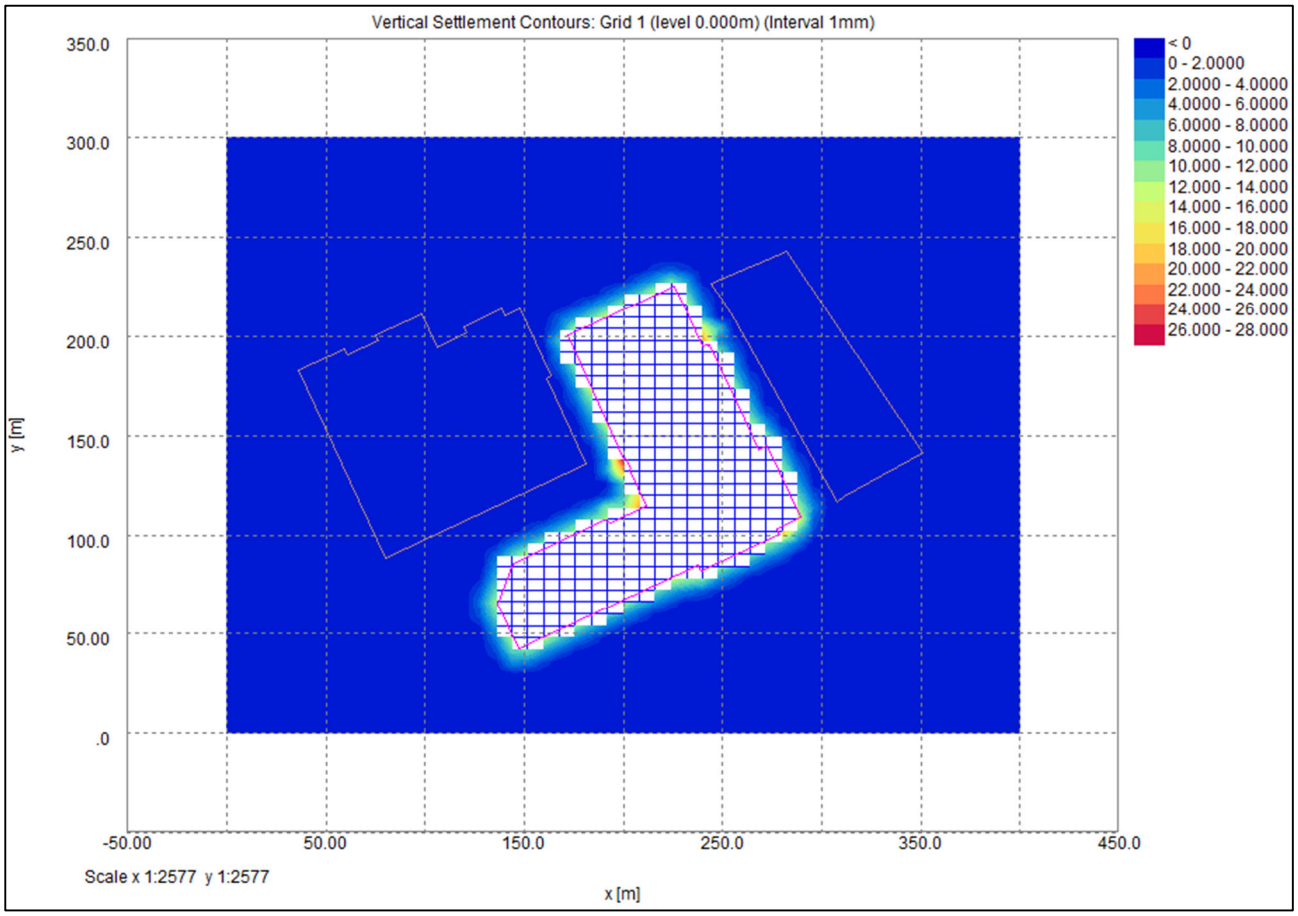


Figure 5-3 Vertical Settlement Contour (Ref: Plan View of XDisp Result)

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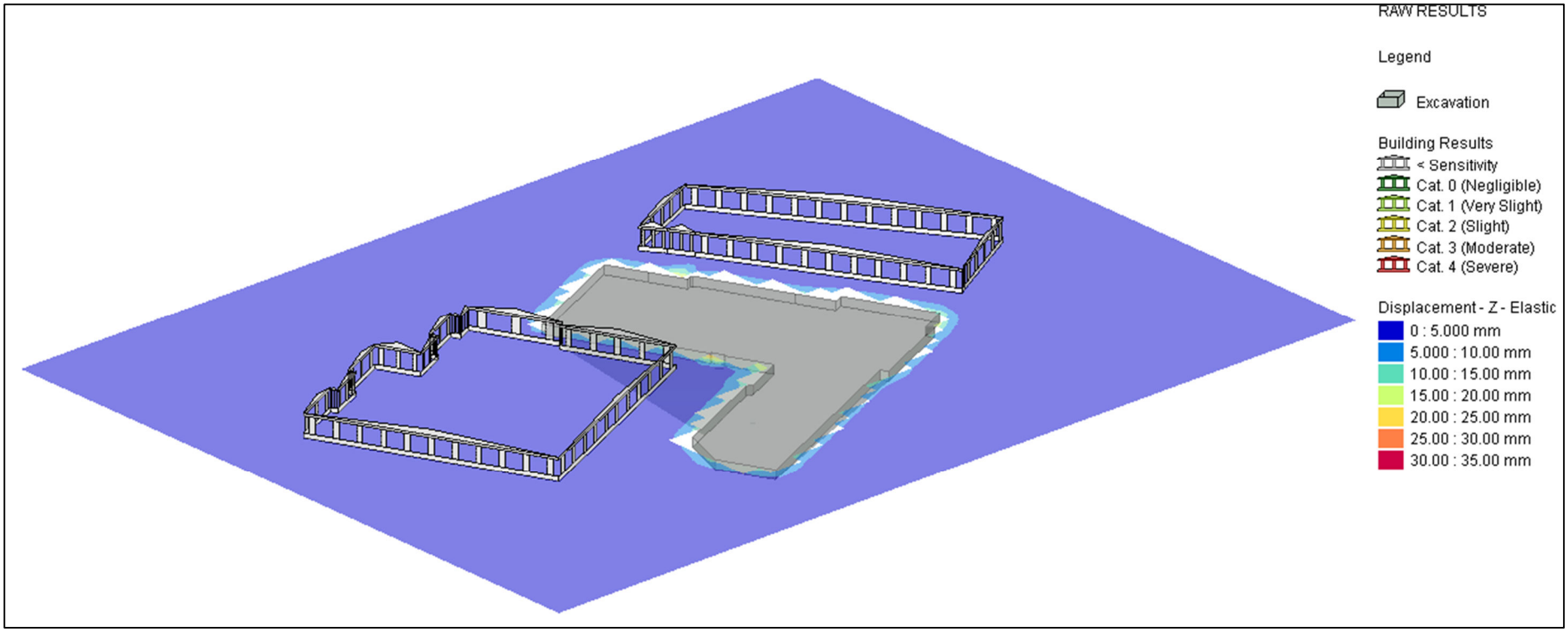


Figure 5-4 Impact of Excavation on the Nearby Building

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[5.6] Monitoring Ground Movement

The predictions of the ground movements given here are considered preliminary and are subject to the detailed design solutions implemented at the construction stage (i.e. rigidity of wall, quality of construction and installation techniques, groundwater control measures, finalized bearing pressures from permanent works etc.). The predictions given here are however considered appropriate estimations for the preliminary BIA.

It is recommended that a condition and foundation-level surveys of adjacent existing structures should be carried out before and after the proposed works. The precise monitoring strategy will be developed at a later stage, and it will be subject to discussions and agreements with the owners of the adjacent properties and structures.

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[6] Summary and Recommendations

Ayesa has completed the Basement Impact Assessment (BIA) for construction of new commercial development at Old Naas Road, Dublin 12. As per the revised proposal, the basement geometry has been revised keeping the same depth of excavation of basement i.e. 4.0mBGL.

The assessment was completed by analysing the ground conditions and hydrogeology of the site and subsequently modelling the basement using the software package XDisp. The assessment included a damage impact assessment on the nearby buildings based on empirical ground movement curves from CIRIA C760 6.15 A & B guidance, assumed ground conditions and adjacent foundation details.

It is expected that the proposed basement will be excavated using open cut excavation techniques (battered slope) where there is adequate clearance between the basement edge and the property boundary line. These have been accounted for in the ground movement and damage assessment carried out as part of the BIA.

The ground movement analysis has concluded that the predicted damage to the neighbouring properties would be deemed to be not sensitive to the excavation.

The predictions of ground movements given are considered preliminary based on the information provided. Based on the clearances outlined, open-cut excavation should be feasible with adequate clearance of 6 m to the adjacent existing structures. Should the clearance be less than indicated and to avoid excessive damage to the existing structures, an embedded retaining wall may be required in localised areas. This requirement shall be reviewed during the construction stage by the design team.

Additionally, the BIA is based on assumed ground conditions and adjacent foundation details. These are to be investigated and confirmed during a site-specific ground investigation.

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