16 HYDROGEOLOGY

16.1 Introduction

This section describes the likely significant effects of the proposed development on hydrogeology. An assessment is made of the likely impacts associated with the construction and operation of the proposed development on these resources. Measures are presented to mitigate or eliminate the impacts of the proposed development on the groundwater beneath the site.

Chapter 3 provides a full description of the proposed development and Chapter 4 describes the construction strategy.

This chapter has been prepared by Eoin Wyse of Arup. Eoin is a Senior Engineer in the Applied Geology sub-group of the Ground Engineering group at Arup. Eoin has experience in a number of contaminated land projects and has particular skills in ground investigation, risk assessment, waste categorisation and Environmental Risk Assessment.

Please refer to Chapter 1 for further details of his relevant qualifications and experience.

16.2 Assessment Methodology

16.2.1 General

The following section outlines the legislation and guidelines considered, and the adopted methodology for preparing this chapter and undertaking the hydrogeology assessment.

This assessment has been undertaken with due regard to the overarching EIA guidance[1,2,3,4] (described in **Section 1.3** of **Chapter 1**) and Institute of Geologists Ireland (IGI) guidance[5].

16.2.2 Guidance and Legislation

The following legislation and guidance is particularly relevant to the management of groundwater:

- Environmental Protection Agency (EPA) (2017) Draft Guidelines on the Information to be contained in Environmental Impact Assessment Reports (*Draft August 2017)*[6]*; and*
- European Commission (2017) Environmental Impact Assessment of Projects: Guidance on the preparation of the *Environmental Impact Assessment Report*[7];
- The EU Water Framework Directive (WFD), 2000/60/EC[8];
- The Groundwater Directive, 2006/118/EC[9];

[1] Department of Housing, Planning and Local Government (2018) Circular PL 05/2018 -Transposition into Planning Law of Directive 2014/52/EU amending Directive 2011/92/EU on the effects of certain public and private projects on the environment (the EIA Directive);
[2] Department of Housing, Planning, Community and Local Government (2017) Key Issues Consultation Paper on the Transposition of 2014 EIA Directive (2014/52/EU) in the Land Use Planning and EPA Licencing Systems;
[3] Department of Housing, Planning, Community and Local Government (2017) Circular PL 1/2017 - Implementation of Directive 2014/52/EU on the effects of certain public and private projects on the environment (EIA Directive): Advice on the Administrative Provisions in Advance of Transposition
[4] Government of Ireland (2018) Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment (August 2018);
[5] Institute of Geologists of Ireland (IGI 2013). Guidelines for the Preparation of Soil, Geology and Hydrogeology Chapters of Environmental Impact Statements. Available at: http://igi.ie/publications/guidelines/. Accessed 10-09-2018
[6] EPA, 2017. Draft Guidelines on the Information to be contained in Environmental Impact Assessment Reports. Available at: http://www.epa.ie/pubs/advice/ea/drafteiarguidelines.html. Accessed October 2019
[7] European Commission (2017) Environmental Impact Assessment of Projects: Guidance on the preparation of the Environmental Impact Assessment Report. Directive 2011/92/EU as amended by 2014/52/EU. Available at: http://ec.europa.eu/environment/eia/eia-support.htm. Accessed October 2019
[8] The EU Water Framework Directive (WFD), 2000/60/EC. Available at: https://eur-lex.europa.eu/homepage.html. Accessed October 2019
[9] The Groundwater Directive, 2006/118/EC. Available at: https://eur-lex.europa.eu/homepage.html. Accessed October 2019

- European Communities (Water Policy) Regulations 2014 (S.I. No. 350 of 2014)[10];
- European Communities Environmental Objectives (Groundwater) Regulations 2010 (S.I. No. 9 of 2010), as amended by the European Communities Environmental Objectives (Groundwater) (Amendment) Regulations 2011 (S.I. No. 389 of 2011) and the European Communities Environmental Objectives (Groundwater) (Amendment) Regulations 2012 (S.I. No. 149 of 2012) and the European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016 *(S.I. No. 366 of 2016)*[11];
- European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. No. 272 of 2009) as amended by the European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations 2012 *(S.I. No. 327 of 2012)*[12];
- European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2015 *(SI No. 386 of 2015)*[13]*;*
- European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003) as amended by the European Communities (Water Policy) (Amendment) Regulations, 2005 *(S.I. No. 413 of 2005)*[14]*;*
- European Communities (Water Policy) (Amendment) Regulations, 2008 (S.I. No. 219 of *2008)*[15]*;*
- European Communities (Water Policy) (Amendment) Regulations, 2010 *(S.I. No. 93 of 2010)*[16]*;*
- European Communities (Drinking Water) Regulations 2014 (S.I. No 122 of 2014), as amended by the European Union (Drinking Water) (Amendment) Regulations 2017 (S.I. No. 464 of *2017)*[17]*;*
- European Communities (Quality of Salmonid Waters) Regulations 1988 (SI no. 293 of *1988)*[18]*;* and
- Water Services Acts (2007 – *2017)*[19]*.*

16.2.3 Study Area

The study area for the hydrogeology assessment extends to areas within 2km of the proposed development outline as defined by the red line boundary illustrated in Figure 15.1 (see appendix 15.1).

[10] European Union (Water Policy) Regulations, 2014. S.I. No. 350 of 2014. Available at: http://www.irishstatutebook.ie/. Accessed October 2019

[11] European Communities Environmental Objectives (Groundwater) Regulations 2010 (S.I. No. 9 of 2010), as amended by the European Communities Environmental Objectives (Groundwater) (Amendment) Regulations 2011 (S.I. No. 389 of 2011) and the European Communities Environmental Objectives (Groundwater) (Amendment) Regulations 2012 (S.I. No. 149 of 2012) and the European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016 (S.I. No. 366 of 2016). Available at: http://www.irishstatutebook.ie/. Accessed October 2019

[12] European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. No. 272 of 2009) as amended by the European Communities Environmental Objectives (Surface Waters) (Amendment) Regulations 2012 (S.I. No. 327 of 2012). Available at: http://www.irishstatutebook.ie/. Accessed October 2019

[13] European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2015 (S.I. No. 386 of 2015). Available at: http://www.irishstatutebook.ie/. Accessed October 2019

[14] European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003) as amended by the European Communities (Water Policy) (Amendment) Regulations, 2005 (S.I. No. 413 of 2005). Available at: http://www.irishstatutebook.ie/. Accessed 10-09-2018

[15] European Communities (Water Policy) (Amendment) Regulations, 2008 (S.I. No. 219 of 2008). Available at: http://www.irishstatutebook.ie/. Accessed 10-09-2018

[16] European Communities (Water Policy) (Amendment) Regulations, 2010 (S.I. No. 93 of 2010). Available at: http://www.irishstatutebook.ie/. Accessed 10-09-2018

[17] European Communities (Drinking Water) Regulations 2014 (S.I. No 122 of 2014), as amended by the European Union (Drinking Water) (Amendment) Regulations 2017 (S.I. No. 464 of 2017). Available at: http://www.irishstatutebook.ie/. Accessed 10-09-2018

[18] European Communities (Quality of Salmonid Waters) Regulations 1988 (SI no. 293 of 1988). Available at: http://www.irishstatutebook.ie/. Accessed 10-09-2018

[19] Water Services Acts, 2007 – 2017. Available at: http://www.irishstatutebook.ie/. Accessed 10-09-2018

16.2.4 Site Visits

Numerous site visits and site walkovers have been conducted by Arup geotechnical and other Arup personnel in late 2018 and early 2019 as part of the desk study phase, ground investigation scoping and pre-mobilisation meetings.

16.2.5 Consultation

Discussions were held with the Waste Enforcement division of Dublin City Council (DCC) on 10th October 2019 in relation to the retention of materials on site where appropriate and also the potential for reuse of suitable materials on site.

In the course of discussions, it was noted that any proposed discharges from the site as part of the dewatering activities would have to occur under licence from DCC.

16.2.6 Categorisation of the Baseline Environment

Baseline conditions of the hydrogeological environment within 2km of the red line site boundary were determined by reviewing publicly available information from the following sources:

- Bing Maps (2018). Aerial photography[20];
- Google Maps (2018). Aerial photography[21];
- Geological Survey of Ireland (GSI) (2018). Geological maps of the site area produced by the Geological Survey of Ireland[22] including;
- Karst Database;
- Bedrock Aquifer and Gravel Aquifer Maps;
- Groundwater Recharge Maps;
- Groundwater Vulnerability Maps;
- Groundwater Wells and Springs Database;
- Drinking Water Protection Areas Database; and
- National Federation Group Water Schemes Database.
- Environmental Protection Agency (2018). Environmental maps of the site area produced by the EPA[23] including:
    - Water Framework Directive;
    - Clean Water and Health;
- GSI (2003). Dublin GWB: Summary of Initial Characterisation. Groundwater Bodies[24];
- National Parks and Wildlife Service (2018). Proposed / Designated NHA, SPA, SAC Sites[25];
- Ordnance Survey of Ireland (OSI) (2017). Current Ordnance Survey (OS) maps available for the study area:

[20] Bing Maps (2019). Aerial photography. Available at: https://www.bing.com/maps, Accessed October 2019
[21] Google Maps (2019). Aerial photography. Available at: https://www.google.ie/maps/, Accessed October 2019
[22] GSI (2019). Public Data Viewer Series. Available from: https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228, Accessed October 2019
[23] EPA (2019). EPA Maps. Available from: https://gis.epa.ie/EPAMaps/, Accessed 18-07-18
[24] GSI (2003). Dublin GWB: Summary of Initial Characterisation. Groundwater Bodies. Available at: https://www.gsi.ie/en-ie/programmes-and-projects/groundwater/activities/understanding-ireland-groundwater/Pages/Groundwater-bodies.aspx, Accessed October 2019
[25] National Parks and Wildlife Service (2018). Proposed / Designated NHA, SPA, SAC Sites. Available at: http://webgis.npws.ie/npwsviewer/, Accessed October 2019

Ground Investigations

The following historic reports have been used to inform this report:

- Arup Consulting Engineers (2003) Site Investigation Report, Parkgate Street Development for Hickeys Fabrics & Co. Ltd., refer to Appendix 15.2 .
- Arup Consulting Engineers (2006) Geotechnical and Environmental Assessment Report for Hickeys Fabrics & Co. Ltd., refer to Appendix 15.3.

The original 2003 report is attached as an appendix (Appendix 15.2) to this report. Reference will be made to the relevant sections of the 2003 report. The 2006 report was prepared as part of a planning report submitted for Hickey's of Parkgate Street Planning Application (Planning Ref. 3613-06) and included the ground investigation results from the 2003 report.

In addition, Ground Investigations Ireland Ltd. (GII), under the instruction of Arup, carried out a project specific GI between March and May 2019. The GII Ground Investigation Report (2019) is contained in Appendix 15.4.

16.2.7 Impact Assessment

The likely significant effects have been assessed by classifying the importance of the relevant attributes and quantifying the magnitude of any likely significant effects on these attributes. This has been undertaken in accordance with the EC Commission Guidance on the preparation of an EIAR [1,2,3,4,7] and the draft EPA guidelines on the preparation of an EIAR[6], along with the IGI guidance[5] which outlines a 13 step methodology that is divided across four distinct elements:

- Initial Assessment;
- Direct and Indirect Site Investigation;
- Mitigation Measures, Residual Impacts and Final Impact Assessment; and
- Completion of the Soils and Geological Sections of the EIAR.

Initial Assessment

The 'Initial Assessment' presents a description of the past and present uses of the land across the study area which may have a bearing on the proposed development. This includes a detailed description of the nature of the ground conditions within the overall planning boundary based on existing literature as well as site specific and neighbouring site investigation data.

Direct and Indirect Site Investigation

Section 16.3.3 provides discussion on the data available from the site-specific ground investigations (GI) carried out in relation to the proposed development. This, along with other sections from within Sections 16.3.1 and 16.3.2 look at the regional setting. The information gathered on the baseline environment during ground investigations corresponds to the second element of the methodology, 'Direct and Indirect Site Investigation and Studies'.

Mitigation Measures, Residual Impacts and Final Impact Assessment

The outcome from examining this available data is a Conceptual Site Model (CSM). The CSM is a summary of geological conditions beneath the proposed development that considers the likely significant effects of the proposed development.

A 'Feature Importance ranking' is then assigned to each feature (likely to be affected by the proposed development based on guidance from the National Roads Authority (NRA)[26] and IGI**Error! Bookmark not defined.**. The IGI guidance draws upon the existing guidance at the time of publication from the NRA and applies it to Soils Geology and Hydrogeology. This facilitates the assessment of likely significant effects which has been undertaken in accordance with the guidance outlined in Section 16.2.2. Section 16.5 outlines the "Mitigation Measures and Monitoring" associated with the works in accordance with the above methodology.

Completion of the Land and Soils Sections of the EIAR

This section has been prepared iteratively whilst undertaking the first three elements. Upon finalisation of the preceding steps, this information has been documented accordingly (i.e. as part of this chapter) which corresponds to the final element of the methodology 'Completion of the Soils, Geological and Hydrogeological Sections of the EIAR'.

16.3 Baseline Conditions

As noted in Section 16.2.7, the existing hydrogeology in the study area has been interpreted from both desk study information and from project-specific site investigations. The current baseline would represent the "Do Nothing Scenario" in relation to hydrogeology, as required under the European Commission Guidance.

16.3.1 Regional Geomorphology and Topography

The proposed development is located on the northern side of the River Liffey which flows from the west to the east along the southern boundary of the site. The River Liffey is tidal in the vicinity of the site and discharges to the Irish Sea approximately 7km east of the site (Figure 15.1, see Appendix 15.1).

16.3.2 Regional Hydrogeology

16.3.2.1 Aquifer Type

The Geological Survey of Ireland (GSI) has devised a system for classifying both bedrock and gravel aquifers in Ireland based on the hydrogeological characteristics, size and productivity of the groundwater resource[27]. The three main classifications are Regionally Important Aquifers, Locally Important Aquifers and Poor Aquifers. These are then further subdivided by their general characteristics.

The limestone bedrock (referred to as the Lucan formation) beneath and in the vicinity of the proposed development is classified by the GSI as a Locally Important Aquifer (Ll) bedrock which is moderately productive in local zones. The GSI have not designated any gravel aquifers beneath or in the vicinity of the proposed development. The aquifer classification map is presented on Figure 16.1 (see Appendix 16.1).

This bedrock aquifer is part of the Dublin Urban groundwater body. The GSI note that the aquifer does not contain significant primary porosity with the majority of flow and storage occurring in fractures[28]. It is reported by the GSI that based on packer tests the permeability was seen to reduce by an order of

[26] Note that the NRA merged with the Railway Procurement Agency (RPA) to become Transport Infrastructure Ireland (TII) in 2015. The NRA tables presented in Tables C2 to C6 of the IGI (2013) document can be found in Box 4.1, Box 4.3, Box 5.1, Box 5.3 and Box 5.4 of the NRA (2008) document available on the TII website.
NRA (2008). Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes. Available at: http://www.tii.ie/technical-services/environment/planning/Guidelines-on-Procedures-for-Assessment-and-Treatment-of-Geology-Hydrology-and-Hydrogeology-for-National-Road-Schemes.pdf

[27] GSI, 2018. Aquifer classification. Available at: https://www.gsi.ie/en-ie/programmes-and-projects/groundwater/activities/understanding-ireland-groundwater/aquifer-classification/Pages/default.aspx

[28] GSI, 2015. Dublin GWB: Summary of initial characteristics, available online;
http://www.gsi.ie/NR/rdonlyres/6B1127AA-6928-4F29-AFBB-254FA8BC3C61/0/Dublin.pdf

magnitude with every 5 m increase in depth[29]. The GSI report that the majority of flow is in the upper weathered bedrock and is also common within fractures and fissures at depth of up to 50 mbgl[29]. Conduits are also recorded at depth between 30 mbgl to 50 mbgl[29].

Regional groundwater flow in the aquifer is towards Dublin Bay and the Irish Sea in the east[29]. It is also reported by the GSI that flow is also seen towards the River Liffey[29] which suggested that that there is a degree of continuity between the groundwater in the Lucan Formation and the River Liffey.

16.3.2.2 Groundwater Vulnerability

Groundwater vulnerability is a relative measure of the ease with which groundwater may be contaminated by human activity. It is based on the aquifer's intrinsic geological and hydrogeological characteristics. The vulnerability is determined by the thickness and permeability of overlying deposits and the depth to groundwater. For example, bedrock with a thick, low permeability, clay-rich overburden is less vulnerable than bedrock with a thin, high permeability, gravelly overburden.

The groundwater vulnerability rating is relevant to groundwater in the bedrock aquifer rather than the subsoil (drift). Where the cover over the glacial sand and gravel is thin the groundwater will be more vulnerable.

Groundwater vulnerability in this area of the city, north of the River Liffey is generally Low and increases to Moderate along the River Liffey corridor (See Figure 16.2, Appendix 16.1).

16.3.2.3 Recharge

Recharge is the amount of effective rainfall that replenishes the aquifer. It is a function of the effective rainfall (i.e. rainfall minus evaporation and run off), transpiration (uptake by plants) and the aquifer characteristics.

According to the GSI groundwater recharge database, the recharge to the area is 68mm/yr which accounts for approximately 20% of the effective annual rainfall (341mm/yr) over the area. The recharge in the area of the proposed development is shown on Figure 16.3, Appendix 16.1.

This is a low rate of recharge which reflects both the relatively low effective rainfall value, the presence of Made Ground in the urban environment above the limestone aquifer. This highlights that there is only a limited capacity for rainwater to infiltrate into the limestone aquifer.

16.3.2.4 Groundwater Receptors – Groundwater Abstractions

Based on the GSI database there are no Source Protection Zones or National Federation of Group Water Scheme Zones of Contribution within 2km of the proposed development site boundary. There are two groundwater well records in the GSI database within 2km of the site (See Figure 16.4, Appendix 16.1).

16.3.2.5 Groundwater Receptors – Groundwater Dependent Ecosystems

Under to the EU Habitats Directive (92/43/EEC)[29] and the EU Birds Directive *(2009/147/EC)*[30], Member States are required to establish a Natura 2000 network of sites of highest biodiversity importance for rare and threatened habitats and species across the EU. In Ireland, the Natura 2000 network of European sites includes Special Areas of Conservation (SACs) and Special Protection Areas (SPAs).

In Ireland, areas which have a nationally important habitat(s) or which have a habitat(s) that needs protection, are granted protection under the Wildlife (Amendment Act) *2000*[31]. Such areas may be designated Natural Heritage Areas (NHAs) or proposed NHAs (pNHAs). Under the *Wildlife Amendment*

[29] OJEC (1992), Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna
[30] OJEC (2009), Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds
[31] Wildlife (Amendment Act) 2000, accessed from http://www.irishstatutebook.ie/eli/2000/act/38/enacted/en/print, October 2019

Act (2000)[31], NHAs are legally protected from damage from the date they are formally proposed for designation.

There are no SACs, SPAs, NHAs or pNHAs within 2km of the site and there are considered to be no groundwater dependant ecosystems within 2km of the site.

16.3.3 Site Specific Environmental Setting

16.3.3.1 Introduction

This section outlines the site specific information available for the proposed development.

16.3.3.2 Site Overview

The River Liffey forms the southern boundary of the site and Parkgate Street runs parallel to the northern site boundary.

The site is located in a built up urban environment.

Significant landmarks in proximity to the site include the Criminal Courts and Phoenix Park, located approximately 200m north-west of the north-western tip of the site. East of the site is Collins Barracks. Heuston Station is south of the site on the southern side of the River Liffey.

16.3.3.3 Site Topography

The topography of the overall site falls to the south towards the River Liffey. Levels on Parkgate Street to the north of the site vary from 5.3 to 5.5mOD, falling to approximately 3.4mOD at the southernmost point of the site adjacent to the River Liffey.

16.3.3.4 Site Specific Ground Investigation

Ground Investigations Ireland Ltd. (GII), under the instruction of Arup, carried out the GI between March and May 2019. The GII Ground Investigation Report (2019) is presented in Appendix 15.4.

The following intrusive works were carried out:

- 18 No. window sample boreholes to recover soil samples;
- 4 No. cable percussion boreholes to a maximum depth of 7.6mbgl;
- 4 No. rotary core follow-on boreholes to a maximum of 15.60mbl;
- 4 No. rotary core follow-on boreholes to a maximum depth of 17.0mbgl;
- Installation of 10 No. groundwater monitoring wells;
- Installation of 3 no. gas monitoring caps;
- Geophysical survey; and
- Geotechnical and environmental laboratory testing.

To give a robust understanding of the nature of contamination within the made ground and natural soils in vertical and lateral extent, environmental samples were taken from both boreholes and window samples. At boreholes, bulk distributed samples were taken from made ground and granular soil at 1m intervals to 8mbgl. In window samples, a small distributed sample was taken from the made ground and natural material at 1m intervals commencing at 0.5mbgl to a 4mbgl or until practical refusal.

Samples were collected in dedicated soil pots and jars as specified and supplied by the analytical laboratory. Samples were taken in accordance with methods specified and referenced in the Investigation of potentially contaminated sites - Code of practice (BS 10175:2011+A2:2017)[32].

[32] British Standards Institution (2017), BS10175:2011+A2:2017; Investigation of potentially contaminated sites – Code of practice, BSI

Representative geotechnical samples of the soils were also collected in dedicated sample pots and bulk bags.

The site geology consists generally of made ground overlying a thin layer of clay with occasional shell fragments, which overlies sand and gravel. Limestone bedrock is present underneath the natural soils. A summary of the strata proven at the site is summarised in Table 16.1. This information is compiled from the borehole and window sample logs from the site investigation as presented in Appendix 15.4 containing the site investigation report produced by Ground Investigations Ireland. The strata proven is consistent with the regional geology and generally consistent with findings from previous site investigations.

Lithology	Description	Depth (mbgl)	Thickness (m)
Made ground	Hardcore Concrete and Tarmacadam	0 – 1.3	0.04 – 1.3
	Clay/ Gravel Brown to dark brown slightly sandy clay and gravel with cobbles and anthropogenic materials (including, but not limited to slag, redbrick, mortar, charcoal). Gravel is angular to subrounded, fine to coarse.	0 – 5.0	1.4 – 5.0
Clay	Soft, light brown to brown, slightly sandy silty clay with occasional shell fragments	1.9 – 6.2	0.3 – 1.4
Sand and gravel	Loose to very dense grey to brown slightly clayey gravelly fine to coarse sand and gravel with occasional cobbles. Gravel is subangular to subrounded.	2.6 – 8.5	1.2 - 3.8
Weathered Bedrock	Angular cobbles of weak, thinly laminated dark grey to black Mudstone and Limestone	6.4 – 8.6	0.2 - 1.5
Limestone Bedrock	Weak to very strong dark grey fine grained limestone with bands of mudstone and calcite veining	6.7 – 17.0 (proven)	8.7 (proven

Table 16.1: Ground Conditions

16.3.3.5 Groundwater Levels and Flow

The only water bearing overburden strata intercepted by the boreholes during the site investigation was the natural sand and gravel. No groundwater was encountered in the made ground. Groundwater monitoring installations were installed in all boreholes, with response zones in the following locations:

- BH101, BH103, BH106 in the natural clay and/ or gravel;
- BH102, BH104, BH105 in the limestone bedrock;
- BH107 in the natural gravel and the limestone bedrock.

Water levels in the new boreholes and historic boreholes (BH101, BH103, BH104, BH105, BH106, BH107, BH01, BH02, BH05, BH06, WS06, WS12 and WS13) were manually recorded on four occasions in May and June 2019 while the site investigation works were ongoing. Water levels were not recorded in BH102 as it was not completed or was not accessible during this time.

Water levels in the boreholes were electronically recorded over a four-week period between 14th August and 12th September 2019 using transducers in BH101, BH102, BH103 and BH106. A summary of this data is presented in

below.

The groundwater level in both the natural sand and gravel aquifer and in the limestone bedrock aquifer varied with the tide during the monitoring period.

BH106 in the south-centre of the site had the maximum variation in groundwater level as it was closest to the River Liffey and so was impacted by the tidal variation most. Groundwater levels in BH103, located

in the north-centre of the site and furthest away from the river, varied the least but was still influenced slightly by tidal variation.

Based on this data, groundwater flow across the site is in a north-west to south-east direction toward the river during low tide and in a south-east to north-west direction at high tide.

Location ID	Aquifer Type	Groundwater Level Maximum (mOD)	Groundwater Level Minimum (mOD)
BH101	Sand and gravel	1.18	0.18
BH102	Limestone bedrock	0.91	0.12
BH103	Sand and gravel	1.08	0.82
BH106	Sand and gravel	1.45	-0.38

Table 16.2: Summary of monitored groundwater levels

The data from the transducers and manual readings are presented in Appendix 15.4.

16.3.3.6 Groundwater Abstractions

Based on the GSI database there is one well record within 1km of the centre of the site. The exact location is unclear as the well location in the GSI database is only accurate to 500m however North Brunswick Street is recorded as the address, which is approximately 750m north east from the site boundary. This well is reported as having a 'good' yield of 393m3/day and understood to be drilled for industrial use. The source of water is from bedrock which is reported to be 2.5mbgl.

16.3.3.7 Groundwater Receptors – Groundwater Dependent Ecosystems

According to the National Parks and Wildlife Service (NPWS) database, there are no European sites, within 2km of the site.

The nearest European sites are those associated with Dublin Bay including the South Dublin Bay and River Tolka Estuary SPA (Site code 004024) which is located approximately 4.37 km to the east, the South Dublin Bay SAC (Site code 000210) which is located approximately 5.41 km to the east, the North Bull Island SPA (Site code 004006) which is located approximately 7.46 km to the east, and the North Dublin Bay SAC (Site code 000206) which is located approximately 7.47 km to the east.

16.3.4 Technical Limitations

The baseline data described and considered in this assessment includes existing data from earlier investigations within the study area and surrounds as well as dedicated field surveys commissioned specifically for the proposed development.

The baseline data provides valuable information on the existing soils, geology and hydrogeological environment at point locations within the study area. Between each point the baseline data has been assessed by conservative interpretation. While hydrogeology can vary, the exploratory locations have been selected following the completion of the comprehensive baseline data collection. This review was completed by studying local geological maps, aerial photography, historic ground investigation and completing site walkovers to provide an understanding of the study area. The location and the spacing of the exploratory locations used as part of the intrusive investigation was chosen in order to gain an understanding of the hydrogeology beneath the site. The findings from the investigations for the majority of cases compared favourably with the desk study of existing information on the baseline conditions.

16.3.5 Conceptual Site Model

16.3.5.1 Introduction

The Conceptual Site Model (CSM) (as presented in Figure 15.6, see Appendix 15.1) summarises the important geological and hydrogeological features in the study area. The CSM was developed based on the data obtained during the intrusive investigations i.e. borehole and trial pit logs, geophysical surveys and groundwater monitoring data.

16.3.5.2 Environment Type

The geological environment at and in the vicinity of the study area can be described as a historically stable geological environment and underlain by a poor aquifer. Consequently, the geological environment is considered to be Passive (type A) as per the IGI guidelines.

16.3.5.3 Importance of Features

The bedrock beneath the proposed development is classified as a Locally Important Aquifer (Ll) which is moderately productive in local zones and the feature is classified as Medium in accordance with the IGI/NRA guidelines.

According to the NPWS database, there are no European sites within 1km of the site. The nearest European sites are those associated with Dublin Bay including the South Dublin Bay and River Tolka Estuary SPA (Site code 004024) which is located approximately 4.37 km to the east, the South Dublin Bay SAC (Site code 000210) which is located approximately 5.41 km to the east, the North Bull Island SPA (Site code 004006) which is located approximately 7.46 km to the east, and the North Dublin Bay SAC (Site code 000206) which is located approximately 7.47 km to the east.

There are no NHAs or pNHAs within 2km of the site.

Feature		**Importance ranking**	**Justification**
Aquifer	Locally important bedrock aquifer	Medium	This is a medium quality attribute and is important on a local scale.
Aquifer	Sand and gravel deposits	Low	While not classified by GSI as an aquifer their importance is based on their connection between the bedrock aquifer and river.
River	River Liffey	Medium	Groundwater baseflow to the river and the site is located directly adjacent the river.
SAC/SPA	South Dublin Bay SAC, North Dublin Bay SAC	Extremely High	Indirect hydraulic connection downstream of River Liffey.

Table 16.3: Hydrogeology Feature Importance

16.3.6 Activities/ Environment Matrix

Error! Reference source not found. outlines the required activities as set out in the IGI guidance that should be undertaken during construction and operation, and the investigations, assessments and surveys that have been carried out to consider those activities.

Work Required under Activity and Type Class (based on IGI Guidelines)	Details of works completed to date
Earthworks	
Invasive site works to characterise nature, thickness, and stratification of soils and subsoils	Site specific site investigation carried out across the study area.
Works to determine groundwater level, flow direction and gradient.	Manual and electronic groundwater monitoring.
Works to determine groundwater-surface water interaction.	Collection of groundwater and surface water samples for water quality analysis
Excavation of materials above the water table	
Site works to characterise nature, thickness, permeability and stratification of soils, subsoils, bedrock geology.	Site specific site investigation carried out across the study area.
Works to determine groundwater level, flow direction and gradient.	Manual and electronic groundwater monitoring
Excavation of materials below the water table	
Site works to characterise nature, thickness, permeability and stratification of soils, subsoils, bedrock geology.	Site specific site investigation carried out across the study area.

Table 16.4: Activities and Environment Matrix

16.4 Likely Significant Effects

The proposed development includes the excavation and construction of foundations with a finished slab level of 5.0mOD.

Based on this level, groundwater ingress is not anticipated in the main dig, however local deepening for the excavation of services and lift pits may require local dewatering.

16.4.1 Do-Nothing Scenario

The current baseline as described in Sections 16.3.1 to 16.3.5 represents the "Do Nothing Scenario" in relation to hydrogeology as required under the EC Guidance. A conservative approach is to assume that the site will remain as described in the baseline sections of this chapter.

However, it is not practicable to complete the consented scheme (ABP-306569-20, Blocks B & C) without a further grant of permission for development that resolves the eastern elevation of Block B2, at the site of proposed Block A.

A 'do nothing' scenario in respect of proposed Block A would be an undesirable planning and environmental outcome, in particular from an optimum site regeneration and a landscape and visual impact perspective, at this pivotal, gateway site.

16.4.2 Assessment of Effects During Construction

The proposed construction methodologies for the development are outlined in Chapter 4, Construction Strategy.

The potential construction effects on the hydrogeological features identified are listed below:

- Removal of Made ground;
- Effect on groundwater quality;
- Effect on groundwater flow and recharge;
- Effect on bedrock aquifer;
- Effect on water level in the River Liffey; and
- Pollution from construction activities.

Removal of Made Ground

As part of the works, some of the made ground from across the site will be removed resulting in a minor positive impact on the site. This is due to the reduced leachate generated from percolation of surface water through the made ground on site.

Effect on groundwater quality

Construction activities which may affect the groundwater quality beneath the proposed scheme during the construction phase are:

- Accidental spillages of polluting materials onsite;
- Release of fines into the groundwater and surface water; and
- The potential for contaminated runoff to enter the groundwater and surface water.

If any of these occur, they may potentially contaminate the groundwater beneath the proposed development. These are potential short-term effects. The magnitude and significance of these potential effects on the receptors are summarised below:

- The magnitude of this potential effect on the sand and gravel deposits could potentially be small adverse leading to a significance rating of slight;
- The magnitude of this potential effect on the River Liffey could potentially be small adverse leading to a significance rating of slight.
- The magnitude of this potential effect on the Locally Important aquifer could potentially be small adverse leading to a significance rating of slight.

Effects on Groundwater Flow and Recharge

Localised groundwater dewatering using a series of sumps and submersible pumps is proposed during the construction of the development.

Any local dewatering is to be discharged to the River Liffey by agreement with the Local Authority and will include necessary treatment as required, such as silt traps and settlement tanks. Alternatively, dewatering may be reinjected to the subsurface through a number of wells or injection points across the site. Similar treatment measures will be adopted prior to reinjection.

The construction of these works will have a negligible effect on the groundwater levels and flows in the sand and gravels which have a low importance. This is due to the proposed slab level of 5.0mOD. Highest groundwater recorded was 1.18mOD. Hence, the magnitude of the impact of this activity would be negligible and the overall significance rating of the effect on groundwater levels and flow is imperceptible.

Effects on Bedrock Aquifer

Localised groundwater dewatering using a series of sumps and submersible pumps is proposed during the construction of the development.

The construction of these works will have a negligible effect on the groundwater levels and flows in the bedrock. This is due to the proposed slab level of 5.0mOD. Highest groundwater recorded was 1.18mOD. Hence, the magnitude of the impact of this activity would be negligible and the overall significance rating of the effect on groundwater levels and flow within the bedrock are imperceptible.

Water Level in the River Liffey

The River Liffey is in continuity with the groundwater in the sand and gravels throughout the study area. As limited dewatering is proposed as part of the construction of the proposed development as outlined above, the effect on groundwater levels in the sand and gravel deposits and river water levels in the Liffey during construction is negligible. The magnitude of the impact of this activity would be negligible and the overall significance rating of the impact on river water levels and flow is imperceptible.

Pollution from Construction Activities

The construction of the proposed development will require the use of fuels and materials which will have the potential to pollute the site, and adjacent, environment. Good housekeeping will be carried out on the sites during construction, and the proper use, storage and disposal of all substances and their containers will help prevent soil contamination. Pollution from construction activities is considered to be a small adverse impact and the significance of this impact is slight.

16.4.2.1 Indirect Effects during Construction

There were no indirect effects identified due to groundwater associated with the construction phase.

16.4.2.2 Cumulative Effects During Construction

In preparing this chapter, consideration was given to the developments listed in Appendix 21.1 in relation to relevant cumulative and in combination effects, along with the development of Blocks B and C as per ABP-306569-20.

Additionally, the main impacts from the proposed development arise during construction. It is unknown at this stage if the construction works associated with other developments would be occurring at the same time as the construction of the proposed development.

Notwithstanding, given the nature and scale of the developments identified, no cumulative effects on hydrogeology are predicted to occur if any one, or all of these developments occur concurrent to the construction of the proposed development.

There are therefore no predicted significant cumulative effects on hydrogeology associated with the proposed development.

16.4.3 Assessment of effects during Operation

The potential effect on hydrogeology during the operational phase will be limited to accidental spillage of potentially polluting substances such as fuels. Accidental spillages will be collected by the surface water drainage systems and not allowed percolate to ground. The likelihood of this occurring is negligible.

The removal of some of the made ground from the site and the construction of sealed SUDs drainage may result in reduced infiltration and therefore reduced leaching from any made ground left in situ. This could then be considered a small positive effect during the operational phase.

16.4.3.1 Indirect Effects during Operation

There were no indirect effects identified due to groundwater associated with the operational phase.

16.4.3.2 Cumulative effects during Operation

It is our opinion that there are no significant cumulative effects on hydrogeology associated with the proposed development in the operational phase.

16.5 Mitigation Measures and Monitoring

16.5.1 Mitigation

16.5.1.1 Mitigation During Construction

Existing Waterbodies

A Construction Environmental Management Plan (CEMP) is contained in Appendix 4.1

Examples of measures to be implemented include:

- Where feasible all excavated spoil will be treated to remove excess fluid prior to stockpiling and transportation;
- Where feasible transfer of excess soil materials from stockpile areas off-site will be undertaken during dry periods;
- Stockpile and transfer of excess soil material will be restricted to specified and impermeable areas that are isolated from the surrounding environment;
- Wheel washes will be provided at site entrances to clean vehicles prior to exiting the work site;
- All staff will be trained and follow vehicle cleaning procedures. Details of these procedures will be posted in all work sites for easy reference; and
- The implementation of the above measures will ensure that the risk of pollution of groundwater and nearby water bodies resulting from the construction activities will be minimised.

Pollution from Construction Activities

The employment of good construction management practices will minimise the risk of pollution of soil, storm water run-off, adjacent watercourses and groundwater. The construction management of the site will take account of the recommendations of the CIRIA guidance Control of Water Pollution from Construction Sites – Guidance for consultants and contractors (Masters-Williams et al., 2001) to minimise as far as possible the risk of soil, groundwater and surface water contamination.

Measures, as recommended in the guidance above, that will be implemented to minimise the risk of spills and contamination of soils and waters, include:

- Training of site managers, foremen and workforce, including all subcontractors, in pollution risks and preventative measures;
- Careful consideration will be given to the location of any fuel storage facilities. These will be designed in accordance with guidelines produced by CIRIA, and will be fully bunded;
- All vehicles and plant will be regularly inspected for fuel, oil and hydraulic fluid leaks. Suitable equipment to deal with spills will be maintained on site;
- Ensure that all areas where liquids are stored, or cleaning is carried out are in designated impermeable areas that are isolated from the surrounding area e.g. by a roll-over bund, raised kerb, ramps or stepped access;
- Minimise the use of cleaning chemicals; and
- Use trigger-operated spray guns, with automatic water-supply cut-off.

16.5.1.2 Mitigation During Operation

No mitigation measures are considered necessary for the operational phase of the proposed development as no significant effects are predicted.

16.5.2 Monitoring

16.5.2.1 Monitoring During Construction

In relation to soils contamination a suitably experienced environmental consultant will be required to oversee the excavation works for the proposed development so that potential contamination can be segregated, classified and suitably disposed.

The works will be monitored by a Resident Engineer.

Visual monitoring will be undertaken as part of the regular site audits during the construction of the proposed development to ensure the groundwater resource is not impacted by the proposed development.

16.5.2.2 Monitoring During Operation

No monitoring is proposed during operation of the proposed development.

16.6 Residual Effects

16.6.1 Residual effects during construction

Table 16.5 summarises the residual effects; however, no residual effects of significance on hydrogeology during construction were identified.

16.6.2 Residual effects during operation

No residual effects during operations are expected.

16.7 Difficulties Encountered

No difficulties were encountered during the compilation of this chapter.

Feature		Importance		Magnitude of Impact		Significance of Impact	Mitigation Measures	Residual Impact	Residual Significance of Impact
		Ranking	Justification	Ranking	Justification				
Aquifer	Locally important bedrock aquifer	Medium	This is a medium quality attribute and is important on a local scale.	Minor beneficial	Removal of made ground and decrease in infiltration from surface	Imperceptible	N/A	N/A	Imperceptible
				Moderate adverse	Accidental releases from site, increased fines into groundwater and surface water, contaminated runoff from site	Moderate	Implementation of CEMP, Good management of sites, management of runoff	Negligible	Imperceptible
				Negligible	Maximum recorded groundwater levels were at 1.18mOD. Basement slab level is at 2.0mOD. Only localised dewatering anticipated.	Imperceptible	N/A	Negligible	Imperceptible
Aquifer	Sand and gravel deposits,	Low	While not classified by GSI as an aquifer their importance is based on their connection between the bedrock aquifer and river	Minor beneficial	Removal of made ground and decrease in infiltration from surface	Imperceptible	N/A	N/A	Imperceptible
				Moderate adverse	Accidental releases from site, increased fines into groundwater and surface water, contaminated runoff from site	Slight	Implementation of CEMP, Good management of sites, management of runoff	Negligible	Imperceptible
				Negligible	Maximum recorded groundwater levels were at 1.18mOD. Basement slab level is at 2.0mOD. Only localised dewatering anticipated.	Imperceptible	N/A	Negligible	Imperceptible
River	River Liffey	Medium	Groundwater baseflow to the river and the site	Negligible	Maximum recorded groundwater levels were at 1.18mOD. Basement	Imperceptible	N/A	N/A	Imperceptible

Feature		Importance		Magnitude of Impact		Significance of Impact	Mitigation Measures	Residual Impact	Residual Significance of Impact
		Ranking	Justification	Ranking	Justification				
			is located directly adjacent the river.		slab level is at 2.0mOD. Only localised dewatering anticipated.				
SAC's/SPA's	Dublin Bay	Extremely High	Downstream from site	Negligible	SAC's / SPA's remote from site	Imperceptible	N/A	N/A	Imperceptible

Table16.5: Residual Effects during Construction