8 WATER

8.1 Introduction

This chapter describes the existing surface water and groundwater regime likely to be encountered beneath and in the general vicinity of the proposed development. It also addresses the potential impact of the proposed development on hydrology (i.e. surface water) and hydrogeology (i.e. groundwater) together with the mitigation measures that will be employed to eliminate or reduce any potential impacts. A more complete description of the proposed development is presented in the Project Description Section of this EIAR.

8.2 Assessment Methodology

The following scope of works were undertaken by Atkins in order to complete this assessment: -

i. Desk-based study including review of available historical information.

ii. Site Walkover Survey on the 26 June and the 18 September 2018.

iii. Groundwater investigation works undertaken by Ground Investigations Ireland Ltd. (GIIL) between 27 June and 29 June 2018. 3no. boreholes were drilled to a target depth using a Dando 2000 drilling rig; each borehole was then converted to a groundwater monitoring well and screened across the shallow groundwater zone (within saturated subsoils generally gravel / sandy gravelly clay). All drilling and installation works were supervised full-time by a Hydrogeologist, who also designed each well installation based on encountered site conditions at each location. Wells were positioned in order to obtain representative baseline data, taking account of the topography of the site (and therefore likely groundwater flow direction), and adjacent land-uses (which may potentially impact groundwater quality beneath the site). One offsite borehole (BH1) was located upgradient of the site, while two boreholes (BH2, BH3) were located onsite, in the eastern and southern portions respectively. All wells were screened within the shallow groundwater zone on the basis that this would be the first groundwater receptor to be impacted in the event of a contamination issue.

iv. Baseline groundwater level monitoring carried out by GIIL between 16 July and 13 September at 3no. groundwater monitoring wells (BH1 to BH3).

v. Baseline groundwater quality monitoring carried out by Atkins on 18 September 2018; 2no. groundwater quality samples (BH1, BH2) were obtained in accordance with best practice environmental sampling procedures. BH3 was observed to be dry at the time of sampling.

The purpose of the initial desk-based task was to characterise the current hydrological and hydrogeological setting of the site. Relevant background information was compiled, specifically from the following data sources: -

- Environmental Protection Agency (EPA) web mapping (consulted October 2019).
- Geological Survey of Ireland (GSI) Datasets Public Viewer and Groundwater web mapping (consulted October 2019).
- GSI 'Wicklow Ground Water Body (GWB): Summary of Initial Characterisation' (GSI).
- Office of Public Works National Flood Hazard mapping web site (consulted October 2019).
- Ordnance Survey of Ireland (OSI) web mapping to assess the surface topography and landforms (consulted October 2019).
- National Parks and Wildlife Service (NPWS) Map Viewer (consulted October 2019).
- Water Framework Directive (WFD) Ireland web mapping (consulted October 2019).
- 'Woodbrook Phase 1 Flood Risk Assessment' Report prepared by Atkins (2019); and,
- 'Woodbrook Phase 1 Stormwater Impact Assessment Report' prepared by Atkins (2019).

- The information obtained during the desk-based review was supplemented by a walkover survey undertaken by an experienced Hydrogeologist on the 12th June and the 18th September 2018, along with groundwater level monitoring (over a three-month monitoring period) and groundwater analysis of 2no. samples (BH1, BH2).

This assessment has been prepared with regard to the following accepted best practice guidance in Ireland: -

- Institute of Geologists of Ireland (IGI) *'Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements'* (IGI, 2013).
- Environmental Protection Agency (EPA) *'Revised Guidelines on the Information to be contained in Environmental Impact Statements'* (EPA, 2015) and '*Advice Notes on Current Practice (in the Preparation of Environmental Impact Statements)*' (EPA, 2015).
- EPA *'Guidelines on the Information to be contained in Environmental Impact Assessment Reports – Draft'* (EPA, 2017).
- ISO 5667-3 '*Water Quality – Sampling'* (ISO, 2018).
- BS10175 '*Investigation of Potentially Contaminated Sites – Code of Practice'* (BS, 2011).

Separately a Flood Risk Assessment (FRA) has been prepared by Atkins (2019) in accordance with the following guidance document; '*The Planning System and Flood Risk Management – Guidelines for Planning Authorities'* DOEHLG 2009, and comprised of Stage 1: Flood Risk Identification, to identify whether there may be any flooding or surface water management issues related to the proposed development that may warrant further investigation.

8.3 Receiving Environment

8.3.1 Flood Risk

Atkins has prepared a Flood Risk Assessment (FRA) to accompany the Planning Application for the proposed development (hereafter referred to as the site). This FRA is presented in full in Appendix 8.1. Based on the findings of this site-specific FRA the following conclusions have been made: -

- There is no historic risk of flooding at the site.
- The OPW CFRAM flood extent maps studies have not been carried out in the area of the site and therefore do not show any flood risk at the site. On this basis the site could be considered to be located within Zone C - low probability of flooding.
- Given that the proposed development site is located in Zone C - low probability of flooding, the development is thus appropriate from a flood risk perspective, subject to consideration of potential sources of flood hazard other than river flooding, and subject to the development meeting the normal range of proper planning and sustainable development requirements.
- Given that the proposed development is located in Zone C and has been shown to be appropriate development, consideration of the Justification Test is not required.
- The proposed development is not at risk of flooding from a 1% AEP (1 in 100 year) event.
- Surface water runoff will be managed through the use of appropriate Sustainable urban Drainage Systems (SuDS) which include: -
    - Swales within Open Space / Park areas adjacent to roads;
    - Permeable paving in light traffic areas (parking bays) and temporary car park;
    - Green roofs to suitable apartment blocks;
    - Green courtyards to suitable apartment blocks;
    - Underground modular system within green corridors / park areas;

- o Filter drains in rear gardens;
- o Tree pits along the main avenue; and,
- o Flow control devices including vortex and orifice plates,

'Residual risks from more extreme events have been considered and it is concluded that these will not affect the site.

The PFRA predicted flood map indicate the south-west corner of the proposed development site to be within the 1 in 100 year fluvial floodplain from the Crinkeen / Woodbrook Stream. However it should be noted that the predicted flood extents are based on low resolution data and is intended to be indicative only. The Eastern CFRAM and DLR SFRA provide further detailed predicted flood maps for the Crinkeen / Woodbrook Stream. Both detailed flood maps show the proposed development site to be outside the potential 1 in 100 year and 1 in 1000 year floodplain. Hence this flood study is not required to proceed to Step 2 – Scoping Assessment'.

A number of design recommendations are included in the FRA report, which have informed the final drainage design proposed as part of this residential development. The residual risk of flooding arising from or to the proposed development is therefore considered to be negligible and does not warrant further evaluation as part of this impact assessment.

8.3.2 Hydrology

There are no onsite streams or rivers (EPA, 2019) and none were identified during the two site walkover surveys completed. A drainage ditch is located within the site as presented in Figure 8.1, however this was observed to be dry during both site visits (on the 12 June and 18 September 2018). During a storm event rainfall runoff from across the site is likely to drain primarily to this ditch, with some recharge also occurring to ground.

Regional total rainfall is 758 mm/yr (based on the 30-year mean recorded at the Dublin Airport Station, Co. Dublin during the period 1981-2010) (Met Eireann, 2019). Effective rainfall (or precipitation) is equal to the difference between total rainfall and actual evapotranspiration and is estimated to be 668mm/yr in the general vicinity of the site and 642mm/yr in a minor section of the northern portion of the site (GSI, 2019). Effective rainfall will be partitioned between overland flow, and infiltration to ground. Based on a recharge cap of 200mm/yr which has been applied to the bedrock aquifer by the GSI (2019), it is estimated that between 468mm/yr to 442mm/yr effective rainfall therefore occurs as overland and sub-surface flow. Overland flow will drain primarily in a south easterly and south westerly direction, to the onsite drainage ditch, which appears to then flow in a southerly direction and is assumed to discharge to Rathmichael River (also referred to as the Crinkeen / Woodbrook Stream) immediately south of the site. This river then flows in a southerly and south easterly direction prior to discharging to Bray Strand c.1.2km downstream (and south east) of the site. Refer to Figure 8.2. Rainfall (albeit minor volumes) will infiltrate to ground in the more permeable areas of the site, for example in the eastern portion, and likely flows via. discrete permeable zones beneath the surface.

The Rathmichael River (also referred to as the Crinkeen / Woodbrook Stream), the Shanganagh River, and the Dargle River are the only named watercourses identified within c.2km of the site as presented in Figure 8.2 (EPA, 2019). The Shanganagh River rises in the Kilternan area c. 8km west of the site and flows in a general easterly direction before discharging to the Irish Sea at Shankill beach (EPA, 2019). The Rathmichael River (also referred to as the Crinkeen / Woodbrook Stream) rises c. 3km upstream (c. 2.5km) northwest of the site and flows in an easterly and southerly direction before discharging to the Irish Sea at Bray Strand (EPA, 2019). The Dargle River rises in Barnaslingan Wood and flows in a general south easterly direction before discharging to the Irish Sea at Bray Harbour.

Of the three identified surface water courses (Shanganagh River, Rathmichael River and Dargle River), Rathmichael River (also referred to as the Crinkeen / Woodbrook Stream) is the only surface water course within c.2km of the site which is hydraulically connected to the proposed development site, as discussed previously. Therefore, it is likely that the site is directly connected to the Irish Sea at Shankill beach via. surface water flow (Rathmichael River), and also indirectly connected, via. shallow groundwater flow and diffuse discharge.

The site is not located within or in the vicinity of any designated Natura 2000 Sites or sites of National Importance. Refer to the Biodiversity Section of this EIAR for further details.

Figure 8.1: Onsite Drainage Ditch (Source: GSI, 2019).

Figure 8.2: Key Hydrological features in vicinity of Proposed Development (Source: EPA, 2019).

8.3.2.1 Surface Water Quality

On a regional scale, the Shanganagh River, the Dargle River and the Rathmichael River (also referred to as the Crinkeen / Woodbrook Stream) have been assigned *'Good'* status in accordance with the River Waterbody Water Framework Directive (WFD) for the 2010 to 2015 period, as presented in Figure 8.3. All onsite drainage ditches were observed to be dry on 12th June and also during the baseline quality monitoring event, undertaken on 18th September; therefore, it was not possible to obtain site specific surface water analytical data as part of this assessment.

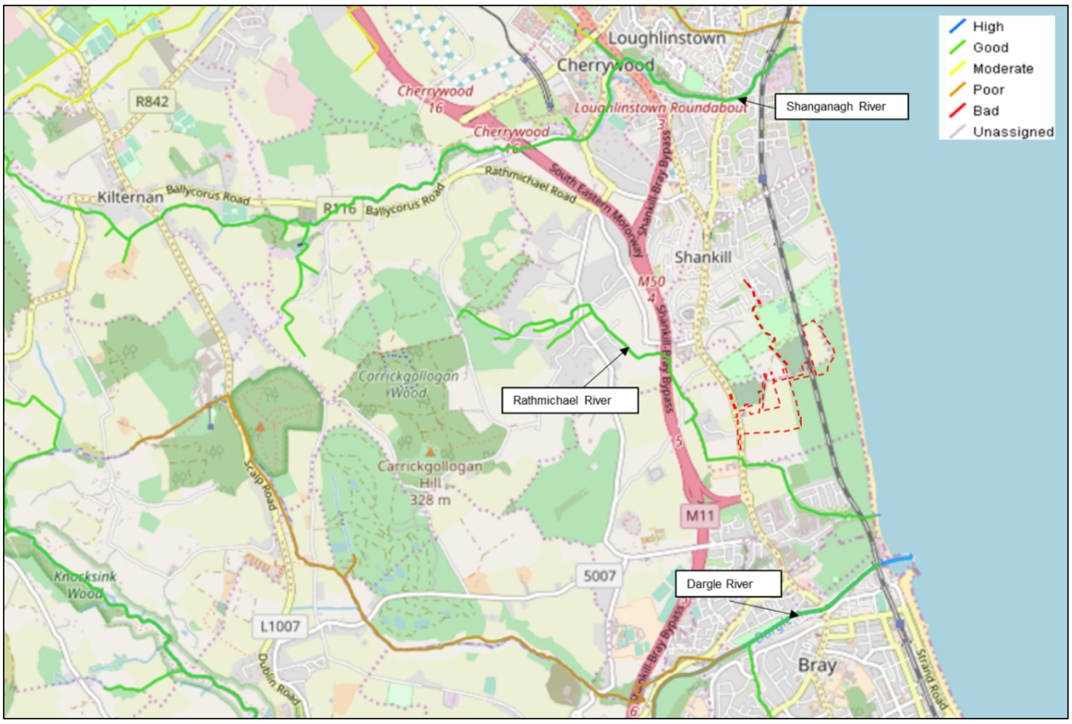


Figure 8.3: Water Quality Status in vicinity of Proposed Development (Source: EPA, 2019).

8.3.3 Hydrogeology

8.3.3.1 Aquifer Characteristics

The GSI provides a methodology for aquifer classification based on resource value (regionally important, locally important and poor) and vulnerability (extreme, high, moderate or low). Resource value refers to the scale and production potential of the aquifer whilst vulnerability refers to the ease with which groundwater may be contaminated by human activities. Vulnerability classification is primarily based on the permeability and thickness of subsoils, as presented in Table 8.1.

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 - 3.0m	0 - 3.0m	0 - 3.0m	0 - 3.0m	-
High (H)	>3.0m	3.0 - 10.0m	3.0 - 5.0m	>3.0m	N/A
Moderate (M)	N/A	>10.0m	5.0 - 10.0m	N/A	N/A
Low (L)	N/A	N/A	>10.0m	N/A	N/A

Notes: (1) N/A = not applicable.
(2) Precise permeability values cannot be given at present.
(3) Release point of contaminants is assumed to be 1-2 m below ground surface.

Table 8.1: Groundwater Vulnerability Rating Table (Source: GSI, 1999).

Bedrock underlying the vicinity of the site and its surrounding area comprises dark blue-grey slate, phyllite & schist of the Maulin Formation, as discussed in detail in the Land, Soils and Geology Section of this EIAR. The bedrock aquifer within the vicinity of the site is classified as '*Ll*', a Locally Important Aquifer which is moderately productive only in local zones (GSI, 2019). Refer to Figure 8.4. There are no gravel aquifers underlaying the site; however, the Enniskerry Gravels Aquifer, which covers an area of c. 10.75km^2, is located c. 1.8km south west of the proposed development (GSI, 2019). This gravel aquifer is classified as '*Lg*', a Locally Important Gravel Aquifer (GSI, 2019). Refer to Figure 8.4. There are no geological structures (including faults or unconformities) present in the vicinity of the proposed development (GSI, 2019).

Killiney Bay, which runs from Killiney to Bray, is located c. 0.1km west of the site and has been designated as Geological Heritage Area due to the presence of '*a 5 kilometres long coastal section exposes a succession of several units of glacial till*' (GSI, 2019), as detailed further in Chapter 7: Land, Soils and Geology.

According to GSI, 2019, the groundwater vulnerability beneath the general vicinity of the proposed development, is classified as '*High*' indicating that bedrock is expected to be relatively shallow in the vicinity (within approximately 3m to 10m), and accordingly would be vulnerable to potential contamination. Refer to Figure 8.5.

Groundwater beneath the general vicinity of the proposed development site forms part of the Wicklow Groundwater Body (GWB). According to the GSI (2004) most groundwater within this GWB (which has a reported area of 1396km^2) flows within a shallow upper weathered zone (typically less than 3m thick). Deeper groundwater flow is possible with deep-water strikes often encountered between 10 and 40m below ground level. Flow paths are likely to be short (a couple of hundred meters) with groundwater discharging to the closest surface water features. Overall, the regional flow direction within this GWB is expected to be to the east, as determined by the topography (GSI, 2004).

There are no karst features within a 10km radius of the proposed development (GSI, 2019); accordingly, the potential for karst connectivity, and groundwater flow via. conduit pathways, does not warrant consideration as part of this assessment. Based on the geological setting of the receiving environment there is no potential for karst features (such as fractures or epikarst) to be present beneath the site.

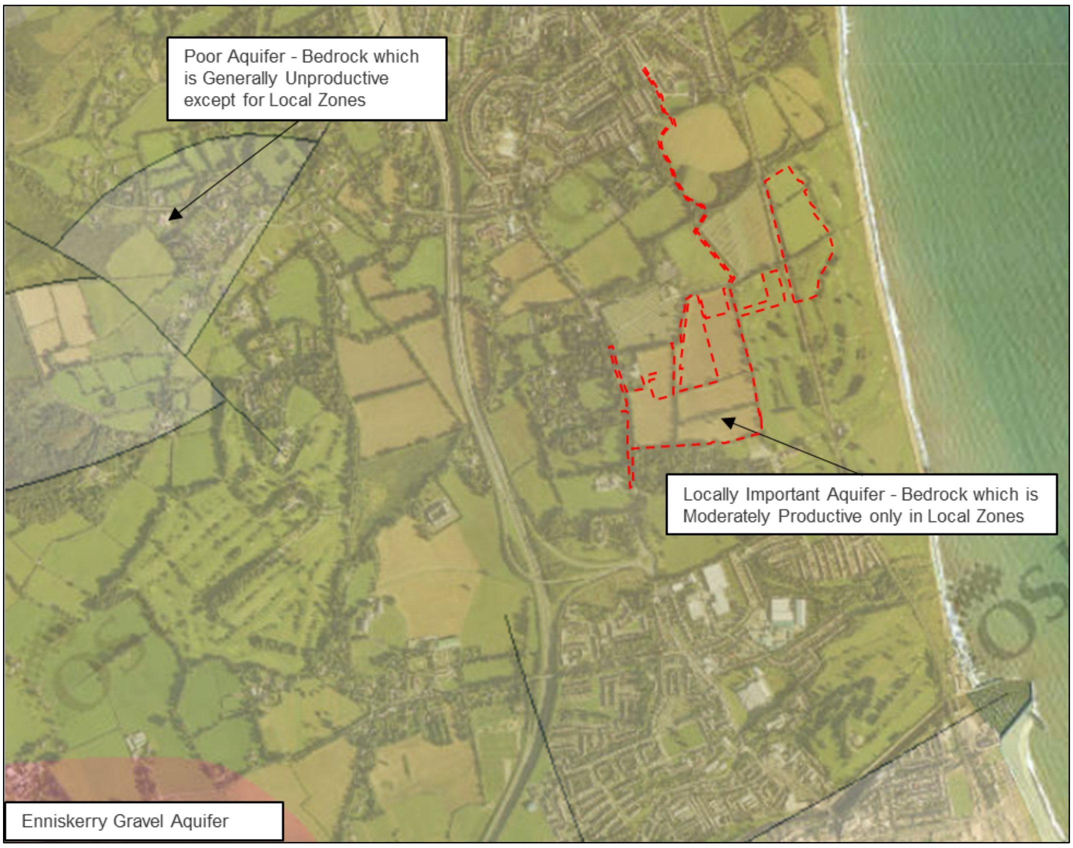


Figure 8.4: Regional Aquifer Classification (Bedrock and Gravel Aquifers) (Source: GSI, 2019).

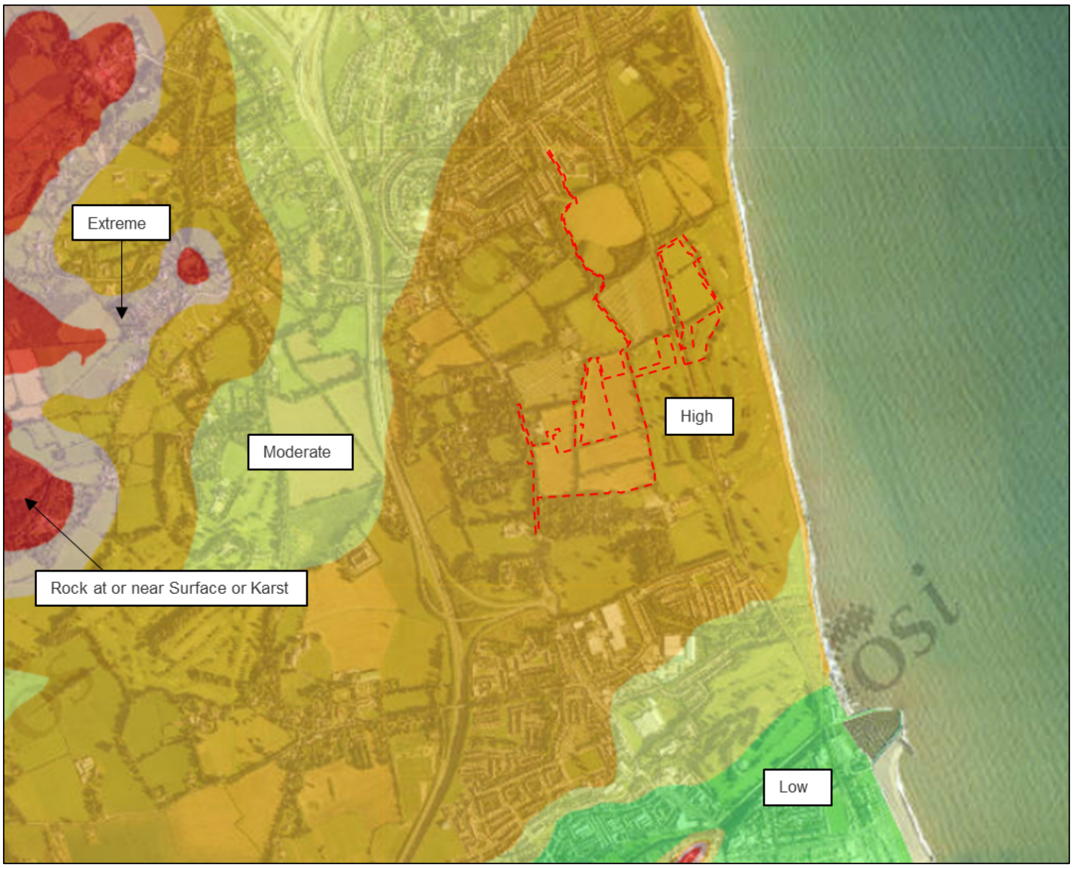


Figure 8.5: Regional Groundwater Vulnerability Rating (Source: GSI, 2019).

8.3.3.2 Groundwater Levels and Flow Direction

3no. shallow groundwater monitoring wells were installed onsite (BH2, BH3) and offsite (BH1) to a maximum depth of 5m below ground level; each well was designed to ensure the response zone was positioned within the saturated subsoils (gravel / sandy gravelly clay) and the well was screened across the shallow groundwater table. Groundwater monitoring well locations are presented in Figure 8.6, and installation details are discussed in Chapter 7 – Land, Soils and Geology and presented in Appendix 7.1. The results of the groundwater level monitoring programme, undertaken by GIIL over a representative three-month monitoring period, are presented in Table 8.2.

Monitoring Location	16 July 2018		19 August 2018		13 September 2018	
	Water Level (mbgl)*	Water Level (mOD)**	Water Level (mbgl)	Water Level (mOD)	Water Level (mbgl)	Water Level (mOD)
BH1	2.18	16.77	2.28	16.67	2.36	16.59
BH2	2.37	16.79	3.32	15.84	3.08	16.08
BH3	4.55	11.35	Assumed Dry	-	Assumed Dry	-

Table 8.2: Measured Groundwater Levels (July 2018 to September 2018).

BH3 was observed to be effectively dry during 2no. of the 3no. groundwater level monitoring events; however, during drilling shallow groundwater was intercepted at a depth of 5m, and rose to 4.40m within 20 minutes, and shallow groundwater was recorded at a depth of 4.55m in July 2018. It is also noted that the groundwater level monitoring programme coincided with a particularly dry summer when drought conditions were reported throughout the country. It would be expected therefore that shallow groundwater levels in all monitoring wells will recover during the seasonally wet autumn / winter period.

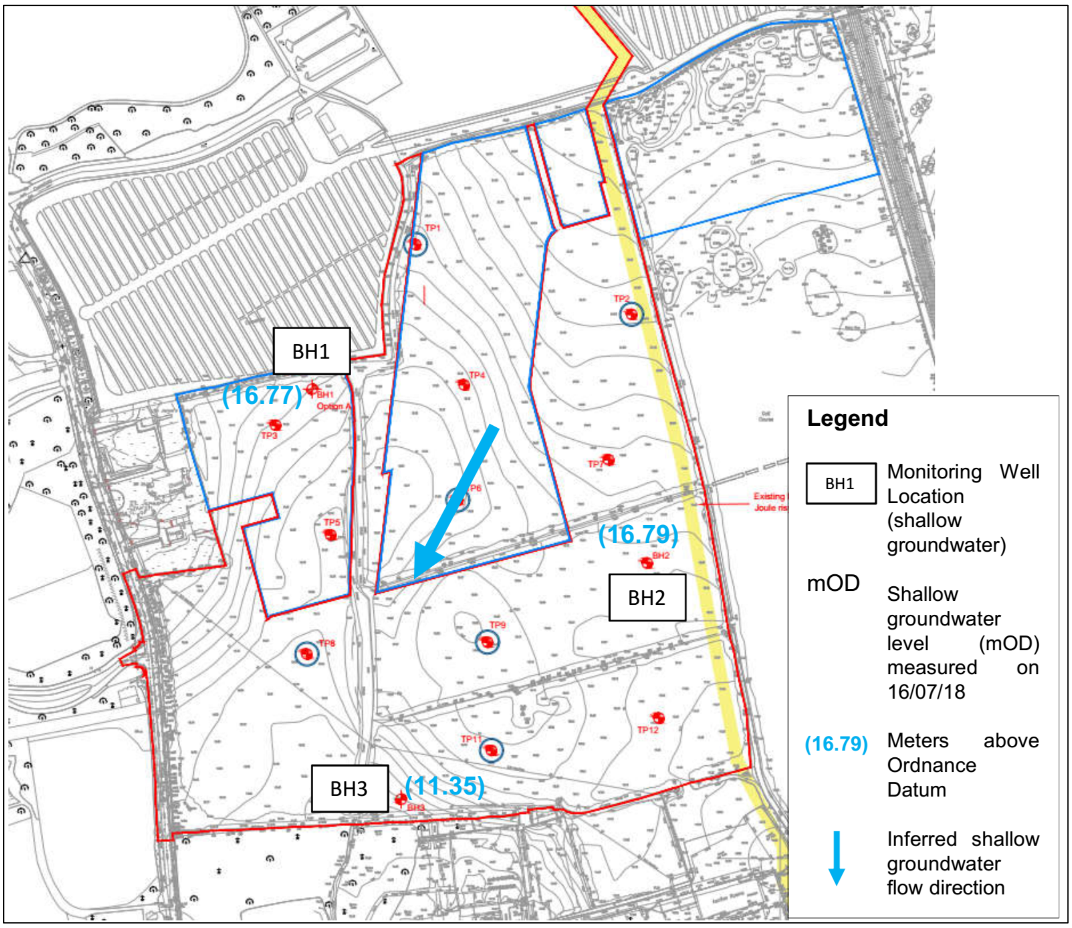


Figure 8.6: Piezometric Map Showing Offsite (BH1) and Onsite (BH2, BH3) Shallow Groundwater Monitoring Locations and inferred shallow groundwater flow direction.

Inferred regional groundwater flow is expected to follow topography in a general easterly direction towards the Irish Sea.

Based on topographic levels shallow groundwater from the western portion of the main site will flow in a south-easterly direction, while shallow groundwater from the eastern portion of the main site will flow in a south-westerly direction. Site-specific groundwater level monitoring data confirms groundwater flow beneath the main portion of the site (the eastern portion) is in a south westerly direction, towards the drainage ditch, as presented in Figure 8.6. Locally shallow groundwater is likely to discharge to the Rathmichael River (also referred to as the Crinken / Woodbrook Stream) further south of the site.

Based on inferred groundwater flow direction, BH1 (offsite) is located upgradient of the site, BH2 (onsite) is located cross-gradient at the site, and BH3 (onsite) is located adjacent to the downgradient boundary.

8.3.3.3 Groundwater Use & Available Resource

A search of the GSI groundwater well database was conducted to identify registered wells within the general area of the site. There are 12no. registered wells within 2km (Figure 8.7) and the following uses are reported: -

- Domestic use – 6no.
- Monitoring wells (Boreholes / Trial Pits) –3no.
- Unknown / other use – 3no.

The closest reported well to the site is located c. 0.5km south; however, this well is of '*Poor*' yield class and its use is unknown. There are no reported Public Supply Source Protection Areas within a 2km radius of the site; the nearest designated public supply source protection zone is the Kilteel Source Protection Area located c.24.5km west (GSI, 2019). The adjacent golf course also uses groundwater supply wells for irrigation purposes.

Figure 8.7: Wells within the vicinity of the Site.

8.3.3.4 Regional Groundwater Quality

The European Communities Environmental Objectives (Groundwater) Regulations, (S.I. 9 of 2010) came into effect on 27 January 2010. The aim of the Regulations is to achieve the environmental objectives established for groundwater by Article 4(1)(b) of the Water Framework Directive (2000/60/EC).

The 2010 Regulations set down groundwater quality standards for nitrate (50mg/L) and active substances in pesticides in Schedule 4 and also established threshold values for pollutants or indicators of pollutants in Schedule 5. Under these regulations the EPA shall also assign a status of '*Good'* or '*Poor'* to those bodies of groundwater where available data and knowledge allows.

Groundwater quality within the general vicinity of the site (located within the Wicklow Groundwater Body), was of '*Good Status'* for the 2010 to 2015 period. The overall objective of the Water Framework Directive for this groundwater body is to '*Protect'* the current good status (WFDI, 2019). A key component of the groundwater classification is the assessment of the impact of pollution on the groundwater body. The groundwater status classification process accounts for the ecological needs of the relevant rivers, lakes and terrestrial ecosystems that depend on contributions from groundwater. Preparations for the second cycle (2015-2021) River Basin Management Plans are currently underway.

According to the EPA (2018) the key change will be that for this cycle the Eastern, South Eastern, South Western, Western and Shannon River Basin Districts will be merged to form one national River Basin District. This cycle is led by the local authorities at regional level.

The second cycle River Basin Management Plan 2018 – 2021 was published by the Department of Housing, Planning and Local Government (DoHPLG) in April 2018. The site is located within the Ovoca-Vartry Catchment (Code: 10). This catchment includes the area drained by the Rivers Avoca and Vartry and by all streams entering tidal water between Sorrento Point, Co. Dublin and Kilmichael Point, Co. Wexford, draining a total area of 1,247km². The largest urban centre in the catchment is Bray. The total population of the catchment is approximately 179,100. The catchment assessment is currently being completed by the EPA.

8.3.3.5 Site-Specific Groundwater Quality

Sampling Methodology

Baseline groundwater quality monitoring was scheduled at targeted key onsite and offsite locations (BH1 to BH3); however, at the time of sampling on 18th of September, monitoring well location BH3 was observed to be dry. Groundwater levels, along with total depths, were measured at the other 2no. wells (BH1, BH2), to enable the purge volume to be calculated. Three well volumes were then purged from each well, prior to collecting baseline samples using dedicated sampling equipment, and sample containers. Field measured parameters including pH, electrical conductivity (EC), temperature and total suspended solids (TDS) were recorded onsite, using calibrated equipment. All groundwater samples were stored in chilled cooler boxes, prior to dispatch to Exova, a UKAS accredited laboratory on the same day, and were fully tracked via. completed chain of custody documentation. A comprehensive baseline analytical groundwater suite was subsequently scheduled based on the site setting and surrounding land-use.

Summary sampling details, along with field measured indicator parameters (pH, EC, temperature and TDS) are presented in Table 8.3 below.

Sample Location	Water level (mbtoc)	Total Depth (mbtoc)	Purge Volume (litres)	Physical Observations of Sample	pH (pH units)	EC (uS/cm)	Temp (oC)	TDS (ppm)
BH1	2.72	3.84	6.72	Brown colour, very silty, odourless	6.66	936	15.6	484
BH2	3.45	5.15	10.2	Brown colour, very silty, odourless	7.36	828	15.6	410

* **mbtoc denotes meters below top of steel casing / cover**

Table 8.3: Groundwater Monitoring Event (18/09/18): Field Measurements and Physical Observations for BH1 and BH2.

Generic Assessment Criteria

Groundwater analytical results were screened against the following Generic Assessment Criteria (GAC): -

- Groundwater Regulations Value (SI. No 9 of 2010 as amended).
- Interim Guidance Values (IGV) (EPA 2003) (used in the absence of available groundwater regulation values).

Baseline Groundwater Analytical Results

Tabulated and screened groundwater analytical results are presented in Table 8.4. Laboratory Reports are presented in Appendix 8.2.

		Sample ID		BH1	BH2
		Depth		2.72	3.45
		Sample Type		Ground Water	Ground Water
		Sample Date		18/09/2018	18/09/2018
Parameter		Groundwater Regulation Value (SI. No. 9 of 2010 as amended - SI. No. 366 of 2016)	Interim Guidelines Value (EPA 2003)		
Dissolved Arsenic	ug/l	7.5	10	<2.5	<2.5
Dissolved Barium	ug/l	-	100	77	62
Dissolved Beryllium	ug/l	-	-	<0.5	<0.5
Dissolved Boron	ug/l	750	1000	34	24
Dissolved Cadmium	ug/l	3.75	5	<0.5	<0.5
Dissolved Calcium	mg/l	-	200	133.2	101.1
Total Dissolved Chromium	ug/l	37.5	30	<1.5	<1.5
Dissolved Copper	ug/l	1500	30	<7	<7
Dissolved Lead	ug/l	7.5	100	<5	<5
Dissolved Magnesium	mg/l	-	50	13.9	8.9
Dissolved Mercury	ug/l	0.75	1	<1	<1
Dissolved Nickel	ug/l	15	20	4	<2
Dissolved Potassium	mg/l	-	5	1.7	1.4
Dissolved Selenium	ug/l	-	-	<3	<3
Dissolved Sodium	mg/l	150	150	45.3	62.7
Dissolved Vanadium	ug/l	-	-	<1.5	<1.5
Dissolved Zinc	ug/l	75	100	<3	<3
Total Hardness Dissolved (as CaCO3)	mg/l	-	200	391	290
PAH MS					
Naphthalene	ug/l	-	1	<0.1	<0.1
Acenaphthylene	ug/l	-	-	<0.013	<0.013
Acenaphthene	ug/l	-	-	<0.013	<0.013
Fluorene	ug/l	-	-	<0.014	<0.014
Phenanthrene	ug/l	-	-	<0.011	<0.011
Anthracene	ug/l	-	-	<0.013	<0.013
Fluoranthene	ug/l	-	-	<0.012	<0.012
Pyrene	ug/l	-	-	<0.013	<0.013
Benzo(a)anthracene	ug/l	-	-	<0.015	<0.015
Chrysene	ug/l	-	-	<0.011	<0.011
Benzo(bk)fluoranthene	ug/l	-	0.5	<0.018	<0.018
Benzo(a)pyrene	ug/l	0.0075	0.01	<0.016	<0.016
Indeno(123cd)pyrene	ug/l	-	0.05	<0.011	<0.011
Dibenzo(ah)anthracene	ug/l	-	-	<0.01	<0.01
Benzo(ghi)perylene	ug/l	-	0.05	<0.011	<0.011
PAH 16 Total	ug/l	-	-	<0.195	<0.195
Benzo(b)fluoranthene	ug/l	-	0.5	<0.01	<0.01

		Sample ID		BH1	BH2
		Depth		2.72	3.45
		Sample Type		Ground Water	Ground Water
		Sample Date		18/09/2018	18/09/2018
Parameter		Groundwater Regulation Value (SI. No. 9 of 2010 as amended - SI. No. 366 of 2016)	Interim Guidelines Value (EPA 2003)		
Benzo(k)fluoranthene	ug/l	-	0.5	<0.01	<0.01
PAH Surrogate % Recovery	%	-	-	81	84
VOC MS					
Dichlorodifluoromethane	ug/l	-	-	<2	<2
Methyl Tertiary Butyl Ether	ug/l	10	30	<0.1	<0.1
Chloromethane	ug/l	-	-	<3	<3
Vinyl Chloride	ug/l	0.375	-	<0.1	<0.1
Bromomethane	ug/l	-	-	<1	<1
Chloroethane	ug/l	-	-	<3	<3
Trichlorofluoromethane	ug/l	-	-	<3	<3
1,1-Dichloroethene (1,1 DCE)	ug/l	-	-	<3	<3
Dichloromethane (DCM)	ug/l	15	10	<5	<5
trans-1-2-Dichloroethene	ug/l	-	-	<3	<3
1,1-Dichloroethane	ug/l	-	-	<3	<3
cis-1-2-Dichloroethene	ug/l	-	-	<3	<3
2,2-Dichloropropane	ug/l	-	-	<1	<1
Bromochloromethane	ug/l	-	-	<2	<2
Chloroform	ug/l	-	12	<2	<2
1,1,1-Trichloroethane	ug/l	-	500	<2	<2
1,1-Dichloropropene	ug/l	-	-	<3	<3
Carbon tetrachloride	ug/l	-	-	<2	<2
1,2-Dichloroethane	ug/l	2.25	-	<2	<2
Benzene	ug/l	0.75	1	<0.5	<0.5
Trichloroethene (TCE)	ug/l	7.5	10	<3	<3
1,2-Dichloropropane	ug/l	-	-	<2	<2
Dibromomethane	ug/l	-	-	<3	<3
Bromodichloromethane	ug/l	-	-	<2	<2
cis-1-3-Dichloropropene	ug/l	-	-	<2	<2
Toluene	ug/l	525	10	<5	<5
trans-1-3-Dichloropropene	ug/l	-	-	<2	<2
1,1,2-Trichloroethane	ug/l	-	-	<2	<2
Tetrachloroethene (PCE)	ug/l	7.5	-	<3	<3
1,3-Dichloropropane	ug/l	-	-	<2	<2
Dibromochloromethane	ug/l	-	-	<2	<2
1,2-Dibromoethane	ug/l	-	-	<2	<2
Chlorobenzene	ug/l	-	1	<2	<2
1,1,1,2-Tetrachloroethane	ug/l	-	-	<2	<2
Ethylbenzene	ug/l	-	10	<1	<1
p/m-Xylene	ug/l	-	10	<2	<2
o-Xylene	ug/l	-	10	<1	<1
Styrene	ug/l	-	-	<2	<2
Bromoform	ug/l	-	-	<2	<2
Isopropylbenzene	ug/l	-	-	<3	<3

		Sample ID		BH1	BH2
		Depth		2.72	3.45
		Sample Type		Ground Water	Ground Water
		Sample Date		18/09/2018	18/09/2018
Parameter		Groundwater Regulation Value (SI. No. 9 of 2010 as amended - SI. No. 366 of 2016)	Interim Guidelines Value (EPA 2003)		
1,1,2,2-Tetrachloroethane	ug/l	-	-	<4	<4
Bromobenzene	ug/l	-	-	<2	<2
1,2,3-Trichloropropane	ug/l	-	-	<3	<3
Propylbenzene	ug/l	-	-	<3	<3
2-Chlorotoluene	ug/l	-	-	<3	<3
1,3,5-Trimethylbenzene	ug/l	-	-	<3	<3
4-Chlorotoluene	ug/l	-	-	<3	<3
tert-Butylbenzene	ug/l	-	-	<3	<3
1,2,4-Trimethylbenzene	ug/l	-	-	<3	<3
sec-Butylbenzene	ug/l	-	-	<3	<3
4-Isopropyltoluene	ug/l	-	-	<3	<3
1,3-Dichlorobenzene	ug/l	-	-	<3	<3
1,4-Dichlorobenzene	ug/l	-	-	<3	<3
n-Butylbenzene	ug/l	-	-	<3	<3
1,2-Dichlorobenzene	ug/l	-	-	<3	<3
1,2-Dibromo-3-chloropropane	ug/l	-	-	<2	<2
1,2,4-Trichlorobenzene	ug/l	-	0.4	<3	<3
Hexachlorobutadiene	ug/l	-	0.1	<3	<3
Naphthalene	ug/l	-	1	<2	<2
1,2,3-Trichlorobenzene	ug/l	-	-	<3	<3
Surrogate Recovery Toluene D8	%	-	-	103	108
Surrogate Recovery 4-Bromofluorobenzene	%		-	107	104
VOC TICs	-	-	-	-	-
Methyl Tertiary Butyl Ether	ug/l	10	30	<0.1	<0.1
Benzene	ug/l	0.75	1	<0.5	<0.5
Toluene	ug/l	525	10	<5	<5
Ethylbenzene	ug/l	-	10	<1	<1
p/m-Xylene	ug/l	-	10	<2	<2
o-Xylene	ug/l	-	10	<1	<1
Surrogate Recovery Toluene D8	%	-	-	103	108
Surrogate Recovery 4-Bromofluorobenzene	%	-	-	107	104
SVOC MS					
Phenols					
2-Chlorophenol	ug/l	-	-	<1	<1
2-Methylphenol	ug/l	-	-	<0.5	<0.5
2-Nitrophenol	ug/l	-	-	<0.5	<0.5
2,4-Dichlorophenol	ug/l	-	-	<0.5	<0.5
2,4-Dimethylphenol	ug/l	-	-	<1	<1
2,4,5-Trichlorophenol	ug/l	-	-	<0.5	<0.5
2,4,6-Trichlorophenol	ug/l	-	-	<1	<1
4-Chloro-3-methylphenol	ug/l	-	-	<0.5	<0.5

			Sample ID	BH1	BH2
			Depth	2.72	3.45
			Sample Type	Ground Water	Ground Water
			Sample Date	18/09/2018	18/09/2018
Parameter		Groundwater Regulation Value (SI. No. 9 of 2010 as amended - SI. No. 366 of 2016)	Interim Guidelines Value (EPA 2003)		
4-Methylphenol	ug/l	-	-	<1	<1
4-Nitrophenol	ug/l	-	-	<10	<10
Pentachlorophenol	ug/l	-	-	<1	<1
Phenol	ug/l	-	-	<1	<1
PAHs					
2-Chloronaphthalene	ug/l	-	-	<1	<1
2-Methylnaphthalene	ug/l	-	-	<1	<1
Phthalates					
Bis(2-ethylhexyl) phthalate	ug/l	-	8	<5	<5
Butylbenzyl phthalate	ug/l	-	-	<1	<1
Di-n-butyl phthalate	ug/l	-	2	<1.5	<1.5
Di-n-Octyl phthalate	ug/l	-	-	<1	<1
Diethyl phthalate	ug/l	6	-	<1	<1
Dimethyl phthalate	ug/l	-	-	<1	<1
Other SVOCs					
1,2-Dichlorobenzene	ug/l	-	-	<1	<1
1,2,4-Trichlorobenzene	ug/l	-	0.4	<1	<1
1,3-Dichlorobenzene	ug/l	-	-	<1	<1
1,4-Dichlorobenzene	ug/l	-	-	<1	<1
2-Nitroaniline	ug/l	-	-	<1	<1
2,4-Dinitrotoluene	ug/l	-	-	<0.5	<0.5
2,6-Dinitrotoluene	ug/l	-	-	<1	<1
3-Nitroaniline	ug/l	-	-	<1	<1
4-Bromophenylphenylether	ug/l	-	-	<1	<1
4-Chloroaniline	ug/l	-	-	<1	<1
4-Chlorophenylphenylether	ug/l	-	-	<1	<1
4-Nitroaniline	ug/l	-	-	<0.5	<0.5
Azobenzene	ug/l	-	-	<0.5	<0.5
Bis(2-chloroethoxy)methane	ug/l	-	-	<0.5	<0.5
Bis(2-chloroethyl)ether	ug/l	-	-	<1	<1
Carbazole	ug/l	-	-	<0.5	<0.5
Dibenzofuran	ug/l	-	-	<0.5	<0.5
Hexachlorobenzene	ug/l	-	0.3	<1	<1
Hexachlorobutadiene	ug/l	-	0.1	<1	<1
Hexachlorocyclopentadiene	ug/l	-	0.1	<1	<1
Hexachloroethane	ug/l	-	-	<1	<1
Isophorone	ug/l	-	-	<0.5	<0.5
N-nitrosodi-n-propylamine	ug/l	-	-	<0.5	<0.5
Nitrobenzene	ug/l	-	-	<1	<1
Surrogate Recovery 2-Fluorobiphenyl	%	-	-	102	101
Surrogate Recovery p-Terphenyl-d14	%	-	-	109	109
Pesticides					

		Sample ID		BH1	BH2
		Depth		2.72	3.45
		Sample Type		Ground Water	Ground Water
		Sample Date		18/09/2018	18/09/2018
Parameter		Groundwater Regulation Value (SI. No. 9 of 2010 as amended - SI. No. 366 of 2016)	Interim Guidelines Value (EPA 2003)		
Organochlorine Pesticides					
Aldrin	ug/l	-	0.01	<0.01	<0.01
Alpha-HCH (BHC)	ug/l	-	-	<0.01	<0.01
Beta-HCH (BHC)	ug/l	-	-	<0.01	<0.01
Delta-HCH (BHC)	ug/l	-	-	<0.01	<0.01
Dieldrin	ug/l	-	0.01	<0.01	<0.01
Endosulphan I	ug/l	-	0.001	<0.01	<0.01
Endosulphan II	ug/l	-	-	<0.01	<0.01
Endosulphan sulphate	ug/l	-	-	<0.01	<0.01
Endrin	ug/l	-	-	<0.01	<0.01
Gamma-HCH (BHC)	ug/l	-	-	<0.01	<0.01
Heptachlor	ug/l	-	-	<0.01	<0.01
Heptachlor Epoxide	ug/l	-	-	<0.01	<0.01
o,p'-Methoxychlor	ug/l	-	-	<0.01	<0.01
p,p'-DDE	ug/l	-	-	<0.01	<0.01
p,p'-DDT	ug/l	-	-	<0.01	<0.01
p,p'-Methoxychlor	ug/l	-	-	<0.01	<0.01
p,p'-TDE	ug/l	-	-	<0.01	<0.01
Organophosphorus Pesticides					
Azinphos methyl	ug/l	-	-	<0.01	<0.01
Diazinon	ug/l	-	-	<0.01	<0.01
Dichlorvos	ug/l	-	0.001	<0.01	<0.01
Disulfoton	ug/l	-	-	<0.01	<0.01
Ethion	ug/l	-	-	<0.01	<0.01
Ethyl Parathion (Parathion)	ug/l	-	-	<0.01	<0.01
Fenitrothion	ug/l	-	-	<0.01	<0.01
Malathion	ug/l	-	0.01	<0.01	<0.01
Methyl Parathion	ug/l	-	-	<0.01	<0.01
Mevinphos	ug/l	-	-	<0.01	<0.01
TPH CWG					
Aliphatics					
>C5-C6	ug/l	-	-	<10	<10
>C6-C8	ug/l	-	-	<10	<10
>C8-C10	ug/l	-	-	<10	<10
>C10-C12	ug/l	-	-	<5	<5
>C12-C16	ug/l	-	-	<10	<10
>C16-C21	ug/l	-	-	<10	<10
>C21-C35	ug/l	-	-	<10	<10
>C35-C44	ug/l	-	-	<10	<10
Total aliphatics C5-44	ug/l	-	-	<10	<10
Aromatics					
>C5-EC7	ug/l	-	-	<10	<10
>EC7-EC8	ug/l	-	-	<10	<10

		Sample ID		BH1	BH2
		Depth		2.72	3.45
		Sample Type		Ground Water	Ground Water
		Sample Date		18/09/2018	18/09/2018
Parameter		Groundwater Regulation Value (SI. No. 9 of 2010 as amended - SI. No. 366 of 2016)	Interim Guidelines Value (EPA 2003)		
>EC8-EC10	ug/l	-	-	<10	<10
>EC10-EC12	ug/l	-	-	<5	<5
>EC12-EC16	ug/l	-	-	<10	<10
>EC16-EC21	ug/l	-	-	<10	<10
>EC21-EC35	ug/l	-	-	<10	<10
>EC35-EC44	ug/l	-	-	<10	<10
Total aromatics C5-44	ug/l	-	-	<10	<10
Total aliphatics and aromatics(C5-44)	ug/l	-	-	<10	<10
Fluoride	mg/l	-	1	<0.3	<0.3
Sulphate as SO4	mg/l	187.5	200	21.2	27.5
Chloride	mg/l	240 - 187.5	30	39.6	55.3
Nitrate as NO3	mg/l	37.5	25	0.9	23
Nitrite as NO2	mg/l	37.5	0.1	<0.02	0.11
Ortho Phosphate as PO4	mg/l	106.4	-	<0.03	<0.03
Ortho Phosphate as P	mg/l	-	0.03	<0.03	<0.03
Total Oxidised Nitrogen as N	mg/l	-	-	0.2	5.2
Ammoniacal Nitrogen as N	mg/l	0.065[A] - 0.175[B]	-	0.13	<0.03
Ammoniacal Nitrogen as NH3	mg/l	-	0.15	0.16	<0.03
Ammoniacal Nitrogen as NH4	mg/l	-	-	0.17	0.03
Hexavalent Chromium	ug/l	7.5	-	<6	<6
Total Dissolved Chromium III	ug/l	-	-	<6	<6
Total Alkalinity as CaCO3	mg/l	-	-	7100	3436
Dissolved Organic Carbon	mg/l	-	-	<2	<2
Formaldehyde	mg/l	-	-	<0.5	<0.5
Total Organic Carbon	mg/l	-	-	<2	<2
Total Dissolved Solids	mg/l	-	1000	574	520
Total Suspended Solids	mg/l	-	-	37273	22848

***Note**: Re. Generic Assessment Criteria (GAC): Analytical results have been screened against relevant groundwater regulation values (SI. No. 9 of 2010 as amended - SI. No. 336 of 2016), or in the absence of an available groundwater regulation value, relevant Interim Guideline Values (IGVs) have been used.*

[A] - Test: Assessment of adverse impacts of chemical inputs from groundwater on associated surface water bodies.

[B] - Test: Assessment of the general quality of groundwater in a groundwater body in terms of whether its ability to support human uses has been significantly impaired by pollution

Grey shading denotes exceedance of relevant groundwater GAC.

Table 8.4: Groundwater Analytical Results for BH1 and BH2.

Discussion of Results

Field measurements at BH1 and BH2 were all within the relevant GAC, with the exception of electrical conductivity at both locations which exceeded the groundwater regulation threshold value (assessment for the presence of saline or other intrusions) of 800 uS/cm. However, given the site location, saline influence on groundwater quality would be expected.

Baseline shallow groundwater quality at BH1 and BH2 is generally very good. Concentrations of total petroleum hydrocarbons (criteria working group) (TPH CWG), polycyclic aromatic hydrocarbons (PAHs), volatile organic carbons (VOCs) and semi-volatile organic carbons (SVOCs) at both locations were all below the relevant laboratory limits of detection (LoD). Similarly, pesticides including organochlorine and organophosphorus pesticides were not detected in the 2no. groundwater samples. All other parameters analysed including metals, inorganic nutrients and indicator parameters, at both BH1 and BH2, were within the relevant GAC, with the exception of an ammoniacal nitrogen (as NH4) concentration of 0.17mg/l at BH1, and total hardness concentration of 391mg/l and 290mg/l at BH1 and BH2 respectively.

Taking account of the site setting and surrounding land-use, key site-specific Contaminants of Potential Concern (COPC) with respect to groundwater have been determined and are presented in Table 8.5.

COPC	Potential Source	Technical Rationale
Total Petroleum Hydrocarbons (TPH)	• Adjacent R119 road (western site boundary). • Adjacent access road to graveyard (northern boundary).	Typical COPC associated with leaks and spillages from roadways and car parking areas.
Pesticides	• Onsite land-use.	Typical COPC associated with agricultural land use.
Ammoniacal nitrogen	• Onsite land-use. • Adjacent Shanganagh Cemetery.	Typical COPC associated with agricultural land use. Ammoniacal nitrogen identified as a COPC (associated with cemeteries) by UK Environment Agency (EA, 2004). Note[1]
Formaldehyde	• Adjacent Shanganagh Cemetery.	Identified as COPC (associated with cemeteries) by UK Environment Agency (EA, 2004).
Mercury	• Adjacent Shanganagh Cemetery.	
Calcium	• Adjacent Shanganagh Cemetery.	

Table 8.5: Identified Contaminants of Potential Concern (COPC) associated with the current site setting.

Groundwater analytical results have been further evaluated with regard to site-specific COPCs and the following conclusions have been made: -

- Concentrations of total petroleum hydrocarbons (TPH), pesticides, formaldehyde and dissolved mercury at both BH1 and BH2 were all below the relevant LoD. Therefore, these potential contaminants are not considered to pose a risk to baseline groundwater quality beneath the proposed development.
- Dissolved calcium concentrations of 133.2mg/l and 101.1mg/l at BH1 and BH2 respectively do not exceed the relevant IGV of 200mg/l. Therefore, this potential contaminant is not considered to pose a risk to baseline groundwater quality beneath the proposed development.

Note [1] *'Potential groundwater pollutants from cemeteries'* published by UK EA (Dec 2004) ISBN: 1 84432 347 1

- Concentrations of ammoniacal nitrogen, as N and NH3, were detected at BH1 at concentrations of 0.13mg/l and 0.16mg/l respectively. These concentrations exceed the lower groundwater regulation value of 0.065mg/l (for the assessment of adverse impacts of chemical inputs from groundwater on associated surface water bodies), and marginally exceed the relevant IGV of 0.15mgl. However, there are no significant surface water bodies present within the vicinity of the site boundary, and the ammoniacal nitrogen (as N) concentration detected at BH1 does not exceed the upper groundwater regulation value of 0.175mg/l (for the assessment of the general quality of groundwater in a groundwater body in terms of whether its ability to support human uses has been significantly impaired by pollution). Furthermore, no detection of ammoniacal nitrogen (above the relevant LoD) has been identified at BH2. Therefore, this potential contaminant is not considered to pose a risk to baseline groundwater quality beneath the proposed development.

In summary, baseline shallow groundwater quality beneath the proposed development is generally very good as evidenced in groundwater analytical results presented in Table 8.4, with only two parameters exceeding the relevant GAC; total hardness concentrations of 391mg/l and 290mg/l at BH1 and BH2 respectively, and ammoniacal nitrogen at BH1, as discussed previously. However, such exceedances would be expected given land-use in the immediate vicinity and site-specific geology, and do not pose an unacceptable human health or environmental risk.

8.4 Potential Impact of the Proposed Development

8.4.1 Hydrological Conceptual Site Model

In addition to flood risk, the following criteria are typically applied when evaluating potential impacts to the water environment: -

- Impacts to surface water / groundwater quality.
- Impacts to surface water flows / groundwater resources.

In terms of groundwater resources, no significant impact is anticipated arising from the proposed development based on the following facts: -

- There are no reported public supply wells within the vicinity of the site. Based on GSI (2019) records the closest reported well to the site is located c. 0.5km from the site; however, this localised supply is unlikely to be impacted by the proposed development. The adjacent golf course also abstracts groundwater via. onsite groundwater supply wells for irrigation purposes. Typical average daily water demands for irrigation on a standard golf course are estimated to be approximately 33m3 note[2]. Due to the nature and scale of the development, offsite groundwater abstraction wells located within the golf course are unlikely to be impacted by the proposed development.
- There will be no significant change to rainfall recharge rates at the proposed development. Storm water generated from the proposed development will be conveyed through a new storm water network based on SuDS. Storm water will be attenuated at greenfield run-off rates prior to discharge to the receiving ditch at the southern boundary of the proposed development, following the existing topographic levels and characteristics of the existing drainage catchment regime.

Note [2] The total licensed volume for golf course irrigation in 2003 in England and Wales was estimated to be 10,112 million litres (833no. abstraction licences for golf course spray irrigation). This equates to an average annual licenced volume of 12.139 million litres (12,139 m^3) per licence holder, or 33.25m^3 per day (12,139 m^3 / 365). Source: *'Assessing optimum irrigation water use: additional agricultural and non-agricultural sectors, Science Report – SC040008/SR1'*, UK Environment Agency, 2008.

- Maximum excavation depths are anticipated to range between approximately 1m (for utilities and services) and 6m (for the proposed wastewater pumping station in the southern portion of the site). Therefore, dewatering will be required during the construction phase, primarily to facilitate the installation of the attenuation tanks (with a maximum excavation depth of 3m). However, given the nature of the proposed deep excavations, such dewatering will likely be localised and temporary and therefore would not be expected to result in any impacts to the regional groundwater resource.
- No additional groundwater abstraction is proposed during the operational phase. The daily domestic water demand (including potable use) for the proposed development is calculated to be 179m^3 [note 3]. An upgrade to the existing watermain network is due for completion by Q4-2019. Irish water has confirmed that the existing water network will have sufficient capacity to meet the combined water requirements of 179m^3 per day from the proposed development, once operational. The proposed relocation of 2no. golf holes is required to facilitate future residential development of a portion of the existing golf course lands (subject to a future planning application). Water requirements (for irrigation use) for the proposed relocated 2no. golf holes will be supplied via. existing groundwater abstraction wells located within the existing golf course. As the proposed development of the 2no. golf holes does not represent any expansion of the existing golf course, but instead a relocation of 2no. golf holes, there will be no change in the existing overall groundwater abstraction rate from the golf course wells (estimated to be in the region of 33m^3 per day).

Therefore, given the nature of the proposed development there will be no impact to regional or local groundwater resources. Accordingly, potential impacts on groundwater resources do not warrant further consideration.

In assessing potential impacts to groundwater quality, the EPA advocates a 'risk-based approach', and states that *'the principal aim in dealing with contaminated land and groundwater related issues is to secure the protection of human health, water bodies (including groundwater) and the wider environment'* (EPA, 2013). In accordance with this risk-based approach a preliminary Source-Pathway-Receptor (SPR) model has been derived for the site.

Five key receptors (in terms of surface water /groundwater quality) have been identified as follows: -

- Shallow groundwater (saturated overburden comprising gravel and sandy gravelly clay).
- Locally important bedrock aquifer (slate, phyllite and schist).
- Onsite drainage ditch (albeit this was observed to be dry during the walkover survey completed as part of this assessment).
- Rathmichael River (also referred to as the Crinkeen / Woodbrook Stream) (via. surface water and groundwater pathways).
- The Irish Sea (via. surface water and groundwater pathways).

The focus of this assessment will therefore be on potential groundwater quality and surface water quality impacts, and surface water flow impacts that may be associated with the proposed development. A preliminary Hydrogeological Conceptual Site Model (CSM) has been derived for the site and is presented in Figure 8.8 and Figure 8.9.

Note [3] Based on Irish Water requirements of 150 l/p/d x average of 2.7 people per house plus daily requirement of 6m3 for creche.

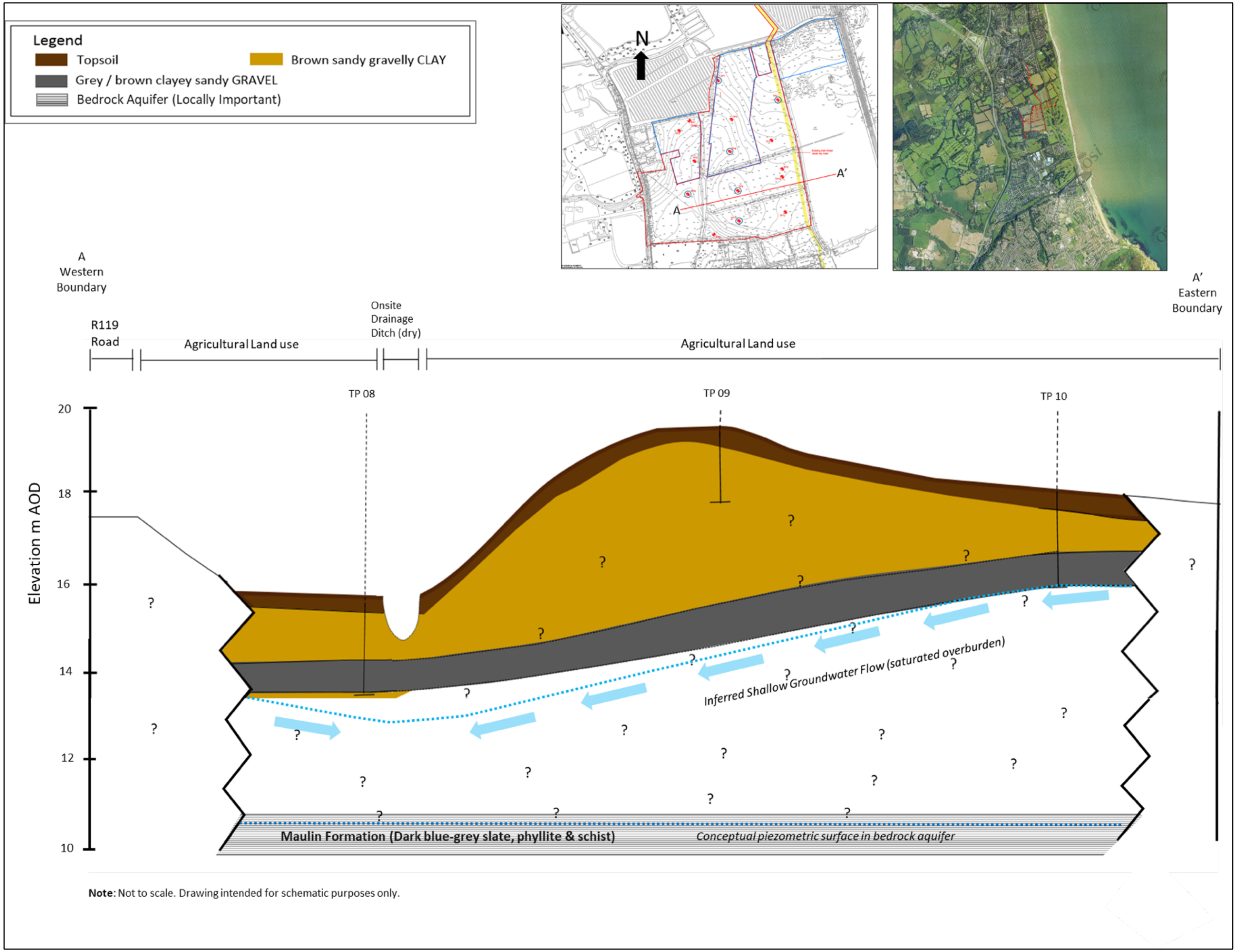
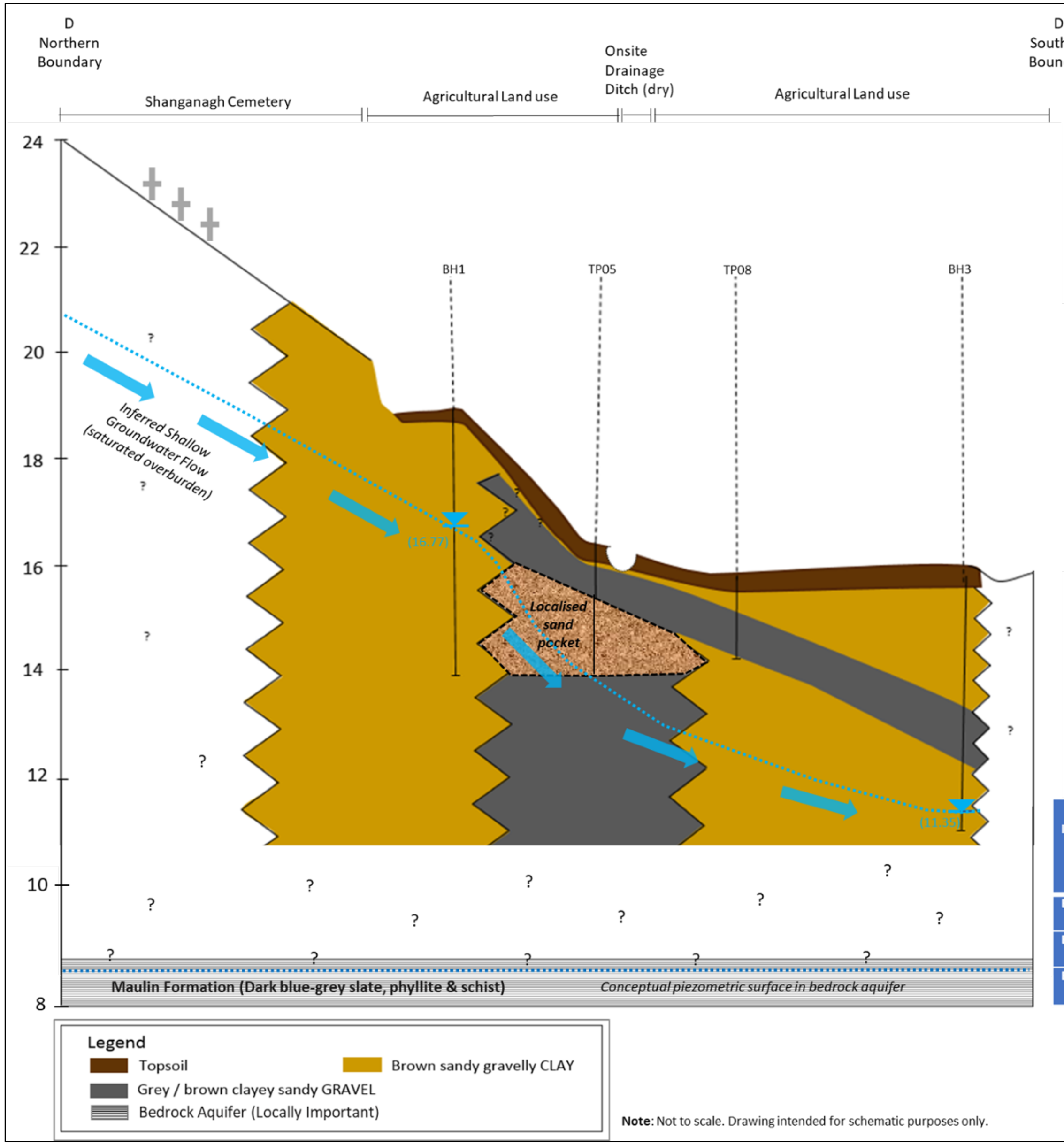


Figure 8.8: Hydrogeological Conceptual Site Model via. West-East Cross Section.



ID	16th July 2018		19th August 2018		13th September 2018	
	Water Level (mbgl)	Water Level (mOD)	Water Level (mbgl)	Water Level (mOD)	Water Level (mbgl)	Water Level (mOD)
BH1	2.18	16.77	2.28	16.67	2.36	16.59
BH2	2.37	16.79	3.32	15.84	3.08	16.08
BH3	4.55	11.35	Dry	-	Dry	-

Figure 8.9: Hydrogeological Conceptual Site Model via. North-South Cross Section.

8.5 Characteristics of the Proposed Development

The project involves the first phase of a new residential development comprising the following: -

- 685no. residential units comprising 207no. houses, 430no. apartments and 48no. duplexes ranging from two to eight storeys in height.
- A creche (approximately 429sq.m).
- A distributor road / avenue through the site with vehicular access and egress onto the Old Dublin Road. The said distributor road would extend as far as the site of the planned Woodbrook DART Station.
- Linear Parks and Green Links (Green Axis / Corridor Park and Coastal Park) supplemented by pocket parks.
- North/South green routes connecting to Shanganagh Public Park including pedestrian / cycle paths.
- Interim landscaping of a future public plaza to serve a future Neighbourhood Centre to allow for full north/south movement through the Green Axis in the interim.
- A dedicated cycle/pedestrian path within the site boundary to serve the Old Dublin Road.
- An internal road network including pedestrian and cycle links;
- Sustainable urban Drainage System infrastructure including underground attenuation and swales.
- Waste water infrastructure (pumping station and 24-hour emergency storage and emergency overflow discharge plus rising foul main).
- Watermain connection to the Old Dublin Road.
- 2no. replacement golf holes on lands to the east of the railway line (northeast of the planned DART Station).
- All associated landscaping and site development works.
- The site has an area of 21.9 hectares (this area includes approximately 4.5 hectares to the east of the railway line for the purposes of providing 2no. replacement golf holes and 1 hectare for the purposes of providing a foul rising main connection to St. Anne's Park. Further details of the proposed development are presented in the Chapter 3 – Description of Proposed Development.

The proposed drainage system (225Ø or greater) has been designed based on 7no. drainage catchment areas within the main portion of the development lands (with a separate drainage network designed for the proposed 2no. replacement golf holes). Storm water from each catchment will pass through various SuDS and an attenuation system prior to the existing drainage ditch along the southern site boundary, which discharges to Rathmichael River immediately south of the site. Storm water from the replacement golf holes will be collected via a network of herringbone drains across the site, discharging into 225Ø storm drains which will feed into the attenuation pond to the south east of this portion of the proposed development.

SuDs techniques to be applied within the development include the following: -

- Swales to be used within the site as conveyance systems for storm water runoff from sections of road.
- Permeable paving to be used in light traffic areas (to the front of residential units and courtyards).
- A green roof (sedum roof) will be provided for the creche (in order to provide reduced peak flow rates, attenuation, evaporation and improved water quality).
- Detention basins to be proposed within green corridors / park areas.

- Underground modular systems to be used within green corridors / park areas to allow for storm water attenuation (designed for up to a 1 in 100-year event).
- Filter drains (only roof run-off from the rear of each residential unit will discharge into the filter drain).
- Flow control to be used throughout the site to allow for storm water control and reduce peak runoff.

In keeping with the Woodbrook – Shanganagh LAP requirements, run-off will pass through at least one level of treatment were possible using a SuDS component prior to the final levels of treatment in the public realm areas. Based on the proposed storm water drainage design, there will be no impact to surface water flows in Rathmichael River. Therefore, potential impacts on surface water flows do not warrant further consideration.

Proposed watermain services (1000 - 250Ø), including firewater requirements for the development will be provided. The daily domestic water demand (including potable use) for the proposed development is calculated to be 277m^3. Typical daily water demands for irrigation purposes on a standard golf course are estimated (note[4]) to be approximately 33m^3. However, all water requirements for irrigation purposes for the 2no. replacement golf holes will be provided for through the use of existing groundwater abstraction sources at the offsite golf course, with no overall change in total abstraction rates, as discussed previously. An upgrade to the existing watermain network is due for completion by Q4-2019. Irish water has confirmed that, following the completion of these upgrade works, the water network will have sufficient capacity to meet the combined operational water requirements of 179m^3 per day from the proposed development.

Proposed foul drainage services (225 - 375Ø) will be provided; all wastewater will discharge via. gravity to the proposed wastewater pumping station in the southern portion of the site, where it will be pumped, via the proposed rising main and discharge on a temporary basis into St. Annes Park housing development. However ultimately foul water from the development will be pumped directly to Shanganagh Bray Wastewater Treatment Plant (WWTP) located approximately 1.5km north of the proposed development in Shankill. Irish water has confirmed that the existing foul network has sufficient capacity to meet the combined wastewater discharge volumes of approximately 277m^3/ day from the proposed development, once operational. The proposed onsite waste water pumping station will be located in the southern portion of the site with capacity for 24-hour emergency storage and with an emergency overflow discharge point to the storm drainage network.

8.6 Potential Impact of the Proposed Development

8.6.1 Proposed Development

8.6.1.1 Construction Phase

There is a potential for degradation in groundwater quality resulting from potential pollution caused by construction activities e.g. plant, fuel/ chemical spillage etc., particularly during excavations for the proposed residential units (up to eight storeys in height) and creche, wastewater pumping station, foul services and rising main, 7no. attenuation tanks, access road, storm water drainage system, watermain services, and 2no. replacement golf holes. The extent of excavation for service / utility trenches will vary; however, the maximum depth will be approximately 1m. The maximum anticipated depth of excavation across the majority of the site is approximately 3mbgl (to facilitate building foundations and the installation of the 7no. underground attenuation tanks), with a maximum excavation depth of approximately 6m in a localised area in the southern portion of the site (to facilitate the installation of the wastewater pumping station). Groundwater levels beneath the proposed development lands range from approximately 2.18mbgl (16.77 mOD) in the northern

[4] The total licensed volume for golf course irrigation in 2003 in England and Wales was estimated to be 10,112 million litres (833no. abstraction licences for golf course spray irrigation). This equates to an average annual licenced volume of 12.139 million litres (12,139 m^3) per licence holder, or 33.25m^3 per day (12,139 m^3 / 365). Source: *'Assessing optimum irrigation water use: additional agricultural and non-agricultural sectors, Science Report – SC040008/SR1'*, UK Environment Agency, 2008.

portion to 4.55mbgl (11.35 mOD) in the southern portion. Therefore, shallow groundwater is likely to be encountered during the proposed excavation works. The shallow water table beneath the site, particularly in any areas where it is intercepted, would be highly vulnerable to water quality impacts through accidental spillages or leaks of oils, fuels, paints or chemicals. This could result in likely moderate adverse temporary effects directly to the quality of groundwater receptors (shallow groundwater, bedrock aquifer), and likely slight adverse temporary effects directly and indirectly (via groundwater migration) to the quality of surface water receptors (onsite drainage ditch, Rathmichael River).

Temporary dewatering will likely be required during the excavation and construction of the proposed attenuation tanks and wastewater pumping station, which may result in excess loadings of suspended solids to the temporary discharge point (presumed to be the onsite dry drainage ditch). This could result in likely moderate adverse temporary effects directly to the surface water quality of the Rathmichael River.

Inadequate soil / storm water management during the construction phase also poses a risk of excess loadings of suspended solids directly to the onsite dry drainage ditch. This could result in likely moderate adverse temporary effects directly to the surface water quality of the Rathmichael River.

General site activities during the construction phase associated with cement handling and pouring pose a potential pollution risk. This could result in likely slight adverse temporary effects directly to the quality of groundwater receptors (shallow groundwater, bedrock aquifer), and directly and indirectly (via groundwater migration) to the quality of surface water receptors (onsite drainage ditch, Rathmichael River).

Based on the results of the ground investigation and site-specific groundwater monitoring data, the potential for groundwater impacts via excavation and mobilisation of any existing subsurface contaminants is negligible. No groundwater or surface water quality impacts are expected as a result of current or historic land-use either at the site or within adjacent lands.

8.6.1.2 Operational Stage

During the operational phase of the development, the quality of groundwater receptors (shallow groundwater, bedrock aquifer) and surface water receptors (onsite drainage ditch, Rathmichael River) could be at risk from occasional fuel / oil leaks along the access roads and paved areas. However, the storm water drainage system has been designed to convey and attenuate design flows from the development and to accommodate the attenuated design flows from the proposed development. Proposed car parking areas will be paved, and the sub-base will filter storm water drainage in addition to attenuation of potential hydrocarbon contaminants via. microbial action. Accordingly, appropriate design measures have been implemented to address this potential risk and traffic-related groundwater / surface water quality impacts do not warrant further consideration.

Groundwater receptors (shallow groundwater, bedrock aquifer) and surface water receptors (onsite drainage ditch, Rathmichael River) are at risk of becoming contaminated through leakages, spill events, equipment failure or structural failure of the proposed wastewater pumping station, during the operational phase. However, the new pumping station will be designed, constructed and operated in accordance with Irish Waters Code of Practises and Technical Standards (IW-CDS-5030-01 to 04 & IW-TEC-800) and manufacturer recommendations. The potential scenarios of leakages, spill events or structural failure arising are therefore unlikely.

In the event of a system failure (e.g. equipment failure) this will trigger an alarm and the relevant authority will be informed of the failure. A back-up pump will automatically kick in. In the event of the failure of the back-up pump, the proposed wastewater pumping station has sufficient capacity for 24-hour emergency storage. Therefore, only in a worst-case scenario (i.e. both pumps have failed, and the system failure has not been resolved within a 24-hour period) will the emergency overflow discharge system be required.

Emergency overflow discharge will comprise wastewater (which has passed through a screening process) and will discharge directly to Rathmichael River, via. the storm water drainage network in the southern portion of the site.

This could result in moderate adverse effects directly to groundwater receptors (shallow groundwater, bedrock aquifer) and significant adverse effects directly to surface water receptors (onsite drainage ditch, Rathmichael River) via. emergency discharge of foul effluent.

These effects are likely to be localised, and temporary in duration. It is expected that any short-term release of contaminants would be attenuated via. dilution in the receiving waters of Rathmichael River. Mitigation measures will be implemented during the operational phase to reduce these potential impacts.

Groundwater receptors (shallow groundwater, bedrock aquifer) and surface water receptors (onsite drainage ditch, Rathmichael River) are at risk of becoming contaminated through routine site maintenance activity during the operational phase. Maintenance of the residential units, creche, open space / amenity areas, access roads and paved areas, utilities, foul, watermain and storm water drainage system, attenuation tanks, pumping station and rising main may result in small quantities of lubricant oils, fuel and chemicals being brought to the site. In the highly unlikely event of a spill this could result in slight adverse effects directly to the quality of groundwater receptors, and directly and indirectly (via groundwater migration) to the quality of surface water receptors. However, mitigation measures will be implemented during the operational phase to avoid these potential impacts.

Given the absence of a gas network within the immediate vicinity of the proposed development it is possible, albeit unlikely, that kerosene / home heating oil could be used onsite in the future. Groundwater receptors (shallow groundwater, bedrock aquifer) and surface water receptors (onsite drainage ditch, Rathmichael River) may be at risk of becoming contaminated via. hydrocarbon contamination in the event of a domestic spill or leak during the operational phase. This could result in moderate adverse effects directly to the quality of the groundwater receptors, and directly and indirectly (via groundwater migration) to the quality of the surface water receptors. Any effects are likely to be localised, and short-term in duration; however, mitigation measures will be implemented during the operational phase to avoid these potential impacts.

Given the nature and scale of the identified potential impacts to both surface water and groundwater which could arise from the proposed development, no potential risk has been identified to the Irish Sea; therefore, the proposed development will have a neutral effect on this receptor.

8.6.1.3 Do-Nothing Scenario

If the proposed residential development is not undertaken the baseline water environment would largely remain unchanged, with no significant potential flood risk (associated with fluvial sources). Storm water run-off across the site would continue to discharge to the onsite drainage ditch and Rathmichael River, with a portion discharging directly to ground (via permeable sands and gravels present beneath the site). Existing baseline surface water and groundwater quality would remain unchanged in the medium term.

8.6.1.4 Cumulative Impacts

A search of Dun Laoghaire – Rathdown Planning records was undertaken. Approximately 80no. committed developments (i.e. developments which have been granted planning permission but have not yet been constructed) in the immediate vicinity of the proposed development were reviewed. The majority of these projects consist of small scale extension works or retention works and therefore are not anticipated to result in cumulative impacts with the proposed development.

The following two projects have been further evaluated: -

- D14A/0872 – Church of St. James at Crinken. Planning permission granted on 08/06/2015 for a single storey extension to the ministry centre immediately to the east of the site; and,
- D17A/0065 - Woodbrook Campus Ltd. Planning permission granted on 19/12/2017 for a 56no. inpatient specialist hospital 20-30m south east of the site.

Based on the nature of the proposed developments identified above, no significant cumulative impacts on the water environment (i.e. surface water or groundwater) are anticipated during the construction or operational phases, nor is a potential cumulative flood risk identified.

8.7 Ameliorative, Remedial or Reductive Measures

8.7.1 Proposed Development

8.7.1.1 Construction Phase

The construction management of the site will take account of the recommendations of the Construction Industry Research and Information Association (CIRIA) guides 'Control of Water Pollution from Construction Sites' and 'Groundwater control - design and practice' to minimise as far as possible the risk of pollution. With regard to groundwater and surface water protection impacts the following mitigation measures are proposed;

- Fuels, lubricants and hydraulic fluids for equipment used on the construction site, as well as any solvents, oils, and paints will be carefully handled to avoid spillage, properly secured against unauthorised access or vandalism, and provided with spill containment according to best codes of practice.
- Waste oils and hydraulic fluids will be collected in leak-proof containers and removed from the proposed development for disposal or re-cycling.
- Any spillage of fuels, lubricants or hydraulic oils will be immediately contained and the contaminated soil removed from the proposed development and properly disposed of.
- All site vehicles used will be refuelled in bunded and adequately sealed and covered areas in the construction compound area.
- Strict supervision of contractors will be adhered to in order to ensure that all plant and equipment utilised on-site is in good working condition. Any equipment not meeting the required standard will not be permitted for use within the site. This will minimise the risk of groundwater becoming contaminated through site activity.
- Stripped soils should be stockpiled a minimum distance of 10m from the drainage ditch and should be appropriately covered. A temporary storm water management system should be implemented by the Contractor.
- All groundwater temporarily dewatered during the construction of the attenuation tanks, wastewater pumping station and any deep building foundations will be treated via the installation of a temporary in-situ water treatment system: -
    - This system should be designed and sized to ensure that all pumped groundwater water is treated prior to discharge to the existing drainage ditch onsite, which drains to the Rathmichael River.
    - The Contractor will be required to provide a site-specific dewatering plan, clearly setting out proposed excavation methodology, estimated dewatering rates, details of proposed treatment system, and discharge location.

The following standard mitigation measures regarding temporary oil / chemical storage and refuelling are proposed: -

- All oil stored on site for construction vehicles will be kept in a locked and bunded area.
- Generators, pumps and similar plant will be placed on drip-trays to prevent contamination.
- All site vehicles used will be refuelled in bunded areas.
- All temporary construction fuel tanks will also be located in a suitably bunded area and all tanks will be double skinned. In addition, oil absorbent materials will be kept on site in close proximity to any fuel storage tanks or bowsers during proposed site development works.

- All deliveries to on-site oil storage tanks will be supervised.
- Records will be kept of delivery dates and volumes.
- All valves should be of steel construction and the open and close positions should be clearly marked.

The following standard mitigation measures regarding cement handling during construction are proposed: -

- No mixing of concrete will be carried out on site. The measures detailed below will be employed where poured concrete is being used in the construction process.
- The production, transport and placement of all cementitious materials will be strictly planned and supervised. Site batching/production of concrete will not be carried out on site and therefore these aspects will not pose a risk to the waterbodies present, namely any temporarily exposed groundwater, or to the onsite drainage ditch or Rathmichael River.
- Shutters will be designed to prevent failure. Grout loss will be prevented from shuttered pours by ensuring that all joints between panels achieve a close fit or that they are sealed.
- Any spillages will be cleaned up and disposed of correctly.
- Where concrete is to be placed by means of a skip, the opening gate of the delivery chute will be securely fastened to prevent accidental opening.
- Where possible, concrete skips, pumps and machine buckets will be prevented from slewing over water when placing concrete.
- Surplus concrete will be returned to batch plant after completion of a pour.

The above mitigation measures will form part of the Outline Construction Environmental Management Plan (CEMP) submitted as part of this planning application, and which will be further developed by the Contractor within the project-specific Detailed CEMP which will be in operation during the construction phase.

8.7.1.2 Operational Stage

The following specific mitigation measures are proposed during the operational phase: -

- All plant and equipment utilised onsite during maintenance works should be checked and in good working condition. Any equipment not meeting the required standard will not be permitted for use within the site.
- Any minor volumes of fuel, oil or chemicals required during routine maintenance works will be brought to and from site by the maintenance contractor. While temporarily onsite all chemicals will be kept in secure and bunded areas. Any fuel / oil tanks temporarily stored on site will be located in a suitably bunded area and all tanks will be double skinned.
- In the unlikely event of a fuel / oil or chemical spill / leak during routine maintenance works, emergency spill response measures will be implemented with the aim of limiting the volume spilled and recovering as much of the lost product as possible.
- In the unlikely event of a domestic fuel spill / leak arising from the use of onsite home heating oil, emergency spill response measures will be implemented with the aim of limiting the volume spilled and recovering as much of the lost product as possible. Remedial works will be undertaken in order to fully address any potential environmental / human health impacts.
- The proposed wastewater pumping station and all associated equipment will be maintained in accordance with industry standards and routinely inspected for any equipment wear and tear in order to minimise risk the potential risk of equipment / pump failure.
- An emergency response plan should be prepared for the proposed wastewater pumping station. Typical details included in such a plan include the availability of infrastructure details,

operation and maintenance plans, appropriately trained and equipped, personnel, and reporting and notification procedures for management, regulators and stakeholders.

- In a worst-case scenario of an emergency overflow of foul effluent, the system should be repaired as quickly as possible to limit the input of pollutants into receiving waters (dry drainage ditch and underlying groundwater, and the Rathmichael River). In the event of a major overflow (i.e. greater than 24 hours) consideration should be given to restricting inflows to the system. Once the system has been repaired an assessment of any potential groundwater, surface water or human health impacts should be immediately undertaken, and remedial action adopted as required. Potential human health risks can be managed by restricting access with temporary emergency fencing and by erecting warning signs. Any residents or members of the public likely to be directly affected by the overflow should be informed. Warning measures must remain in place until there is no potential human health risk arising from the overflow. It is noted that the potential occurrence of an emergency overflow of foul effluent is considered to be unlikely, and any such events would be rare.

8.8 Residual Impact of the Proposed Development

8.8.1 Proposed Development

8.8.1.1 Construction Stage

The residual impact to groundwater quality and to surface water quality resulting from potential pollution caused by site activities e.g. plant, fuel/ chemical spillage etc. or associated with cement handling and pouring during the construction phase is slight adverse.

The residual impact to surface water quality resulting from excess loadings of suspended solids, via temporary discharge during dewatering of excavations, or via inadequate onsite soil / storm water management, during the construction phase is slight adverse.

8.8.1.2 Operational Stage

The residual impact to groundwater quality resulting from potential pollution caused by emergency overflow discharge of effluent from the onsite wastewater pumping station during the operational phase is slight adverse. The residual impact to surface water quality resulting from potential pollution caused by the emergency overflow discharge of effluent during the operational phase is moderate adverse.

The residual impact to groundwater quality and to surface water quality resulting from occasional maintenance works during the operational phase is slight adverse.

The residual impact to groundwater quality and to surface water quality resulting from potential onsite use of home heating oil (kerosene) during the operational phase is slight adverse.

Therefore, taking account of the proposed mitigation measures, no significant adverse impacts are anticipated to the receiving water environment arising from the proposed development during the construction or operational phases. On a regional scale, the proposed development will not affect the current ‘Good’ ecological status of the Rathmichael River as required under the European Communities Environmental Objectives (Surface Waters) Regulations, 2009 and as amended 2012. Similarly, the proposed development will not affect the current ‘Good’ status of the Wicklow Groundwater Body as required under the European Communities Environmental Objectives (Groundwater) Regulations, 2010 and as amended 2016.

8.9 Water and Human Health

Potential human health risks associated with impacts to groundwater and/or surface water arising from the proposed development during both the construction and operational phases include the following: -

- Risk of direct contact with contaminated storm water / surface water / groundwater (to onsite construction and maintenance workers, onsite residents, offsite golf course users and offsite residents) via potential onsite leaks / spills, domestic oil spills, or emergency overflow effluent.
- Risk of inhalation of volatile hydrocarbons from localised contaminated groundwater (to onsite construction and maintenance workers, and onsite residents) via. potential onsite leaks / spills or domestic oil spills.

Taking account of the proposed mitigation measures during both the construction and operational phases, any human health risks to onsite and offsite receptors as a result of groundwater or surface water impacts will be imperceptible. No human health risks associated with long term exposure to contaminants (via. surface water or groundwater pathways) resulting from the proposed development are anticipated.

8.10 Monitoring

8.10.1 Proposed Development

8.10.1.1 Construction Phase

Should dewatering of deep excavations and temporary discharge of pumped groundwater be required during the construction phase, it is good practice for the Contractor to monitor surface water quality upstream and downstream (at the development site boundary) of the temporary discharge point.

8.10.1.2 Operational Phase

Based on the findings of this assessment no groundwater or surface water quality monitoring is required for the proposed development during the operational phase.

8.11 Reinstatement

All temporary construction compounds and site entrances are to be removed upon completion of the construction phase. Such areas are to be reinstated in accordance with the landscape architects plan and engineer's drawings. All construction waste and / or scrapped building materials are to be removed from site on completion of the construction phase. Oil, fuel etc. storage areas are to be decommissioned on completion of the construction phase. Any remaining liquids are to be removed from site and disposed of at an appropriate licenced facility.

8.12 Difficulties Encountered

No difficulties were encountered during the preparation of this water impact assessment.