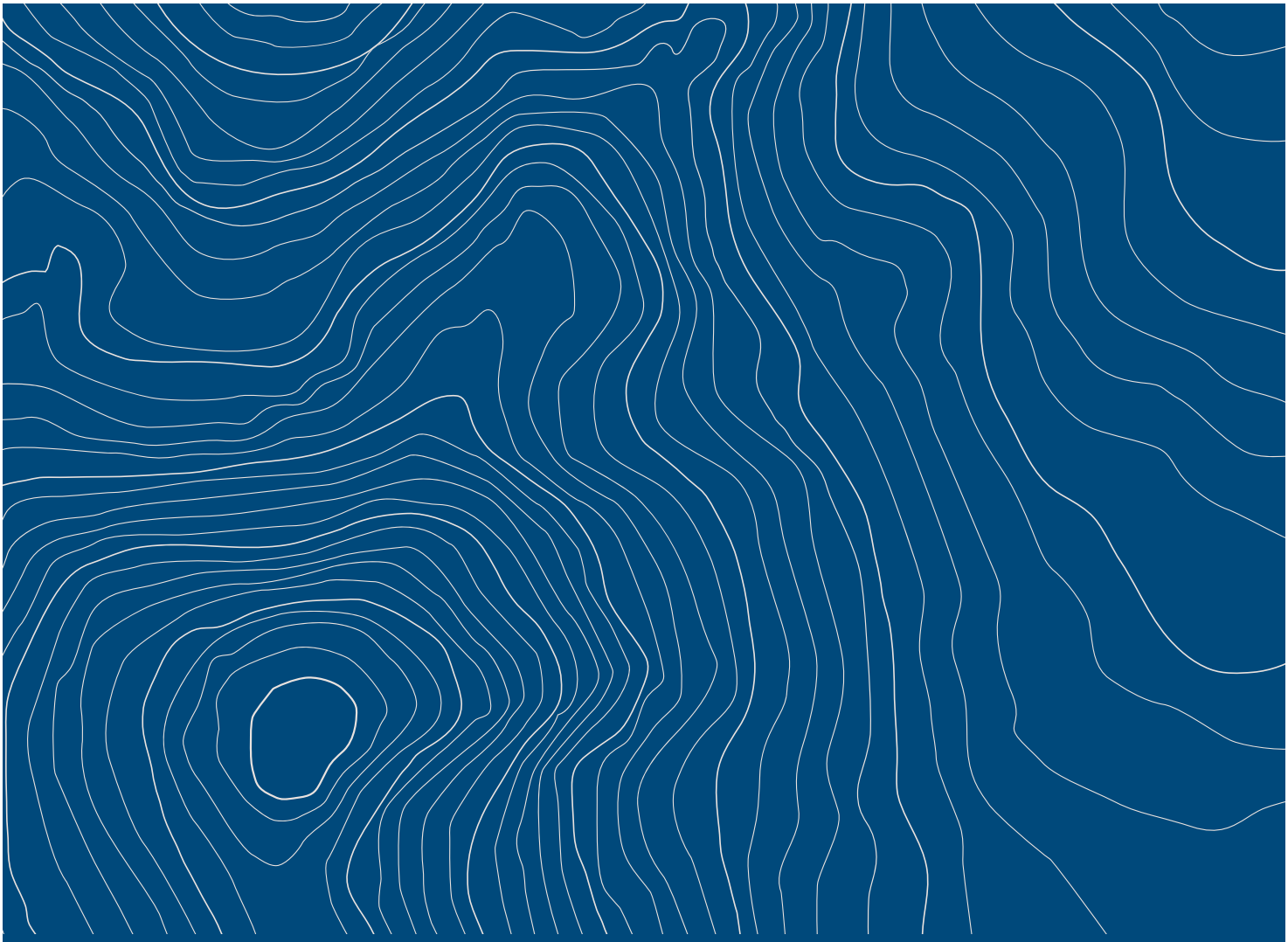

DublinArray
Generation for generations

EIAR Volume 6: Onshore Infrastructure Technical Appendices Appendix 6.5.4-1: Water (Hydrology, Hydrogeology and Flood Risk) Technical Baseline Report

Kish Offshore Wind Ltd.

RWE SLR GoBe APEM Group

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Dublin Array Offshore Wind Farm

Environmental Impact Assessment Report

Volume 6, Appendix 6.5.4-1: Water (Hydrology, Hydrogeology and Flood Risk) Technical Baseline Report

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Acronyms

Term	Definition
AEP	Annual Exceedance Probability
AFA	Area for Further Assessment
AMAX	Annual Maximum
AOD	Above Ordnance Datum (Ordnance Datum for Ireland is Malin)
bgl	Below Ground Level
BH	Borehole
BOD	Biochemical Oxygen Demand
$CaCO^3$	Calcium Carbonate
CDP	County Development Plan
CFRAM	Catchment Flood Risk Assessment and Management
DART	Dublin Area Rapid Transit
DFRS	Deansgrange Flood Relief Scheme
DLRCC	Dún Laoghaire-Rathdown County Council (Local Authority)
ECR	Export Cable Route
EIAR	Environmental Impact Assessment Report
EPA	Environmental Protection Agency
EU	European Union
FRA	Flood Risk Assessment
FRMP	Flood Risk Management Plan
FSU	Flood Studies Update
GCP	Grid Connection Point
GI	Ground Investigation
GSI	Geological Survey of Ireland
GPR	Ground Penetrating Radar
GWB	Ground Water Body
HWM	High Water Mark (tidal)
IFI	Inland Fisheries Ireland
IGI	Institute of Geologists of Ireland
ISIS	Irish Soils Information System
LI	Locally Important Aquifer

LTA	Long Term Averages
m AOD	Meters Above Ordnance Datum (Malin OD)
MMF	Mean Monthly Flows
MW	Megawatts
O&M	Operations and Maintenance
OES	Onshore Electrical System
OSS	Onshore Substation
OPW	Office of Public Works
OSi	Ordnance Survey of Ireland
PI	Poor Aquifer
RBD	River Basin District (under WFD)
RBMP	River Basin Management Plan
SDZ	Strategic Development Zone
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection (for flood defenses)
TGr	Tills derived from Granite
TJB	Transition Joint Bay
TLs	Tills derived from Limestone
UoM	Unit of Management (under WFD)
WFD	Water Framework Directive
WTG	Wind Turbine Generator
WWTP	Waste Water Treatment Plant

1 Introduction

1.1 Baseline characterisation report

1.1.1 The purpose of the technical baseline report is to robustly characterise the baseline water environment (Hydrology, Hydrogeology and Flood Risk) for the purposes of informing the impact assessment of the Dublin Array onshore Infrastructure works. It covers terrestrial water courses only from the High Water Mark (HWM).

1.1.2 This baseline characterisation report has been prepared specifically for the Volume 5, Chapter 4: Water (Hydrology, Hydrogeology and Flood Risk) (hereafter referred as the Water Chapter) of the Environmental Impact Assessment Report (EIAR) relating to the Dublin Array onshore infrastructure works, comprising the Onshore Electrical System (OES) from Shanganagh to Jamestown and the Operations and Maintenance (O&M) Base in Dún Laoghaire Harbour.

1.2 Project overview

1.2.1 Dublin Array will comprise between 39 and 50 Wind Turbine Generators (WTG) and will include infrastructure that is required to transmit the power generated at the turbines to the offshore substation via inter-array cables, before then being transmitted via onshore export cables to the OSS. The onshore infrastructure is comprised of the OES i.e. the Landfall Site at Shanganagh Cliffs, the Onshore Export Cable Route (ECR), the proposed Onshore Substation (OSS) at Jamestown and the grid connection to the existing Carrickmines 220 kV substation, the grid connection point (GCP) and the O&M Base in Dún Laoghaire Harbour.

1.2.2 The proposed OSS is located in the Ballyogan Landfill Facility and Recycling Park, adjacent to the former landfill area.

1.2.3 A more detailed description of the proposed development is provided within Volume 2, Chapter 6 Project Description (hereafter referred to as the Project Description Chapter).

1.2.4 This technical appendix describes the baseline relevant to the assessment of potential environmental effects that might result from the onshore infrastructure.

1.3 Practitioner competency

1.3.1 This Baseline Technical Appendix to the EIAR has been prepared by SLR Consulting. The competent practitioners responsible for the preparation of this baseline report include:

- Dominica Baird (BSc, MSc, CGeol, EurGeol) Hydrogeology; and
- Peter Glanville (PhD, MSc, PGeo, EurGeol) Hydrology.

1.3.2 Dominica Baird is a chartered hydrogeologist with 20 years consultancy experience. She has practised hydrogeology, groundwater risk assessment and contaminated land in London, Edinburgh and Dublin and leads groundwater monitoring, water resources and due diligence projects. Key competencies include preparation of EIARs, hydrogeological assessments and aquifer characterisation, developing conceptual site models, quantitative and qualitative groundwater risk assessments and groundwater investigations.

1.3.3 Peter Glanville is a chartered geologist with over 23 years of experience in environmental consultancy. He is a Professional Geologist (PGeo. EurGeol.) with the Institute of Geologists of Ireland and has experience in preparation of EIARs and the assessment of Hydrology, Flood Risk, Quaternary Geology, Geomorphology, Resource Assessments, Regional and National Mineral Constraints and Hydromorphology.

1.3.4 Dominica Baird is a chartered Geologist (Hydrogeology) and Peter Glanville is a chartered geologist. In addition, SLR staff are chartered members of The Chartered Institution of Water and Environmental Management (CIWEM) and chartered Engineers with Institute of Civil Engineers.

1.3.5 Further information in relation to SLR Consulting can be found at www.slrconsulting.com.

2 Methodology

2.1 Approach

2.1.1 The methodology for baseline characterisation has comprised a combination of a detailed desktop review to establish the baseline information available on the onshore water environment within the defined study areas (described in section 2.2 below). This desktop review was then combined with a site walkover which provided a further understanding of the study areas in relation to the water environment to inform the baseline description of the project's receiving environment.

2.1.2 Groundwater baseline information has been gathered within a 2 km wide buffer either side of the site application boundary (as per the study area described in section 2.2 and shown in Figure 1). This approach aligns with the Institute of Geologists of Ireland's (IGI) guidelines (2013) for baseline data. The following attributes have been gathered for this wider area:

- Bedrock aquifer;
- Groundwater body;
- Groundwater abstractions and wells; and
- Groundwater vulnerability.

2.2 Study area

2.2.1 The two study areas comprise:

- The Onshore Electrical System (OES) study area; and
- Operations and Maintenance (O&M) Base study area.

2.2.2 The study area buffers are shown in Figure 1.

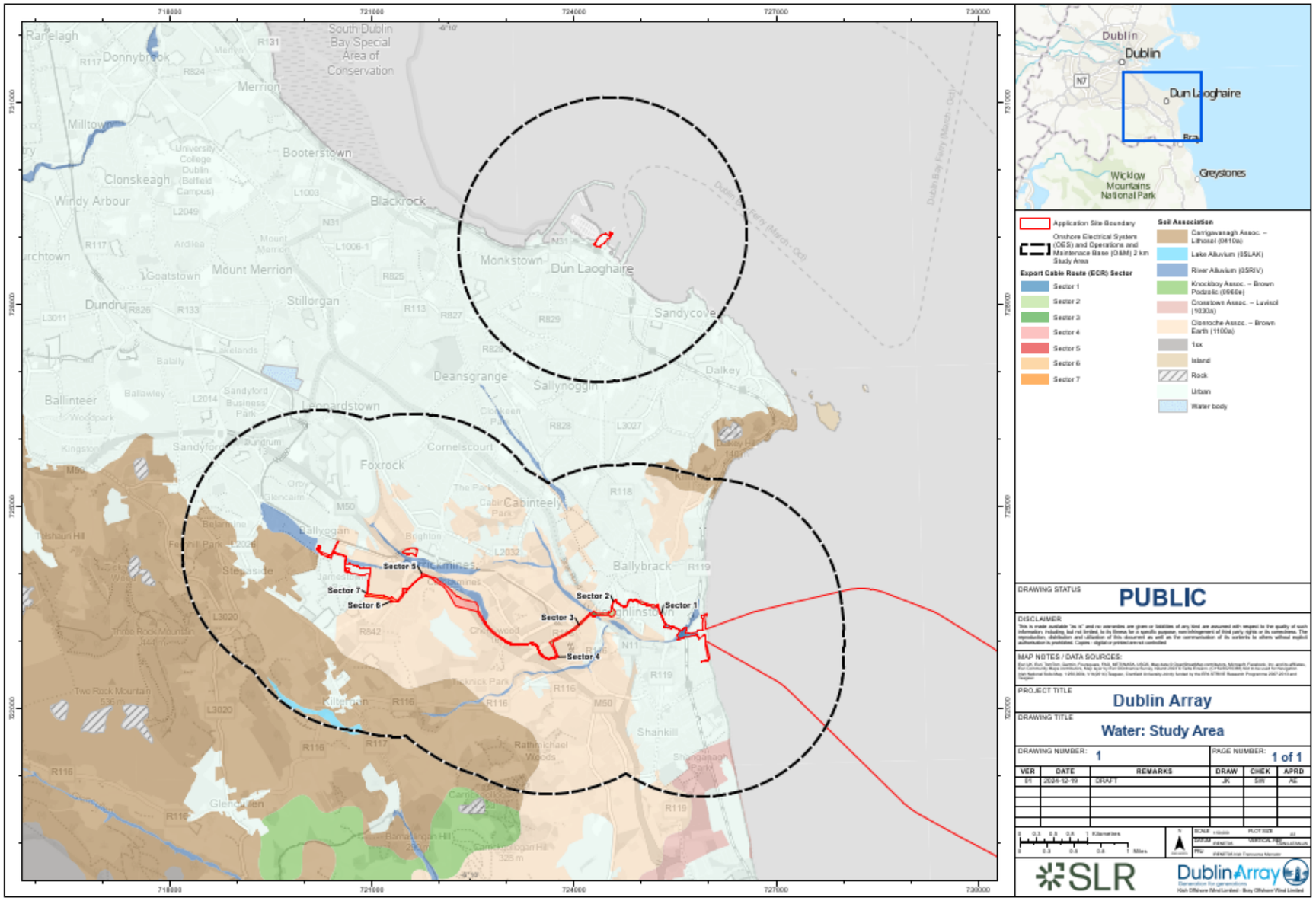


Figure 1 Water study area

OES study area

2.2.3 The OES study area comprises the area within which the proposed onshore works described in section 1.2 are proposed. The proposed Onshore ECR is divided into a total of 7 Sectors along the Onshore ECR for reference purposes. The sectors run west of the Landfall Site at Shanganagh Cliffs (Sector 1) and terminate at the OSS boundary (Sector 7). Temporary construction compounds (TCCs) are located along the length of the onshore ECR comprising: the Landfall Site TCC; Clifton Park TCC (sector 1); and Leopardstown TCC.

2.2.4 The OES study area comprises this area plus a buffer of 2 km to reflect the sensitivity of the surface water and groundwater. This is in line with the Institute of Geologists of Ireland's (IGI) guidelines (2013). This area is shown on Figure 1.

2.2.5 The IGI guidelines state that the minimum distance of 2 km should be reviewed in the context of the geological/hydrogeological environment as well as the scale of development and increased to reflect the sensitivity of the subsurface. The IGI guidelines also state that maps should be sourced to allow for the review of the geological and hydrogeological conditions that exist within a minimum of 2 km of the site boundary (from the outer limit of the planning and/or licence area) and presented at a scale of 1:25,000. The baseline maps produced in this EIAR are at a range of scales from 1:10,000 to 1:35,000.

2.2.6 Desktop hydrology and hydrogeological information is presented across the whole of the study area.

2.2.7 There are a number of river channels which run through the study area, the main ones being the Loughlinstown/Shanganagh River (referred to here as the Shanganagh River), the Kill-o-the-Grange Stream and the Carrickmines Stream. The Carrickmines Stream is a sub-catchment of the Shanganagh River.

O&M Base study area

2.2.8 The O&M Base will be located in Dún Laoghaire Harbour. The O&M Base will consist of a building providing office space, warehousing and welfare facilities located along Saint Michael's Pier, as well as shared parking spaces with Dún Laoghaire-Rathdown County Council (DLRCC) Harbour personnel, a new gangway providing access to a new 70 m long pontoon will be installed adjacent to St. Michaels Pier. The footprint of the existing harbour maintenance building which is currently used by the DLRCC Harbour operations team, and the main pier have been used to develop the design. The site boundary for the O&M Base is shown on Figure 1.

2.2.9 The study area for the proposed O&M Base extends outwards to 2 km from the base, following the same approach adopted for the OES study area. This is shown on Figure 1

2.3 Data sources

2.3.1 Baseline information on the receiving environment has been obtained from:

- Ordnance Survey of Ireland (OSi) mapping to establish former channel courses and any diversion/culvert works in streams and rivers;
- Teagasc/Environmental Protection Agency (EPA)/Geological Survey Ireland (GSI) Soil and subsoils mapping for Ireland (Teagasc, n.d.);
- Office of Public Works (OPW) stream flow, fluvial and tidal flood risk data and flood modelling information including proposals under the OPW Catchment Flood Risk Assessment and Management (CFRAM) for a flood relief scheme along the Shanganagh River at Loughlinstown;
- Dún Laoghaire-Rathdown County Council (DLRCC) County Development Plan (CDP) (2022-2028) Appendix 15 Strategic Flood Risk Assessment (SFRA);
- Dún Laoghaire-Rathdown Flood Relief Scheme for Deansgrange Stream (also known as Kill-o-the-Grange Stream);
- Geological Survey of Ireland (GSI) groundwater information; geological information.
- EPA consented abstractions, discharges and licences;
- EPA water quality results and WFD (Water Framework Directive) surface water and groundwater status;
- River Basin Management Plan (RBMP);
- Inland Fisheries Ireland (IFI) survey and water quality information;
- Local authority monitoring results (surface water and groundwater) for Kilboggett Park (historic landfill) and Ballyogan (former local authority landfill); and
- Ground Investigation information and groundwater measurement data from site investigations undertaken at the OSS, Landfall Site and along the onshore ECR.

2.3.2 These data sources are presented by receptor group in Table 1.

Table 1 Data sources consulted for the baseline.

Environmental data	Data source
Soils	▪ Teagasc (Irish Soils Information System (ISIS))
Subsoil Geology	▪ Teagasc/GSI/EPA (Subsoil Mapping)

Bedrock Geology	▪ GSI (Bedrock Geology)
Surface Water	▪ OSi (Discovery Series mapping); ▪ Environmental Protection Agency (Water Framework Directive data and catchment flow); ▪ OPW (CFRAM); ▪ DLRCC County Development Plan (2022-2028) SFRA.
Groundwater	▪ GSI (bedrock and gravel aquifer); ▪ GSI (Groundwater body description documents); and ▪ Environmental Protection Agency (Water Framework Directive data);
Climate	▪ Met Eireann (Rainfall data)
Protected Areas, Environmental Pressures	▪ Environmental Protection Agency (Water Framework Directive data); ▪ National Parks and Wildlife Service (Designated Areas)

2.4 Site specific surveys

2.4.1 The OES study area was visited in July and August 2020 by way of a walkover survey to identify water features and potential sensitive hydro receptors. Site walkovers were also undertaken by SLR staff in September 2024.

2.4.2 The purpose of the walkover surveys was to confirm the key features identified from the desktop study. The walkover also focused on the proposed alignment river/ stream crossing points and potential flood risk areas along the proposed alignment.

Ground Investigations

2.4.3 A number of geotechnical ground investigations have been undertaken along the OES, including:

- Volume 6, Technical Appendix 6.5.3-2: Dublin Array Onshore Site Investigation Report May 2023 (hereafter referred to as the Onshore SI Report), undertaken for Dublin Array; and
- Volume 6, Technical Appendix 6.5.3-3: Dublin Array Onshore Cable Route Ground Investigation Report, February 2024 (hereafter referred to as the Onshore Cable Route Ground Investigation Report), undertaken for Dublin Array.

Landfall Site and OSS Site Investigation

2.4.4 A site investigation (SI) was undertaken across two sites, the Landfall site and at the proposed OSS location, (see the Onshore SI Report).

2.4.5 The SI was conducted between 5th September and 7th October 2022, comprised:

- Eleven boreholes by sonic drilling methods;
- Standpipe installation in nine boreholes for groundwater and gas monitoring;
- Sixteen machine dug trial pits;
- An infiltration test performed in six trial pits;
- Thirteen variable head tests (falling head); and
- Eight plate load tests.

2.4.6 The boreholes extended between 10.5 m below ground level (bgl) and 15 m bgl at Ballyogan and 30 m bgl at Shanganagh Cliffs. Sixteen trial pits were excavated using a 6 t or 13 t tracked excavator fitted with a 300 mm or 600 mm wide bucket, to depths up to 4.50 m bgl.

2.4.7 The ground conditions encountered are summarised here.

Shanganagh Cliffs

2.4.8 A summary of the ground types encountered in the exploratory holes is listed below, in approximate stratigraphic order:

- Topsoil: encountered across the site with a thickness range of 200-300 mm;
- Made Ground (fill): reworked sandy gravelly clay/sand/gravel fill encountered across the site to a maximum depth of 2.10 m in WP2_BH02. Varying amounts of concrete, red brick, plastic, timber, rebar and ceramic pipes were encountered within the made ground;
- Glacial Sands & Gravels: Loose to dense gravelly silty sand and sandy silty gravel encountered greatest in extent in WP2_BH03 and WP2_BH04 adjacent to the coastline; and
- Glacial Till: sandy gravelly clay, frequently with low cobble content, typically firm or stiff in upper horizons, becoming very stiff with increasing depth often with lenses of granular material.

Ballyogan

2.4.9 A summary of the ground types encountered in the exploratory holes is listed below, in approximate stratigraphic order:

- Topsoil: encountered across the site with a thickness range of 100-300 mm;
- Made Ground (fill): reworked sandy gravelly clay encountered across the site to a maximum depth of 3.30 m in WP1_TP03. Varying amounts of plastic, red brick, concrete, ducting, rebar, electrical cable and timber were encountered within the made ground across the site;
- Glacial Till: sandy gravelly clay, frequently with low cobble content, typically firm or stiff in upper horizons, becoming very stiff with increasing depth often with lenses of granular material; and
- Bedrock (Granite): Rockhead was encountered at a depth of 11.30 m in WP1_BH01.

Onshore Export Cable Route (ECR) ground investigation

2.4.10 The extent of the ground investigations (GI) included boreholes, trial pits, slit trenches, soil and rock core sampling, environmental sampling, groundwater monitoring, in-situ and laboratory testing, and the preparation of a factual report on the findings, see the Onshore Cable Route Ground Investigation Report.

2.4.11 The GI works were conducted across various sites along the proposed ECR from the OSS at the most western extent, to the proposed Landfall Site at the most eastern extent, south of the Shanganagh wastewater treatment plant (WWTP).

2.4.12 The GI was conducted between 11th September and 15th November 2023, and comprised:

- fifteen boreholes, including:
  - Three light cable percussion boreholes (two of which were inspection pits only);
  - Ten boreholes by light cable percussive extended by rotary follow-on drilling methods; and
  - Two boreholes by rotary drilling methods only.
- A standpipe installation in one borehole;
- Fifteen machine dug trial pits/slit trenches; and
- Ground Penetrating Radar (GPR) surveys.

2.4.13 Seven of the boreholes (BH) conducted as part of the GI are no longer representative as one of the route options has not been progressed as part of the development consent application. Those boreholes are around the Luas M50 bridge at Carrickmines and on the northern side of the Carrickmines M50 Junction and one BH on the southern side of the M50 at Laughanstown.

2.4.14 Following completion of site works, a groundwater data logger was installed in WP03_BH06 to monitor groundwater levels over the course of 12 months. Ground water monitoring was carried out using a water interface probe.

2.4.15 Several phases of GPR surveys were completed across the proposed cable corridor from March to November 2023, by Scantech Geoscience Ltd. to identify the location and type of any services present. Results of the survey have been presented to Dublin Array electronically and are included with the Causeway Geotech report.

Ground types encountered during investigation of the site

2.4.16 A summary of the ground types encountered in the exploratory holes is listed below, in approximate stratigraphic order:

- Topsoil: encountered across the site in either its natural state or reworked state with a thickness range of 100-300 mm;
- Made Ground (sub-base): aggregate fill was encountered within some of the slit trenches in the landfill site, generally surrounding services;
- Made Ground (fill): generally reworked sandy gravelly clay fill or gravelly clayey sand encountered to various extents across the site. Pieces of plastic were encountered within the strata in WP03_TP04A and WP03_TP08. Encountered greatest in extent in WP03_BH07, where the driller noted a hydrocarbon odour from the strata, WP03_BH05, the location of an old construction compound;
- Alluvium: Medium dense to dense sand and gravel encountered adjacent to a stream in WP03_BH07 and WP03_BH08 to depth of 8.00 m bgl.
- Glacial Sands & Gravels: Extensive sand and gravel deposits encountered in WP03_BH14 to a depth of 25.00 m bgl.
- Glacial Till: sandy gravelly clay, frequently with low cobble content, typically firm or stiff in upper horizons, becoming very stiff with increasing depth, often with lenses of dense granular material.
- Bedrock (Granite): Granite of various strengths was encountered across the site from 2.30 m in WP03_BH02 to depths of 20.30 m in WP03_BH06, with depth to bedrock generally increasing eastwards across the site towards the Irish Sea.

2.4.17 Details of the individual groundwater strikes, along with any relative changes in levels as works proceeded, are presented on the exploratory hole logs for each location and groundwater strikes are shown in Table 6 of the Onshore Cable Route Ground Investigation Report.

2.4.18 Several phases of GPR surveys were completed across the proposed ECR from March to November 2023, by Scantech Geoscience Ltd. to identify location and type of any services present. Results of the survey have been presented to the Dublin Array electronically and are included within the Onshore Cable Route Ground Investigation Report.

O&M Base

2.4.19 The O&M Base study area was visited in September 2024 by way of a walkover survey to identify water features and potential sensitive terrestrial hydro receptors. The purpose of the walkover survey was to confirm the key features identified from the desktop study.

3 Baseline

3.1 Introduction

3.1.1 This section describes the baseline conditions of the two study areas: the OES study area; and the O&M Base study area. As set out in section 2, the data described here has been derived from a mixture of desktop published information and from a walkover survey where access was possible. Where relevant, data sources are cited.

3.2 Rainfall

3.2.1 The nearest synoptic Met Éireann weather station is at Casement Aerodrome, which is located approximately 17.5 km northwest of the OES study area. The total monthly rainfall at Casement for the period January 2021 to December 2023 is shown in Table 2 (Met Éireann, 2024).

Table 2 Monthly rainfall totals for 2021, 2022 and 2023 at Casement (Met Eireann, 2024)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2023	52.1	15.7	109.3	67.3	24.3	45	124.2	84.5	112.5	116	41.2	77.9
2022	21	99.3	40.1	46.9	59.6	78.3	40.4	18.7	119.2	100.6	51.9	92.2
2021	95.8	69.7	29.6	17.9	112.7	17.8	94	47.3	42.1	77.2	16.4	76.4

3.2.2 Long Term Averages (LTA) or 'normals' are used for comparison purposes and to put rainfall values in context.

3.2.3 The current Met Éireann LTA is for the 30-year period 1991-2010 (Met Éireann, 2020). The average monthly rainfall values for the 30-year period 1991-2010 can be seen in Table 3. The average annual rainfall at Casement synoptic station over this LTA period was 754.2 mm.

3.2.4 The east coast of Ireland is relatively dry with lower rainfall compared to other parts of the country and the catchments in the study area are also located in the lee of the Dublin and Wicklow Mountains from the prevailing south westerly winds, which generally results in lower rainfall.

3.2.5 The long-term average monthly rainfall totals in Table 3 indicate a slightly wetter autumn and winter between October and January and a drier period between February and September, with the exception being August. During the late spring and summer evapotranspiration rates will be higher due to longer daylight hours and the lowest stream flows and groundwater levels will tend to coincide with the end of this period and can be July and August for flows and August and September for groundwater levels.

Table 3 Mean monthly rainfall total (mm) 1991-2010 Casement (Met Éireann, 2024)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
65	55.2	51.8	55.3	59.1	65.7	59.4	71.2	61.6	81.6	81.9	75.7

3.3 Topography

OES study area

3.3.1 The ground topography within the OES study area rises from sea level at Killiney Bay to c. 90 m Above Ordnance Datum (AOD) at the far western extremity of the study area at Ballyogan/Carrickmines, County Dublin.

3.3.2 The study area ground elevation initially rises up vertically by c.12 m at the sea cliffs to the transition joint bay (TJB) beside the Shanganagh Wastewater Treatment Plant. From there it reaches an initial high point at the Dublin Area Rapid Transit (DART) Rail Line and falls back down to the Shanganagh River at c. 1 mAOD.

3.3.3 From the Shanganagh River the OES study area rises gently along the Kill-o-the-Grange Stream and Carrickmines Stream before rising up to c. 70 mAOD at Laughanstown.

3.3.4 From Laughanstown the study area is relatively level to Carrickmines where it rises up to c. 90 mAOD at Ballyogan, at the far western end of the study area.

O&M Base

3.3.5 The O&M Base is to be located in Dún Laoghaire Harbour. The design level for the O&M Base on St. Michael's Pier is at c. 2 mAOD. The study area at the O&M Base ranges in elevation from 0 to 15 mAOD.

3.4 Physical features

OES study area

3.4.1 The principal natural physical features within the OES study area are a number of surface water courses, which have formed the valleys through the study area. These river valleys are generally broad and flat, particularly along the Kill-o-the-Grange Stream and the upper section of the Carrickmines Stream from Carrickmines to the western end of the study area at Ballyogan.

3.4.2 However, the section of the Carrickmines stream from Carrickmines to the Shanganagh River at Loughlinstown flows through a relatively steep sided valley, compared with the aforementioned broad and flat channels. At Loughlinstown the valley opens out into a relatively wider section with a flat wide valley floor but with relatively steep valley sides.

O&M Base

3.4.3 The principal natural physical features within the O&M Base study area includes coastline features such as the rocky shoreline and the Irish sea. The area in Dún Laoghaire is largely urbanised, with the Dart rail line running through the study area, and the active harbour contributing to a large portion of the study area.

3.5 Soils and geology

3.5.1 The soils, subsoils and bedrock geology along the proposed development areas is discussed in detail in Volume 5, Chapter 3 Land, Soils & Geology (hereafter referred to the Land, Soils and Geology Chapter), and is summarised below, see also Figure 2 and Figure 3 below with subsoils and bedrock geology. The EPA, Teagasc and GSI databases were consulted to form the below descriptions.

OES study area

3.5.2 The OES study area is underlain by three principal soil types:

- Urban (made ground);
- Alluvium along the watercourses; and
- Clonroche Soil Association.

3.5.3 The urban areas within the study area are classified as Urban Soils where the urban development has occurred, and the natural soils have been disturbed.

3.5.4 Along the watercourses Alluvial soils occur which host the channel water flows.

3.5.5 The remainder of the study area is underlain by soils from the Clonroche Soil Association which is a Brown Earth soil comprised from a predominantly fine loamy glacial till parent material primarily composed of sedimentary siliceous stones/geology.

3.5.6 These soils are underlain by glacial till and alluvium subsoils with some beach deposits at the coastline at Killiney bay. There are also extensive areas of mapped 'made ground' through the study area where urban development has occurred.

3.5.7 The subsoils are subsequently underlain by the four following bedrock formations (as described in the Land, Soils and Geology Chapter):

- Maulin Formation;

- Type 2p microcline porphyritic Granite;
- Type 2e equigranular Granite; and
- Type 3 muscovite porphyritic Granite.

Figure 2 Subsoils

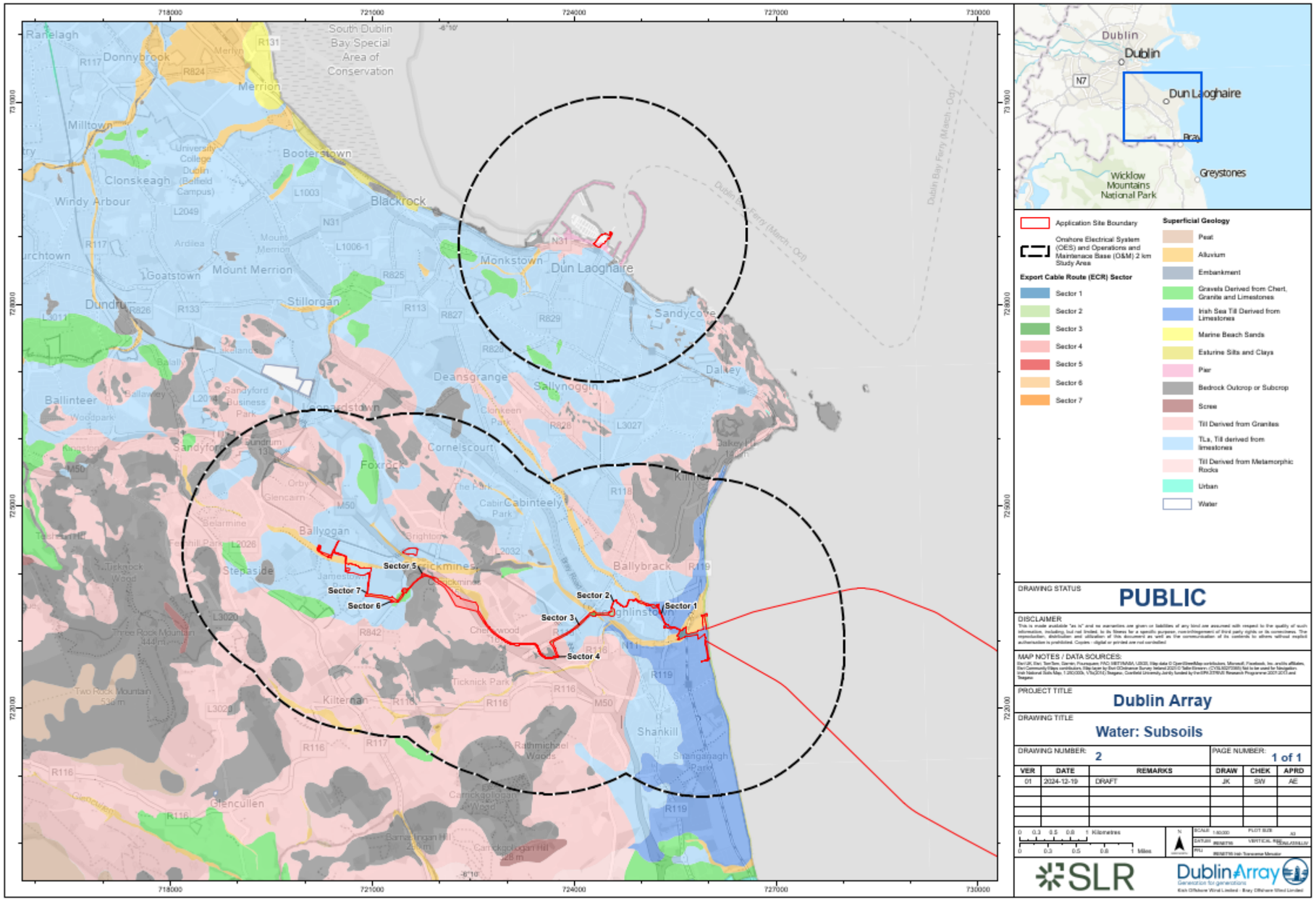
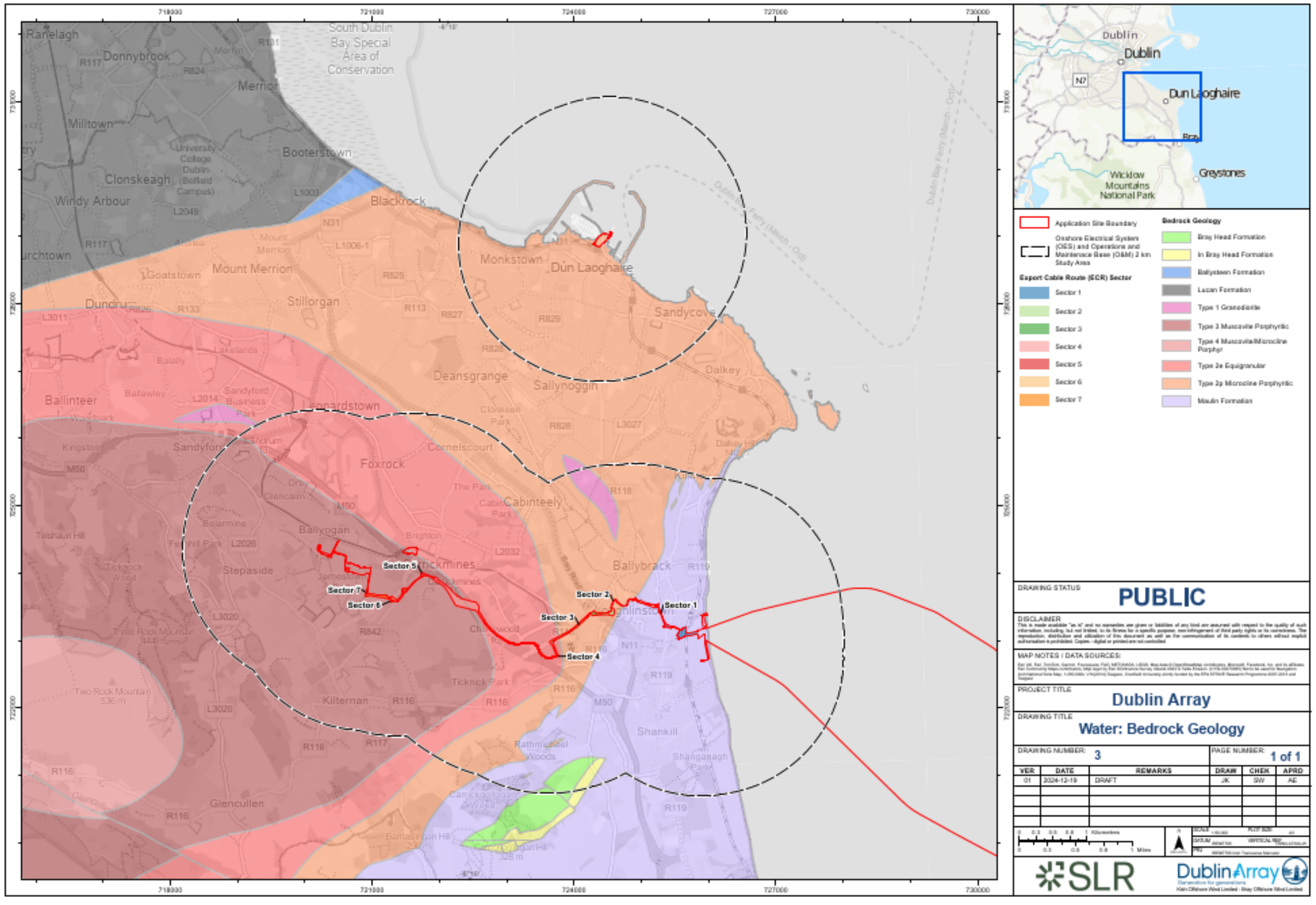


Figure 3 Bedrock geology



O&M Base

3.5.8 The study area for the O&M Base comprises the St. Michael's pier, Dún Laoghaire Harbour and is underlain by an Urban soil type, indicating that urban development has occurred, and the natural soils have been disturbed.

3.5.9 The subsoils underlying the site include Till derived from limestones (TLs) and Till derived from Granites (TGr). A minor area of bedrock outcrop or subcrop is also located within the study area.

3.5.10 The GSI online bedrock mapping shows the O&M Base study area to be underlain by Type 2p microcline porphyritic Granite.

3.6 Surface water features

OES study area

3.6.1 A walkover survey was undertaken in July and August 2020 to investigate the surface water features crossing the OES study area. This was followed by an update walkover survey in September 2024.

3.6.2 The study area is located within the Dargle River sub catchment of WFD hydrometric Area No. 10, which includes the Avoca, Vartry and Dargle Rivers. The EPA Water maps show the following surface water bodies to be in the study area, see Figure 4:

- Shanganagh River;
- Carrickmines Stream; and
- Kill-o-the-Grange Stream.

3.6.3 The stream and river names used here are the ones used by the EPA under the WFD. For clarity we have adopted the EPA WFD naming structure for the watercourses. The water courses are also known locally as:

- Kill-o-the-Grange Stream is often referred to as the Deansgrange Stream;
- Shanganagh River is often referred to as the Loughlinstown River; and
- Carrickmines Stream (which is a tributary of the Shanganagh River) is often referred to as the Ballyogan Stream or Barnacullia Stream further upstream.

3.6.4 There are further watercourses within the study area as shown on Figure 5 comprising:

- Laughlanstown Stream (south of Cherrywood in Sector 4);
- Cabinteely Stream (running north from the Carrickmines Stream at Cherrywood in Sector 5);

- Jamestown 10 and Glenamuck North streams, which are located south of Carrickmines Retail Park in Sector 7).

3.6.5 The surface watercourses crossing the OES study area have been significantly modified in the past. The channels have been canalised and straightened with a loss of the natural floodplain. Significant sections of the watercourses have also been culverted in Sectors 3 and adjacent to the site of the OSS.

3.6.6 Only a few short sections of relatively natural channel and floodplain remain in the study area, and these occur along the Carrickmines Stream to the north of Cherrywood.

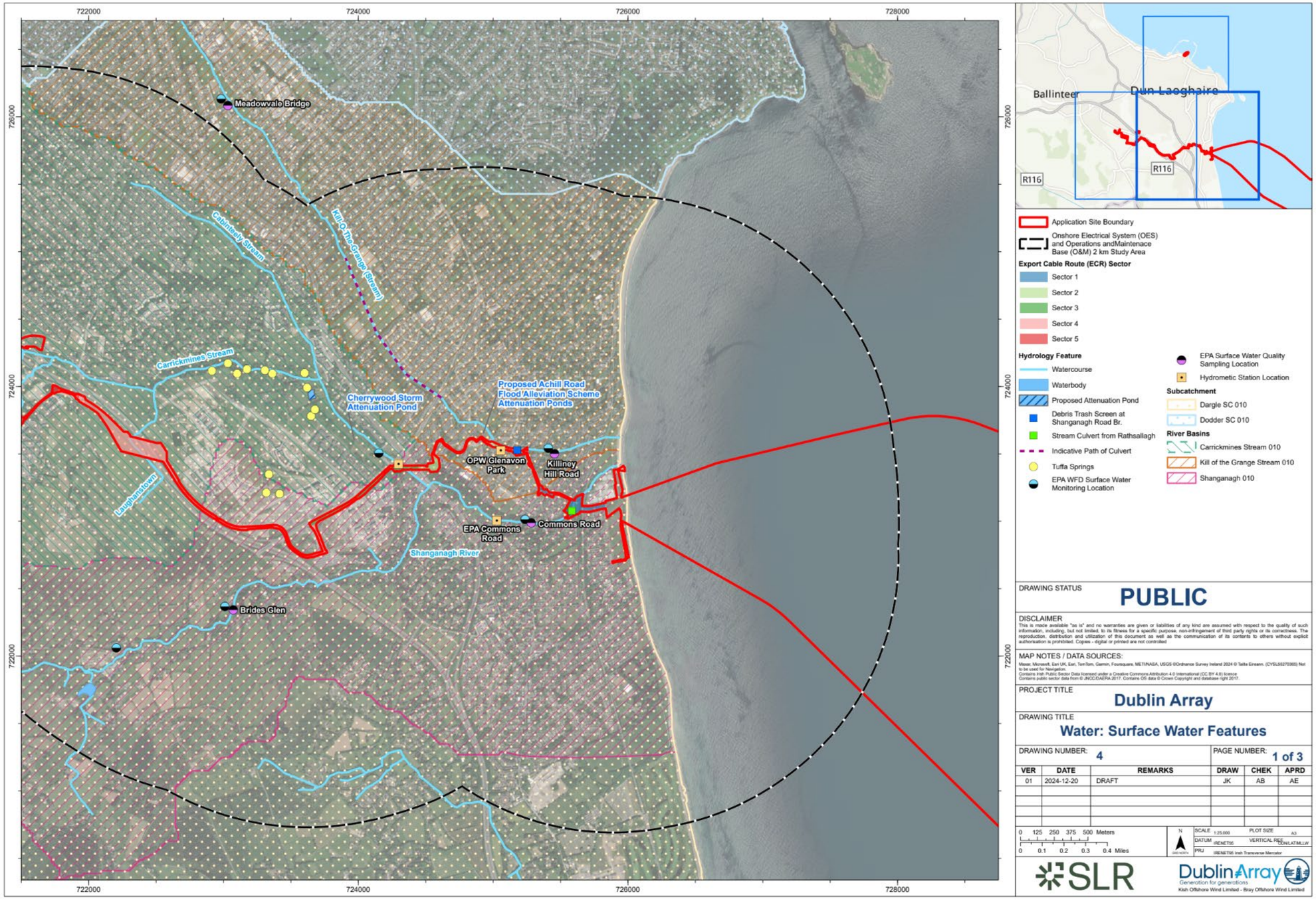


Figure 4 Surface water features

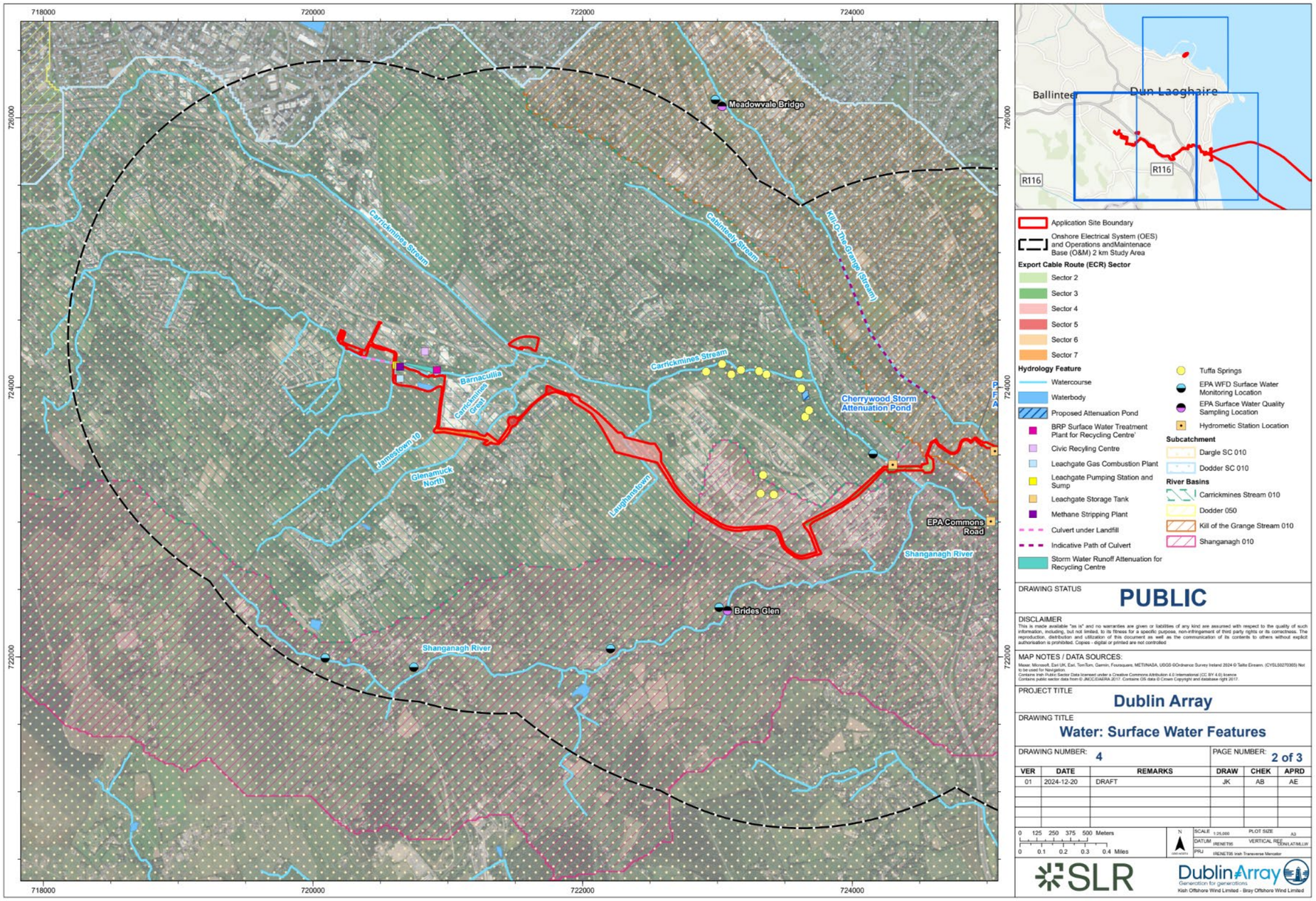


Figure 5 Surface water features

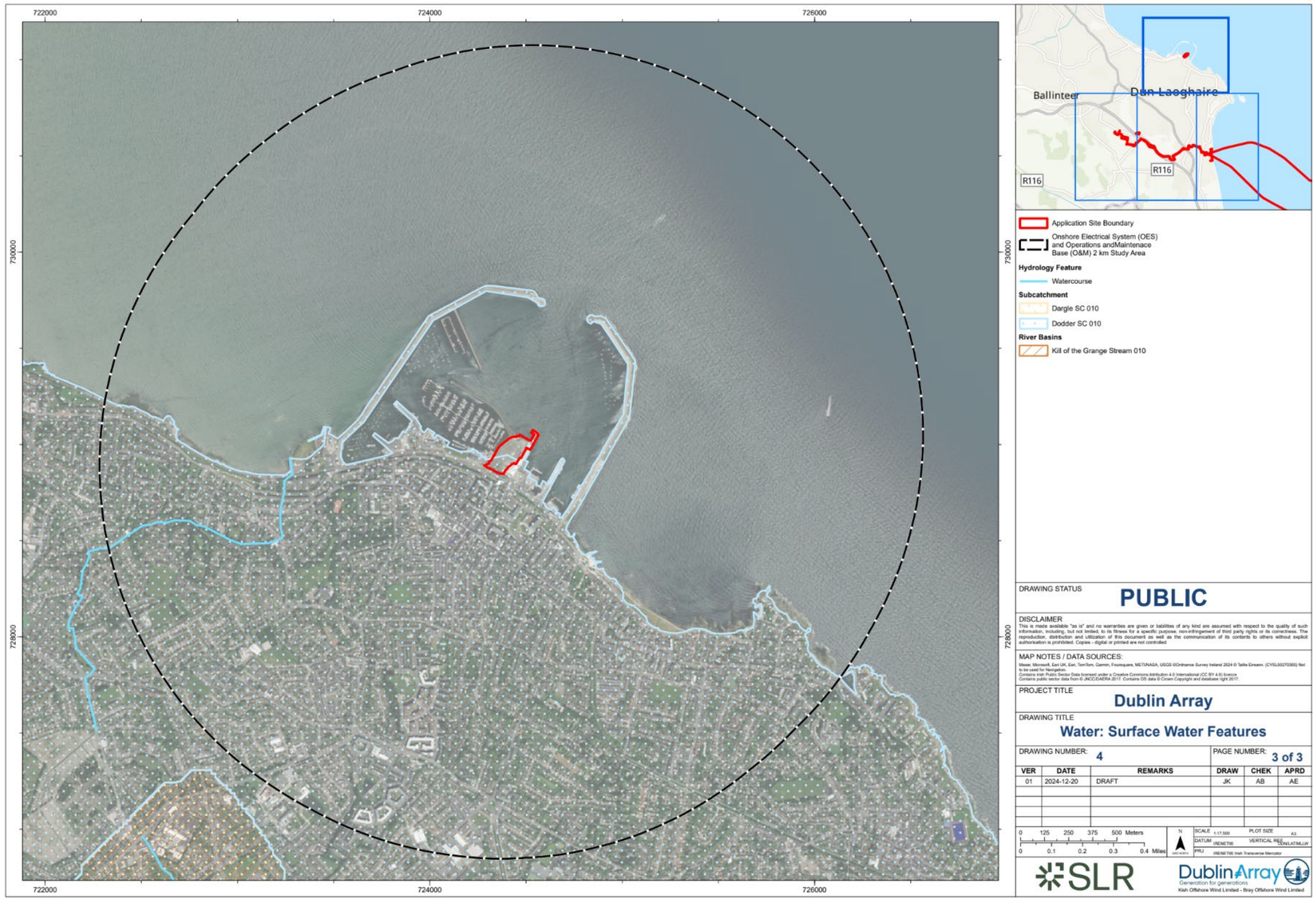


Figure 6 Surface water features

O&M Base

3.6.7 The O&M building for the development is proposed to be located at St. Michael's Pier in Dún Laoghaire Harbour (Figure 6). The port is located in the Dodder_SC_010 sub-catchment (09_16), of the wider Liffey and Dublin Bay Catchment (09), and the study area includes the Dublin Bay coastal waterbody. There are no rivers, streams or lakes identified on the EPA Water Maps within the study area.

Identified surface water features

3.6.8 The summary details of the surface water courses from the desktop mapping and walkover survey are shown in Table 4**.**

Table 4 Summary of surface water features along the OES study area

Sectors	Watercourse features/Hydromorphology
OES study area	
Landfall	▪ Located to the south of the Shanganagh River and Shanganagh WWTP.
Sector 1	▪ This section of the study area is located to the south of and crosses, the Shanganagh River. ▪ There is a small stream culvert at the crossing point on the Shanganagh River which runs from the Rathsallagh housing estate area to the south. This culvert was identified from the walkover survey. ▪ Discussions between the Applicant and DLRCC have identified that consideration is being given to dredging this section of river as part flood alleviation measures in the area (Deansgrange Flood Relief Scheme). Plate 1 Shanganagh River crossing point with small drainage culvert located beneath railings on bank:

Sectors	Watercourse features/Hydromorphology
	
Sector 2	▪ Sector 2 crosses over the Kill-o-the Grange Stream at Achill Road and running parallel to the stream on its northern side for approximately 200 m before crossing over the stream again and travelling along the south-western edge of Loughlinstown Linear Park. ▪ As part of the Glenavon Park storage project a flood storage area will be provided at Glenavon Park. The proposed onshore ECR will pass around the southern edge of the proposed flood storage area. Plate 2 Stream Channel at crossing point at Achill Road:

Sectors	Watercourse features/Hydromorphology
	
Sector 3	▪ The Carrickmines Stream goes under the Wyattville Road (R118) flyover and along aside the N11 road for a short distance before passing under the N11 road at Loughlinstown. Plate 3 Carrickmines Stream beneath the Wyattville Road (R118) flyover: 
Sector 4	▪ Sector 4 crosses the Lehaunstown stream, which is a tributary of the Carrickmines Stream. The stream runs under the M50 at this location.

Sectors	Watercourse features/Hydromorphology
Sector 7	▪ Sector 7 includes the Jamestown 10 and Glenamuck North streams, which are located south of Carrickmines Retail Park.
OSS	▪ The proposed location for the OSS at Ballyogan is located on the southern side of the Carrickmines Stream. Plate 4 Carrickmines Stream immediately downstream of the Ballyogan Culvert at start adjacent to the OSS site:  ▪ There are a number of surface water features adjacent to the OSS within the former Ballyogan Landfill Facility including the stream channel itself, a settlement/attenuation pond for storm runoff from the recycling centre at Ballyogan and treatment ponds for dirty water runoff from the recycling centre. ▪ The treated runoff from the recycling centre goes to the stream.
Grid Connection	▪ This sector runs from the proposed OSS location to the Carrickmines GCP at Ballyogan crossing the Carrickmines stream. The stream is culverted for c. 270 m beneath the former landfill site at this point. Plate 5 Culvert outfall along proposed access road to OSS:

Sectors	Watercourse features/Hydromorphology
	
Leopardstown TCC	▪ The western corner of the TCC it is adjacent to the Carrickmines Stream, that is culverted in this location (to pass beneath the Leopardstown Racecourse Access Road and the light rail LUAS line).
O&M Base study area	
O&M Base	▪ The operations and maintenance building for the development is proposed to be located at St. Michael's Pier in Dún Laoghaire Harbour. There are no rivers, streams or lakes identified on the EPA Water Maps within the study area, however the site is adjacent to the Dublin Bay coastal waterbody.

3.7 Surface water abstractions

OES study area

3.7.1 The available EPA online maps do not indicate the presence of any surface water abstractions at or downstream of the study area, either for drinking water purposes or any other uses.

3.7.2 Shanganagh River is designated as a drinking water river under Article 7 - Abstraction for Drinking Water, of the WFD, and the river was delineated as a drinking water river in accordance with European Communities (Drinking Water) (No. 2) Regulations 2007 (SI no. 278/2007).

3.7.3 The Shanganagh River is designated for drinking water abstraction under DLRCC Drinking Water Zones 3 & 5 which covers Ballyedmonduff and Kilternan Water Treatment Plants local supplies only. Both Ballyedmonduff and Kilternan Water Treatment Plants were formerly supplied by the headwaters of the Shanganagh River, hence the entire length of the river was delineated as a drinking water river in accordance with the 2007 regulations (SI no. 278/2007).

3.7.4 The Ballyedmonduff and Kilternan Water Treatment Plants are understood to no longer be in use, and therefore do not abstract any water from the headwaters of the Shanganagh River for local supplies and instead Dún Laoghaire-Rathdown Supply Zones 3 & 5 are supplied with treated water from Stillorgan Reservoir.

3.7.5 Although the local drinking water treatment plants at Ballyedmonduff and Kilternan are no longer used the Shanganagh River remains designated for drinking water abstraction.

O&M Base

3.7.6 The available EPA online maps do not indicate the presence of any surface water abstractions at or downstream of the study area, either for drinking water purposes or any other uses.

3.7.7 There are no surface waters in the vicinity of the proposed O&M Base designated as drinking water protected features.

3.8 Surface water quality

3.8.1 Information on waterbodies, including data on quality including the chemistry, macroinvertebrates, plants, fish and hydromorphology is collected under the WFD is assessed and this information provides details on the overall status of individual water bodies. The WFD classification scheme for water quality based on five status classes, High, Good, Moderate, Poor and Bad depending on the assessment of the quality information and details on the overall status of individual water bodies.

3.8.2 High status is defined as the biological, chemical and morphological conditions associated with no or very low human pressure and this is the 'reference condition' as it is the best status achievable for any waterbody.

3.8.3 The quality of a waterbody is then assessed based on the extent of deviation from the reference conditions, following the definitions in the WFD: Good status means 'slight' deviation, 'moderate status' means 'moderate' deviation. Waters achieving a status below moderate are classified as Poor or Bad.

OES study area

3.8.4 The EPA water quality (Q) monitoring locations in the study areas are shown on Figure 4 and Figure 5. The water quality monitoring indicates that the Shanganagh River has a water quality Q values of Good to Poor, whilst the Kill-o-the-Grange Stream has an EPA water quality Q values of Poor. The Carrickmines Stream at Carrickmines Bridge has a Q value of Poor; there is no Q value water quality monitoring points on the Carrickmines Stream near Ballyogan and the OSS.

3.8.5 The EPA Water maps indicate that the Carrickmines River and Kill-o-the Grange Stream have river urban runoff pressures. Urban runoff pressures are often due to combined sewer overflows between foul and surface water lines where foul water can enter the surface water drainage system and is discharged to surface watercourses.

3.8.6 EPA surface water quality data from 2007 to 2024 was obtained for the following locations on the Kill-o-the Grange Stream and the Shanganagh River:

- Kill-o-the Grange Stream at Meadowvale Bridge (sample location no. RS10K020200) and Killiney Hill Road (sample location no. RS10K020500); and
- Shanganagh River at Commons Road (sample location no. RS10S010600) and Brides Glen (sample location no. RS10S010460).

3.8.7 The sample locations are shown on Figure 4 and Figure 5 and the summary water quality results at each of the sample locations, including minimum, average and maximum recorded values, are shown in Annex 1.

3.8.8 The surface water quality in the Kill-o-the-Grange Stream is hard ($CaCO_3$) with elevated ortho-phosphate, Ammonia, Conductivity and Biochemical Oxygen Demand (BOD) reflecting the predominantly urban nature of this catchment, see results in Annex 1.

3.8.9 The surface water quality in the Shanganagh River is moderately hard ($CaCO_3$) while the ortho-phosphate, Ammonia, Conductivity and BOD are good and reflecting the predominantly rural nature of the catchment at Brides Glen, and to a lesser extent at Commons Road which includes more flow from areas of urban land use, see Annex 1.

3.8.10 The water quality and status of the three catchments: the Shanganagh; Carrickmines; and Kill-o-the Grange catchments, and risks to the rivers are set out in the EPA (2018) report (10 Ovoca-Vartry Catchment Summary WFD Cycle 2.pdf) for the Ovoca Vartry catchment assessment.

3.8.11 The EPA catchment assessment report indicates that there was an improvement in the status of the Shanganagh River, while the Carrickmines and Kill-o-the-Grange streams status stayed the same for the period 2007-2009 to 2010-2015 and are at risk of not achieving their environmental objectives. The Shanganagh River is classified as having Good water quality and not at risk under the WFD 2016 - 2021 (https://www.catchments.ie/), whilst the Kill-o-the-Grange Stream is reported to have Poor water quality and is at risk under WFD 2016 - 2021.

3.8.12 The EPA catchment assessment report indicates that hydromorphology, principally the presence of culverted sections of channel, and the Urban Wastewater agglomeration network are both significant pressures on the Kill-o-the-Grange stream, and for both the Carrickmines and Kill-o-the-Grange streams diffuse urban pressures caused by misconnections, leaking sewers and runoff from paved and unpaved areas, have been identified as significant pressures.

O&M Base

3.8.13 There are no EPA monitoring stations reporting river Q values within the vicinity of the O&M Base study area. The Dublin Bay coastal waterbody has 'Good' water quality status and is not at risk under the WFD 2016 - 2021.

3.9 Surface water levels and flows

OES study area

3.9.1 There are four active EPA hydrometric stations in the of the OES study area, on the EPA website (HydroNet). The stations are:

- Glenavon, Kill-o-the Grange Stream Stn. No. 10047 - water level only;
- Commons Road, Shanganagh River Stn. No. 10021 - water level and flow;
- Brides Glen, Shanganagh River Stn. No. 10056 - water level only; and
- Cherrywood, Loughlinstown Stn. No. 10048 - water level only.

3.9.2 The locations of these monitoring stations are shown on Figure 4 and Figure 5.

3.9.3 The stations record water level change and flow or discharge is also record at the Commons Road station. The data is publicly available on the EPA hydronet website.

3.9.4 There is an inactive station at Carrickmines:

- Carrickmines Stn. No. 10022 was located on the Carrickmines Stream at Carrickmines.

3.9.5 Flows were reported for the Carrickmines station up until 2005, no flow data is available for the station since.

3.9.6 Surface water flow is estimated for ungauged catchments using the EPA ungauged catchment Hydrotool for the Kill-o-the-Grange Stream catchment and the Shanganagh River Catchment including the Carrickmines Stream. The data results for the ungauged catchments include naturalised mean monthly flows (MMF).

3.9.7 The Kill-o-the-Grange catchment is c. 6.68 km^2 and has an estimated mean annual flow of c. 0.11 m^3/s, the highest flow is January with MMF of c. 0.18 m^3/s and the lowest flow is during September with MMF of c. 0.04 m^3/s, see Chart 1 below.

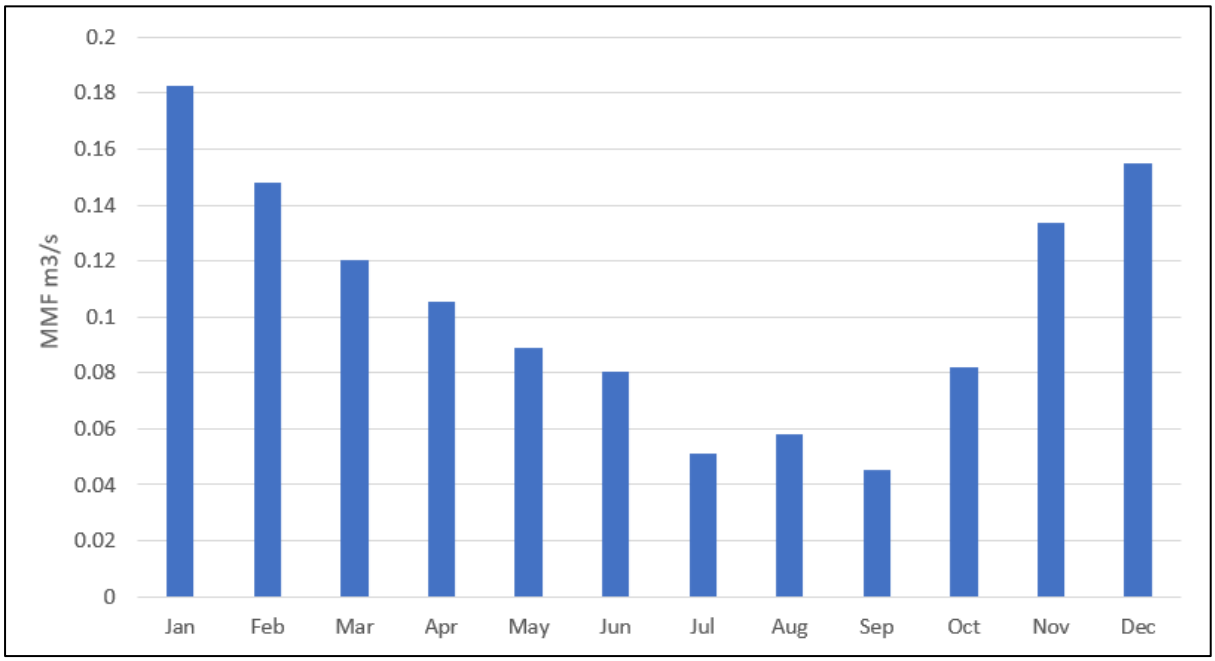


Chart 1 Estimated mean monthly flows for the Kill-o-the-Grange Stream

3.9.8 The Shanganagh catchment, including the Carrickmines Stream catchment, is c. 33.24 km^2 and has an estimated mean annual flow of c. 0.49 m^3/s, the highest flow is January with MMF of c. 0.82 m^3/s and the lowest flow is during September with MMF of c. 0.18 m^3/s, see Chart 2.

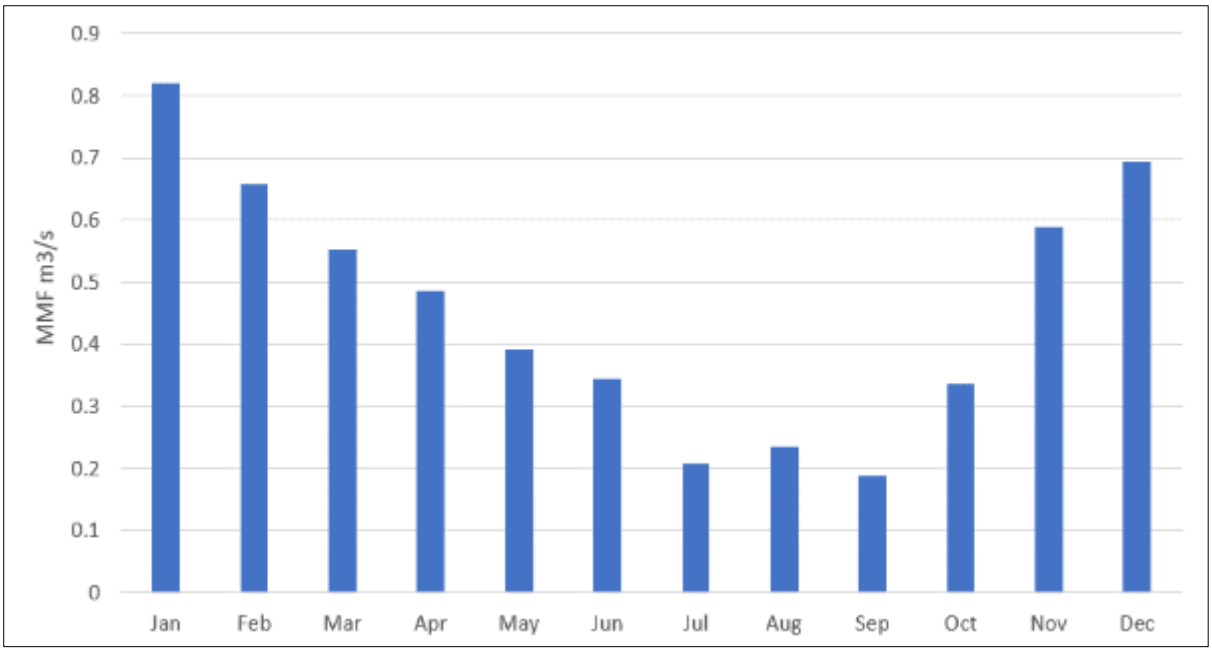


Chart 2 Estimated mean monthly flows for the Shanganagh River Catchment including the Carrickmines Stream

3.9.9 Flow data for the Shanganagh River gauge station at Commons Road (Stn. No. 10021), is available on the OPW Flood Studies Update (FSU) portal; the Q_{MED} flow at the gauge station is reported as 7.36 m^3/s. The Q_{MED} flow is the flood with a return period of 2 years and is approximately equivalent to the channel bankfull flow.

3.9.10 The Kill-o-the-Grange Stream catchment is ungauged and the ungauged catchment estimated Q_{MED} is 2 m^3/s (urban estimate) on the OPW FSU portal.

3.9.11 The mean flow information indicated in Chart 1 and Chart 2 above indicate increased stream flows during the period from November to March with the lowest flows during July, August and September. The stream flows are influenced not only by rainfall but by soil moisture deficits and both evaporation and evapotranspiration in the catchments.

3.9.12 Flooding can occur at any time of year and can be caused by a range of factors. While flows are higher during the autumn and winter, flooding can also occur during summer months due to intense storm events.

O&M Base

3.9.13 There are no surface waters in the vicinity of the O&M Base with EPA monitoring stations. There are several coastal monitoring stations in Dublin Bay owned by the EPA and DLRCC.

3.9.14 There is one hydrometric gauge within the study area named Dún Laoghaire (9061). The station historically recorded water levels only, however it is no longer active.

3.10 Flood risk

OES study area

3.10.1 A Flood Risk Assessment (FRA) has been undertaken for the OES, see Volume 6, Technical Appendix 6.5.4-2: Flood Risk Assessment for the Dublin Array OES (December 2024) (hereafter referred to as the OES FRA). The FRA comprised a Stage 1 and Stage 2 Assessment and was undertaken with regard to the 'The Planning System and Flood Risk Management Guidelines for Planning Authorities' (2009).

O&M Base

3.10.2 An FRA report was undertaken for the O&M Base by Waterman Moylan Consulting Engineers see Volume 6, Appendix 6.5.4-3: Flood Risk Assessment for the Dublin Array O&M Base (October 2023) (hereafter referred to as the O&M Base FRA).

3.10.3 Reference should be made to these reports for a description of the potential for flooding within the study areas.

3.11 Groundwater resources

OES study area and O&M Base

3.11.1 The bedrock aquifers, or groundwater resources, from the GSI are shown in Figure 7, within the study area. The bedrock aquifer type reflects the underlying geology throughout the study areas and are summarised in Table 5.

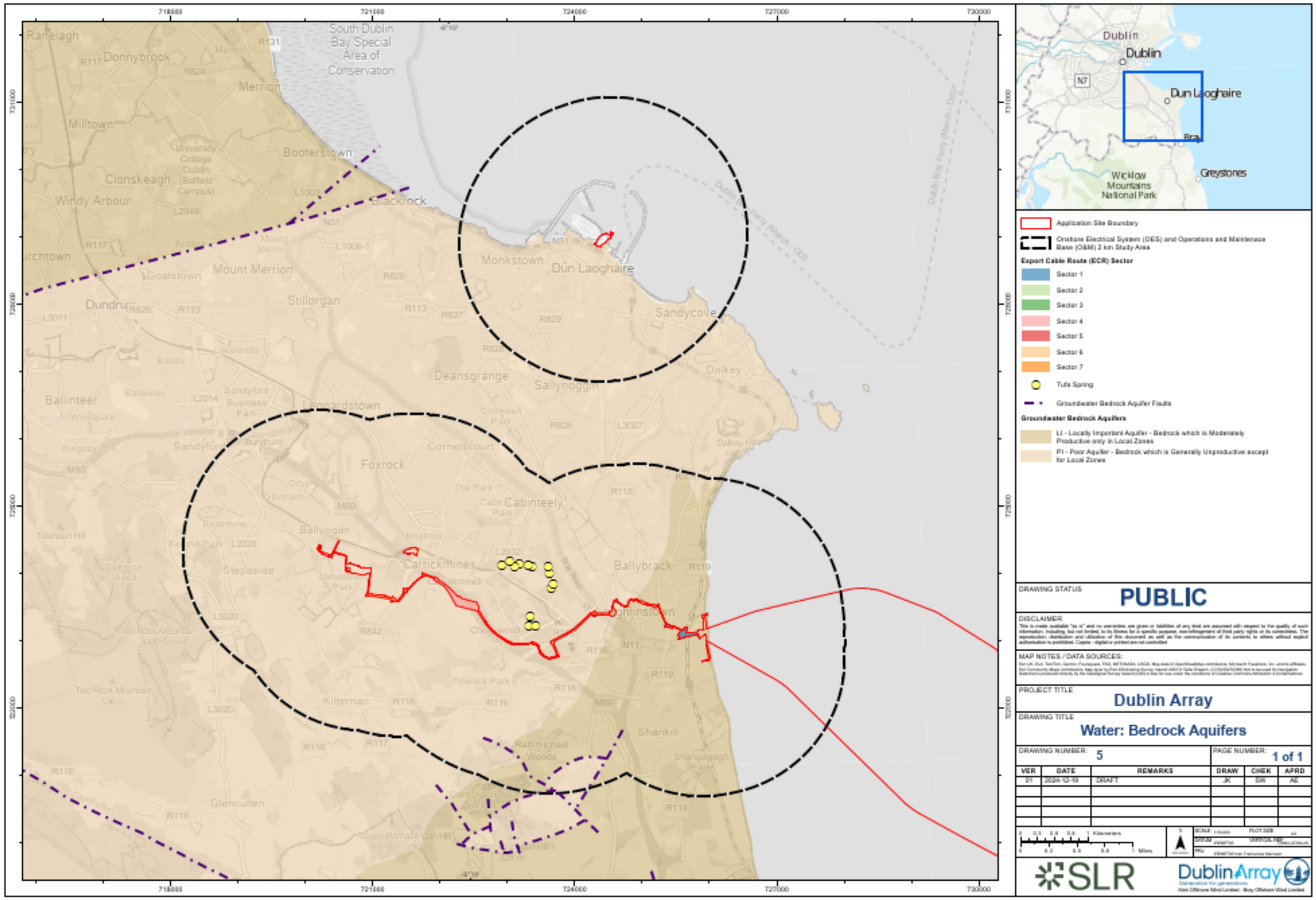
Table 5 Bedrock Aquifers underlying the study areas

Study area sector	Bedrock aquifer
OES study area	
Landfall and Sector 1	▪ The study area is underlain by metamorphic rocks from the Maulin Formation which are classified as a Locally Important Aquifer (LI) - Bedrock which is Moderately Productive only in Local Zones.
Sector 2	▪ The initial part of Sector 2 is underlain by both Locally Important and Poor Aquifers.
Sectors 2 to 7 OSS and grid connection Leopardstown TCC	▪ This part of the study area is underlain by igneous granite rocks which are classified as Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones.
O&M Base study area	

Study area sector	Bedrock aquifer
O&M Base	▪ The O&M Base study area is underlain by igneous granite rocks which are classified as Poor Aquifer - Bedrock which is Generally Unproductive except for Local Zones.

3.11.2 The groundwater resources available depend on the nature of the geology and the bedrock aquifer. Aquifers can only provide a sustainable supply or resource, where geological conditions permit. Poor aquifers and Locally Important aquifers are generally not suitable to provide a sustainable groundwater supply and hence a resource.

Figure 7 Bedrock aquifers



3.12 Groundwater bodies

OES study area

3.12.1 The study area is in the northern part of the Wicklow Ground Water Body (GWB). Initial characterisations of the GWBs have been developed by the GSI, see **Annex 2**. A summary of the groundwater body descriptions is included here.

3.12.2 Groundwater flow within the GWB occurs mostly in a shallow upper weathered zone. Deeper groundwater flow is possible along fractures, joints and major faults. Groundwater recharge occurs diffusely through the subsoils and via outcrops. There are large areas where the rock is close to surface, which would suggest high potential recharge values, but calculations must consider the effect of rejected recharge from the lower permeability rocks.

3.12.3 The aquifers within the GWB are generally unconfined but may become locally confined where the subsoil is thicker and/or of lower permeability. Groundwater flow is considered to recharge and discharge on a local scale. Drainage density values suggest shorter flow paths in the granites than on the flatter Lower Palaeozoic's.

3.12.4 Groundwater discharges to the numerous small streams crossing the aquifers, to springs and seeps and also directly to the Irish Sea.

3.12.5 The groundwater body status and risks in the study area are set out in the EPA (2018) report for the Avoca Vartry catchment assessment and is assessed as being of Good Status, except at the Industrial Emissions Licence (IE Ref. No. P0019-02) site on Pottery Road, Dún Laoghaire, which is in the Kill-o-the-Grange catchment. The groundwater beneath this site is classified as being of Poor Status and the groundwater is considered to be at risk at the industrial site.

3.12.6 Groundwater monitoring is undertaken by DLRCC at the former Ballyogan Landfill Facility, which is adjacent to the OSS site and the Carrickmines GCP substation. The monitoring is undertaken in compliance with the requirements of the EPA Waste Licence for the Ballyogan Landfill Facility and Recycling Park (W00015-01), and groundwater quality and level monitoring is undertaken at the site on a biannual basis.

3.12.7 Monitoring at the Ballyogan site includes 18 no. groundwater monitoring boreholes both upgradient and downgradient of the landfill area. Five of the groundwater monitoring wells are located around the perimeter of the proposed OSS site, between the landfill facility and the existing Carrickmines 220 kV substation site.

3.12.8 The 2019 Q3-Q4 groundwater monitoring report indicated that groundwater conditions downgradient of the landfill had not been altered in any significant manner as a result of the landfilling activities.

O&M Base

3.12.9 The study area is in the northern part of the Kilcullen GWB. Initial characterisations of the GWBs have been developed by the GSI and augmented by the River Basin District (RBD) consultants and are presented in Annex 2. A summary of the groundwater body descriptions is included here.

3.12.10 The majority of groundwater flow will occur in the top couple of metres. This flow is mostly in along a weathered zone in a lateral direction towards rivers and springs. In some instances, a greater degree of structural deformation may provide a fracture network, which will allow groundwater movement at greater depths. Only flow in isolated fractures is expected below 30 m.

3.12.11 The dominant recharge process in this area will be diffuse recharge from water percolating through the overlying tills and into the aquifer. High rates of potential recharge are expected in the hilly areas where there are very thin subsoils and high rainfall. A large portion of this potential recharge will be rejected because the rocks in this area are considered to be poor aquifers and hence do not have a high enough storativity to accept all the water. Therefore, the runoff component to streams will be higher, this must be taken into account when recharge calculations are being considered. An indication of this process can be seen in the very high drainage density in the area. The drainage density is higher in the Granites (1.232 km/km^2) and a higher proportion of potential recharge will enter the aquifer over this rock type.

3.12.12 Discharge via springs at the break of slopes located at the foot of hills throughout the area. The GWB will also discharge to the overlying streams and rivers as baseflow. The proportion of river flow that is baseflow will vary throughout the area.

3.12.13 The O&M Base is located on made ground, St. Michaels Pier, within Dún Laoghaire Harbour and therefore the is no groundwater at this site. Any groundwater beneath the urban area of Dún Laoghaire will discharge to the sea. There are no identified groundwater springs in the study area.

3.13 Groundwater vulnerability

OES study area and O&M Base

3.13.1 The GSI has developed a groundwater vulnerability classification for Ireland. The groundwater vulnerability at a particular point can be determined based on the natural geological and hydrogeological characteristics at that point. The vulnerability depends on the nature of the subsoils (i.e. their permeability characteristics), the type of recharge (point or diffuse) and the thickness of the unsaturated zone (depth to groundwater).

3.13.2 The GSI groundwater vulnerability mapping is presented in Figure 8 below and shows the study area to be classified as the following vulnerability shown in Table 6 below.

Table 6 Groundwater vulnerability underlying the OES and O&M Base study areas

Study area sector	Groundwater vulnerability classification
OES study area	
Landfall	▪ Low vulnerability
Sector 1	▪ Low vulnerability
Sector 2	▪ Low vulnerability
Sector 3	▪ Moderate to High vulnerability with small area of Extreme vulnerability
Sectors 4, 5 and 6	▪ High to Extreme vulnerability
OSS Grid connection Leopardstown TCC	▪ High vulnerability
O&M Base study area	
O&M Base	▪ Moderate to High vulnerability with a small section of Extreme vulnerability within study area

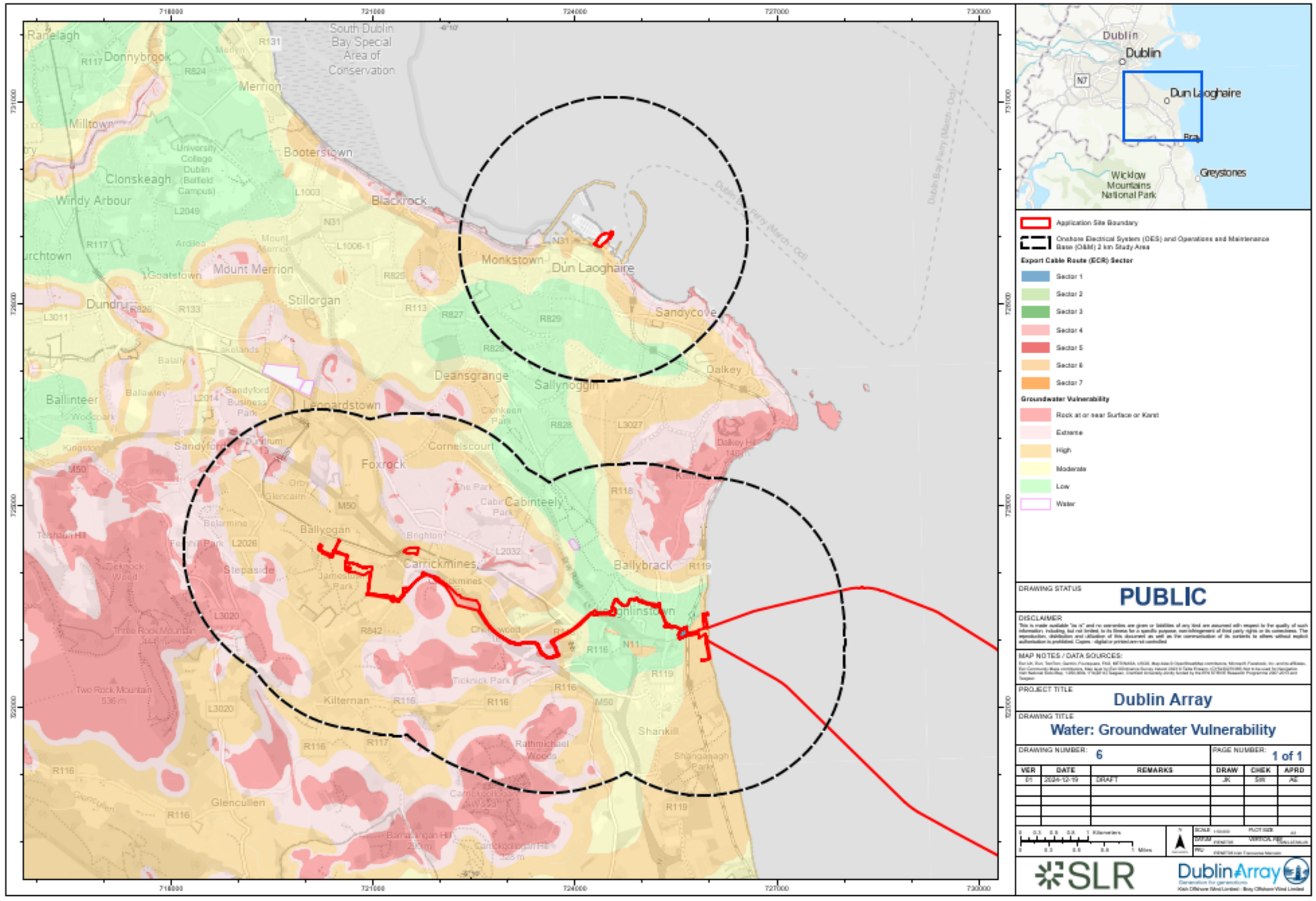
3.13.3 The GSI groundwater vulnerability rating classification is outlined in Table 7 below.

Table 7 GSI vulnerability rating classification

Vulnerability rating	Hydrogeological conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (e.g. 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)	0-3.0 m	0-3.0 m	0-3.0 m	0-3.0 m	-
High (H)	>3.0 m	3.0-10.0 m	3.0-5.0 m	>3.0 m	N/A
Moderate (M)	N/A	>10.0 m	5.0-10.0 m	N/A	N/A
Low (L)	N/A	N/A	>10.0 m	N/A	N/A
Notes: (i) N/A= not applicable (ii) Precise permeability value cannot be given at present. (iii) Release point of contaminants is assumed to be 1-2 m below ground surface.					

3.13.4 The potential impact on groundwater quality arising from human activities increases as the groundwater vulnerability rating increases from Low to Extreme. Any development activities must recognise where the risk to groundwater is greatest and provide measures to mitigate against any potential impacts.

Figure 8 Groundwater vulnerability



3.14 Groundwater recharge

OES study area

3.14.1 The GSI Groundwater Recharge map shows the average groundwater recharge rates across Ireland. The rates of groundwater recharge depend on a number of factors; however the principal one is the type of ground subsoils present.

3.14.2 Average groundwater recharge rates across areas of sandy coastal sand material is of the order of 200 mm/yr.

3.14.3 Average groundwater recharge rates across areas of low permeability alluvium and Irish Sea Glacial till material is low, of the order of 48 mm/yr.

3.14.4 Across urban areas with made ground within the study area the average groundwater recharge rates are of the order of 100 mm/yr to 128 mm/yr.

3.14.5 Average groundwater recharge rates across areas of glacial till material within the study area are of the order of 100 mm/yr.

O&M Base

3.14.6 There is no groundwater at the O&M Base on St. Michael's Pier in Dún Laoghaire Harbour. Within the wider study area at the O&M Base there will be little groundwater recharge across the urban area of Dún Laoghaire as the majority of rainfall will runoff via existing urban storm water drainage systems.

3.15 Tufa springs at Cherrywood

OES study area

3.15.1 Tufa springs have been identified to the north of the proposed onshore ECR on the sides of Druid Valley, in both hydrogeology and ecology reports relating to development proposals in the Cherrywood Strategic Development Zone (SDZ) (see Figure 7). It is understood that the springs are fed by localised permeable limestone deposits within the glacial till subsoil deposit. The groundwater flow paths are expected to be relatively short within the subsoil deposit. The proposed onshore ECR (Section 4) is c. 400 m to the south of the identified tufa springs at Druids Valley.

3.16 Groundwater abstraction and wells

3.16.1 The GSI online database of wells was reviewed and shows the presence of one groundwater borehole within the study area ay Cherrywood, see details below. There are no wells or springs identified in the O&M Base study area.

3.16.2 The groundwater supply borehole GSI reference number is 3221NWW003. The borehole was drilled in 1994 to a depth of 61 m and the depth to rock is 39.5 m. The GSI yield class is good, with 220 m^3/d reported. There are no reported details of the use of the well. Given the ongoing construction in the Cherrywood area, it is considered unlikely that this borehole is still in existence.

3.16.3 There are no groundwater supply well source protection zones within the study area.

3.17 Protected areas

3.17.1 For the OES study area, the Shanganagh River is designated as a drinking water abstraction river however it is understood that this designation is outdated as the river is no longer used for drinking water abstraction for either the Kilternan or Ballyedmonduff public water supplies.

3.17.2 For the O&M Base study area, the Kilcullen GWB is designated as a drinking water abstraction groundwater body.

3.17.3 Volume 6, Appendix 6.5.2-1: Biodiversity Technical Baseline Report provides details of sites protected for nature conservation.

3.18 Water Framework Directive

3.18.1 The EU (European Union) Water Framework Directive (WFD) became EU law in December 2000 and provides for a single European framework to assess water quality (Ecological status) and allows for the comparison of results across European Member States. The WFD covers rivers, lakes, estuaries or transitional waters, coastal waters as well as groundwaters. Background summary details on the WFD are presented in **Annex 3** for information purposes.

OES study area

3.18.2 The OES study area falls within the Dargle_SC_010 sub-catchment (10_5) of the wider Ovoca-Vartry Catchment Area (10).

3.18.3 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 1,247 km^2. The largest urban centre in the catchment is Bray. The other main urban centres in this catchment are Dún Laoghaire-Rathdown, Arklow, Wicklow Town, Rathnew, Newtown Mount Kennedy, Greystones, Delgany and Kilcoole. The total population of the catchment is approximately 179,100 with a population density of 144 people per km^2. The higher areas of the Wicklow Mountains are underlain by granite bedrock while metamorphic slates and quartzites underly the eastern coastal part of the catchment.

3.18.4 The Dargle_SC_010 sub-catchment covers an area of 176.94 km^2, with the study area located to the north of the sub-catchment area. There are eleven rivers, two lakes, one coastal waterbody, one transitional waterbody and four groundwater bodies located within the sub-catchment.

3.18.5 The majority of the rivers and lakes in the sub-catchment have Good to High water quality status under the WFD 2016 – 2021. The surface waterbodies in the study area include the SHANGANAGH_010, the CARRICKMINES STREAM_010 and the KILL OF THE GRANGE STREAM_010, all of which are river waterbodies. The Shanganagh and Carrickmines rivers are classified as having Good water quality and are not at risk under the WFD 2016 - 2021. However, the Kill o' the Grange Stream is reported to have Poor water quality and is at risk under the WFD 2016 - 2021.

3.18.6 The groundwater body underlying the study area is the Wicklow GWB. The GWB is reported to have Good water quality but is at risk under the WFD 2016 - 2021.

3.18.7 The Southwestern Irish Sea - Killiney Bay coastal waterbody runs along the eastern coastline and border of this sub-catchment. The coastal waterbody is reported to have High water quality and is not at risk under the WFD 2016 - 2021.

O&M Base

3.18.8 The O&M Base study area falls within the Dodder_SC_010 sub-catchment (09_16), of the wider Liffey and Dublin Bay Catchment (09), and the study area includes the Dublin Bay coastal waterbody.

3.18.9 This catchment includes the area drained by the River Liffey and by all streams entering tidal water between Sea Mount and Sorrento Point, Co. Dublin, draining a total area of 1,616 km^2. The largest urban centre in the catchment is Dublin City. The other main urban centres are Dun Laoghaire, Lucan, Clonee, Dunboyne, Leixlip, Maynooth, Kilcock, Celbridge, Newcastle, Rathcoole, Clane, Kill, Sallins, Johnstown, Naas, Newbridge, Athgarvan, Kilcullen and Blessington. The total population of the catchment is approximately 1,255,000. The Liffey catchment contains the largest population of any catchment in Ireland and is characterised by a sparsely populated, upland Southeastern area underlain by granites and a densely populated, flat, low lying limestone area over the remainder of the catchment basin.

3.18.10 The Dargle_SC_010 sub-catchment covers an area of 167.77 km^2, with the study area located in the Eastern most section of the sub-catchment area. There are ten rivers, two lakes, three coastal waterbodies, two transitional waterbodies and four groundwater bodies located within the sub-catchment.

3.18.11 There are no rivers, streams or lakes identified on the EPA Water Maps within the study area. The closest river to the study area is the BREWERY STREAM_010, which is currently under review with Poor water quality reported for the WFD 2016 - 2021.

3.18.12 The Dublin Bay coastal waterbody surrounds the study area at Dún Laoghaire Harbour. The waterbody is reported to have Good water quality and is not at risk under the WFD 2016 - 2021.

3.18.13 The groundwater body underlying the study area is the Kilcullen GWB. The GWB is reported to have Good water quality but is at risk under the WFD 2016 - 2021. The GWB is also a designated drinking water protected feature.

3.19 Identified environmental receptors – water

OES study area

3.19.1 The following sensitive receptors have been identified in the receiving environment:

- Watercourses, including the Shanganagh River, Carrickmines Stream and the Kill-o-the-Grange Stream and their tributaries;
- Storm water flood alleviation measures along the Kill-o-the-Grange stream; and
- Underlying Locally Important and Poorly Productive aquifers.

O&M Base

3.19.2 The following sensitive receptors have been identified in the receiving environment:

- Coastal waters.

4 Future receiving environment

4.1.1 Clean water is an important natural resource and is essential for wildlife, human health and the economy; however, there are existing and ongoing pressures on this vital resource from a range of sources, including agriculture, hydromorphology, urban wastewater, forestry domestic wastewater, urban runoff, industry and mines & quarries (EPA, 2019). These pressures on water quality and quantity will continue in the future if not addressed through targeted mitigation measures, either for existing pressures or also new development.

4.1.2 The 'Water Quality in 2023 - An Indicators Report' by the Environmental Protection Agency (EPA, 2024) provides an update on the quality of Ireland's rivers, lakes, transitional and coastal waters, and groundwater using data collected in 2023. The report highlights key indicators of water quality, including biological quality and nutrient levels. It sets out that over the period 2020 to 2023, 55% of river water bodies were classified as high or good biological quality, while 45% were moderate, poor, or bad.

4.1.3 The EPA aims to maintain high and good status waters and prevent deterioration, aligning with the objectives of the WFD and the River Basin Management Plan (RBMP) for Ireland 2022-2027 (Department of Housing, Local Government and Heritage, 2024).

4.1.4 The aim of the WFD is to maintain high and good status waters where they exist and prevent deterioration of status in all waters. This aim is achieved through the monitoring of the existing environment and the identification of the critical pressures on water quality and the development and implementation of mitigation measures to maintain high and good status where it is currently achieved and to improve those waterbodies whose current status is moderate or poor, to at least good and at best high status.

4.1.5 The current RBMP for Ireland for 2022-2027 outlines the approach to protect rivers, lakes, estuaries and coastal waters. The plan uses an evidence-based approach to underpin the plan decision-making, at both the national and local levels, and new initiatives and policies will be implemented to address the water-quality challenges in Ireland.

4.1.6 The current RBMP states with the effective implementation of the plan actions and measures will result in an improvement in water quality in over seven hundred water bodies across the country. Actions and measures include changes in agricultural approaches and an increase in urban waste-water treatment which it is stated should lead to reduced pollution pressures.

4.1.7 The following priorities are adopted in the current RBMP to:

- Ensure full compliance with relevant EU legislation;
- Prevent deterioration;

- Meet the objectives for designated protected areas; Protect high-status waters; and
- Implement targeted actions and pilot schemes in focused sub-catchments aimed at (1) targeting water bodies close to meeting their objective and (2) addressing more complex issues that will build knowledge for the third cycle.

4.1.8 The implementation of the policies and strategy in the current RBMP focuses on ensuring the full implementation of existing measures through the relevant national authorities and, where these measures are not sufficient to meet the objectives of the WFD, the implementation of targeted supporting measures.

5 Data gaps and uncertainties

5.1.1 This baseline report has been prepared based on existing available desktop information which is in the public domain, site walkover surveys and the professional expertise and knowledge of the authors.

5.1.2 Available flood risk information from published reports has been used here to indicate where flooding may occur, however the flood extent information referenced is based on the data and assumptions used to inform the relevant flood studies.

6 Summary

6.1.1 This baseline study describes the key surface water and groundwater attributes within a defined onshore study area using existing available desktop information which is in the public domain, site walkover surveys and the professional expertise and knowledge of the authors.

6.2 OES study area

6.2.1 There are a number of watercourses which run through the study area, the main ones being the Loughlinstown/Shanganagh River (referred to here as the Shanganagh River), the Kill-o-the-Grange Stream and the Carrickmines Stream. The Carrickmines Stream is a sub-catchment of the Shanganagh River.

6.2.2 The land use throughout the study area is predominantly urban with areas of parkland and open space particularly along the river valleys. Other land uses include amenity and transport comprising road and light-rail.

6.2.3 The surface watercourses within the study area have been significantly modified in the past; channels have been canalised and straightened with a loss of the natural floodplain. Significant sections of the watercourses have also been culverted, particularly along the Kill-o-the-Grange Stream at Kilbogget Park. The watercourse channels are considered to be of low sensitivity due to their hydromorphology.

6.2.4 The Shanganagh River is designated for drinking water abstraction although it is understood that there is no abstraction from the river for drinking water at present.

6.2.5 The EPA catchment assessment indicates that there was an improvement in the status of the Shanganagh River, while the Carrickmines and Kill-o-the-Grange streams status stayed the same and are at risk of not achieving their environmental objectives under the WFD.

6.2.6 Hydromorphology, principally the presence of culverts, and the Urban Wastewater agglomeration network are both significant pressures on the Kill-o-the-Grange stream, and for both the Carrickmines and Kill-o-the-Grange streams diffuse urban pressures, caused by misconnections, leaking sewers and runoff from paved and unpaved areas, have been identified as significant pressures on these waterbodies.

6.2.7 Flooding has the potential to occur at any time of year and can be caused by a range of factors. While watercourse flows are generally higher during the autumn and winter, flooding can also occur during summer months due to intense storm events.

6.2.8 The study area is within the Wicklow Groundwater Body (GWB) as designated under the WFD. The geology, both bedrock and subsoils, has implications for groundwater and the aquifer types which will vary depending on the geological characteristics.

6.2.9 Within the study area the bedrock aquifer is classified as a locally important aquifer (Ll) along the coastal area around Shanganagh and is classified as a Poor Aquifer across the remainder of the study area inland.

6.2.10 Poor aquifers and Locally Important aquifers are generally not suitable to provide a sustainable groundwater supply.

6.2.11 The groundwater is assessed as being of Good Status by the EPA across the study area, except for a small area associated with an Industrial Emissions Licence site located in the Kill-o-the-Grange catchment where the groundwater is of Poor Status and is considered to be at risk.

6.2.12 A number of Tufa springs have been identified in the vicinity of Cherrywood along the steep valley sides of the Druid Valley and Carrickmines Stream. The springs are fed by localised permeable limestone deposits within the glacial till subsoils.

6.2.13 Localised areas of Tufa spring formation appear to be supported by relatively shallow groundwater flow systems within permeable zones of the subsoil with the limestone parent material within the subsoil acting as the source of the calcium carbonate. The Tufa spring formation is limited to where the limestone parent material is present in the subsoils and where there is a groundwater flow and discharge such as at localised slope banks.

6.2.14 From the baseline review, the following sensitive hydrological and hydrogeological receptors have been identified in the receiving environment:

6.2.15 Rivers and Streams including the Shanganagh River, Carrickmines Stream and the Kill-o-the-Grange Stream:

- Underlying Locally Important and Poorly Productive aquifers;
- Areas of flood risk around proposed river crossings; and
- Tufa deposits identified in the Druids Glen area at Cherrywood.

6.3 O&M Base study area

6.3.1 The O&M Base is not located in a modelled Flood Zone a or Zone B. The adjacent car parking area to the west of the O&M building is shown to be vulnerable to wave overtopping from the local quay wall adjacent to the base in the DLRCC SFRA report.

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Annex1 WFD Summary Surface Water Quality Data

Shanganagh River - Commons Rd. (RS10S010600)	Unit	SW EQS	Minimum	Average	Maximum
Alkalinity-total (as CaCO3)	mg/l		113	184	216
Ammonia-Total (as N)	mg/l	≤0.065 AA	0.005	0.02	0.14
BOD - 5 days (Total)	mg/l	<1.5 AA	0.5	1.9	17
Chloride	mg/l		15	30	49.3
Conductivity @20Â°C	µS/cm		327	473	571
Dissolved Oxygen	% Saturation	80% to 120%	76	99	127
Dissolved Oxygen	mg/l		8.8	10.9	14
Nitrate (as N)	mg/l		0.790	1.724	2.680
Nitrate (as N)	mg/l		0.002	0.006	0.022
ortho-Phosphate (as P) - unspecified	mg/l	≤0.035 (MRP AA)	0.005	0.04	0.25
pH	pH units	6.0< pH <9.0	8.1	8.2	8.4
Sulphate	mg/l		14	25	45
Total Hardness (as CaCO3)	mg/l		136	222	269
Total Oxidised Nitrogen (as N)	mg/l		0.79	1.73	2.69
True Colour	Hazen		6	17.6	164
Shanganagh River - Heron Ford Lane (RS10S010460)	**Unit**	**SW EQS**	**Minimum**	**Average**	**Maximum**
Alkalinity-total (as CaCO3)	mg/l		79	170	217
Ammonia-Total (as N)	mg/l	≤0.065 AA	0.005	0.02	0.14
BOD - 5 days (Total)	mg/l	<1.5 AA	0.5	1.6	15
Chloride	mg/l		19	25	32
Conductivity @20Â°C	µS/cm		268	408	493
Dissolved Oxygen	% Saturation	80% to 120%	71	98	123
Dissolved Oxygen	mg/l		8.4	10.9	14
Nitrate (as N)	mg/l		0.910	1.706	2.800
Nitrate (as N)	mg/l		0.002	0.004	0.017
ortho-Phosphate (as P) - unspecified	mg/l	≤0.035 (MRP AA)	0.005	0.03	0.12
pH	pH units	6.0< pH <9.0	7.9	8.2	8.4
Sulphate	mg/l		11	15	23
Total Hardness (as CaCO3)	mg/l		116	201	258
Total Oxidised Nitrogen (as N)	mg/l		0.91	1.70	2.8
True Colour	Hazen		5	17.4	72

Kill-o-the-Grange Meadowvale Fb. (RS10K020200)	Unit	SW EQS	Minimum	Average	Maximum
Alkalinity-total (as CaCO3)	mg/l		42	207	266
Ammonia-Total (as N)	mg/l	≤0.065 AA	0.01	0.20	2.5
BOD - 5 days (Total)	mg/l	<1.5 AA	0.5	2.7	8.4
Chloride	mg/l		8	35	299
Conductivity @20Â°C	µS/cm		114	539	880
Dissolved Oxygen	% Saturation	80% to 120%	49	92	177
Dissolved Oxygen	mg/l		5.1	9.7	19.2
Nitrate (as N)	mg/l		0.46	2.794	5.34
ortho-Phosphate (as P) - unspecified	mg/l	≤0.035 (MRP AA)	0.05	0.13	0.66
pH	pH units	6.0< pH <9.0	7.4	8.0	8.7
Sulphate	mg/l		3	38	69
Total Hardness (as CaCO3)	mg/l		52	264	341
Total Oxidised Nitrogen (as N)	mg/l		0.48	2.89	5.36
True Colour	Hazen		0.5	7.8	36

Kill-o-the-Grange Stream - Killiney Hill Rd. Br. (RS10K020500)	Unit	SW EQS	Minimum	Average	Maximum
Alkalinity-total (as CaCO3)	mg/l		108	216	277
Ammonia-Total (as N)	mg/l	≤0.065 AA	0.02	0.24	0.89
BOD - 5 days (Total)	mg/l	<1.5 AA	0.5	2.8	12
Chloride	mg/l		13	32	76.5
Conductivity @20Â°C	µS/cm		278	559	772
Dissolved Oxygen	% Saturation	80% to 120%	63	94	123
Dissolved Oxygen	mg/l		7.1	10.1	12.7
Nitrate (as N)	mg/l		1.400	3.221	5.200
Nitrite (as N)	mg/l		0.005	0.072	0.339
ortho-Phosphate (as P) - unspecified	mg/l	≤0.035 (MRP AA)	0.014	0.07	0.21
pH	pH units	6.0< pH <9.0	7.8	8.1	8.4
Sulphate	mg/l		4	33	56
Total Hardness (as CaCO3)	mg/l		124	272	402
Total Oxidised Nitrogen (as N)	mg/l		1.43	3.33	5.2
True Colour	Hazen		2.5	10.1	27

Annex 2 Wicklow Groundwater Body – Summary of Initial Characterisation

Wicklow GWB: Summary of Initial Characterisation.

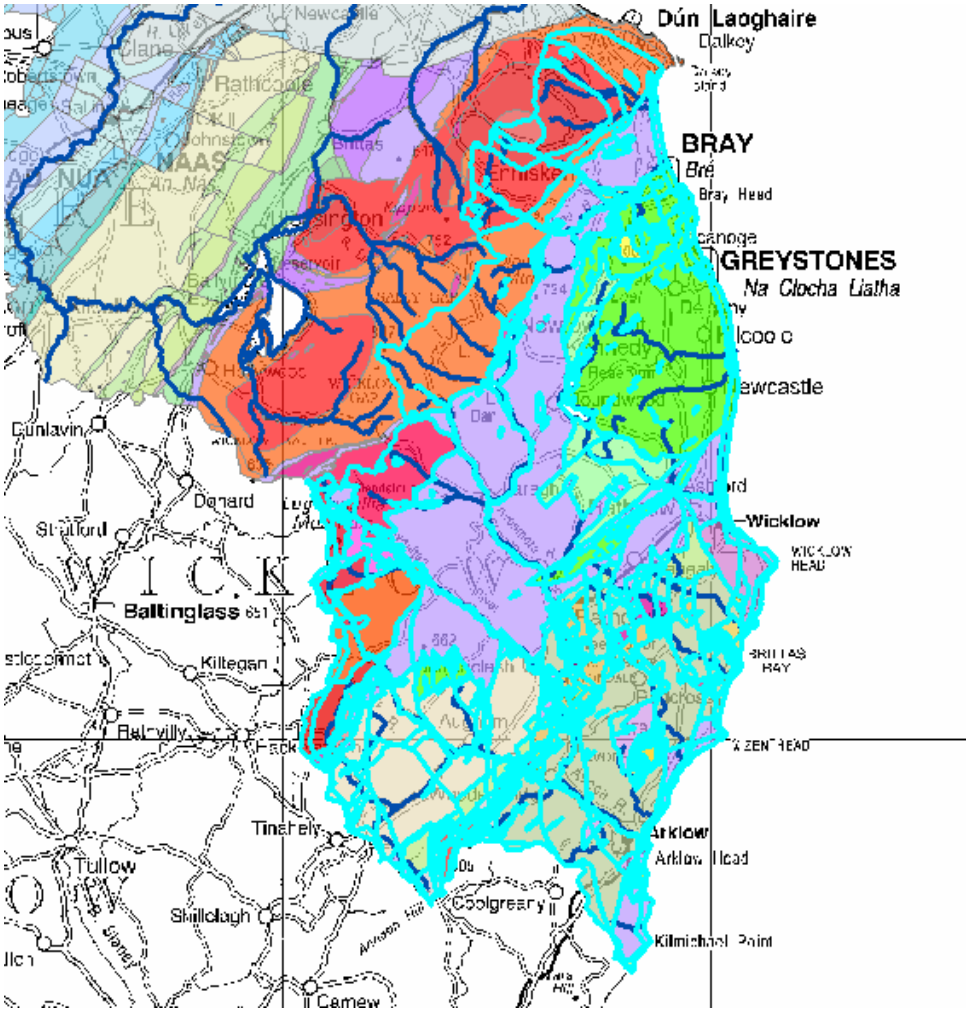
Hydrometric Area Local Authority		Associated surface water bodies	Associated terrestrial ecosystems	Area (km^2)
Hydrometric Area 10 Wicklow Co. Co. Wexford Co. Co. Dublin Co. Co.		Avoca, Aughrim, Avonbeg, Avonmore, Ballyduff stream, Cloghoge Brook Derry Water, Ow, Glenealy, Glendasan, Templerainy Stream, Redcross, Potters, Three Mile Water, Vartry, Newcastle, Newtownmountkennedy, Dargle, Glencullen, Glencree, Shanganagh, Kill-o-the Grange Stream.	Vartry Reservoir (1771); Avoca River Valley (1748); Avoca Town Marsh (1931); Buckroney - Brittas Dunes and Fen (SAC 729); Magherabeg Dunes (SAC 1766); Dalkey Coastal Zone and Killiney Hill (1206); Ballybetagh Bog (1202); Knocksink Wood (SAC 725); Kilmacanoge Marsh (724); Carriggower Bog (716); Powerscourt Waterfall (1767); Dargle River Valley (1754); The Murrough (730).	1396
Topography		This GWB is a large area within Co. Wicklow and a smaller area of Co. Dublin. The topography is mountainous, comprising the Wicklow and Dublin Mountains. Elevations range from sea level along the coast to high elevations along the western boundary between the Eastern and Southeastern RBDs with the highest peak of 840 m OD at Mullaghcleevaun.		
Geology and Aquifers	Aquifer type(s) Main aquifer lithologies	**Ll:** Locally important aquifer, moderately productive only in local zones **Pl:** Poor aquifer, generally unproductive except for local zones **Pu:** Poor aquifer, generally unproductive The Leinster Granites Ordovician Metasediments Cambrian Metasediments *Small amounts of* Ordovician Volcanics (0.7 %)		
	Key structures.	The Lower Paleozoic rocks have a complex geological history and comprise a large range of rock types including greywackes (turbidites), volcaniclastic sediments, lavas, shales, mudstones, quartzites and cherts. During the Ordovician the Iapetus Ocean began to close and volcanoes formed adjacent to the continental margins, giving rise to a complex suite of volcanic and deep-water sediments. As two continents collided, the accumulated sediments were squeezed up to form a chain of mountains (Caledonian Orogeny). These rocks are thus highly folded and faulted with several phases of deformation. Large granite plutons were intruded and the surrounding rocks have been metamorphosed on a regional scale, transforming the original shales and sandstones and giving the rocks their pervasive fabric or cleavage. There are varying degrees of rock deformation, which has influenced the bedrock permeability. Rocks deform mainly by folding and faulting; both of which are associated with fracturing and permeability development.		
	Key properties	The area includes varied hydrogeological settings. In general there are three main areas of consideration: the Granites are considered to be a Pl aquifer, the majority of the Ordovician metasediments are Ll, and the other Lower Paleozoic rocks are classified as Pl and Pu aquifers. In addition to the variety in these rock types, the topography is very varied, with mountainous granite areas in the west and areas of low-lying land towards the coast. The topographic slope will influence the hydraulic gradient in the aquifer, which in turn will influence the velocity and volume of groundwater flow. The Ordovician Metasediments are one of the better aquifers within this GWB and a number of small public supplies are abstracted from these rocks. GSI source protection reports have been written for the following two examples: The Roundwood public water supply is located in the Maulin Formation (Ordovician Metasediments). Pumping Tests from PW1 and 2 suggest a transmissivity of about 30 m^2/d. (Woods 2003) The underlying aquifer at Redcross, the Kilmacrea Formation (Ordovician Metasediments) is composed of fractured and weathered shales. Analysis of the 12 hour pumping test provided an apparent transmissivity of about 32 m^2/d. There is a probable zone of higher permeability close to the surface, and the permeability decreases with increasing depth below ground level. (Woods 2003)		
	Thickness	The majority of groundwater flow will occur in the top few metres. This flow is mostly in along a weathered zone in a lateral direction towards rivers and springs. In some instances a greater degree of structural deformation may provide a fracture network which will allow groundwater movement at greater depths. Only flow in isolated fractures is expected below 30m.		
Overlying Strata	Lithologies	Till ('boulder clay') is the most widespread subsoil in the groundwater body. Several types of till occur. South of Wicklow town the dominant type is Till derived from Lower Paleozoic rocks. There are some smaller areas of till derived from granites in the Western areas of the body and some gravel deposits along river channels. North of Wicklow there is a greater variety of till types, although the Lower Paleozoic and Granite till are still found along the central and western areas of the body respectively. There is greater variety in sediment deposition in the east of the body where there are areas of gravel deposits, tills derived from limestones and Irish Sea Till.		
	Thickness	The tills are very thin in mountainous areas. Thickness increases further down slope and also towards the southeast.		
	% Area aquifer near surface	High - there are large areas of outcrop present in the higher altitudes of the Wicklow Mts.		
	Groundwater Vulnerability	Mostly Extreme above 200mOD. Below this the vulnerability is mainly High with some smaller areas of Moderate and Low in places along the coast and southeast.		

Recharge	Main recharge mechanisms	The dominant recharge process will be diffuse recharge from water percolating through the overlying tills and into the aquifer. High rates of potential recharge are expected in the hilly areas where there are very thin subsoils and high rainfall. A large portion of this potential recharge will be rejected because the rocks in this area are considered to be poor aquifers with low storativity. In addition, the steep slopes in the area will increase surface runoff. Therefore the rapid runoff component to streams will be higher, which must be taken into account in recharge calculations. The very high drainage density in the area gives an indication of this. The drainage density is lower in the Lower Paleozoic rocks (0.687km/km^2) than in the Granites (1.021km/km^2).
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	Springs and large known abstractions	GSI Source Reports – Redcross (220), Roundwood (185) EPA Sources Register – Location (Abstraction (m^3/d)) Glencullen (Bore No. 3) (250), Glencullen (Bore No. 4) (100), Bulford Farm (70), Windgates/Templecarrig (70), Barndarrig (34), Ballycoogue (27), Johnstown/Thomastown (18), Kirikee (13), Thomastown, Ballycoogue, Brittas Bay (North), Laragh/Annamore PWS (@ Raheen) (374), Rathdrum (560), Knockananna (39), Aughrim/Annacurra (375),
	Main discharge mechanisms	Groundwater will discharge directly to the sea along the coast. The GWB will also discharge to the over lying streams and rivers as baseflow. The proportion of river flow that is baseflow will vary through out the area. Mountainous rivers have a "flashy" profile and rivers on slopes lower down have a flatter profile. The geomorphology also plays a role in defining the flow characteristics of the rivers. There are a large number of small springs in the area. These are located at the foot of hills at the break in slope, where the water table comes to the surface.
	Hydrochemical Signature	Five County Council sources located in the granite show that the groundwater is a calcium bicarbonate type and is **soft** to **moderately hard** (50–250 mg/l $CaCO_3$). Six Council sources sampled for the Ordovician Rocks (data also available for several other areas) show the groundwaters are generally of calcium bicarbonate type, and **soft** to **moderately soft** (20–80 mg/l $CaCO_3$). Some areas in east Wicklow, around Enniskerry and Ashford, show slightly higher hardness and alkalinity, probably because the overlying tills, sands and gravels include limestone clasts, which chemically alter the recharge. Low conductivity values 130 - 220
Groundwater Flow Paths		The majority of groundwater flow in this aquifer will take place in the upper 3m of the rocks. This will be lateral flow towards discharge point such rivers and streams. Deeper groundwater flow is possible and deep-water strikes are often encountered (between 10 and 40 m.b.g.l.) but they are more isolated features located along open fractures, which allow groundwater flow. Regional groundwater flow paths are not considered to develop, as the rocks do not have sufficient transmissivity to transport water over long distances. Typical groundwater flow paths will be in the order of a couple of hundred metres, with discharge occurring to the closest surface water feature.
Groundwater & surface water interactions		There will be highly varied groundwater and surface water interaction processes occurring within the large area of this groundwater body. The nature of these interactions will be determined by local factors and it is therefore impossible to generalize over such a large area. Such local influences could include the depths and permeability of subsoil, slope, local permeability of the rock, overlying surface water bodies and human alterations to the environment. Such interactions should be considered on a local scale where the importance of them is most critical e.g. at protected areas.
Conceptual model	This GWB is a large area within Co. Wicklow and a smaller area of Co. Dublin. The topography of the area is mountainous, comprising the Wicklow and Dublin Mountains. The GWB is composed primarily of low permeability rocks, although localised zones of enhanced permeability do occur. The boundaries of the GWB are defined by the extent of Hydrometric Area 10. Groundwater flow occurs mostly in a shallow upper weathered zone; deeper groundwater flow is possible along fractures, joints and major faults. Recharge occurs diffusely through the subsoils and via outcrops. There are large areas where the rock is close to surface, which would suggest high potential recharge values, but calculations must consider the effect of rejected recharge from the lower permeability rocks. The aquifers within the GWB are generally unconfined, but may become locally confined where the subsoil is thicker and/or of lower permeability. Groundwater flow is considered to recharge and discharge on a local scale. Drainage density values suggest shorter flow paths in the granites than on the flatter Lower Paleozoics. Groundwater discharges to the numerous small streams crossing the aquifer, to springs and seeps and also directly to the Irish Sea.	
Attachments		
Instrumentation	Stream gauge: 10001, 10002, 10003, 10004, 10005, 10006, 10007, 10008, 10009, 10010, 10012, 10013, 10014, 10015, 10016, 10017, 10018, 10019, 10020, 10021, 10022, 10023, 10024, 10025, 10026, 10027, 10028, 10029, 10030, 10031, 10032, 10033, 10034, 10035, 10036, 10037, 10070, 10071 Borehole Hydrograph: Some are present within the area of the GWB but they measure the Groundwater Levels in Gravel Aquifers. EPA Representative Monitoring boreholes: Roundwood (WIC027), Redcross (WIC026)	

Information Sources	McConnell B, Philcox M, Sleeman A G, Stanley G, Flegg A M, Daly E P & Warren W P. 1994. *A Geological description to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 16, Kildare-Wicklow*. Geological Survey of Ireland, 70 pp. Tietzsch-Tyler D & Sleeman A G. (1994) Geology of Carlow - Wexford. A geological description to accompany the Bedrock Geology 1:100,000 map series, Sheet 19, Carlow - Wexford. Geological Survey of Ireland. Woods L & Wright G R (2003) Redcross Water Supply. Groundwater Source Protection Report. Wicklow Groundwater Protection Scheme. GSI report to Wicklow Co. Co. Woods L & Wright G R (2003) Roundwood Water Supply. Groundwater Source Protection Report. Wicklow Groundwater Protection Scheme. GSI report to Wicklow Co. Co. Wright G R & Woods L (2003) *County Wicklow Groundwater Protection Scheme*. Report to Wicklow County Council. Geological Survey of Ireland
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

Formation Name	Code	Description	Rock Unit Group	Aquifer Classification
Aplite	apl		Granites & other Igneous Intrusive rocks	Pl
Appinite	app		Granites & other Igneous Intrusive rocks	Pl
Arklow Head Formation	AH	Black slates overlain by rhyolitic tuffs	Ordovician Metasediments	Pu
Arklow Head Formation & Felsic volcanics	fvAH	Black slates overlain by rhyolitic tuffs	Ordovician Metasediments	Pu
Avoca Formation	AV	Rhyolitic volcanics, dark grey slate	Ordovician Metasediments	Pu
Avoca Formation & Felsic volcanics	fvAV	Rhyolitic volcanics, dark grey slate	Ordovician Metasediments	Pu
Avoca Formation & Intermediate volcanics	ivAV	Rhyolitic volcanics, dark grey slate	Ordovician Metasediments	Pu
Ballybeg Member	MNbb	Dark grey semi-pelitic, psammitic schist	Ordovician Metasediments	Ll
Ballylane Formation	BY	Green & grey slate with thin siltstone	Ordovician Metasediments	Pl
Ballymoyle Formation	BL	Rhyolitic volcanics, grey & black slate	Ordovician Volcanics	Pl
Ballymoyle Formation & Felsic volcanics	fvBL	Rhyolitic volcanics, grey & black slate	Ordovician Metasediments	Pl
Ballymoyle Formation & Quartzite	qzBL	Rhyolitic volcanics, grey & black slate	Ordovician Volcanics	Pl
Barravore Aplogranite	LqBv	Fine-grained, muscovite-rich aplogranite	Granites & other Igneous Intrusive rocks	Pl
Bray Head Formation	BR	Greywacke & quartzite	Cambrian Metasediments	Pl
Bray Head Formation & Quartzite	qzBR	Greywacke & quartzite	Cambrian Metasediments	Pl
Butter Mountain Formation	BZ	Dark slate-schist, quartzite & coticule	Ordovician Metasediments	Ll
Carrawaystick Aplite	LqCw	White, saccharoidal garnetiferous aplite	Granites & other Igneous Intrusive rocks	Pl
Croghan Kinshelagh Granite	Ck	Grey to pink even-grained granite	Granites & other Igneous Intrusive rocks	Pl
Devils Glen Formation	DG	Greywacke & shale	Cambrian Metasediments	Pl
Devils Glen Formation & Mafic volcanics	mvDG	Greywacke & shale	Cambrian Metasediments	Pl
Diorite	Di		Granites & other Igneous Intrusive rocks	Pl
Dolerite	D		Granites & other Igneous Intrusive rocks	Pl
Glencullen River Formation	GL	Buff-coloured tuff & greywacke	Ordovician Metasediments	Pl
Glendalough Adamellite	LqGd	Adamellite with microcline phenocrysts	Granites & other Igneous Intrusive rocks	Pl
Granite (undifferentiated)	Gr		Granites & other Igneous Intrusive rocks	Pl
Kilmacrea Formation	KA	Dark grey slate, minor pale sandstone	Ordovician Metasediments	Ll
Kilmacrea Formation & Felsic volcanics	fvKA	Dark grey slate, minor pale sandstone	Ordovician Metasediments	Pl
Knockree Member	MNkr	Quartzite	Ordovician Metasediments	Ll
Maulin Formation	MN	Dark blue-grey slate, phyllite & schist	Ordovician Metasediments	Ll
Maulin Formation & Intermediate volcanics	ivMN	Dark blue-grey slate, phyllite & schist	Ordovician Metasediments	Ll
Maulin Formation & Mafic volcanics	mvMN	Dark blue-grey slate, phyllite & schist	Ordovician Metasediments	Ll
Maulin Formation & Quartzite	qzMN	Dark blue-grey slate, phyllite & schist	Ordovician Metasediments	Ll
Microgranite	mGr		Granites & other Igneous Intrusive rocks	Pl
Moneyteige Member	BYmt	Metagreywackes, slates & metadolerites	Ordovician Metasediments	Pl

Oaklands Formation	OA	Green, red-purple, buff slate, siltstone	Ordovician Metasediments	LI
Percys Table Granodiorite	LqPt	Aphyric granodiorite	Granites & other Igneous Intrusive rocks	PI
Roundwood Member	MNrw	Basalt breccia	Ordovician Metasediments	LI
Serpentinite	S		Granites & other Igneous Intrusive rocks	PI
Tober Colleen Formation	TC	Calcareous shale, limestone conglomerate	Dinantian Upper Impure Limestones	PI
Type 1 Granodiorite	Nt1	Fine-grained granodiorite to granite	Granites & other Igneous Intrusive rocks	PI
Type 2 Equigranular Granite	Tw2e	Pale, fine to coarse-grained granite	Granites & other Igneous Intrusive rocks	LI
Type 2 Microcline Porphyritic Granite	Tw2m	Granite with microcline phenocrysts	Granites & other Igneous Intrusive rocks	PI
Type 2 Sparsely Porphyritic Granite	Tw2i	Granite, some microcline phenocrysts	Granites & other Igneous Intrusive rocks	PI
Type 2e equigranular Granite	Nt2e	Pale grey fine to coarse-grained granite	Granites & other Igneous Intrusive rocks	PI
Type 2p microcline porphyritic Granite	Nt2p	Granite with microcline phenocrysts	Granites & other Igneous Intrusive rocks	PI
Type 3 muscovite porphyritic Granite	Nt3	Granite with muscovite phenocrysts	Granites & other Igneous Intrusive rocks	PI
Type 4 muscovite/microcline porphyritic Granite	Nt4	Muscovite-microcline porphyritic granite	Granites & other Igneous Intrusive rocks	PI
Wicklow Head Formation	WH	Silver-grey mica-schist	Ordovician Metasediments	PI



SLR GoBe APEM Group

Annex 3 Summary Details of the Water Framework Directive

Introduction

The EU Water Framework Directive1 (WFD) became EU law in December 2000 and provides for a single European framework to assess water quality (Ecological status) and allows for the comparison of results across European Member States.

The WFD covers rivers, lakes, estuaries or transitional waters, coastal waters as well as groundwaters.

Surface waters are classified into five quality classes (Ecological status) under the WFD; High, Good, Moderate, Poor and Bad Ecological status. Groundwater is classified into just two quality classes, Good and Poor Ecological status. High Ecological status is when the water is unpolluted, while at the opposite end of the classification Bad Ecological status is when the water is highly polluted.

The WFD required baseline water quality in all waterbodies to be established for biological, chemical and hydromorphology quality. These three quality variables are combined to give the overall Ecological status classification of the waterbody; good or high ecological status and good chemical status for surface waters and good chemical and quantitative status for groundwaters.

The two principal objectives of the WFD are:

- that all water bodies must reach at least 'Good' overall status by 2027, at the latest. For surface waters, good overall status is a combination of good ecological status (or potential) and good chemical status; and
- that the status of each water body, including all the quality elements which make up the overall status, must not deteriorate relative to the baseline reported in the relevant RBMP.

The WFD identifies where actions are required to achieve Good Ecological status or maintain waterbodies which are already Good or High Ecological status. Waterbodies can be restored to Good and High Ecological status by using targeted actions and measures to reduce the impact of human activities on them.

For heavily modified or artificial water bodies, which are incapable of achieving Good Ecological status without impairing an existing specified water use, the environmental objective is to achieve good ecological potential.

[1] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

The WFD requires that management plans are prepared on a river basin basis and specifies a structured method for developing these plans.

River Basin Management Plans

The River Basin Management Plans (RBMP) provide a single system of water management based on the natural delineation of river catchments and is the method by which the aims of the WFD are achieved.

For each river basin district in Ireland a RBMP needs to be established and updated every six years, to provide the context for the co-ordination requirements of the WFD key aims which are to:

- Provide for protection to all waters, surface waters and groundwater;
- achieving Good Ecological status for all waters by 2027;
- establish water management measures based on river basin catchment areas;
- establish a combined approach of emission limit values and quality standards for waters;
- involving citizen more closely in the WFD and RMBMP; and
- streamlining and aligning national legislation.

The RBMP provides a detailed account of how the objectives set for each river basin in terms of ecological status, quantitative status, chemical status and protected area objectives are to be reached within the timescale of the plan. The plans include the results of the catchment analysis including the river basin's characteristics, a review of the impact of human activity on the status of waters in the basin, estimation of the effect of existing legislation and the remaining gap to meeting these objectives; and establish a set of measures designed to meet the objectives.

River Basin Management Plan for Ireland 2022-2027

The current RMBP report for Ireland is at the draft stage[2]. The draft report states that while substantial progress has been made in the management of water services and how we work together to protect, restore and improve water quality with the improvement in some areas and aspects of water quality, many waterbodies are still subject to mounting environmental pressures and overall water quality is in decline primarily due to nutrient pollution.

The RMBP states that due to the overall decline in water quality stronger measures are now required which will improve overall water quality; the sustainable management of

[2] Draft River Basin Management Plan for Ireland 2022-2027, Government of Ireland

water resources is important to address and adapt to the impacts of climate change, with many of the required measures having co-benefits for climate mitigation and biodiversity. Protecting and restoring water quality in Ireland will most of all need measures to address:

- the loss of agricultural nutrients to water;
- continue to improve waste water treatment; and
- to re-establish natural free-flowing conditions in more rivers.

The plan states that Ireland's water resources and services face challenges on a number of fronts including a continued need for investment in infrastructure and an ever increasing demand for water services due to urbanisation, population and economic growth. These challenges are set against a backdrop of widespread, rapid, and intensifying climate change.

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